The role of digital transformation within construction project management in South Africa

.”

Pierre Snyman

2527205

2527205@stdents.wits.ac.za / +960 965561

Supervisor: Dr Tebogo Sethibe

Research presented to the Faculty of Commerce, Law, and Management at the University of the Witwatersrand as a partial requirement for obtaining a Master of Management degree in Digital Business.

Johannesburg, 2023

ABSTRACT

In the rapidly evolving landscape of South Africa's construction industry, integrating digital technology has emerged as a pivotal factor influencing project management practices. This study delves into the role of digital transformation within construction project management, framed within the context of technological advancements and shifting industry paradigms.

This investigation used a qualitative research methodology to gather data through structured interviews with the South Africa construction sector and international professionals. The sample comprised individuals actively involved in project management, offering insights into the current state of digitalisation and challenges in the planning phase of construction projects.

The findings reveal a significant integration of digital tools such as CCS MSP and Primavera P6, highlighting their contribution to enhanced efficiency and effectiveness in project management. The study also uncovers the cultural and age-related challenges in adopting these technologies, alongside the role of regulatory reforms and the DD in their implementation. Advanced collaboration methods, including BIM, Virtual and Augmented Reality (VR/AR), and cloud-based tools, were identified as key to improving stakeholder communication and project success.

Conclusively, this research underscores the transformative role of digitalisation in construction project management in South Africa. It advocates for strategic policy interventions and targeted training initiatives to bridge the digital divide, particularly among older professionals, and to harness the full potential of digital tools for improved project outcomes. The study provides valued insights for practitioners and policymakers who want to explore and achieve a deeper understanding of the complexities of modern project management in the construction industry during digital transformation.

KEYWORDS

Digital transformation, CPM, project planning, PM software, project efficiency, digital strategy

DECLARATION

I, Pierre Snyman, with a profound sense of responsibility and academic integrity, hereby declare that the research report presented herein genuinely reflects my intellectual endeavour. Anchored in my experiences over three decades in construction and project management and enriched by insights from my professional journey across nine countries, which is a culmination of my dedicated pursuit in the field of digital business. This work, submitted for esteemed consideration by the University of the Witwatersrand, Johannesburg, represents my commitment to advancing knowledge in the realm of DT in CPM. This is submitted in partial completion of the Master of Management in Digital Business degree requirements. I affirm that the ideas, analyses, and conclusions outlined in this report are original, except where duly acknowledged and referenced. This report has not been submitted to any other institution for the award of any academic degree or professional qualification. In submitting this report, I celebrate the collaborative spirit of academia and honour the ethical standards that underpin scholarly research. My journey, encapsulated in these pages, stands as a testament to my dedication to lifelong learning and to the advancement of our industry through digital innovation.

Name: Pierre Snyman Signature: PSnyman

Signed at Male Maldives

On the 19 February 2024

DEDICATION

From the vibrant landscapes of SA to the serene shores of the Maldives, where this research journey finds me, this work is a confluence of global perspectives and local insights. It is dedicated to the pioneers of DT in CPM, whose innovative spirit transcends geographical boundaries. To the professionals and visionaries in SA whose efforts in integrating DTEC in construction have been the focal point of this study, your dedication and foresight are the pillars of this research. Your work is not only reshaping the industry in SA but also providing valuable lessons and inspiration to global counterparts. This dedication extends to my colleagues and mentors across the nine countries I have had the privilege to work in and now, from my current base in the Maldives. Your diverse experiences and wisdom have been instrumental in shaping my understanding of how DT can be effectively harnessed in our field. Special appreciation is given to the communities in SA and beyond, who are the ultimate beneficiaries of our industry's advancements. This research is a tribute to your aspirations for more efficient, sustainable, and inclusive construction practices. To my fellow construction planners and project managers, your relentless pursuit of excellence, adaptability to change, and passion for innovation continue to drive the evolution of our profession. This research is a celebration of our collective journey towards a digitally empowered future in CPM.

ACKNOWLEDGEMENTS

I would like to begin by expressing my profound gratitude to my academic supervisor, Dr Tebogo Sethibe, for his expert guidance, constructive feedback, and unwavering support throughout the course of this research project. His mentorship has been invaluable in shaping not just this thesis but also my broader academic journey.

I extend my appreciation to the faculty members of the Business School at Wits University. Their collective wisdom and expertise have enriched my understanding of MMDB, and their constructive critiques have been instrumental in refining my research methodology.

Special thanks are due to my individual participants, who have generously provided access to critical data that significantly enriched this study. I am grateful for their trust and Collaboration, and I assure them that all data have been treated with the utmost confidentiality and integrity.

To my incredible wife Selisia, you are the unsung hero of this journey. Your love has been my Sanctuary, a place where I could retreat to find peace and strength. The countless times you've stayed up late to talk through my research quandaries or simply to listen when I needed to vent are moments I hold dear. You've been my sounding board, my confidante, and my greatest supporter. Your sacrifices, such as taking on extra responsibilities at home to allow me the time and space to focus, have been monumental. You've even become an expert in making my favourite comfort foods precisely when I needed them the most. Your love is the invisible ink that writes the pages of this thesis, and I am eternally grateful for your unwavering support.

To my son Evan, you are the heartbeat that keeps me going, even on the most challenging days. Your laughter fills our home with warmth, and your endless curiosity about the world is a constant reminder of why I strive for excellence. When I've had to lock myself away to meet deadlines or solve complex problems, your understanding and patience have been extraordinary. You'd leave little notes or drawings under the door, each one a treasure that lifted my spirits and reminded me why all this hard work is worth it This achievement is not solely an

academic milestone; it's a family triumph, and you, my young man, have been an integral part of this journey.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

Abbreviation	Full Form
AI	Artificial Intelligence
AR	Augmented Reality
BIM	Building Information Modelling
CC	Construction Projects
CCS	Construction Computer Software
CI	Construction Industry
CPM	Construction Project Management
DCIM	Digital Construction-Phase Information Management
DD	Digital Divide
DoI	Diffusion of Innovation
DPM	Digitalisation Project Management
DT	Digital Transformation
DTEC	Digital Technology
ICT	Information and Communications Technology
IoT	Internet of Things
IT	Information Technology
MSO	Microsoft Project
OQ	Output Quantity
PM	Project Management
PMM	Project Management Method
PMO	Project Management Office
PMP	Project Management Planning
PPI	Potential Positive Roles
QA	Quality Assurance
QC	Quality Control
SACI	South African Construction Industry
SACPM	South African Construction Project Management
SA	South Africa
TAM	Technology Acceptance Model
VR	Virtual Reality

CHAPTER 1. INTRODUCTION

1.1 Statement of purpose

The objective of this study is to examine the role of DT in project management, with a particular focus on the planning phase within the SACI. The study adopts a dual approach: firstly, it investigates the formulation and implementation of DT strategies in the context of CPM, and secondly, it delves into how these strategies interact and are influenced by the unique challenges of the CI in SA. This qualitative research is structured as a case study, offering an in-depth exploration of DT processes within a specific sector, thereby providing valuable insights into the integration and role of digital tools and methodologies in construction project planning.

1.2 Context of the study

Project management in the construction sector of SA is evolving, primarily driven by the rapid advancement of DTEC. This evolution encompasses numerous disciplines, often facing demanding schedules, stringent deadlines, and unpredictable hazards. The introduction of DT and advancements in information technology presents promising solutions that can significantly benefit the management of construction projects (Nicholas & Steyn, 2017). The SACI has recently seen an increasing trend towards digital project management. This shift aims to enhance efficiency, reduce costs, and ensure compliance with regulatory standards (Newman et al., 2021).

Key to this transformation is the integration of digital tools and software solutions. These technological advancements are reshaping traditional project management tasks, including scheduling, budget tracking, and resource management. They also facilitate improved communication and collaboration among stakeholders involved in construction projects. Advanced technologies like BIM, drones, and VR are increasingly employed in the SACI. Their application offers more efficient project planning, enhances construction quality, and improves post-construction maintenance (Pan & Zhang, 2021).

Despite the progress, the CI in SA faces challenges in fully embracing digitalisation. There are widespread obstacles to adopting new technologies, including a shortage of qualified staff, restricted availability of digital infrastructure in remote locations, and companies' reluctance to invest due to cost concerns and potential disruption to current operations (Union, 2020).

The forthcoming study explores the challenges and opportunities associated with digitalising the construction design process in SA. The research seeks to understand the implementation and role of digitalisation in the sector, with the goal of bridging the existing DD. By conducting a thorough analysis of the digitalisation of CPM, this research will offer valuable knowledge to companies of all sizes. It will guide the effective implementation of digital tools in their project management practices (Malacarne, Toller, Marcher, Riedl, & Matt, 2018).

1.3 Research problem

The SACI, traditionally reliant on manual processes and conventional project management methods, is experiencing a significant shift. As the sector adopts digital alternatives, traditional practices are being re-evaluated. This transition mirrors the global trend where industries are moving towards digitalisation to meet changing demands and enhance efficiency. Historically, the CI has been characterised by intense pressure, stringent timelines, and many independent subcontractors and suppliers, each bringing unique challenges to project management (Nicholas & Steyn, 2017). However, DT presents an opportunity to revolutionise these traditional practices.

This study aims to investigate the role of DT on the planning phase of project management in the SACI. Despite the increasing use of planning software tools such as CCS MSP and Primavera P6, there still needs to be a gap in fully embracing digitalisation to improve efficiency and effectiveness (Windapo, 2021). The research problem involves comprehending the challenges and opportunities of digitalisation and exploring their navigation to facilitate successful implementation in CPM.

1.3.1 Main Problem:

Role of DT on PMP:

The primary focus is on evaluating how DT, including technologies like BIM, AR/VR, and other advanced tools, roles the efficiency and outcomes of project planning in the SA construction sector (Pan & Zhang, 2021).

1.3.2 Sub-problem 1

Challenges and Opportunities of Digitalisation:

This sub-problem examines the difficulties and prospects of digitalisation in the CI. It explores the need for skilled workers, the challenges of limited access to digital infrastructure, and the resistance to adopting new technologies due to costs and potential disruption of existing processes (Union, 2020).

1.3.3 Sub-problem 2

Strategies for Effective Digitalisation Implementation:

The second sub-problem aims to identify effective strategies for implementing DTEC in CPM. It considers integrating digital tools in the planning phase and their role on efficiency and project success, addressing both opportunities and challenges in the DT (A Kozarkiewicz, 2020).

By addressing these problems, the research seeks to provide a comprehensive understanding of the DT landscape in the SACI. It aims to develop strategies for navigating and leveraging the challenges and opportunities presented by digitalisation, involving a thorough examination of the current state of digitalisation and potential future developments in this area (A Kozarkiewicz, 2020; Windapo, 2021)

Research objectives

Main Objective:

To investigate the role of DT in project management's planning phase within the South African CI, focusing on understanding the challenges and opportunities presented by digitalisation and exploring strategies for successful implementation.

Sub-objectives:

1. To examine the current state of digitalisation in the planning phase of CPM in SA, including using planning tools to identify areas where further digitisation could enhance efficiency and effectiveness.
2. To explore the challenges associated with digitalisation in the planning phase of CPM, including cultural adjustments, regulatory reforms, the implementation of advanced Collaboration methods, and the role of the DD.
3. To identify and evaluate the opportunities presented by digitalisation in the planning phase of CPM, such as improved communication, enhanced decision-making, increased productivity, and more accurate and efficient planning, and to develop strategies for leveraging these opportunities for improved project outcomes.

1.4 Significance of the study

The significance of this research lies in its exploration of the role of DT on construction planning and project management within the SA context. This study aims to provide critical insights into the CI 's practical and theoretical aspects of digital transformation.

CPM involves complex, data-intensive tasks such as risk management, progress tracking, resource allocation, and real-time communication. Digitisation has the potential to significantly enhance these processes by automating and streamlining tasks (Feise & Graf von Hatzfeldt Trachenberg, 2019). This research, therefore, seeks to understand the current state of digitisation in the SACI, identify areas for further digital technology adoption, and comprehend their implications for project management processes (Moroz, 2018).

The study confronts specific challenges in the SACI, including limited access to digital infrastructure, a shortage of skilled workers, and resistance to technological change (Moroz, 2018). The research aims to facilitate the digitisation of construction planning project management by identifying and proposing solutions to these challenges.

In addition, the research evaluates the implementation of DT in the field by analysing software options for project scheduling, expense monitoring, workforce allocation, and innovative technologies like BIM, drones, and Virtual Reality (VR) used in construction endeavours (Feise & Graf von Hatzfeldt Trachenberg, 2019).

Theoretically, the research aims to expand our understanding of the current digitalisation status in CPM and identify areas for enhancement. The findings are expected to offer recommendations for overcoming digital adoption barriers, designing effective training programs, encouraging investment in new technologies, and enhancing efficiency and profitability in CPM (Moroz, 2018).

In essence, the study is of great practical and theoretical value, as it investigates the influence of DT on construction planning project management in SA, aiming to advance the industry's project management practices through a thorough understanding of digitisation's current state, challenges, and potential solutions.

1.5 Delimitations of the study

Figure 1: Research focus areas

- Understanding Digital Transformation's Role: This research primarily unravels how DT influences the planning phase in project management within SA's CI. It focuses on integrating DTEC, such as planning software, BIM, AR/VR, and their role on enhancing project management efficiency and effectiveness.
- Assessing Technology Integration: The study scrutinises the increasing employment of digital tools in CPM, aiming to bolster operational efficiency and cost-effectiveness. It evaluates how digital tools and software solutions automate and streamline project management activities, enhancing stakeholder collaboration and communication.
- Challenges and Opportunities of Digitalisation: By identifying the necessity for further digitisation in the industry, this research probes into specific challenges like skill shortages, limited digital infrastructure access, and resistance to new technology investments. It explores opportunities for digitisation to enhance project management practices.
- Digitisation in Planning Phase: This study focuses on the planning phase of project management. It investigates how integrating DTEC can significantly uplift planning processes' efficiency and project outcomes' quality.
- Cultural Adaptation and Regulatory Framework: This research delves into the cultural adjustments and regulatory reforms needed for effective digital

adoption. It examines the role of the DD, particularly in the SA context, and how it influences the equitable adoption of DTEC across various sectors.

- Broad-Spectrum Analysis: The study provides a comprehensive analysis of digitalisation in CPM, encompassing the current state and potential future advancements in SA's CI.
- Theoretical and Practical Contributions: Aimed at both practical and academic circles, the study enhances the understanding of effective digital technology implementation in CPM. It provides insights for overcoming adoption barriers and developing appropriate training programs.
- Promoting Diversity and Inclusion: An additional focus of this research explores the role of non-traditional experiences and diverse backgrounds on the DT in the CI. It examines how varied perspectives and skill sets can contribute to successful digital adoption.
- Supporting Industry Evolution: The overarching aim of this study is to facilitate the effective implementation of DTEC in CPM, thereby contributing to the industry's growth and SA's economic development.

1.6 Definition of terms

Term	Definition
DT	Conversely, signifies a significant shift in an organisation brought about by digital automation technologies (Benbasat, 1987).
Critical path	Refers to the sequence of tasks that represents the longest path and determines the shortest project duration (Cost, 2012).
Cloud-based project management tools	project management tools are becoming more prevalent, transitioning project data from internal servers to cloud-based solutions (Lamacchia, 2020).
Digitisation	Involves applying DTEC to transform operational and business processes, improving revenue and opportunities ("https://www.gartner.com,"). It involves converting analogue or physical forms into digital formats (Bloomberg, 2018).
CPM	A coordinated and comprehensive management of a project, encompassing all stages from conception to completion, including commissioning, focusing on achieving defined objectives in terms of functionality, usefulness, and quality. It involves effectively utilising resources such as materials, equipment, funds, and people (Reis, Amorim, Melão, & Matos, 2018; Walker, 2015).

1.7 Assumptions

It is assumed that Digitalisation and all its offerings will allow the area of project management to increase productivity while also improving the time, cost, and quality aspects of Project management.

Assumptions for the study on digitisation within the Construction PMP field in SA:

1. CI in SA is facing challenges related to PMP and coordination, which can be mitigated through the adoption of digitisation technologies.

2. The current adoption rate of digitisation technologies in the Construction field in SA needs to be higher.

3. Adopting digitisation technologies can improve PMP, coordination, Collaboration, and communication among construction project team members.

4. Using digital tools can improve project monitoring and reporting efficiency and accuracy, leading to reduced costs and time overruns.

5. Obstacles within the adoption of digitisation technologies within the CI in SA include lack of understanding, lack of skills and education/ subject knowledge, and the resistance to change.

6. Developers and builders that have embraced digitisation technologies have experienced significant benefits resulting in improved profitability.

7. The effectiveness of digitisation technologies on PMP may differ based on the project's size, complexity and scope and other project-specific factors.

8. The use of digitisation technologies in the CI will automate many formerly manual tasks, freeing up resources and reducing human error.

9. Adopting digitisation technologies will require changes in current practices, regulatory laws, and ethical practices.

10. Finally, introducing digitisation technologies in the CI will require a new skill set and training methods within the industry.*(Snyman, 2022)*

1.8 Chapter Outline

Chapter 1 – The first chapter introduces this study and provides information about digitalisation in project management; the statement of purpose, background and definitions are covered.

Chapter 2 - Chapter Two presents' findings from literature reviews on peer-reviewed and authored articles. It includes a breakdown of the results of the research questions posed in Chapter One and concludes the literature review.

Chapter 3- The third chapter's focus is to comprehensively explain the research design and methodology employed in the study. This section thoroughly elaborates on the methods and strategies implemented during the research process. It outlines the systematic data collection, analysis, and interpretation procedures, ensuring a robust and credible research process. The chapter also discusses the rationale behind the chosen methodology, highlighting how it aligns with the research objectives and contributes to a comprehensive understanding of the study's subject matter.

Chapter 4 - In Chapter 4, we concisely summarise the critical findings regarding digitalisation in SACPM. This includes the integration and role of digital tools, the challenges of digital adoption, and the emerging opportunities for enhancing project outcomes. The summary highlights key technologies such as BIM, AI, and IoT and their influence on the industry's evolution.

Chapter 5- In Chapter 5, the discussion delves into the implications of the findings presented in Chapter 4, examining how digitalisation is reshaping CPM in SA. This chapter thoroughly examines how digital tools have been integrated, the existing difficulties, and the methods employed to enhance project results. It contextualises the findings within the broader industry trends and explores the potential future trajectory of digitalisation in the sector.

Chapter 6- Chapter 6 presents the conclusions drawn from the research, synthesising the key insights on digitalisation in CPM in SA. This chapter articulates the significant roles, challenges, and opportunities identified in the study. It also offers well-founded recommendations for practitioners and stakeholders in the industry, guiding future

digital adoption strategies and policymaking to enhance project management efficacy and innovation.

CHAPTER 2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 Introduction

This chapter critically examines DT within the realm of CPM, mainly focusing on the planning phase in the SA context. The literature review aims to present a thorough overview of existing research concerning the utilisation and role of DT in CPM, thus establishing a comprehensive foundation for the study. It delves into how DTEC, such as BIM, cloud-based tools, and other advancements influence project planning processes. The review also investigates the challenges and opportunities of digitisation in this sector, including issues related to cultural adjustments, regulatory reforms, and the DD. In this chapter, a comprehensive examination of these elements will be presented, leading to a cohesive final argument that integrates the primary ideas and discoveries found in the literature.

2.2 Definition of topic or background discussion

Digitisation, digital transformation, and digitalisation

Digitisation, digital transformation, and digitalisation are related but distinct concepts representing different stages of adopting and integrating digital technology within construction planning and project management (Oesterreich & Teuteberg, 2016). SA construction companies can leverage these concepts to improve efficiency, collaboration, and decision-making in their projects, enhancing their competitiveness in the industry (Agboola et al., 2019). Digital innovations have three main characteristics: based on digital technology, this can be manipulated, and DT is necessary to generate more digital technology (Arditi & Pulket, 2010; De Reuver, Sørensen, & Basole, 2018; Kallinikos, Aaltonen, & Marton, 2013). Such innovations result in convergence and uniformity, and they can be replicated and scaled in ways that traditional methods cannot *(Um, Yoo, Wattal, Kulathinal, & Zhang, 2013; Yoo, Boland Jr, Lyytinen, & Majchrzak, 2012).* Project management involves controlling tasks and resources for the desired outcome *(Edition, 2018).* The digital economy

significantly roles the technologies used and the transformation of strategies, business models, structures, and skills *(Alina Kozarkiewicz, 2020)*

Agile & waterfall method

The Agile method and Waterfall model are two distinct approaches to software development. Agile prioritises collaboration, flexibility, and continuous improvement, breaking the process into small sprint increments. It focuses on delivering software that works expeditiously while adapting to changing needs. Agile organisations value open communication, cross-functional capabilities, and regular feedback.
The Waterfall model is a subsequent methodology where every stage is achieved before moving on to the next. It is easy to understand and implement, with clear project scope and schedule. However, it can be inflexible, making changes in requirements or design difficult. It is more suitable for larger, complex projects with well-defined parameters.

Figure 2 illustrates the key differences between the Agile method and the Waterfall model. The figure clearly shows the sequential nature of the Waterfall model compared to the iterative approach of Agile, highlighting how each methodology manages project phases differently.

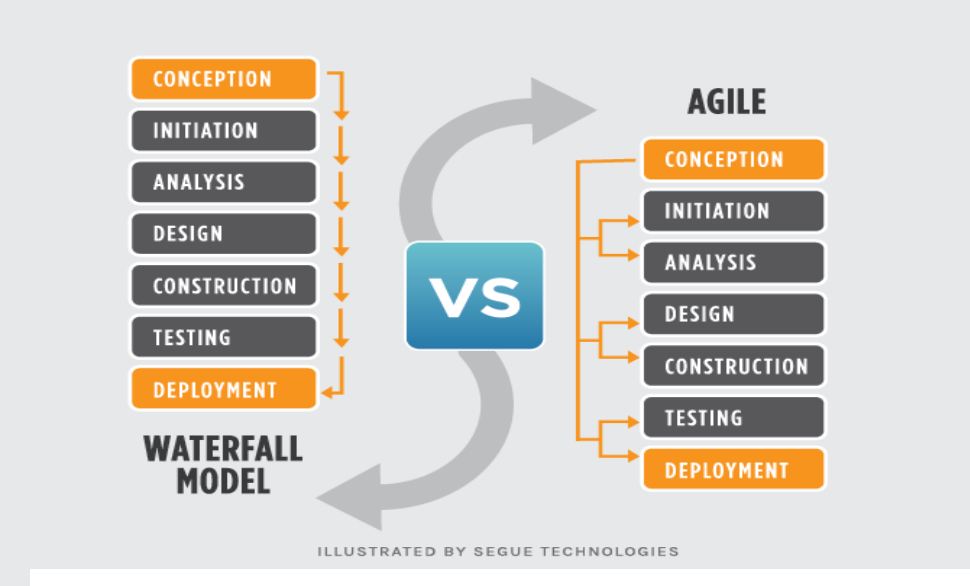

Figure 2: Agile vs Waterfall Method

- *(BIM)* building information modelling: The process that employs digital information configurations to establish a understanding of a construction project, enhancing data management, collaboration, and communication among stakeholders throughout the project lifecycle *(Eastman, Teicholz, Sacks, & Liston, 2011)*

Figure 3 illustrates the functionality of 5-D BIM, which integrates design, cost, and schedule in a 3-D output. The figure shows how BIM provides a digital representation of the physical and functional characteristics of a project, forming a reliable basis for decisions during the project's life cycle. It highlights the elements that can be embedded in a 3-D model, including geometry, spatial data, specifications, aesthetics, thermal properties, and acoustic properties. Additionally, it demonstrates how the elements of the 3-D model are linked to the execution schedule (4-D) and budget (5-D), illustrating the comprehensive capabilities of BIM in managing construction projects.

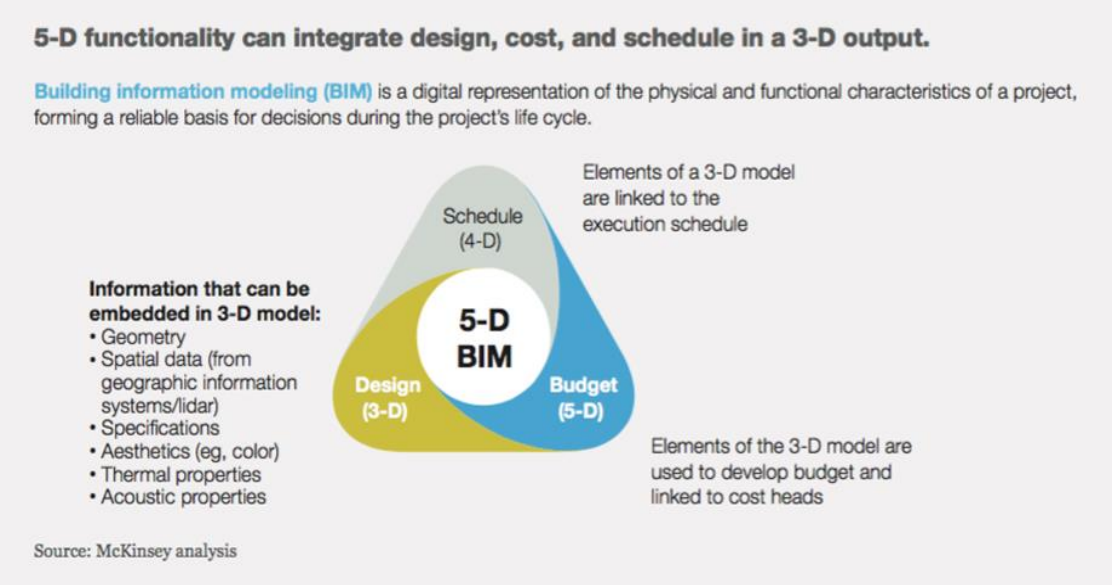

Figure 3: BIM functionality

- 3D models*:* A digital representation of a construction project in three dimensions, which facilitates better visualisation and understanding of the final project outcome compared to traditional 2D drafting methods (Azhar, Carlton, Olsen, & Ahmad, 2011)

- Data management*:* For convenience of organising and storing project information in a central repository to ensure all stakeholders have access to the most current information and encourage continuous data flow. (Arayici, Egbu, & Coates, 2012)
- Collaboration*:* An interdisciplinary teamwork approach among architects, engineers, contractors, and other stakeholders, encouraged by BIM technology, that fosters real-time input and feedback, improved coordination, and enhanced decision-making (Sacks, Koskela, Dave, & Owen, 2010)
- Communication: The process of sharing ideas, requirements, and concerns among project stakeholders, facilitated by BIM technology through visual representation and compatibility between different software platforms (Azhar et al., 2011; Eastman et al., 2011).
- Project management: The discipline of planning, executing, and completing projects using various methodologies and tools to manage resources, which involves identifying a problem, developing a plan to address the issue, and following the plan until the problem is resolved ("Projectmanager.com,").

2.2.1 Defining Digitisation, Digital Transformation, and Digitalisation in CPM

Understanding the distinctions and interrelations between digitisation, digital transformation, and digitalisation in the SACI is key for advancing project management practices.

Digitisation is the foundational process of converting analogue or physical data into digital formats. It is a critical step in modernising construction management, making project information more accessible and easier to manage. This transformation enables the CI to lay the groundwork for more advanced digital innovations (Bloomberg, 2018).

DT represents a comprehensive change within construction organisations, driven by the comprehensive integration of DTEC. This transformative process redefines business models and operational processes, moving beyond adopting new tools to completely reimagining how construction projects are planned, executed, and managed. It encompasses the adoption of advanced technologies such as BIM, augmented and virtual reality (AR/VR), and cloud-based solutions, fundamentally altering traditional construction practices (Benbasat, 1987).

Digitalisation refers to applying DTEC to overhaul operational and business processes, enhancing efficiency, collaboration, and decision-making in construction projects. It signifies a paradigm shift in how construction teams operate, challenging the industry's traditional resistance to change and new methodologies (Dallasega, Rauch, & Frosolini, 2018).

In SA, the construction sector is increasingly adopting digital tools like CCS MSP and Primavera P6 for project scheduling and management. However, challenges such as limited digital infrastructure, skill shortages in DTEC, and resistance to change hinder full adoption (Moroz, 2018).
Despite these obstacles, the potential benefits of DT in CPM are significant. DTEC can streamline processes, enhance planning and execution accuracy, and improve project outcomes. BIM, for instance, offers a more integrated approach to project management, fostering better visualisation, collaboration, and communication among stakeholders (Windapo, 2021).

To harness these benefits, SA construction firms must tackle these challenges by investing in new technologies, cultivating a culture open to change, developing relevant skills in their workforce, and adapting to new regulatory frameworks. This comprehensive approach will enable them to improve competitiveness and efficiency in a rapidly evolving digital landscape.

2.2.2 Theoretical Framework on DT in CPM

2.2.2 Theoretical Framework on DT in CPM
DT within CPM signifies a comprehensive shift towards integrating DTEC into various aspects of construction firms' operations. This change is essential to increase efficiency, maintain a competitive advantage and promote innovation in the rapidly growing construction sector.

Integration of DTEC:

The core of DT in CPM lies in adopting advanced DTEC, including mobile applications, cloud computing, collaboration tools and big data analytics. These innovations are

instrumental in streamlining project management processes, improving stakeholder communication, and optimising data utilisation, thereby revolutionising traditional construction practices (Ismail, Khater, & Zaki, 2017).

Strategic DT for Competitive Advantage:

Construction firms must formulate and execute strategic DT plans to navigate the complexities of digital transformation. These strategies are essential for providing direction, optimising the use of resources, and ensuring cohesive decision-making across the organisation. The goal is to leverage DTEC to enhance operational effectiveness and sustain market competitiveness (Hess et al., 2016). (Grant & Osanloo, 2014) stress the importance of a well-defined business strategy encompassing DT efforts to address the multifaceted nature of organisational change.

Investment in DTEC for Enhanced Profitability:

The correlation between strategic digital technology investments and increased profitability underscores the necessity for construction firms to invest in technology and align these investments with their strategic business objectives. Effective management of DTEC can significantly contribute to a firm's financial performance, distinguishing it from competitors (Fitzgerald, Kruschwitz, Bonnet, & Welch, 2014).

TAM in DT:

The TAM plays a key role in understanding the adoption of DTEC within CPM. TAM assesses users' willingness to adopt new technologies based on usefulness and ease of use. This model provides insights into how construction professionals and firms perceive and subsequently integrate digital tools into their daily operations, influencing the overall success of DT initiatives.

Figure 4 illustrates the TAM model, showing the relationship between perceived usefulness, perceived ease of use, attitude towards use, intention, and behaviour. By

understanding these factors, stakeholders can better facilitate the adoption of digital technologies within the construction industry.

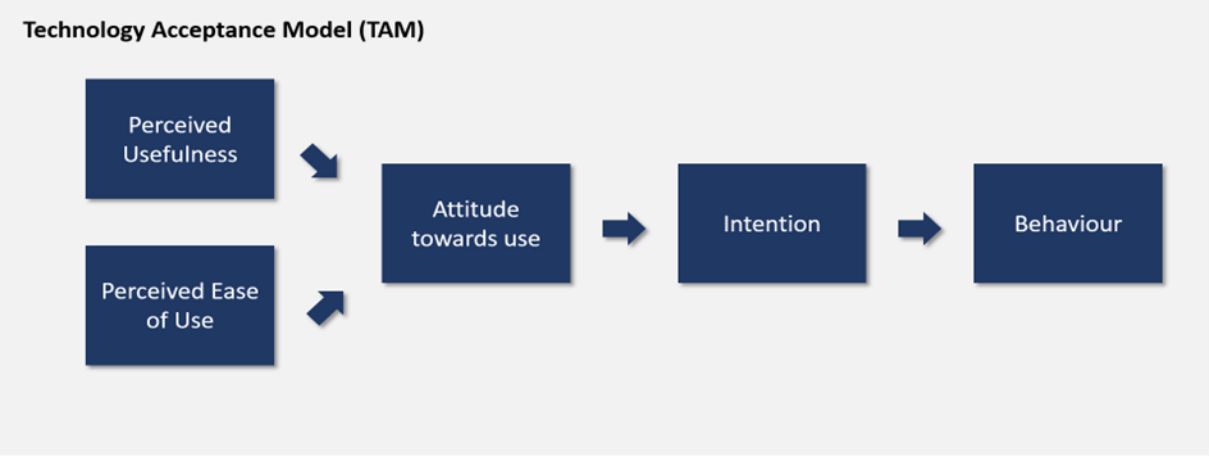

Figure 4: TAM model (Snyman, 2022)

Organisational Capabilities and Business Model Transformation:

Achieving a successful DT extends beyond the mere introduction of new technologies. It requires a comprehensive re-evaluation and modification of the business model to capitalise on digital advancements fully. This transformation encompasses reshaping business operations, products, and processes to align with digital goals, necessitating a wide range of organisational capabilities (Reis et al., 2018).

Overcoming Challenges in Digital Transformation:

The journey towards DT is fraught with challenges, including deriving tangible benefits from DTEC and managing the complexity of organisational change. A successful transformation demands a strategic approach to digital system utilisation, a complete organisational restructuring, and effective leadership to steer the firm through the digital transition (Fitzgerald et al., 2014; Reis et al., 2018).

In summary, the theoretical framework for DT in CPM emphasises the critical integration of DTEC, strategic planning, and organisational adaptability. It highlights the significance of the Technology Acceptance Model in gauging technology adoption and the need for a holistic approach to navigate the challenges of DT effectively.

2.3 DT Strategy

2.3.1 Introduction

In SACPM, the terms digitisation, DT, and digitalisation represent pivotal stages in integrating digital technology into construction planning and project management.

Digitisation marks the initial phase of this integration, focusing on converting analogue or physical data into digital formats. This process is essential for modernising construction management practices, making project information more accessible and manageable. In essence, digitisation lays the groundwork for further digital advancements within the industry (Bloomberg, 2018).

DT, however, takes a much broader scope than mere digitisation. It represents a significant shift within an organisation, catalysed by the comprehensive integration of DTEC. This transformative process involves not only the adoption of new tools but also a profound reimagining and reforming of business models, operational processes, and cultural practices in response to digital possibilities (Benbasat, 1987). In the context of CPM, DT entails the adoption of technologies such as BIM, AR/VR, and cloud-based solutions, which fundamentally alter the way projects are planned, initiated, designed, executed, and managed.

Digitalisation, on the other hand, refers to applying DTEC to transform operational and business processes. This transformation enhances efficiency, collaboration, and decision-making. For the CI, digitalisation implies using digital tools to elevate project planning, focusing on risk management, resource allocation, contractual obligations, and stakeholder communication to new heights. However, the shift to digitalisation is often challenged by the industry's traditional resistance to new methods ("https://www.gartner.com,").

In the SA construction sector, embracing these concepts is key for propelling the industry forward. The increasing adoption of digital tools like CCS MSP and Primavera P6 for project scheduling and management signifies a growing awareness of the benefits of digital integration. Yet, the full embrace of these technologies is hindered

by challenges such as limited access to digital infrastructure, a shortage of competent workers in DTEC, and resistance to change (Moroz, 2018).

Despite these obstacles, the expected return of DT in CPM is substantial. DTEC have the power to streamline processes, enhance the accuracy of planning and execution, and improve overall project outcomes. For example, BIM offers a more integrated approach to project management, enabling better visualisation, improved collaboration, and more effective communication among project stakeholders (Windapo, 2021).

To fully realise the benefits of digital transformation, construction companies in SA must confront these challenges directly. This requires not only investment in new technologies but also cultivating a culture receptive to change, developing necessary skills within the workforce, and adapting to evolving regulatory environments. By tackling these issues, SA construction companies can significantly enhance their competitiveness and efficiency in an increasingly digitalised world.

2.3.2 Formulation and Implementation of DT Strategy in CPM

Formulating and implementing a DT strategy in CPM is key in the evolving landscape of the SACI. This strategy transcends mere technological adoption and encompasses a comprehensive re-evaluation of operational and business models within construction firms.

Integrating DT within the sector involves more than just incorporating advanced tools like BIM, AR/VR, or cloud-based project management solutions. It necessitates a strategic overhaul of traditional PMM, requiring organisational cultural and operational shifts (Walker, 2015). This re-evaluation of processes and practices is essential for maximising the potential of DTEC in enhancing project management efficiency, collaboration, and decision-making.

Strategic alignment of digital strategies with overall business objectives is critical in the CI. As the industry continues to evolve, there is a need for seamless integration of digital tools into existing project management frameworks. This strategic integration

should focus on technology adoption and adapting organisational structures and workflows to digital advancements (Reis et al., 2018).

Leadership plays a key role in steering DT in CPM. The shift towards digital necessitates visionary leaders who can navigate the intricacies of adopting and integrating digital tools. These leaders must champion the adoption of new technologies and cultivate an organisational culture receptive to digital innovations (Parviainen, Tihinen, Kääriäinen, & Teppola, 2017).

Successful implementation of digital strategies in CPM involves overcoming various challenges, including bridging the DD, addressing the skill gap, and mitigating resistance to change. Effective strategies should, therefore, include comprehensive plans for workforce training, change management, and stakeholder engagement (Moroz, 2018).

In conclusion, formulating and implementing a DT strategy in the SACI requires a holistic approach. This approach should encompass strategic planning, leadership commitment, cultural change, and workforce empowerment. By addressing these aspects, construction firms can effectively navigate the DT journey, enhancing competitiveness and project management efficiency in a digital era (Windapo, 2021).

2.3.3 Digitisation, DT, and Digitalisation in CPM

The integration of digital technology within construction planning and project management encompasses three distinct but interconnected stages: digitisation, DT, and digitalisation. These stages play crucial roles in enhancing efficiency, collaboration, and decision-making processes within the SACI, ultimately improving the industry's competitiveness (Agboola et al., 2019). Digital innovation, underpinned by its foundation in digital technology, is characterised by its manipulable nature and its capacity to generate further advancements. This innovation exerts a transformative influence on CPM (Arditi & Pulket, 2010). The resultant transformation leads to convergence, uniformity, and scalability, which surpass traditional methodologies (Yoo et al., 2012; Zhang, 2022)

In project management, adopting digital strategies is significantly shaping the industry. It involves not just controlling tasks and resources but also transforming strategies, business models, structures, and skills in line with the digital economy (A Kozarkiewicz, 2020). Integrating DTEC in construction planning and project management presents numerous benefits, including improved communication, collaboration, risk management, and resource allocation. However, the transition to digital also poses challenges, such as the need for cultural adjustments, navigating regulatory landscapes, and bridging the DD within the industry.

SA construction companies, in embracing digital transformation, must navigate these challenges while leveraging opportunities to enhance project outcomes and remain competitive in an increasingly digital landscape. This evolution requires a holistic approach beyond the mere adoption of digital tools to a comprehensive restructuring of PMM and practices in line with digital advancements.

2.3.4 Proposition 1: Rethinking Business Models in the Face of Digital Transformation

The concept of DT in CPM extends far beyond the mere incorporation of DTEC. It fundamentally requires reevaluating existing business models and operational strategies within the CI. This shift is vital in adapting to the rapidly evolving technological landscape of SA's construction sector.

The process of DT in CPM is multifaceted. It integrates advanced digital tools like BIM, augmented and AR/VR, and cloud-based PM software. However, the real challenge lies in embedding these technologies into the traditional fabric of project management, requiring significant changes in both business and operational models (Reis et al., 2018; Walker, 2015).

A strategic approach is necessary to navigate this transformation effectively. Construction firms must align their digital strategies with their overarching business goals, ensuring that technological advancements are harmoniously integrated into their operational processes. This alignment is key to leveraging digital tools for improved efficiency, enhanced decision-making, and overall project success.

Leadership plays a pivotal role in this transformative journey. Leaders within the CI must advocate for adopting new technologies but also foster an organisational culture that is receptive to change and innovation. This cultural shift is critical in realising the full potential of DT in CPM (Zhang, 2022).

In summary, Proposition 1 underscores the necessity for construction firms to rethink their business and operational models in the wake of digital transformation. Construction firms can successfully navigate the challenges and opportunities of the digital era by adopting a holistic approach that includes integrating technology, strategic planning, demonstrating leadership commitment, and adapting to new cultural norms. This will ultimately result in improved project management outcomes. (Windapo, 2021).

2.4 Project Management

2.4.1 Defining PMP

PMP is a key phase within the broader project management discipline. It embodies a coordinated and comprehensive approach that spans all project stages, from its initial conception to its successful completion and commissioning. This strategic phase ensures that projects meet their defined objectives in functionality, usefulness, and quality while optimising diverse resources, including materials, equipment, financial investments, and human capital (Reis et al., 2018; Walker, 2015).

PMP involves the meticulous organisation and preparation necessary to bring a project to fruition. This process is foundational to the project's success, as it sets the parameters within which the project is expected to operate, delineates the project scope, and establishes clear, actionable plans for achieving project goals. Effective planning is characterised by several key activities and considerations essential for managing the complexities inherent in bringing a project from concept to reality.

Establishing Project Frameworks and Objectives:

The planning phase begins with defining the project's objectives regarding its intended functionality, performance criteria, and quality standards. This involves thoroughly

understanding the project's purpose and the value it aims to deliver to stakeholders (Gabriele Hofinger, Alfnes, Kjersem, & Andersen, 2019).

Budgeting, Scheduling, and Milestone Identification:

A critical component of PMP is the development of a comprehensive budget and timeline, which outlines the financial and temporal parameters of the project. This includes setting milestones as significant checkpoints or goals throughout the project lifecycle and providing a structured framework for tracking progress (Gabriele Hofinger et al., 2019).

Resource Allocation and Logistics:

Effective planning requires detailed resource allocation, ensuring all necessary materials, equipment, and human resources are identified, allocated, and optimally utilised. This step also encompasses the logistics of resource deployment, including procurement schedules and workforce planning (Gabriele Hofinger et al., 2019).

Risk Management Strategies:

Identifying risks and developing strategies to mitigate it is a **key** aspect of the planning phase. This proactive approach to risk management enables project teams to anticipate challenges and implement contingency plans to maintain project integrity (Gabriele Hofinger et al., 2019).

Change Management and Communication Protocols:

Given the dynamic nature of projects, incorporating a structured change management process is key for effectively addressing scope adjustments, resource changes, or timeline shifts. Similarly, establishing clear communication protocols ensures that all project stakeholders remain informed and engaged throughout the project (Gabriele Hofinger et al., 2019).

PMP is an indispensable part of the project lifecycle, providing the strategic blueprint for guiding a project towards its completion. By encompassing budgeting, scheduling, resource allocation, risk management, and communication strategies, this phase lays the groundwork for effective project execution and control. Through meticulous planning, project managers can ensure that projects meet their defined objectives and

achieve the highest standards of functionality, usefulness, and quality, as emphasised in the foundational works of (Reis et al., 2018; Walker, 2015).

2.4.2 Theory of Project Management and PMP

Project management and PMP theory encompasses a comprehensive approach to managing and executing projects, integrating traditional and contemporary methodologies to optimise project outcomes. This section delves into the core principles and processes underpinning effective project management, focusing on the planning phase as a critical determinant of project success.

Foundational Principles of Project Management:

Project management transforms inputs, such as resources and requirements, into desired outputs or deliverables through well-defined tasks. This transformation process is central to project management, involving meticulous planning, execution, and control to achieve project objectives (Koskela, 2000). Traditional views emphasise the linear progression of tasks. However, recent insights from experts like Koskela and Howell advocate for a broader perspective, including the flow of work, value generation, and organisational factors such as work environment, communication, and experiential learning.

Expanding Project Management Perspectives:

The limitations of the traditional PM approach, Koskela and Howell propose viewing projects through additional lenses—considering projects as flows and emphasising value generation for customers. This expanded view integrates alternative project management methods, such as the Last Planner System and Scrum, demonstrating significant improvements in project performance by focusing on task sequencing, timing, and the overall creation of value (Koskela, 2000).

PMP Phase:

The planning phase is pivotal, laying the groundwork for successful project execution. This phase involves:

- Establishing Budgets, Timelines, and Milestones: Crafting a detailed financial plan and timeline ensures the project remains on track financially and temporally, with milestones marking significant progress points (Gabriele Hofinger et al., 2019).
- Resource Planning and Assessment: Identifying and securing necessary resources, including human, material, and technological assets, is key for smooth project execution. This step thoroughly assesses resource costs and availability (Gabriele Hofinger et al., 2019).
- Risk Management and Mitigation Strategies: Effective risk management involves identifying potential project disruptors and developing strategies to mitigate these risks, ensuring project resilience (Gabriele Hofinger et al., 2019).
- Implementing Change Processes: Adapting to changes is integral to project management, requiring a structured approach to manage scope, resource, or timeline adjustments efficiently (Gabriele Hofinger et al., 2019).
- Establishing Communication Protocols: Clear communication protocols are essential for keeping stakeholders informed and aligned, facilitating effective information exchange throughout the entire lifecycle of the project (Gabriele Hofinger et al., 2019).

Key Aspects of Effective PMP:

Effective PMP also emphasises collaboration, iterative planning, late decision-making, frontline worker involvement, and continuous improvement. These elements are key for fostering better communication, commitment, and adaptability within project teams,

ensuring that planning processes are responsive to real-time information and conducive to learning and improvement (Gabriele Hofinger et al., 2019).

The theory of project management and PMP underscores the importance of a strategic, comprehensive approach to managing projects. By integrating traditional project management principles with expanded perspectives on workflow, value creation, and organisational support and emphasising the planning phase, project managers can enhance project efficiency, effectiveness, and overall success. This

integrated approach addresses the complexities inherent in PM and sets a solid foundation for achieving transformational project goals.

Figure 5 illustrates these key aspects, showing how each element interrelates to support the Plan-Do-Check-Act cycle and ensure just-in-time information flow, making problems visible and encouraging learning. This diagram highlights the importance of input and agreement in the collaboration phase, the cycle of iterative planning, the timing of decision-making, the involvement of frontline workers, and the ongoing process of continuous improvement.

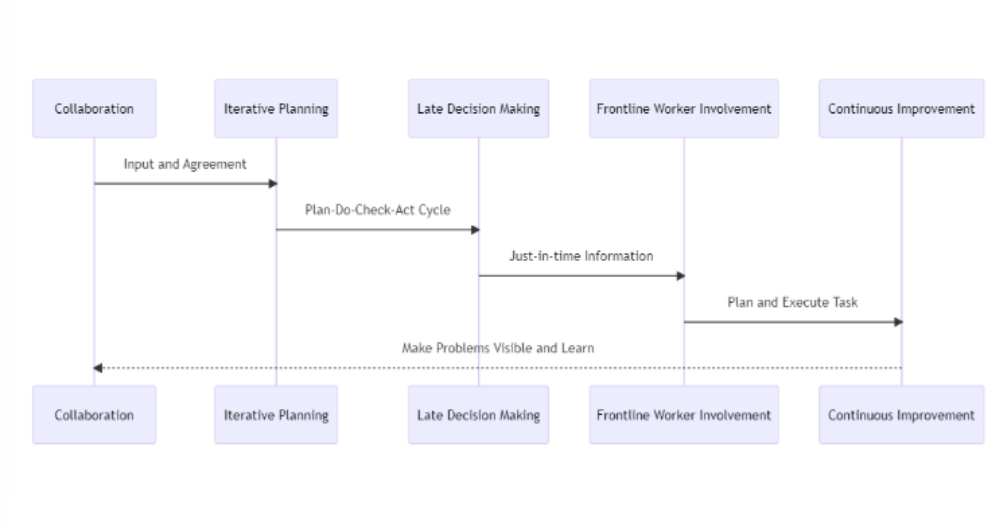

Figure 5: flow of Planning in construction (Snyman, 2022)

2.4.3 Challenges and Opportunities in Construction PMP

The DT within construction PMP in South Africa presents a multifaceted scenario of obstacles and prospects. This critical analysis is essential for bridging significant gaps in research, enabling global competitiveness, and understanding the influence of digital tools on project planning efficiency, cost management, and quality enhancement.

Challenges in Construction PMP:

1. Research Deficiency: A notable need for more focused studies on digitalisation within South Africa's CI, particularly at the planning stage, poses a challenge. This shortfall limits the capacity for local professionals and policymakers to devise and implement strategies grounded in robust empirical evidence, thereby restricting the optimal utilisation of digital innovations (Ikuabe, Aghimien, Aigbavboa, & Oke, 2020).

2. Adoption and Integration of Digital Tools: Despite a gradual increase in the adoption of DTEC, the complete integration and efficiency of these tools in enhancing planning processes need further development. The sector's slow alignment with international digital adoption trends may jeopardise its competitiveness on a global scale (Köster, 2009).

3. Workforce Development and Digital Proficiency: The transition to a digitally empowered CPM approach necessitates a workforce skilled in contemporary technologies. The challenge lies in updating educational programs and professional training to furnish the industry with digitally savvy professionals (Kim, Park, Lim, & Kim, 2013).

Opportunities in Construction PMP:

1. Boosting International Competitiveness: Benchmarking digital adoption against international standards offers an avenue for identifying and addressing gaps. This strategic insight can propel South African construction firms toward improved competitiveness, attracting more excellent foreign investment and fostering sectoral growth (Lee, Park, & Kim, 2023).

2. Project Planning Efficiency and Quality Enhancement: Leveraging digital planning tools such as Primavera P6, CCS MSP, and Microsoft Project can significantly elevate the precision and dynamic nature of project planning. These tools facilitate effective resource management and risk assessment, contributing to timely, budget-compliant, and quality-centric project completion (Marnewick & Marnewick, 2022).

3. Guiding Policy and Investment Decisions: The findings from digitalisation research can shape policy frameworks and guide strategic investments in technology. This informed approach can catalyse the creation of a digital-friendly regulatory environment, encouraging widespread digital adoption and sectoral innovation (Lee et al., 2023; Prebanić & Vukomanović, 2021).

4. Industry Futureproofing: Identifying and evaluating digital tools' current usage and role equips the CI with future technological shifts. This proactive stance ensures that firms are prepared for ongoing digital evolutions, maintaining agility and competitiveness (A Kozarkiewicz, 2020; Parviainen et al., 2017).

5. Optimising Resource Utilisation: Adopting DTEC offers unparalleled opportunities for optimising resource allocation in project planning. Data-driven insights enable more accurate forecasting and use of materials, labour, and equipment, enhancing project success and efficiency (Parviainen et al., 2017).

Navigating the digital landscape in CPM planning in South Africa involves tackling inherent challenges while capitalising on the opportunities presented by DTEC. Addressing the research gap, enhancing digital tool integration, and fostering workforce digital literacy is key for leveraging the full potential of digitalisation. Simultaneously, the potential to elevate international competitiveness, improve project outcomes, and futureproof the industry underscores the transformative role of digitalisation. Strategic research, supportive policies, and targeted investments in digital innovations are vital for surmounting these challenges and seizing the opportunities, leading to a more efficient, competitive, and sustainable CI.

2.4.4 Proposition 2: Navigating Modernisation in Construction PMP

The drive towards modernisation within the realm of construction PMP in South Africa encapsulates a strategic endeavour to integrate DTEC, addressing the current challenges and leveraging potential opportunities. This proposition focuses on the critical need for a systematic approach to digital transformation, aiming to enhance the CI 's efficiency, quality, and global competitiveness.

Addressing the Challenges:

Bridging the Research Gap: The first step in navigating modernisation is to address the existing research deficiency. Undertaking targeted studies that focus on the integration and role of digital tools in the planning phase is imperative. This effort will provide a solid empirical foundation for guiding the industry's DT , ensuring strategies are data-driven and contextually relevant (Ikuabe et al., 2020).

Enhancing Digital Tool Integration: Modernisation necessitates a broader and more effective adoption of DTEC. Overcoming the slow pace of digital tool integration involves adopting state-of-the-art planning software and ensuring these tools are fully leveraged to streamline planning processes. This step requires a concerted effort to increase awareness, training, and support for these technologies within the industry (Köster, 2009; Tariq & Gardezi, 2023).

Fostering Digital Literacy: Developing a digitally proficient workforce is paramount. Modernisation efforts must include revising educational curricula and professional development programs to equip current and future industry professionals with the necessary digital skills. This approach will ensure that the workforce can navigate and maximise the benefits of DTEC in project management (Kim et al., 2013).

Leveraging Opportunities:

Global Competitiveness: Modernisation offers a pathway to enhancing the SACI's competitiveness on the international stage. By benchmarking digital adoption against global standards, identifying gaps, and implementing targeted improvements, the industry can attract more foreign investment and engage in projects that demand high standards of efficiency and innovation (Lee et al., 2023).

Quality and Efficiency in Project Planning: Using advanced digital planning tools promises significant improvements in project planning quality and efficiency. Tools like Primavera P6, CCS MSP, and Microsoft Project enable precise planning and resource management, leading to projects completion within budget, high-quality standards and on time. Embracing these tools is key for modernising the planning phase of CPM (Marnewick & Marnewick, 2022).

Informing Policy and Strategic Investments: Insights from research into digitalisation can inform policy-making and strategic investment decisions, fostering a conducive environment for digital adoption. Policies supporting digital innovation and technology investments will drive the industry toward comprehensive modernisation, ensuring its long-term sustainability and growth (Lee et al., 2023; Prebanić & Vukomanović, 2021).

Futureproofing the Industry: Embracing modernisation prepares the CI for future technological advancements. By staying abreast of digital trends and evaluating the effectiveness of current tools, the industry can adapt to ongoing changes, maintaining its relevance and competitiveness in a rapidly evolving global market (Alina Kozarkiewicz, 2020; Parviainen et al., 2017).

Navigating modernisation in construction PMP is a multifaceted endeavour that requires addressing current challenges while simultaneously seizing emerging opportunities. By fostering a research-driven approach to digital adoption, enhancing digital literacy, and leveraging advanced planning tools, the South African CI can significantly improve project planning and execution. This strategic modernisation effort will improve the industry's efficiency and quality and enhance its global competitiveness, ensuring its long-term sustainability and success in the face of technological advancements.

2.5 Conclusion of the Literature Review on DT in CPM in SA

This literature review meticulously examines the DT landscape within CPM in South Africa, focusing on the planning phase. It presents a detailed exploration of existing research on the utilisation and role of DTEC, such as BIM, cloud-based tools, and other advancements, on project planning processes. This comprehensive analysis reveals several key insights:

Strategic Integration of DTEC:

The DT process transcends the mere adoption of digital tools, demanding a strategic overhaul of business models and operational processes. Construction firms must

embed DTEC within the core of project management strategies, ensuring these innovations drive efficiency, enhance decision-making, and bolster competitiveness. Integrating digital tools into project planning and execution underscores construction firms' need to approach digitalisation holistically, leveraging these technologies as fundamental elements of their strategic vision.

The Complexity of DT:

DT in CPM is recognised as a multifaceted endeavour that extends beyond technological adoption to encompass cultural and process changes. This transformation is poised to significantly improve project planning, execution, and communication, enhancing project outcomes and efficiency. However, the implementation journey is often met with resistance to change, underscoring the need for effective change management practices and investment in technology and skills development.

The Role of Organisational Leadership:

Management plays a fundamental role in driving the DT process. The literature highlights the importance of roles such as Chief Information Officer (CIO) and Chief Digital Officer (CDO) in managing this process.

While the CIO focuses on technological implementation, the CDO ensures digital strategies are aligned with the organisation's broader goals. Effective leadership is key in managing the dynamics of change, promoting a culture receptive to digital innovations, and aligning digital initiatives with strategic business objectives.

Navigating Challenges and Leveraging Opportunities:

The transition towards digitalisation presents challenges and opportunities for the South African CI. Firms face integrating advanced digital tools into traditional project management practices, overcoming cultural resistance, and addressing the DD. Despite these challenges, the opportunities for streamlining project management processes, improving collaboration and communication, and enhancing overall project quality and efficiency are significant. To realise these benefits, construction firms must

adopt a comprehensive approach that includes strategic planning, skill development, and fostering an organisational culture that embraces digital change.

The literature on DT within CPM in SA underscores the importance of a strategic, integrated approach to adopting DTEC. For construction firms to thrive in the digital era, they must overcome inherent challenges through robust planning, change management, and leadership. Embracing DT can significantly PMP, leading to greater efficiency, competitiveness, and success in the CI.

2.5.1 Proposition 1

Proposition 1 in the study emphasises that DT in SACPM involves more than just integrating digital tools; it necessitates a fundamental rethinking of business models and operational processes to adapt to the evolving digital landscape effectively.

2.5.2 Proposition 2

The drive towards modernisation in South Africa's construction PMP underscores the importance of integrating DTEC to enhance industry efficiency, quality, and global competitiveness. Addressing the research gap, promoting the adoption of advanced digital tools, and fostering workforce digital literacy are key strategies for overcoming current challenges. This initiative aims to improve planning processes, make strategic policy and investment decisions, and prepare the industry for future technological advancements. By capitalising on these efforts, the South African CI can achieve significant improvements in project planning and execution, positioning itself as a competitive player on the international stage and ensuring long-term sustainability in the digital era.

CHAPTER 3. RESEARCH METHODOLOGY

Investigation of the role of DT on CPM in SA through a comprehensive literature review.

The chosen research methodology for this study is a qualitative approach utilising secondary data sources (Denzin, Lincoln, & Giardina, 2006). It was selected due to its appropriateness for comprehending the complex, nuanced influence of DT within the CPM industry in SA.

Qualitative research focuses on understanding phenomena in their natural environment and aims to explain them based on the meanings people attribute to them (Denzin & Lincoln, 2011). Given the exploratory nature of this research study, which seeks to understand the role of DT on CPM, a qualitative research approach is highly suitable.

This study will rely on secondary data, including existing research studies, industry reports, and published materials. Utilising secondary data analysis allows researchers to explore research questions using pre-existing datasets. This approach is valuable when investigating a broad field, such as DT in the CI, where significant previous research and data are available.

The qualitative, secondary data analysis approach relies on several assumptions. Firstly, it assumes that existing data sources provide sufficient and reliable data to address the research questions. Secondly, it assumes that the meanings, interpretations, and understandings derived from these secondary sources are valid and can be extrapolated to the broader context of DT in the SACPM industry.

By employing this research methodology, a comprehensive understanding of the role of DT on the CPM industry in SA can be achieved. This approach will facilitate the identification of key trends, challenges, and opportunities, providing valuable insights for industry stakeholders and contributing to the broader body of knowledge on this key topic.

3.1 Research approach

The research approach for this study employed a qualitative methodology, primarily using semi-structured interviews for data collection. The study's goal of investigating the effects of DT on CPM in SA led to the decision to implement this approach. A qualitative framework was key for capturing industry professionals' nuanced perspectives and experiences.

In this study, semi-structured interviews were essential for gathering in-depth insights. The design of these interviews was carefully crafted, considering the theoretical concepts found in the literature review and in line with the study's research objectives. This approach enabled a flexible yet structured exploration of topics, ensuring comprehensive coverage while accommodating each participant's unique insights.

The qualitative research approach, primarily through semi-structured interviews, presented numerous benefits:

- Depth of Understanding: The approach facilitated an in-depth exploration of the complex dynamics of DT within the CPM sector.
- Contextual Relevance: Conducting interviews in environments familiar to the participants allowed the study to capture the challenges and opportunities of DT in the SA construction context.
- Rich Data: The qualitative data collected through these interviews were rich and detailed, revealing the intricacies of DT in CPM.

The research method played a key role in the investigation. It allowed for a thorough investigation into how DT affects project management in the CI in SA, providing valuable perspectives from professionals in the field. This approach provided a detailed and contextual understanding of the phenomenon, key for the study's objectives.

3.2 Research design

The research design for this study adopted a qualitative, interpretive framework, utilising a comprehensive literature review and semi-structured interviews. This approach was aligned with the exploratory and interpretive nature of the study's objectives, which aimed to understand the influence of DT on the CPM industry in SA.

The qualitative design facilitated an in-depth exploration of the complex phenomena under study, particularly suitable for research requiring a deep understanding of varied experiences, perceptions, and nuanced roles of DT within the CI. As part of this qualitative design, an interpretive framework guided both the literature review and the analysis of interview data, as recommended by (Becker, Bryman, & Ferguson, 2012). This framework was pivotal in acknowledging stakeholders' subjective experiences and perceptions within the CPM industry, enabling an extensive understanding of the influence of DT in this context.

The study's approach included a detailed literature review that examined existing research studies, industry reports, and published materials (Becker et al., 2012), alongside semi-structured interviews that offered direct, experiential insights from industry professionals. The thematic analysis of interview data, conducted by (Clarke & Braun, 2017), enriched the study with practical perspectives on DT in CPM.

Combining a literature review with a thematic analysis of interviews, this integrative method was efficient and cost-effective, providing a rich, nuanced understanding of the complex phenomena under study. It allowed for the exploration of diverse perspectives, which was key for a comprehensive understanding of the multifaceted implications of digital transformation.

However, this research design had its limitations. It relied on the quality and relevance of existing literature. The generalisability of findings was constrained due to the qualitative nature of interviews and inherent subjectivity in thematic analysis. Despite these limitations, a research design that included a comprehensive literature review complemented by a thematic analysis of semi-structured interviews was deemed more appropriate to answer the research questions according to the guidelines set forth by (Clarke & Braun, 2017).

3.3 Data Collection Methods

The data collection methods selected for this secondary qualitative study were instrumental in gathering the comprehensive data necessary to address the research questions concerning the role of DT on CPM in SA. These methods facilitated a thorough understanding of the subject matter from both theoretical and practical perspectives.

- Literature Review: A literature review formed the backbone of this research, providing a comprehensive overview of existing scholarly work on DT in CPM. As (Rowley & Slack, 2004) mentioned, this review was vital for understanding the theoretical foundations of the research questions, identifying gaps in current knowledge, and establishing the study's theoretical framework. The literature review covered various academic articles, industry reports, and other relevant publications, offering a broad perspective.
- Document Analysis: In addition to reviewing relevant literature, documents were examined to explore the practical implications of DT in the construction sector. As (Bowen, 2009) outlines, this method provides an in-depth understanding of real-world challenges, industry trends, and policy implications. The analysis of these documents contributed significantly to understanding the practical context of DT and its implications for CPM in SA.
- Semi-Structured Interviews: Complementing the secondary data, semi-structured interviews were conducted with industry professionals with experience in DT initiatives within CPM. These interviews provided first-hand insights into the practical application, challenges, and benefits of DT in the field. The flexible nature of semi-structured interviews allowed for in-depth discussions, ensuring a wide range of perspectives and experiences were captured.

Combining literature review, document analysis, and semi-structured interviews ensured a comprehensive data collection approach. This triangulation of methods strengthened the reliability and validity of the research findings, providing a rich and nuanced understanding of DT in CPM in SA.

3.4 Population and sample

Given the nature of this secondary qualitative study, the population and sample are not determined in the traditional sense as in primary research. Instead, the 'population' can be conceptualised as the body of existing research and documents relevant to the influence of DT on CPM in SA.

3.4.1 Population

The population comprises academic articles, industry reports, case studies, conference papers, policy documents, and white papers related to DT in the CPM field, specifically within the SA context.

3.4.2 Sample and Sampling method

The sample consists of specific sources selected for analysis in this study. A strategic sampling approach is utilised to identify the most relevant and insightful sources, considering criteria such as relevance to the research questions, publication date, credibility, quality, and representation of diverse perspectives and contexts within the field.

The sampling process relied on the extent and comprehensiveness of analysis needed to address the research inquiries, thus determining the number of sources included. It was key to ensure that the sample was sufficient in quantity and quality to provide a comprehensive and nuanced understanding of the research topic.

Division	Number of Interviewees
Project Manager	6
Senior Planner	1
Construction Manager	5
Total	**12**

3.5 The research instrument.

The research instrument used in this study was interview guide, which proved to be highly effective in gathering in-depth qualitative data. These interviews were designed to be flexible, allowing for exploring a wide range of topics related to DT in CPM in SA.

The interview process began with an introduction, providing a brief overview of the research objectives and the purpose of the interview. This set the stage for a focused and informed discussion. Questions were then presented to understand the extent and rate of digital adoption within the respondents' organisations. These inquiries were aligned with the empirical concept of 'Rate of Digital Adoption,' grounded in the theory of Digital Transformation.

Furthermore, the interviews delved into the role of regulatory environments on digital adoption, correlating with the 'Regulatory Role' concept and informed by Institutional Theory. Cultural factors were also a significant focus, with questions designed to assess organisational culture and readiness for DT based on Social Constructivism.

An essential aspect of the interviews was understanding the DD within organisations. Questions in this area aimed to uncover disparities in digital adoption across different departments or locations, informed by the concept of 'DD' and Social Constructivism principles.

At the end of each interview, there was a recap and a chance for participants to share any extra thoughts or perspectives they wanted to include. By utilising this structure effectively, a thorough investigation was conducted on the identified themes in the literature review and analytical framework. This approach facilitated a well-rounded comprehension of how DT affects CPM in SA.

Semi-structured interviews were instrumental in this study, offering the depth and flexibility necessary to capture complex and nuanced insights. However, it is essential to acknowledge that this approach, while rich in detail, required considerable time and was limited by the sample size, potentially impacting the findings' generalisability. Despite these limitations, the interviews were vital in achieving the research objectives, providing valuable insights into the multifaceted nature of DT in the SACI.

3.6 Procedure for data collection

For this study, interviews were conducted remotely using Microsoft Teams, accommodating international participants. Each interview commenced with an explanation of the study's context, emphasising the participants' selection based on their experience in DT within CPM. This initial dialogue informed and engaged participants about the study's objectives.

Participants were allowed to inquire or seek clarification before starting the interviews. This preparatory step was essential for establishing an informed and comfortable discussion environment, ensuring effective and meaningful participation.

In line with ethical research practices, participants must sign consent forms (as detailed in Appendix A) before the interviews. These forms outlined the study's purpose, participants' rights, and the confidentiality of their contributions. They also emphasised the voluntary nature of their participation.

Conducting the interviews via Microsoft Teams enabled a broader inclusion of international perspectives, enriching the study's findings with diverse insights into DT in CPM. The use of remote technology facilitated global participation and ensured the efficiency and flexibility of the data collection process, which is key for this qualitative research.

To collect data for this study, the following steps were taken:

- Sample Identification: Participants were selected based on their job function, tenure, and seniority within their organisations. This was key for ensuring a diverse and comprehensive understanding of DT in CPM.
- Participant Approach: Participants were approached through Microsoft Teams, considering their international locations. This approach facilitated a broader inclusion of diverse insights.
- Securing Participation: Following consent, follow-up emails were sent to schedule the interviews. These interviews were planned to last approximately 60 minutes.

- Setting the Context: At the start of each interview, the purpose and context of the study were explained. This step allowed participants to ask questions and understand the study's scope before the interview commenced.
- Consent and Recording: Participants were requested to consent to the interview recording. The interviews were conducted using Microsoft Teams, ensuring clear audio quality and an uninterrupted conversation flow.
- Transcription: After completing all interviews, the recorded data were transcribed for analysis. This transcription was essential for capturing the full depth of the discussions and facilitating detailed data analysis.

These steps, tailored to the qualitative nature of the study and the international scope of participants, were instrumental in gathering rich, nuanced data on DT in CPM. By conducting the interviews remotely, a wide range of perspectives were incorporated into the study, enhancing the research outcomes.

3.7 Data analysis strategies and interpretation

Thematic Analysis Process in the Study:

- Familiarisation with Data: Transcribed interviews and secondary data sources were thoroughly reviewed to gain an in-depth understanding of the content.
- Generation of Initial Codes: Using qualitative data analysis software, initial codes were generated. This step involved breaking the data into manageable segments while remaining open to emerging patterns.
- Identification of Themes: Codes were analysed and grouped into potential themes. This involved interpreting the underlying meaning and significance of the coded data segments.
- Reviewing of Themes: The themes were then reviewed for coherence and relevance to the research questions. This step ensured that the themes accurately represented the data.
- Definition and Naming of Themes: Each theme was defined and named, ensuring that they accurately captured the data's essence and aligned with the research objectives.

- Writing of Report: Finally, the findings were compiled into a coherent narrative, with the themes forming the basis of the report's structure and discussion.

This process helped in systematically organising and interpreting the qualitative data, ensuring a thorough and insightful analysis of the role of DT on CPM in SA.

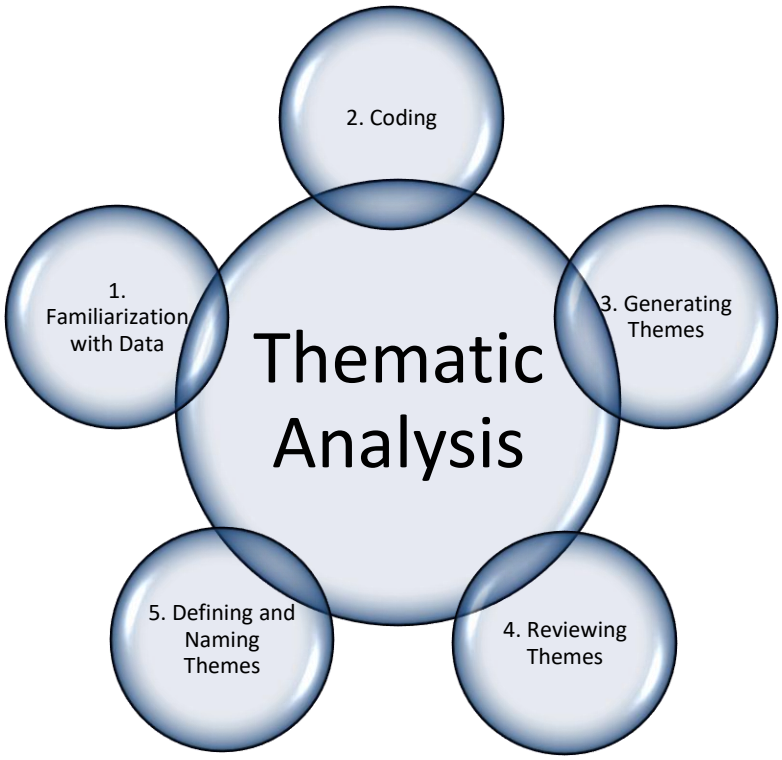

Figure 6: Thematic analysis process

3.8 Limitations of the study

The research utilised a qualitative approach, which allowed for a thorough understanding of perspectives and experiences but constrained the applicability of the findings to a broader population.

- Time limitations were inherent due to the qualitative nature of the study, potentially restricting the depth and breadth of data collection and analysis.

- Virtual data collection methods were primarily used owing to practical constraints. This reliance on virtual interviews could role the quality and richness of the data collected.
- The subjectivity involved in thematic analysis could introduce bias. The researcher's perspectives and preconceptions may influence the interpretation of themes.
- Sampling bias is present as the study focuses specifically on managing construction projects in SA. This focus may limit the applicability of the findings to other regions or industries.
- The rapidly changing technological landscape in DT means that findings might become quickly outdated as new technologies and practices emerge.
- Limited access to proprietary information in the CI might have affected the study's comprehensiveness and ability to access specific industry-specific data.
- The lack of quantitative data means that while the study provides rich and detailed qualitative insights, it limits the generalisability of findings to a larger population.

3.9 Quality Assurance

Transferability and Dependability

3.9.1 Transferability

The assessment of transferability in this qualitative study was focused on evaluating the external validity, specifically whether the research methodology and findings were applicable beyond the immediate study context (Denzin & Lincoln, 2011). A consistent data collection approach was utilised throughout the study, employing an interview guide to ensure homogeneity in gathering data. While acknowledging the absence of a singular interpretive method for qualitative data, the systematic data analysis process adopted in this study aimed to enhance the potential for transferability.

3.9.2 Credibility

Credibility in this study pertained to its internal validity, a critical aspect of qualitative research integrity (Denzin & Lincoln, 2011). To ensure the credibility of the research, the interview questions were meticulously developed, drawing from established and published studies, complemented by questions reviewed and validated by the academic supervisor. This approach aimed to ensure that the questions were relevant, clear, and effective in eliciting meaningful responses pertinent to the research objectives.

3.9.3 Dependability

The Dependability of the study was centred on the consistency and reliability of the findings (Denzin & Lincoln, 2011). A rigorous thematic analysis process was meticulously followed to achieve this, as outlined in section 3.7 of this document. These steps were documented in detail to facilitate replication by future researchers interested in exploring similar topics. However, it was acknowledged that the dynamic nature of the subject matter, particularly the evolving context of DT in CPM, might affect the repeatability of the study. This consideration was key in understanding the potential variations subsequent research in this field might encounter.

3.10 Demographic profile of respondents

The participant group consisted of 12 individuals, predominantly male (nine males and three females), reflecting standard gender distribution in construction management roles. The roles varied: Project Managers, Senior Planners, and Construction Managers. Their experience in technology adoption ranged from novice to proficient, providing diverse insights into integrating digital tools in CPM.

Most participants were in middle to senior management positions, indicating substantial involvement in DT initiatives. Their experience spanned from foundational digital tools to advanced technologies like Primavera P6 and BIM. This diverse demographic profile contributed to a comprehensive understanding of DT within the SACPM sector.

3.11 Ethical considerations

- The study's aim and objectives were communicated to all participants, who were assigned aliases ranging from CPM1 to CPM12 to maintain their anonymity. This approach ensured the confidentiality of participant identities, aligning with ethical research practices.
- Before participants took part in the study, their informed consent was obtained. Participants had to sign consent forms acknowledging voluntary participation and understanding of the study's purpose.
- The relevant institutional review board sought and granted ethical approval for the research. This process involved submitting research permission letters stipulated by the university's ethical guidelines.
- The individual participants' identities and their organisations' specific details were not disclosed in the final report. Instead, generic terms like 'CPM professionals' were used to ensure confidentiality and prevent potential identification.
- A plagiarism declaration form will be signed upon the report's finalisation to uphold academic integrity. Additionally, a Turnitin report will be provided to verify the originality of the research and adherence to plagiarism-free standards.
- By adhering to these ethical considerations, the study ensured that all research activities were conducted with the utmost respect for participant privacy, institutional guidelines, and academic integrity.

CHAPTER 4. PRESENTATION OF RESULTS / FINDINGS

4.1 Introduction

The introductory chapter of this study embarks on an exploratory journey into digitalisation within the planning phase of CPM in SA, employing qualitative research methodologies. This exploration is underpinned by interviews with 12 industry professionals, and the ensuing data is rigorously analysed through thematic analysis using Atlas-ti 22. The methodological approach adheres to a structured framework that escalates from lower levels of abstraction, encompassing meaning units, codes, categories, and subthemes, culminating in the crystallisation of overarching themes. This approach aligns with the analytical framework posited by (Clarke & Braun, 2017).

The chapter commences with a detailed exposition of the participant sample, laying the groundwork for the following thematic exploration. This is key for contextualising the findings within the broader digitalisation landscape in CPM. Subsequently, the chapter delves into the four central research questions that form the backbone of this study. These questions are pivotal in dissecting the multifaceted nature of digitalisation and its ramifications within the sector.

A balanced presentation of the advantages and challenges of digital integration in CPM is provided. This includes acknowledging the potential benefits digitalisation can usher in and the hurdles that might impede its successful integration. The chapter is dedicated to a comprehensive analysis of these findings to thoroughly analyse the role of digitalisation and propose recommendations for future efforts in this area. This discourse is instrumental in delineating the pathways through which digitalisation can be leveraged to optimise the construction PMP phase in SA, thereby contributing significantly to the field.

4.2 Overview of the sample

Table 1: Profile of participants

PAT	Role	Gender	Experience in Tech Adoption	Job Level
1	**Project Manager**	Female	**Proficient:** With over 15 years of experience in CPM, this participant has developed a strong proficiency in digital tools like Primavera P6 and risk management software, enhancing project efficiency and effectiveness.	Middle Management
2	**Project Manager**	Male	**Novis:** A project manager with 10 years of experience, primarily focused on traditional construction methods, is now exploring digital tools and technologies in construction management.	Middle Management
3	**Project Manager**	Male	**Intermediate:** With 12 years in CPM, this participant has a fair understanding of basic digital tools like Microsoft Projects, but limited experience with more advanced construction technologies.	Middle Management
4	**Project Manager**	Female	**Intermediate:** This project manager, with over 14 years of experience, emphasised foundational planning principles and has a growing familiarity with digital planning tools in construction.	Middle Management
5	**Project Manager**	Male	**Intermediate:** With 18 years in the field, this senior project manager is comfortable with basic digital planning tools and is actively working to integrate more advanced software into his planning processes.	Senior Management
6	**Project Manager**	Male	**Proficient:** A seasoned project manager with over 20 years of experience, proficient in a range of technological tools and adept at integrating them into complex construction projects.	Executive
7	**Senior Planner**	Male	**Proficient:** With 22 years in construction planning, this senior planner excels in using advanced tools like Primavera P6 and BIM, enhancing planning accuracy and team collaboration.	Senior Management
8	**Construction Manager**	Male	**Intermediate:** A construction manager with 17 years of experience, he has a solid understanding of digital tools like MSP and CCS and is keen on further developing his skills in advanced construction technologies.	Senior Management
9	**Construction Manager**	Male	**Intermediate:** With 15 years in construction management, this individual is familiar with digital planning tools and is actively seeking to	Senior Management

PAT	Role	Gender	Experience in Tech Adoption	Job Level
			expand his expertise in more complex PM software.	
10	**Construction Manager**	Male	**Intermediate:** This construction manager, with 16 years of experience, is adept with basic digital tools and is progressively engaging with more advanced construction technologies.	Senior Management
11	**Construction Manager**	Male	**Proficient:** An experienced construction manager with over 20 years in the field, proficient in advanced digital tools, particularly in project scheduling and resource management.	Senior Management
12	**Construction Manager**	Male	Proficient: With 18 years of experience, this construction manager is proficient in a range of construction technologies, focusing on efficient project management and digital tool integration.	Middle Management

This scale provides a concise yet comprehensive framework to categorise the technological experience levels of the participants in the study.

- Novice: Minimal or no experience with construction technology. Requires training and support.
- Intermediate: Fair understanding and comfort with basic digital tools, but limited experience with advanced technologies.
- Proficient: Good command over a range of technological tools, capable of integrating them effectively into work processes.
- Advanced: Extensive experience with a wide range of construction technologies, leads adoption of new tools, and can provide training.
- Expert/Innovator: Deep expertise in construction technology, involved in developing or significantly improving technological solutions.

4.2.1 Suitability of the Sample

The sample composition for this study was meticulously considered to ensure it was representative of the various levels of expertise and roles within the SACI, particularly in the context of digital transformation. As shown in Table 3, the sample consisted of 12 participants, encompassing roles such as Project

Managers, Senior Planners, and Construction Managers. This diversity in professional roles enabled a comprehensive understanding of the DT in the planning phase of CPM from multiple perspectives.

A noteworthy aspect of the sample was the balanced gender representation among Project Managers, which is key for inclusive research. The sample included male and female Project Managers, bringing diverse viewpoints and experiences to the study.

The participants' experience in technology adoption ranged from 'Novice' to 'Proficient', which was key for assessing the role of digital skills and knowledge on the implementation and effectiveness of digital tools in CPM. Including participants with different levels of technological proficiency, from Project Managers at the middle management level with a basic understanding of digital tools to Senior Planners and Construction Managers at senior management levels with advanced skills, provided insights into the various stages of DT across different job levels.

Moreover, the depth of experience in the CI among the participants was significant, with experience ranging from 10 to 22 years. This extensive experience ensured that the participants understood the CI 's dynamics and the evolving role of digital tools and technologies in project management. The variation in years of experience also enabled the study to capture historical and contemporary perspectives on DT in the industry.

In summary, the sample's suitability was marked by its diversity in professional roles, gender balance, varying levels of experience in technology adoption, and depth of industry experience. This diverse and comprehensive sample provided a robust foundation for understanding the complexities and nuances of DT in the construction PMP phase in SA. As advised by (Rahman, 2023), the purposive sampling method effectively facilitated the selection of participants who could offer relevant, rich, and diverse insights into the study's objectives.

4.3 Research Objectives

The research objectives for this study were meticulously crafted to delve into the various aspects of digitalisation in CPM within South Africa, focusing specifically on the challenges, opportunities, and strategies for leveraging digital tools to enhance project outcomes. These objectives guided the thematic analysis conducted in the subsequent section.

Objective 1: Challenges of Digitalisation

This objective investigated the challenges encountered in integrating digitalisation within CPM. The focus was on exploring the extent of digital tool integration during the planning phase, understanding cultural and organisational barriers to digital adoption, assessing the role of regulatory reforms, and addressing the challenges in advanced collaboration methods and the deployment of digital tools.

Objective 2: Opportunities for Digitalisation

The second objective centred on identifying and exploring the opportunities presented by digitalisation in CPM. This encompassed examining the potential for further digitisation to enhance efficiency and effectiveness, exploring how digitalisation could improve communication and decision-making processes, and understanding the contribution of digital tools to increased productivity and planning accuracy.

Objective 3: Leveraging Digitalisation for Improved Outcomes

The final objective focused on developing and identifying strategies to leverage digitalisation effectively for improved project outcomes. This involved evaluating successful strategies employed within the South African Construction Industry (SACI), drawing key lessons from these implementations, and understanding how these could be adapted in various project contexts to maximise the benefits of digitalisation.

Each objective was designed to dissect and understand a critical aspect of digitalisation within the construction industry, from the challenges hindering its full implementation to the vast opportunities it presented and the strategic approaches needed to capitalise on its potential. These objectives framed the research and provided a clear direction for the following thematic analysis.

4.4 Analysis using thematic analysis process.

In this pivotal section of our study, we embark on a thematic analysis, a methodical and insightful approach to examining qualitative data gathered on digitalisation in CPM in SA. Thematic analysis is particularly effective in qualitative research for its versatility and depth, enabling a comprehensive understanding of complex data. This analysis is key for distilling insights related to the integration, challenges, and opportunities of digital tools in the CI. A detailed diagram illustrating the thematic analysis process is presented to facilitate understanding, outlining each sequential step and its interconnections.

- Familiarisation with Data: Initially, the focus is on immersively engaging with the data collected from SA construction project managers. This step involves thorough readings, noting initial impressions, and identifying patterns relevant to the construction sector's digitalisation.
- Generating Initial Codes: Following this, the data undergoes systematic coding. This key step involves tagging parts of the data with codes highlighting significant aspects of digitalisation practices, challenges, and opportunities in CPM.
- Searching for Themes: At this juncture, the codes are scrutinised to identify overarching themes. These themes are expected to encapsulate critical aspects of digitalisation in CPM, from its implementation to the various challenges and opportunities it presents.
- Reviewing Themes: These themes are rigorously reviewed and refined, ensuring they represent the coded data and align with the study's objectives. This may involve amalgamating or dividing themes for coherence and relevance.

- Defining and Naming Themes: Each theme is then distinctly defined and named, providing clarity and depth to the aspects of digitalisation in CPM. This involves a detailed exploration of each theme's essence and implications.
- Producing the report: The final step is the compilation of the report. This comprehensive narrative interweaves the thematic analysis with broader research contexts and literature. It presents a detailed discussion on how digitalisation shapes CPM in SA.

Figure 6 illustrates the thematic analysis process, highlighting each step involved in the methodical examination of the qualitative data. The process includes familiarisation with the data, generating initial codes, searching for themes, reviewing themes, defining, and naming themes, and producing the final report.

Figure 7: Thematic analysis process

4.4.1 Familiarisation with the Data

Objective 1: Challenges of Digitalisation

As reflected by the interviewees, the challenges of digitalisation in CPM primarily revolve around integrating and effectively using planning software tools. CPM1's

statement, "Planning software is a tool", suggests a recognition of the utility of digital tools, yet there appears to be an underutilisation or superficial application in some instances. CPM3 and CPM5 highlight the extensive use of specific tools like Primavera P6 and Microsoft Project, indicating some level of sophistication in the application. However, the overall sentiment, as echoed by CPM7 and CPM9, is one of a moderate degree of digital integration, with concerns about over-complexity and the cost-prohibitive nature of advanced software. A significant concern is the foundational planning principles, as inadequate preliminary analysis can lead to flawed planning processes, a sentiment expressed by CPM10.

The disparity in digital adoption rates between larger and smaller firms is a critical challenge. CPM5 rates the SA market at "about a four and a half, maybe 5" on a scale of digitalisation integration, pointing to a moderate yet not fully realised adoption of digital tools. Smaller firms' express concerns regarding the financial implications of adopting new technologies, as mentioned by CPM7. The need for further digitalisation and its effective connection to BIM for enhanced productivity and effectiveness is underscored by CPM9 and CPM10. This indicates a DD that roles the uniformity in project management and execution standards across the industry.

Objective 2: Opportunities for Digitalisation

The opportunities for digitalisation in the planning phase are promising, with significant potential for efficiency improvements and enhanced accuracy. CPM2's reference to the statistical record of project cost and schedule overruns underscores the critical need for and potential role of digitalisation. Adopting visualisation tools, augmented reality, and mobile technology for field data collection, as discussed by CPM4, CPM6, and CPM8, illustrates the potential for enhanced planning accuracy and efficiency. These technologies enable real-time data collection directly from construction sites, leading to more accurate and feasible project plans.

Digital dashboards and reporting tools are valuable for improving the planning phase. As CPM10 notes, these tools provide a real-time overview of various

project aspects, enabling quick decision-making and effective project control. This is particularly beneficial in areas like time management and budget control. Integrating planning software with BIM is highlighted to improve team members' collaboration and productivity. CPM1, CPM3, and CPM5 emphasise the necessity of DT across all sectors, suggesting that embracing digitalisation is no longer optional but essential for staying competitive and efficient in the CI.

Objective 3: Leveraging Digitalisation for Improved Outcomes

In leveraging digitalisation for improved outcomes, the emphasis is on strategic implementation and collaboration. CPM1 and CPM10 highlight the importance of a holistic approach to digital adoption, where it is integrated into every aspect of the project lifecycle. This includes providing necessary training and fostering a culture of innovation and openness to change. The integration and interoperability of digital tools are key factors in realising their full potential. This integration extends to collaboration with external stakeholders, consultants, suppliers, and subcontractors, suggesting that the benefits of digitalisation are maximised when it facilitates a more cohesive and coordinated project management approach.

As underscored by CPM4 and CPM7, data-driven decision-making processes are pivotal for leveraging digitalisation effectively. Embracing analytics and big data is key to unlocking deeper insights into project performance, customer needs, and market trends. This approach enables more informed and strategic decision-making in construction projects. Integrating technologies like AI and IoT in construction management systems are also highlighted to predict potential project delays or cost overruns, thereby proactively mitigating risks. The responses collectively suggest that successful digitalisation hinges on technological and cultural shifts within organisations, focusing on strategic implementation, collaboration, and data-driven processes.

4.4.2 Initial Codes

Generating Initial Codes: The transcribed data will then be systematically coded, categorising key concepts, ideas, and themes. This coding process is essential for identifying significant patterns and recurring themes in the data.

Table 2: Initial codes table

Objective/Code	Description
Objective 1: Challenges of Digitalisation	
Digital Skills Gap	Reluctance among seasoned employees to adapt to new digital tools (CPM1).
Cost and Complexity	High cost and complexity of digital tools for smaller firms (CPM7).
Integration Issues	Difficulties in integrating various digital systems (CPM9).
Digital Adoption Disparity	The gap in digital adoption rates between larger and smaller firms (CPM5).
Underutilisation of Tools	Despite availability, advanced tools like Primavera P6 are underutilised (CPM3).
Objective 2: Opportunities for Digitalisation	
Efficiency Gains	Potential for improved efficiency in project management (CPM2).
Enhanced Accuracy	More accurate planning and estimating using digital tools (CPM4, CPM6).
Mobile Technology Use	Benefits of mobile technology in field data collection (CPM8).
Improved Stakeholder Management	Use of digital dashboards for transparency (CPM10).
Innovative Methodologies	Opportunity to employ innovative construction methods (CPM6).
Objective 3: Leveraging Digitalisation for Improved Outcomes	
Strategic Implementation	Need for a strategic approach in digital tool adoption (CPM1, CPM10).
Data-Driven Decision Making	Use of analytics for informed decision-making (CPM4).

Objective/Code	Description
Collaboration and Integration	Effective teamwork and integration with BIM (CPM3, CPM5).
Adapting to Project Needs	Importance of adapting digital strategies to specific project goals (CPM7).
Cultural Shifts in Organisations	Human element in digital adoption, including training and decision-making (CPM9).

The table presented is an organisational tool used in the initial phase of thematic analysis of qualitative data from interviews conducted with CPM professionals in SA and abroad. This initial phase involves generating codes, labels or tags assigned to specific data pieces that appear relevant to the research questions at hand.

4.4.3 Identification of themes

Introduction to the Section:

In the evolving landscape of the SACI, the integration of DTEC in project management is increasingly becoming a critical factor. This section of the study concentrates on the current state of digitalisation in the planning phase of CPM in SA. It aims to delve into the complexities, challenges, and opportunities presented by digitalisation in this sector. Through a series of meticulously formulated research questions, the study endeavours to investigate various dimensions of digital integration, from the utilisation of specific planning software tools to the broader implications of DT on project outcomes.

Objective 1: Challenges of Digitalisation

1. Resistance to Change and Skill Gap: A recurring theme is the reluctance of experienced staff to adapt to new digital tools, as highlighted by CPM1's comments on the digital skills gap. This reflects a broader resistance to change within the industry, indicating a need for focused training and education.

2. Economic and Technical Barriers: CPM7's remarks on digital tools' high costs and complexity for smaller firms underscore the economic and technical barriers. This theme speaks to the need for more accessible, user-friendly, and cost-effective digital solutions in the industry.
3. System Integration and Standardisation Challenges: Integration issues, as discussed by CPM9, and the disparity in digital adoption rates (CPM5) highlight the challenges in system integration and the need for industry-wide standardisation to facilitate smoother digital transformation.

Objective 2: Opportunities for Digitalisation

1. Operational Efficiency and Accuracy: The potential for improved efficiency in project management, mentioned by CPM2, demonstrates the significant opportunities digital tools offer in enhancing operational efficiency and planning accuracy.
2. Technological Advancement in Field Operations: The benefits of mobile technology in field data collection (CPM8) and the application of innovative methods like 3D printing (CPM6) point to a trend towards leveraging technological advancements for better field operations and project execution.
3. Enhanced Stakeholder Engagement: Improved stakeholder management, as noted in CPM10's remarks on digital dashboards, suggests evolving project collaboration and client relations driven by enhanced communication tools.

Objective 3: Leveraging Digitalisation for Improved Outcomes

1. Strategic Digital Integration: The emphasis on a strategic approach in digital tool adoption (CPM1, CPM10) underscores the importance of well-planned technology integration in project management, aligning digital strategies with overall project goals.
2. Data-Driven Culture in Decision Making: The focus on data-driven decision-making (CPM4) reflects a shift towards a more analytical approach, leveraging data analytics for informed planning and execution.
3. Organisational and Cultural Adaptation: Recognising the human element in digital adoption (CPM9) highlights the need for organisational and

cultural changes, focusing on continuous training, leadership commitment, and inclusive decision-making to successfully navigate digital transformation.

These themes, enriched with specific references from the CPMs, provide a deeper understanding of the dynamics influencing DT in SA's CPM sector.

Table 3: Research questions, sub-themes, and themes of the study (Proposition 1)

Research Questions	Subthemes	Themes
Objective 1: Challenges of Digitalisation		
How extensively is digitalisation integrated into the planning phase of CPM in SA?	Integration Level and Tools Used	Challenges of Digitalisation in CPM
What cultural adjustments are required within construction organisations to successfully implement digitalisation in the planning phase?	Cultural Adjustments and Change Management	Challenges of Digitalisation in CPM
How do regulatory reform's role the implementation of digital tools and techniques in construction project planning?	Regulatory Role and Compliance	Challenges of Digitalisation in CPM
What advanced collaboration methods have been adopted during the DT process?	Collaboration Methods and Challenges	Challenges of Digitalisation in CPM
How does the DD affect the successful implementation of digitalisation in the planning phase?	DD and Equity Strategies	Challenges of Digitalisation in CPM
Objective 2: Opportunities of Digitalisation		
In what ways can further digitisation be implemented in the planning phase to enhance efficiency and effectiveness?	Implementation Strategies and Areas of Role	Opportunities of Digitalisation in CPM
How does digitalisation in the planning phase lead to improved communication among project stakeholders?	Communication Enhancement	Opportunities of Digitalisation in CPM
In what ways does digitalisation enhance decision-making processes in construction project planning?	Decision-Making and Data Analytics	Opportunities of Digitalisation in CPM
How has digitalisation increased productivity during the planning phase of construction projects?	Productivity and Workflow Optimisation	Opportunities of Digitalisation in CPM
How does digitalisation contribute to more accurate and efficient planning in construction projects?	Planning Accuracy and Efficiency	Opportunities of Digitalisation in CPM

Research Questions	Subthemes	Themes
Objective 3: Strategies for Leveraging Digitalisation		
Based on experiences in the SACI, what successful strategies have been employed to leverage the opportunities presented by digitalisation for improved project outcomes?	Successful Strategies and Adaptability	Strategies for Leveraging Digitalisation
What key learnings or best practices can be drawn from successful implementation stories in the planning phase of CPM?	Key Learnings and Best Practices	Strategies for Leveraging Digitalisation

4.4.4 Review of Themes

Reviewing and Refining Themes: The identified themes will be critically reviewed and refined to ensure their accuracy and relevance to the research objectives. This iterative process is essential for the validity of the findings.

Objective 1: Challenges of Digitalisation

Upon review, the theme of Resistance to Change and the Skill Gap could be refined to Adapting to Technological Evolution, emphasising the reluctance to change and the necessity of adapting to technological advancements in the industry. This refinement considers CPM1's observations about the digital skills gap, suggesting a broader scope that includes resistance and the need for adaptation.

The theme of Economic and Technical Barriers remains pertinent but could be expanded to the Accessibility and Usability of Digital Tools. This expansion includes CPM7's concerns about costs and complexity, recognising that economic and technical barriers extend to issues of accessibility and user-friendliness, particularly for smaller firms.

System Integration and Standardisation Challenges could be redefined as Harmonisation of Digital Practices. This new phrasing, inspired by CPM9's integration issues and CPM5's comments on adoption disparities, suggests a

move towards harmonising digital tools and practices across the industry for better integration.

Objective 2: Opportunities for Digitalisation

The Operational Efficiency and Accuracy theme is accurate but could be broadened to Streamlining Project Management Processes. This broader theme, informed by CPM2's insights, encompasses both efficiency and accuracy and the overall streamlining and optimisation of project management processes through digital tools.

Technological Advancement in Field Operations could be further refined to Innovative Technologies Enhancing Field Dynamics. Drawing on CPM8 and CPM6's inputs, this refinement focuses on how cutting-edge technologies like mobile tech and 3D printing revolutionise field operations.

Enhanced Stakeholder Engagement could be expanded to Transforming Stakeholder Communication and Collaboration, incorporating CPM10's insights about digital dashboards. This expansion emphasises the transformation in stakeholder engagement brought about by digital tools.

Objective 3: Leveraging Digitalisation for Improved Outcomes

Strategic digital integration could be more inclusively termed comprehensive digital strategy and implementation. This theme, reflecting CPM1 and CPM10's views, underscores the need for a comprehensive, strategic approach encompassing the entire spectrum of digital tool adoption.

Data-Driven Culture in Decision Making can be refined to Cultivate a Data-Centric Organisational Mindset. This revision, influenced by CPM4's emphasis on data-driven decisions, represents a broader cultural shift towards valuing and utilising data in all aspects of project management.

Organisational and Cultural Adaptation might be better termed as Fostering Digital-Ready Organisational Culture. Inspired by CPM9's observations, this theme acknowledges the broader implications of digital adoption, encompassing the need for organisational readiness and cultural shifts to embrace digitalisation fully.

These refined themes provide a more nuanced and comprehensive understanding of DT within the CPM sector in SA, aligning closely with the research objectives and ensuring the validity of the findings.

4.4.5 Defining and Naming Themes

Defining and Naming Themes: "Ongoing analysis to refine the specifics of each theme and the overall story the analysis tells involves generating clear definitions and names for each theme." This step transforms the themes from just being descriptive to being interpretive.

Objective 1: Challenges of Digitalisation

Theme: Embracing Digital Evolution

Definition: This theme encapsulates the industry's challenge in adapting to rapidly evolving digital tools and practices. As noted by CPM1, a noticeable hesitation among seasoned professionals to embrace new technologies indicates a broader resistance to change. CPM5 and CPM9 further highlight the disparities in digital adoption rates and integration difficulties, emphasising the need for a cultural and educational shift towards a more digitally savvy workforce.

Interpretation: The theme signifies the sector's transition phase, where traditional methods gradually give way to digital approaches. It underscores the necessity for strategic planning and targeted initiatives to foster a receptive culture to digital advancements.

Theme: Bridging Economic and Technical Divides

Definition: Stemming from CPM7's concerns, this theme reflects small to medium-sized firms' economic and technical barriers when adopting digital tools.

It involves the challenges relating to the cost, complexity, and accessibility of DTEC, which can hinder equitable digital progression across the industry.

Interpretation: This theme points to the critical need for developing cost-effective, user-friendly, and accessible digital solutions that cater to the diverse needs of the construction sector, fostering inclusivity and widespread adoption.

Objective 2: Opportunities for Digitalisation

Theme: Optimising Project Management

Definition: Based on CPM2's insights, this theme highlights digital tools' significant opportunities to enhance project management efficiency and accuracy. It suggests the potential for DTEC to improve resource allocation, streamline processes, and boost overall project success.

Interpretation: The theme reflects an evolving project management landscape where digital tools are supplementary and integral to achieving optimal project outcomes.

Theme: Technological Innovation in Construction

Definition: Informed by CPM6 and CPM8, this theme explores the transformative role of emerging technologies, including mobile applications and 3D printing on construction site operations and stakeholder engagement.

Interpretation: This theme underscores a paradigm shift in field operations, where innovative technologies reshape traditional construction practices and enhance stakeholder communication and collaboration.

Objective 3: Leveraging Digitalisation for Improved Outcomes

Theme: Strategic Digital Integration

Definition: Echoing CPM1 and CPM10, this theme focuses on strategically integrating digital tools into CPM. It involves planning and implementing digital strategies that align with project objectives and industry trends.

Interpretation: The theme emphasises the need for a holistic and forward-thinking approach to digital tool adoption, ensuring that technological advancements are effectively harnessed to drive project success.

Theme: Cultivating a Data-Driven and Adaptive Culture

Definition: Inspired by the insights of CPM4 and CPM9, this theme highlights the need for organisations in the construction sector to develop a culture that values data-driven decision-making and is adaptable to technological changes. It involves embracing data analytics and fostering an environment conducive to continuous learning and innovation.

Interpretation: This theme signifies the shift towards a more informed and flexible approach to project management, where data is leveraged for strategic planning, and the workforce is equipped to navigate and thrive in a digitally evolving landscape

By defining these themes, the study provides a structured insight into the multifaceted nature of digitalisation within CPM. Each theme is named to reflect its core focus, allowing for a narrative accessible and resonant with the broader objectives of enhancing project management through digital means. This critical step sets the stage for a detailed analysis and discussion in the final sections of the study.

4.4.6 Emerging themes

Table 4: Emerging Themes (Proposition 2)

Objective	Themes
Objective 1: Challenges of Digitalisation	Embracing Digital Evolution

Objective	Themes
Objective 1: Challenges of Digitalisation	Digital Skills Gap
Objective 1: Challenges of Digitalisation	Cost and Complexity
Objective 1: Challenges of Digitalisation	Integration Issues
Objective 1: Challenges of Digitalisation	Digital Adoption Disparity
Objective 1: Challenges of Digitalisation	Underutilisation of Tools
Objective 2: Opportunities for Digitalisation	Efficiency Gains
Objective 2: Opportunities for Digitalisation	Enhanced Accuracy
Objective 2: Opportunities for Digitalisation	Mobile Technology Use
Objective 2: Opportunities for Digitalisation	Improved Stakeholder Management
Objective 2: Opportunities for Digitalisation	Innovative Methodologies
Objective 3: Leveraging Digitalisation for Improved Outcomes	Strategic Implementation
Objective 3: Leveraging Digitalisation for Improved Outcomes	Data-Driven Decision Making

Objective	Themes
Objective 3: Leveraging Digitalisation for Improved Outcomes	Collaboration and Integration
Objective 3: Leveraging Digitalisation for Improved Outcomes	Adapting to Project Needs
Objective 3: Leveraging Digitalisation for Improved Outcomes	Cultural Shifts in Organisations

Table 5: Proposition 2 Legacy and modernisation

Element	Application in CPM (Based on CPM Responses)
Abstraction Layer	Utilising platforms like BIM to abstract complex project data into manageable and user-friendly formats. CPM6: “BIM allows us to simplify complex project aspects into visual models, making it easier for all stakeholders to comprehend.”
Orchestration Layer	Implementing advanced project management tools (e.g., Primavera P6) to orchestrate various project elements. CPM2: “With Primavera P6, we orchestrate resources, schedules, and workflows efficiently.”
Waterfall Approach and Agile Squads	Combining traditional (Waterfall) and modern (Agile) project management approaches to leverage the strengths of both. CPM7: “We use a hybrid approach, mixing Agile flexibility with Waterfall's structured planning.”
Middleware and API’s	Employing APIs and middleware for seamless integration of new digital tools with existing systems. CPM3: “We use APIs to connect our legacy systems with new digital platforms, ensuring smooth data flow.”
Drive Digital Whilst Running Legacy	Balancing the upkeep of legacy systems while progressively implementing digital tools. CPM5: “Our focus is on integrating digital solutions without disrupting our existing legacy systems.”
Multi Squads	Forming diverse teams with varied expertise to tackle different aspects of digital transformation. CPM4: “We have set up multiple squads focusing on different digital initiatives, from BIM integration to data analytics.”

Table 6: Final themes (Proposition 1&2)

Objective	Final Themes
Objective 1: Challenges of Digitalisation	Embracing Digital Evolution
	Economic and Technical Divides
Objective 2: Opportunities for Digitalisation	Technological Innovation in Construction
	Optimising Project Management
Objective 3: Leveraging Digitalisation for Improved Outcomes	Strategic Digital Integration
	Cultivating a Data-Driven and Adaptive Culture

Figure 7 illustrates the thematic map, showing how the research objectives are tied to the central theme of digitalisation in construction project management. This visual representation helps to understand the interconnectedness of various themes and sub-themes identified during the analysis.

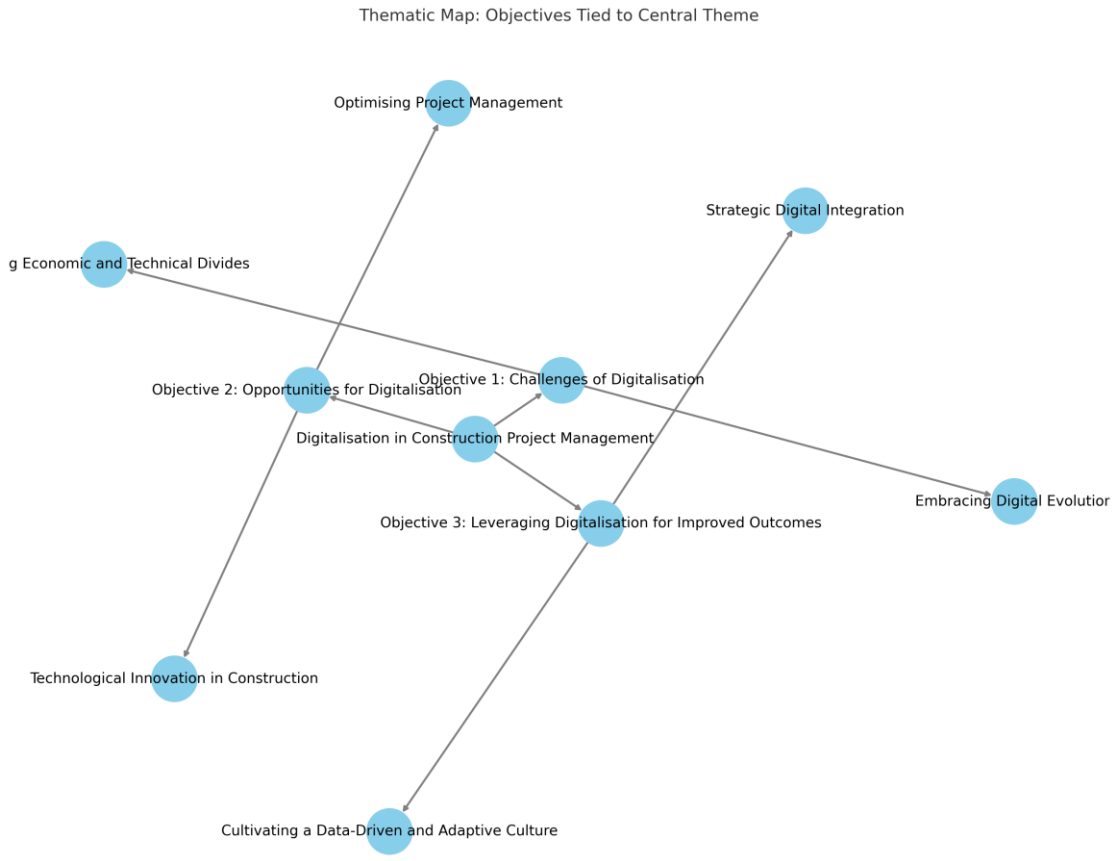

Figure 8: Thematic map based on Proposition 1.

4.5 Results Of Proposition 1

DT in the CI extends beyond merely adopting technological tools; it fundamentally involves rethinking and reshaping the entire project management paradigm and operational processes within the sector. To thoroughly examine and validate this proposition, the collected interview data was meticulously analysed through the thematic analysis process, as detailed earlier in the study.

This proposition focuses on understanding how digitalisation roles not just the technological aspect but also the core business model and operational functionality of CPM. The thematic analysis was grounded in the research instrument introduced in Chapter 3, which was designed to explore the multifaceted dimensions of digital strategy formulation and its implementation within the context of CPM in SA.

The primary data included in this investigation was garnered through comprehensive online interviews, targeting senior leadership and experienced professionals in the construction sector. With their profound knowledge and insight into the industry's DT journey, these individuals provided invaluable perspectives on the challenges, opportunities, and strategic considerations associated with embracing digital tools and methodologies in CPM.

The ensuing sections will present the results derived from the thematic analysis, exploring how DT is perceived, implemented, and operationalised in the SACI. This analysis aims to shed light on the realities of digitalisation within this sector, exploring how it transcends mere technological adoption and necessitates a holistic reconsideration of traditional project management practices.

4.5.1 Digital Embracing the digital evolution in CPM (Objective 1)

In SACPM, digital strategy is not simply synonymous with technological innovation but a call to radically rethink business models and operational functions. As the industry grapples with digital transformation, it becomes clear

that there needs to be a more cohesive understanding of what 'digital' truly means within the construction sector.

The digital strategy emerged through the thematic analysis of various responses, which did not explicitly test for a definition of DT but elucidated the industry's perception of the term. For some, like CPM3, it is a broad, ecosystem-wide change, while for others, such as CPM5, it signifies the practical enablement of project management channels.

Digital Strategy and Culture:

The thematic analysis of interview responses unveiled a prominent dichotomy in understanding DT within SACPM. This divide is not merely technical but cultural, indicating a broader variance in strategic direction and the adoption of digital tools across the sector.

CPM1's perspective encapsulates DT as an "ecosystem transformation, " suggesting a holistic approach that encompasses adopting new technologies and a fundamental reconfiguration of business processes and operational methodologies. This viewpoint implies a comprehensive cultural shift, requiring a change in mindset at all levels of the organisation to embrace a fully integrated digital environment.

On the contrary, CPM5 characterises DT as "channel enablement", a narrow interpretation focusing on utilising digital platforms to enhance existing operational channels. This perspective prioritises adopting digital tools to streamline specific processes or project phases rather than advocating for wholesale organisational change.

The contrast between these views highlights the cultural adjustments required for successful digital strategy implementation. The transition to digital-centric operations necessitates infrastructure and tools and a shift in organisational culture. It requires building a digitally literate workforce, fostering an environment where innovation is encouraged, and redefining the role of technology within the CPM paradigm.

To bridge this divide, there is a need for clear communication and leadership to define what DT means for the organisation. Leaders must articulate a digital vision that aligns with the company's strategic goals and resonates with the workforce's cultural context. This involves addressing the concerns and resistance that may come from longstanding employees who are accustomed to traditional methods. As CPM1 highlighted, adopting digital tools may become a piecemeal effort without such leadership, lacking the full-fledged integration necessary for true transformation.

Moreover, the industry must address the challenges associated with the disparity in digital adoption rates. While larger firms may possess the resources to undertake comprehensive digital strategies, smaller firms, as alluded to by CPM5, may only implement digital tools to the extent that they enhance specific channels, often due to resource constraints.

In summary, the cultural aspect of digital strategy is as key as the technological one. For DT to be effective, it must permeate every aspect of the organisational culture, recalibrating the fabric of CPM. This necessitates a concerted effort to cultivate a digital-first mindset, equipping teams with the required knowledge and skills to navigate a rapidly evolving digital landscape and ensuring that digital strategies are inclusive and accessible to all within the industry.

Operating Model and Skills:

The operational models adopted by construction firms within SA reveal a significant digital skills gap, particularly among seasoned professionals who exhibit hesitancy towards embracing new digital tools. This hesitancy is not merely a reflection of a preference for traditional methods. However, it points to a broader systemic issue affecting operational efficiency and the progression of digital strategies within the industry.

Seasoned professionals with extensive experience with traditional construction methodologies often find themselves at a crossroads when faced with rapidly evolving digital tools. This intersection between established practices and innovative technologies represents a pivotal challenge that construction firms must navigate to stay competitive. As CPM7 insightfully notes, there is an

"ambiguity in the application of digital objectives," suggesting that while the intent to integrate digital tools exists, the practical application and strategic implementation are often unclear or inconsistent.

This gap in digital skills and the subsequent reluctance to adapt has far-reaching implications for the operational models of construction firms. It creates bottlenecks in adopting new technologies, hampers the streamlining of processes, and, most critically, can slow down the industry's ability to innovate and improve operational efficiencies. The inability to fully leverage digital tools can result in a competitive disadvantage, particularly as international standards and client expectations evolve to demand more sophisticated, technology-driven project management solutions.

To bridge this skills gap, a multi-faceted approach is necessary. First, firms must commit to ongoing professional development and training programs tailored to the specific digital tools and platforms they intend to integrate into their operations. This training should be designed to accommodate varying levels of technological proficiency, ensuring inclusivity and a smoother transition for all employees.

Furthermore, there is a need to redefine the operational models themselves, moving away from hierarchies and silos that may impede digital integration towards more agile and collaborative structures that foster a culture of continuous learning and adaptation. Incorporating digital tools should be viewed not merely as an addition to existing practices but as an opportunity to reassess and potentially re-engineer processes to realise DT ’s benefits fully.

Leadership plays a key role in this transition. Leaders must articulate a clear digital vision, establish benchmarks for digital proficiency within their teams, and champion the adoption of digital tools through example and advocacy. They must also be attuned to the workforce's concerns and resistant points, addressing these proactively with empathy and strategic planning.

In conclusion, the digital skills gap presents both a challenge and an opportunity for construction firms in SA. By embracing a strategic approach to workforce development and operational model restructuring, firms can close this gap and

harness the full potential of digital tools to enhance their competitive edge, operational efficiency, and project outcomes.

Architecture and Strategy:

In the context of CPM, the architecture of digital strategies is of fundamental importance. However, within SA construction firms, there is a pattern of fragmented digital strategies, which reflects a lack of cohesive direction and a unified vision for DT. This fragmented approach can lead to disjointed and piecemeal adoption of DTEC, ultimately undermining the potential benefits of a full-scale DT.

The fragmented nature of digital strategies often stems from a strategic ambiguity that pervades many construction firms. As pointed out by CPM3, there is a palpable uncertainty surrounding the adoption and implementation of digital tools.

This lack of clarity hinders the strategic planning process and affects the operationalisation of digital initiatives. With a clear strategy, firms can prioritise digital investments, integrate new technologies with legacy systems, and align digital initiatives with broader business objectives.

To address these challenges, firms need to develop a comprehensive digital strategy integrated into the overall business plan. This strategy should be grounded in a deep understanding of the firm's current digital maturity, the specific needs of the industry, and the opportunities that digitalisation presents. It requires a systematic approach that considers all aspects of the firm's operations, from design and planning to execution and delivery.

In developing a digital strategy, firms should consider the following key components:

- Vision and Leadership: Clear leadership and a well-articulated vision for DT are key. Leaders must communicate the digital strategy effectively across the organisation, ensuring all stakeholders understand the direction and rationale of digital initiatives.

- Stakeholder Engagement: Engaging with all stakeholders, including clients, employees, and suppliers, is vital to ensure that the digital strategy aligns with the needs and expectations of each group. This engagement can also foster a culture of collaboration and innovation.

- Technology Assessment: Conducting a thorough assessment of available technologies and their relevance to the firm's operations will help identify the right tools to drive efficiency, improve accuracy, and enhance collaboration.

- Skills and Training: Investing in the right skills and providing comprehensive training to employees will ensure that the workforce is equipped to utilise digital tools effectively. This should be an ongoing process, reflecting the continual evolution of technology.

- Process Reengineering: Often, the adoption of digital tools will necessitate a rethinking of existing processes. This may involve re-engineering workflows to capitalise fully on the efficiencies offered by DTEC.

- Data Governance and Security: As digital strategies increasingly rely on data, establishing robust data governance and security protocols is critical. This ensures data integrity, confidentiality, and availability throughout the project lifecycle.

- Performance Metrics: Implementing clear metrics to measure the success of digital initiatives will help firms monitor progress and make data-driven decisions.

By developing a cohesive digital strategy that integrates these elements, construction firms can move beyond the fragmented adoption of digital tools and towards a more structured and strategic approach. This shift can lead to considerable improvements in project delivery, cost management, and overall competitiveness in the industry. With a strategic and holistic approach to

digitalisation, construction firms can set the stage for sustained growth and innovation in an increasingly digitalised world.

Modernisation:

Modernisation within the SACI represents one of the most formidable challenges in DT. Companies often grapple with the complex task of integrating cutting-edge digital innovations with entrenched, legacy systems that have been the backbone of their operations for many years. This struggle is not merely a technical dilemma but also reflects broader economic and technical divides that can impede uniform digital adoption across the industry.

CPM9's insights shed light on the inconsistency in digital adoption rates, highlighting a divide between larger firms with more resources to invest in new technologies and smaller firms that may need more infrastructure or capital to modernise legacy systems. The disparity in adoption rates can create competitive imbalances and hinder the industry's progression towards a unified digital standard.

To navigate the challenges of legacy modernisation, construction firms may consider the following strategies:

- Incremental Modernisation: Instead of large-scale overhauls, companies can adopt a gradual approach to modernisation. This could involve updating components of the legacy system that are most amenable to integration with new technologies, thereby minimising disruption to existing workflows.

- Phased Implementation: Breaking down the modernisation process into distinct phases allows for better management of resources and reduces the risks associated with system-wide changes. Each phase can be evaluated for effectiveness before proceeding to the next, ensuring the modernisation process is controlled and measured.

- Hybrid Solutions: Developing hybrid systems that allow new technologies to work alongside legacy systems can provide a bridge between the old

and the new. This approach leverages established systems' reliability while gradually introducing the efficiencies of modern technology.

- Stakeholder Collaboration: Involving all stakeholders, including IT professionals, project managers, and end-users, in the modernisation process can facilitate a smoother transition. Collaboration ensures that legacy systems' nuances are understood and that the new technologies align with user needs and industry practices.

- Customisation and Integration: Tailoring digital solutions to fit a company's specific needs can make the process of modernising legacy systems more manageable. Integrating new software with existing hardware or databases can preserve the value of legacy systems while enhancing their functionality with digital capabilities.

- Training and Support: Providing extensive training and support to employees will aid in the transition from legacy systems to modernised digital platforms. Ongoing support helps to address technical issues promptly and ensures that users feel confident in utilising new technologies.

- Cost-Benefit Analysis: Executing a comprehensive cost analysis can help justify the investment in modernisation. By quantifying the potential gains in efficiency, productivity, and competitiveness, firms can make a compelling case for modernisation initiatives.

- Leveraging Data: Legacy systems often contain valuable historical data. Modernisation efforts should include strategies to extract, preserve, and utilise this data within new digital systems to inform better decision-making and strategic planning.

By addressing the challenges of legacy modernisation with a strategic and collaborative approach, construction firms can reduce the economic and technical divides noted by CPM9. This effort positions companies to better

compete in a digital marketplace and contributes to the industry's collective advancement towards digital maturity and innovation.

In conclusion, the ambition to digitise is a common thread running through the strategic plans of construction firms, with a clear recognition of the benefits and efficiencies that DT promises. However, as CPM7 insightfully notes, the transition from strategic intent to tangible outcomes in project execution is fraught with challenges. The disparity in understanding and applying digital strategies observed during the interviews reflects a broader issue within the industry. There is a need for a shared vision and a well-articulated digital strategy that resonates across all levels of an organisation.

The significance of establishing a comprehensive digital strategy cannot be overstated. The blueprint guides the adoption of new technologies and the reengineering of business processes. With a coherent strategy, efforts to digitise can become cohesive, leading to suboptimal deployment of resources, and missed opportunities for innovation. Moreover, a unified digital strategy can catalyse cultural change within firms, fostering an environment where digital adoption is embraced, and the digital skills gap can be addressed through development initiatives and targeted training.

The industry is at a critical juncture. To remain competitive on a global stage and capitalise on the efficiencies offered by digital tools, SACPM must embrace DT in theory and practice. This involves a commitment to continuous learning, investment in technology, and a willingness to reevaluate and adapt traditional operational models. Furthermore, it necessitates a concerted effort to bridge the divide between larger firms that can readily invest in new technologies and smaller firms that may struggle with the costs associated with such advancements.

The construction sector's ability to navigate this DT will hinge on its collective commitment to developing and adhering to a shared digital strategy. Such a strategy should clearly define what 'digital' means in CPM, set out the pathways for technology integration, and establish benchmarks for measuring success. By doing so, the industry can ensure that the digitalisation of project management is

not just a strategic objective but a practical reality that enhances efficiency, drives innovation, and delivers on the promise of digital transformation.

4.5.2 Economic and Technical Divides (Objective 2)

Economic and technical divides regarding digital strategy and transformation in the SACPM sector are starkly pronounced. The thematic analysis has illuminated the depth of these divides, revealing how they influence the adoption and efficacy of digital initiatives within the industry. As we delve into the narratives of construction professionals, it becomes evident that the disparity in economic resources and technical capabilities is a critical barrier to uniform digital progression across firms of varying sizes and scopes.

CPM9's insights highlight the inconsistency in digital adoption rates, underscoring the divide between well-resourced firms that can navigate the digital landscape relatively easily and smaller firms that grapple with economic and technical constraints. This divide not only roles the immediate operational capacity of these firms but also shapes their strategic planning and long-term digital roadmap.

Economic divides manifest in the ability to invest in new technologies and the infrastructure required to support them. For larger firms, allocating funds for digital tools and systems is often part of strategic growth plans. In contrast, smaller firms may perceive such investments as prohibitive, choosing instead to allocate limited resources to more immediate operational concerns. This economic disparity results in a tiered industry landscape, where the benefits of digital transformation—such as increased efficiency, accuracy, and competitiveness—are not evenly distributed.

The technical divides are equally challenging, often stemming from a need for in-house expertise or access to the technical support necessary to implement and maintain sophisticated digital systems. While larger firms may employ dedicated IT teams or engage with external consultants to drive their digital strategies, smaller firms may rely on a patchwork of ad hoc solutions or outdated systems that cannot fully leverage the advantages of modern digital tools.

To address these economic and technical divides, a multifaceted approach is essential:

Industry-wide Collaboration:

The thematic analysis highlights the transformative potential of industry-wide collaboration in mitigating the economic and technical divides in SACPM. Such collaborative efforts can democratise access to digital tools, fostering a more equitable environment where firms, regardless of size or economic power, can benefit from the digital revolution.

- Shared Resources and Knowledge Exchange: The concept of shared resources and knowledge exchange platforms has been echoed by industry professionals, including CPM9, who acknowledge the need for a unified approach to navigating the digital landscape. By pooling resources, smaller firms can access advanced digital tools and systems that would otherwise be beyond their means. Knowledge exchange platforms are a conduit for sharing best practices, innovations, and troubleshooting strategies, allowing firms to learn from collaborative experiences and apply these learnings to their operations.

- Cooperative Procurement Initiatives: Establishing cooperative procurement initiatives can further alleviate the financial burden of digital adoption. By collectively negotiating the purchase of digital tools and systems, construction firms can leverage their combined purchasing power to obtain more favourable terms and pricing. This approach reduces individual firms' costs and encourages technology providers to tailor their offerings to meet the industry's collective needs.

- Industry Experts' Insights: CPM1 highlights the effectiveness of collaborative learning, suggesting that "cross-company training sessions and joint problem-solving workshops can expedite the industry's digital skill acquisition." Meanwhile, CPM7 advocates for "joint ventures or consortiums that enable resource sharing, especially for high-value digital infrastructure investments, to spread costs and risks."

- Leveraging External Expertise: External expertise is key in supporting firms with limited in-house technical capabilities. CPM3 and CPM5 discuss the benefits of engaging with digital consultants and IT service providers who can offer guidance and support in implementing and maintaining digital tools. These partnerships can provide a lifeline for smaller firms that need more technical staff to manage complex digital systems.

- Government and Sector Support: The role of government and sector-specific associations is critical in fostering an environment conducive to collaboration. Policies that encourage digital innovation and funding or subsidy programs aimed at DT can incentivise firms to engage in collective digital endeavours. As CPM2 points out, "Government-led initiatives and incentives can catalyse industry collaboration, driving collective advancement towards digital proficiency."

- Championing Change: Industry leaders can champion change by facilitating forums and roundtable discussions where firms can share insights and coordinate DT strategies. CPM4 notes, "Regular industry symposiums and digital expos can showcase cutting-edge DTEC and provide networking opportunities for collaboration."

In conclusion, industry-wide collaboration is not just a strategic choice but necessary for bridging the DD in SACPM. By adopting a culture of cooperation and shared progress, the industry can collectively overcome economic and technical barriers, enabling all firms to engage with digital tools and strategies effectively. This collaborative spirit can lay the foundation for a more resilient and innovative industry poised to meet future challenges.

Government and Association Interventions:

The importance of government and industry associations in steering the construction sector towards a more digitally inclusive future cannot be overstated. Their role in facilitating the development of digital infrastructure and incentivising

investment in technology is pivotal in addressing the economic and technical divides that exist within the industry.

- Government's Role in Digital Infrastructure: Government initiatives are key in laying the groundwork for widespread digital adoption. By investing in national digital infrastructure, such as high-speed internet access and data centres, the government can remove significant barriers to digital transformation. CPM9 suggests, "With the robust digital infrastructure in place, even the most remote construction sites can access advanced digital tools, levelling the playing field for all firms."

- Incentives and Subsidies: Financial support from the government can lower the entry barrier for smaller firms to embrace DTEC. Subsidies, tax incentives, and grants aimed at DT can make it economically feasible for these firms to invest in new technologies. As CPM5 notes, "Government incentives are often the catalyst that prompts smaller firms to leap digitalisation, which they may not risk otherwise."

- Industry Associations' Support: Industry associations can amplify the role of government initiatives by acting as intermediaries between policymakers and construction firms. They can advocate for the needs of their members, ensuring that government interventions are well-aligned with the industry's requirements. "Associations can facilitate workshops and training sessions partially funded by government grants, making them accessible to a broader range of firms," adds CPM2.

- Best Practices and Standards: Associations play a notable role in establishing best practices and standards for digital adoption. Creating industry-wide digital standards can provide a roadmap for businesses looking to integrate digital tools into their operations. CPM7 emphasises the importance of standardisation, stating, "Having a common set of digital standards helps firms understand what they should be aiming for and ensures interoperability between different digital systems."

- Knowledge Dissemination: Industry associations can be a hub for knowledge dissemination, sharing insights into the latest digital trends and practices. This can help construction firms stay up to date with technological advancements and understand how to implement them effectively. "Regularly published case studies and success stories by our association inspire firms to pursue their DT journeys," remarks CPM3.

- Collaborative Platforms: Creating collaborative platforms by associations can encourage knowledge-sharing and collective problem-solving among firms. CPM1 highlights the effectiveness of such platforms, "Industry-specific digital platforms can connect firms with technology providers, facilitating the exchange of ideas and solutions tailored to CPM."

- Regulatory Frameworks: Both government and associations can work together to develop regulatory frameworks that support digital innovation while ensuring compliance and security. CPM6 mentions, "Clear regulations regarding digital data handling and cybersecurity can give firms the confidence to invest in DTEC without fearing legal repercussions."

In conclusion, government and industry association interventions are instrumental in catalysing DT within the construction sector. By providing the necessary infrastructure, financial support, and guidance, they can help bridge the DD, ensuring that all firms, regardless of size, can participate in and benefit from the digital era. The combined efforts of policymakers, industry leaders, and associations can create an environment that nurtures innovation, fosters collaboration, and drives the industry towards a more prosperous and technologically advanced future.

Education and Training:

The significance of education and training in bridging the technical divide in the CI cannot be understated. Enhancing digital literacy and skills is a critical step towards ensuring that all personnel can effectively engage with digital tools and methodologies, regardless of their initial proficiency.

- Vocational Training Programs: Vocational training programs designed for the CI can be vital in building a digitally competent workforce. CPM2 points out, "Tailored training programs that focus on practical applications of digital tools in construction can help workers and managers alike to understand and embrace these technologies." These programs should cover various topics, from basic digital literacy to advanced applications like BIM and PM software.

- Seminars and Workshops: Regular seminars and workshops by industry experts can provide construction professionals with insight into the latest digital trends and practices. CPM5 emphasises the importance of such events, noting, "Workshops and seminars are not just about learning new skills; they are also about understanding the broader role of digitalisation on the industry."

- Continuous Professional Development (CPD): CPD opportunities are essential for keeping construction professionals up to date with the evolving digital landscape. CPM7 highlights, "Continuous learning is key in an industry rapidly changing due to technological advancements. CPD programs can ensure that our workforce does not fall behind."

- Collaboration with Educational Institutions: Partnerships between construction firms and educational institutions can foster a curriculum that aligns with industry needs. CPM3 suggests, "Collaborations with universities and technical colleges can ensure that the upcoming workforce is well-prepared for the digital demands of the CI."

- Online Learning Platforms: Using online learning platforms can provide flexible and accessible training options for construction professionals. CPM9 mentions, "Online courses and certifications allow our employees to learn at their own pace and according to their own schedules, which is key in our busy industry."

- Mentorship and On-the-Job Training: Mentorship programs and on-the-job training initiatives can complement formal education. CPM1 states, "Pairing less digitally savvy employees with tech-savvy mentors can facilitate hands-on learning and practical understanding of digital tools in a real-world context."

- Specialised Skill Development: Focusing on specialised skills, such as data analysis, cybersecurity, and software-specific training, is essential for advanced digital adoption. CPM6 notes, "As we integrate more complex digital systems, specialised data security and analytics skills become increasingly important."

In conclusion, a multifaceted approach to education and training is imperative to close the technical divide in the CI. By investing in vocational training, workshops, CPD, and collaboration with educational institutions, the industry can cultivate a workforce adept at using digital tools. This commitment to continuous skill development and learning will ensure that all members of the construction sector are equipped to thrive in a digitally transforming landscape, leading to more efficient, innovative, and competitive PMP.

Flexible and Scalable Solutions:

Adopting flexible and scalable digital solutions is key in addressing the economic and technical divides within the SACI. Such solutions can accommodate firms' varying capabilities and resources, regardless of their size, allowing for a more equitable and progressive adoption of technology.

- Adaptability to Firm Size and Resources: Scalable digital solutions offer the advantage of being adaptable to different construction firms' specific needs and capacities. CPM4 highlights this: "Scalable technology allows smaller firms to start with basic functionalities and gradually add more complex features as their proficiency and resources grow." This approach ensures that smaller firms can handle the complexity and cost of comprehensive digital systems.

- Cost-Effective Implementation: Cost is a significant barrier to digital adoption for many firms, especially smaller ones. Flexible and scalable solutions can be more cost-effective, allowing firms to invest in technology incrementally. CPM7 notes, "By choosing scalable solutions, we can manage our budgets more effectively, investing in technology as our financial situation allows."

- Ease of Integration: Scalable digital tools often offer easier integration with existing systems, reducing the need for extensive overhauls. CPM2 emphasises, "The ability to integrate new tools with our current systems without major disruptions is key for our operational continuity."

- Customisation Options: Flexibility in digital solutions also means they can be customised to meet each firm's unique needs. CPM5 states, "Customisable digital tools allow us to tailor the technology to our specific project requirements and workflow, enhancing our efficiency."
- Training and Support: Firms should provide adequate training and support to maximise the benefits of scalable solutions. CPM6 suggests, "Ongoing training and technical support are essential to help our teams make the most of these digital tools, especially as we scale up their functionalities."

- User-Friendly Design: Ensuring that digital tools are user-friendly and intuitive is vital for encouraging adoption, particularly among less tech-savvy personnel. CPM1 remarks, "The user-friendliness of a digital tool is a key factor in its adoption. If our team finds it too complex, they are less likely to use it effectively."

- Pilot Programs: Implementing pilot programs can allow firms to test and adjust digital solutions before full-scale implementation. CPM3 shares, "Pilot programs have been instrumental in helping us understand how a particular digital solution works in our context before we commit to it fully."

- Feedback Mechanisms: Establishing feedback mechanisms can help in continuously improving digital tools. CPM8 states, "Regular feedback from our team members who use these tools daily helps us to identify areas for improvement and ensure the technology evolves with our needs."

In conclusion, flexible and scalable digital solutions represent a pragmatic approach to bridging the economic and technical divides in the CI. Construction firms can progressively and efficiently integrate technology into their operations by providing adaptable, cost-effective, and user-friendly digital tools, along with adequate training and support. This approach facilitates a more inclusive DT, ensuring firms of all sizes can participate in and benefit from the evolving digital landscape in CPM.

Open-source and Community-driven Technologies:

Promoting open-source digital tools in the SACI presents a viable, cost-effective alternative for firms, especially those constrained by budget limitations. Developed and supported by community-driven initiatives, open-source technologies can significantly reduce the financial barriers to digital adoption.

- Cost-Effectiveness of Open-source Tools: Open-source tools offer cost-free availability, contrasting with proprietary software, which entails licensing fees, consequently facilitating accessibility for smaller construction businesses. CPM7 underscores this point: "The affordability of open-source tools has enabled us to leverage digital solutions that we previously thought were out of our financial reach."

- Community-driven Development and Support: The community-driven aspect of open-source technologies fosters a collaborative environment where users and developers can contribute to improving and customising the tools. CPM4 elaborates, "With open source, we are not just users; we are part of a community that constantly enhances and tailors the software to our industry's evolving needs."

- Customisation to Industry Needs: Open-source platforms often provide the flexibility to be customised according to specific project or firm requirements. CPM2 remarks, "The ability to modify and adapt open-source tools to fit our unique project demands has been a game-changer in our digital strategy."

- Enhanced Security and Transparency: Open-source technologies are typically subject to rigorous peer review, enhancing their security and reliability. CPM6 notes, "The transparency in open-source software development gives us confidence in the security and robustness of the tools we use."

- Knowledge Sharing and Skill Development: Using open-source tools can also facilitate knowledge sharing and skill development within the construction community. CPM5 comments, "Engaging with the open-source community has provided us with valuable tools and enhanced our team's digital skills through shared learning experiences."

- Encouraging Innovation: The collaborative nature of open-source development encourages innovation, allowing businesses to stay on top of the latest technological advances. CPM3 adds, "Being part of an open-source community keeps us at the forefront of innovation, as we are constantly exposed to new ideas and technologies."

- Lower Entry Barrier: Open-source tools lower the entry barrier for firms exploring digital transformation. CPM1 states, "For smaller firms, open-source software can be a stepping stone into the digital world, providing them with the opportunity to test and learn without significant financial commitment."

- Building Industry-specific Solutions: The construction sector can benefit from open-source tools specifically developed or adapted for its needs. CPM8 suggests, "Leveraging community-driven technologies means we

can develop solutions precisely tailored to the challenges and requirements of CPM."

In conclusion, open-source and community-driven technologies offer a practical and inclusive pathway for digital adoption across the SACI. By embracing these tools, firms of all sizes can access cost-effective, customisable, and innovative digital solutions. Moreover, the community-driven model promotes a culture of collaboration, knowledge sharing, and continuous improvement, which is essential for the industry's collective growth and advancement in the digital era.

Pilot Projects and Case Studies:

Implementing pilot projects and compiling detailed case studies is key to driving DT in the SA construction sector. These initiatives provide tangible, real-world examples of successful digital implementations, serving as blueprints and inspiration for firms embarking on their digital journey.

- Role of Pilot Projects: Pilot projects act as testbeds for new DTEC and methodologies, allowing firms to assess their practicality and effectiveness in a controlled environment. CPM3 highlights this: "Pilot projects have been key in our digital transition, offering a risk-managed approach to testing new tools before full-scale implementation." These projects provide valuable insights into the challenges and opportunities of digital tools, enabling firms to make informed decisions about broader adoption.

- Learning from Case Studies: Detailed case studies document the experiences, processes, outcomes, and lessons learned from digital initiatives. As CPM6 notes, "Case studies from successful digital projects are a rich source of learning. They offer a roadmap of what worked, what did not, and how challenges were overcome." These narratives benefit smaller firms or those new to DT, providing a practical reference that demystifies the process.

- Inspiration and Confidence Building: Showcasing success stories through case studies and pilot projects can inspire and build confidence among

other firms in the industry. CPM5 remarks, "Seeing real examples of digital success in our industry gives us the confidence to pursue our digital initiatives."

- Benchmarking and Best Practices: Pilot projects and case studies establish benchmarks and best practices for digital adoption in CPM. CPM2 says, "These initiatives help set industry standards for digital transformation, offering a benchmark others can aim for."

- Addressing Scepticism: Pilot projects and case studies effectively address scepticism and resistance to digital change. CPM7 says, "By providing concrete examples of digital tools delivering tangible benefits, we can convince the sceptics within our teams and the broader industry."

- Encouraging Collaboration and Knowledge Sharing: These initiatives promote a collaborative and knowledge-sharing environment within the industry. CPM1 believes, "Sharing our experiences through case studies encourages a collaborative approach to digital transformation, benefiting the entire industry."

- Facilitating Tailored Solutions: Pilot projects allow firms to develop and refine digital solutions tailored to their needs and constraints. CPM4 adds, "Through pilot projects, we can customise digital tools to fit our unique project requirements, enhancing their effectiveness."

- Replicability and Scalability: Successful pilot projects and case studies provide models that can be replicated and scaled across different projects and firms. CPM8 observes, "Learning from these cases helps us understand how to scale digital solutions effectively across various project sizes and types."

In conclusion, pilot projects and case studies are vital in advancing DT in the SACI. They provide practical examples and learning opportunities and play a key role in building confidence, establishing benchmarks, and fostering a

collaborative and innovative digital culture. By leveraging these tools, firms can navigate the complexities of DT more effectively, paving the way for a more technologically advanced and efficient construction sector.

Digital Advocacy in CPM:

In the SACI, the role of digital advocacy by industry leaders is paramount for driving the adoption of DT. This involves championing the strategic importance of DTEC and highlighting the potential return on investment to all stakeholders, including financiers, clients, and the workforce.

- Leadership and Vision: Effective digital advocacy requires visionary leadership. Industry leaders must articulate a clear and compelling vision of how DTEC can transform project management. CPM1 emphasises this: "As leaders, our role is to paint a picture of the digital future, showcasing how it can revolutionise our industry, from improved efficiency to better project outcomes."

- Educating Stakeholders: Educating stakeholders about the benefits of DT is key. CPM2 notes, "It is about showing financiers and clients the long-term value and efficiencies digital tools bring, not just in cost-savings but also in quality and sustainability of projects."

- Demonstrating Return on Investment: A key aspect of advocacy is demonstrating the tangible return on investment of digital initiatives. CPM3 adds, "We use case studies and data to show how digital tools reduce project timelines, cut costs, and improve accuracy."

- Addressing Workforce Concerns: Digital advocacy also involves addressing the workforce's concerns and hesitations. CPM4 says, "We need to ensure our teams understand how digital tools can make their

work easier and more efficient, offering training and support where needed."

- Influencing Policy and Regulations: Leaders should also advocate for supportive policies and regulations that encourage digital adoption. CPM5 suggests, "Engaging with policymakers to develop regulations that support digital innovation is key for industry-wide transformation."

- Showcasing Success Stories: Sharing success stories within the industry can serve as a powerful advocacy tool. CPM6 remarks, "By publicising our successful digital projects, we can demonstrate the practical benefits and encourage others to follow suit."

- Building Partnerships: Forming strategic partnerships with technology providers and educational institutions can bolster digital advocacy. CPM7 believes, "Collaborating with tech firms and universities can bring fresh perspectives and drive innovation in our digital strategies."
- Fostering a Culture of Innovation: Creating a culture that values continuous learning, improvement and learning innovation. CPM8 states, "We aim to foster a culture where trying new digital methods is encouraged, and learning from failures is part of the journey."

- Empowering Change Agents: Identifying and empowering change agents within organisations can accelerate digital adoption. As CPM9 observes, "Change agents can be instrumental in driving digital initiatives and getting buy-in from various levels of the organisation."

- Sustainability and Competitive Edge: Finally, digital advocacy should highlight the role of technology in achieving sustainability and maintaining a competitive edge. CPM10 concludes, "In a global market, staying competitive means embracing digital innovations that support sustainable construction practices."

In conclusion, digital advocacy by industry leaders is essential for driving the DT of CPM in SA.

Leaders can play a pivotal role in transitioning the industry towards a more efficient, sustainable, and technologically advanced future by effectively communicating the benefits, addressing concerns, and fostering a culture of innovation.

Significant economic and technical divides mark the journey towards DT in SACPM. Addressing these disparities is essential for fostering a more inclusive and innovative industry. Strategic initiatives and supportive policies are pivotal in navigating these challenges, offering a pathway to mitigate the disparities and harness the full benefits of DTEC.

Collaborative efforts across the industry, coupled with government and association interventions, can provide the necessary support and infrastructure to facilitate this transformation. Emphasising education and training ensures a digitally literate workforce equipped to handle modern CPM demands. Adopting flexible and scalable digital solutions enables firms of all sizes to integrate technology at a feasible pace and scale. In contrast, open-source and community-driven technologies offer cost-effective alternatives for those with limited resources.

Promoting pilot projects and detailed case studies provides practical blueprints and inspiration for firms embarking on digital journeys. Moreover, industry leaders' strong digital advocacy underscores this transformation's strategic importance, highlighting its potential for enhanced efficiency, competitiveness, and innovation.

By embracing these approaches, the SACPM industry can forge a more equitable and comprehensive path towards digitalisation. This addresses the current economic and technical divides and empowers firms to fully exploit DTEC, leading to a more robust, efficient, and forward-thinking construction sector. Such a concerted effort ensures that the industry meets contemporary challenges and sets a standard for future developments in the global construction landscape.

4.5.3 Technological Innovation in Construction

In SACPM, technological innovation is not merely a concept of advanced tool adoption but an integral aspect of evolving business models and operational methodologies. Through its journey in digital transformation, the sector recognises the imperative of integrating technology into every facet of its operations.

The theme of 'Technological Innovation in Construction' surfaced distinctly during the thematic analysis, revealing insights into how modern technologies are perceived and utilised within the industry. The analysis highlighted a spectrum of technology adoption, from essential digitisation to integrating sophisticated tools like BIM and advanced PM software.

Integration of BIM and Advanced Tools:

Integrating BIM into CPM marks a significant evolution in the industry, fundamentally changing how projects are planned, executed, and managed. CPM6's observation, "BIM's adoption has revolutionised our planning and execution stages," underscores the transformative role of this technology. BIM facilitates a more integrative and collaborative approach, enabling a seamless transition between various construction phases.

- Holistic PM: BIM's role extends beyond mere tool functionality; it represents a paradigm shift in project management. As CPM4 describes, "BIM is a new way of working." This technology transcends traditional project management boundaries, allowing for an all-encompassing view of the construction process. It integrates different aspects of a project – from architectural design to structural engineering and MEP (Mechanical, Electrical, and Plumbing) – into a cohesive and interactive model.

- Enhanced Precision and Collaboration: One of the most important benefits of BIM is the precision and collaboration it brings to construction projects. CPM6 notes the unparalleled precision in the planning and execution stages, highlighting how BIM allows for more accurate and detailed project visualisation. CPM2 elaborates, "With BIM, we can pre-emptively identify

potential issues, which greatly reduces on-site problems and change orders." This pre-emptive problem-solving capability is a key advantage of BIM, enabling teams to address issues before they manifest on the construction site.

- Real-time Collaboration and Stakeholder Involvement: BIM also fosters enhanced collaboration among all stakeholders involved in a project. As CPM7 points out, "BIM allows us to engage with stakeholders in real-time, making collaboration more dynamic and inclusive." This engagement ranges from instant feedback on design changes to more efficient coordination among various teams. CPM3 adds, "Through BIM, we have brought architects, engineers, and contractors onto the same page, significantly improving project coherence."

- Challenges in Adoption and Implementation: However, adopting BIM is challenging. CPM5 highlights smaller firms' difficulties: "The cost and complexity of BIM can be daunting for smaller players in the industry." This challenge is echoed by CPM8, which notes, "Training and cultural adaptation are key in successfully implementing BIM, but they require significant investment."

- Opportunities for Growth and Innovation: Despite these challenges, the opportunities presented by BIM and advanced tools are substantial. CPM1 observes, "Adopting BIM has allowed us to undertake more complex and ambitious projects." This sentiment is shared by CPM9, who states, "BIM has opened doors to innovation in project management, allowing us to explore new construction methods and technologies."

In summary, integrating BIM and advanced tools in SACPM represents a significant stride towards more efficient, precise, and collaborative project execution. While challenges in adoption exist, particularly regarding cost and complexity, the benefits of BIM in enhancing project outcomes are undeniable. As the industry evolves, BIM and advanced tools will become increasingly central, driving innovation and excellence in CPM.

Advanced project management software:

The incorporation of advanced PM software such as Primavera P6 and Microsoft Project marks a significant shift in CPM in SA. As highlighted by CPM2, these tools have become integral in modern construction practices, offering unparalleled benefits in the planning and execution phases. The role of these software solutions extends far beyond traditional management methods, providing a sophisticated approach to project oversight and resource allocation.

- Enhanced Efficiency and Control: The primary advantage of using advanced PM software is its remarkable efficiency in project scheduling and resource management. CPM7's statement, "These software solutions have been game-changers," reflects these tools' transformative effect on project management. They allow for intricate planning, detailed scheduling, and comprehensive resource allocation, enabling project managers to maintain a high level of control over every aspect of a project. This degree of control was previously challenging to achieve with more conventional methods.

- Precise Scheduling and Forecasting: One of the critical features of software like Primavera P6 and Microsoft Project is their ability to provide precise scheduling. As CPM4 notes, "With these tools, we can forecast project timelines more accurately, identifying potential delays before they occur." This predictive capability is vital in managing complex projects where timing and coordination of various elements are key.

- Resource Optimisation: Furthermore, these tools allow for optimal resource management. CPM5 explains, "Utilising software for resource allocation helps us to avoid over or under-utilisation of our workforce and materials." This optimisation enhances efficiency and contributes to cost management, ensuring that projects remain within budget.

- Integration with Other Digital Tools: The integration capabilities of these software solutions with other digital tools like BIM and analytics platforms

are also noteworthy. CPM6 remarks, "The ability to integrate our PM software with other digital tools has streamlined our workflow significantly." This integration fosters a more cohesive and comprehensive approach to CPM, enabling teams to work more collaboratively and efficiently.

- Challenges in Adoption: Despite their advantages, adopting advanced PM software is challenging. CPM8 highlights the learning curve associated with these tools, stating, "There is a considerable training requirement to leverage the capabilities of these software solutions fully." Additionally, CPM3 points out, "The cost of these tools can be a barrier for smaller firms, impacting the uniform adoption across the industry."

- Opportunities for Innovation and Growth: Nevertheless, the opportunities presented by advanced PM software are significant. As CPM9 observes, "These tools have improved our project management capabilities and opened up new avenues for innovation." By adopting these advanced software solutions, construction firms can undertake more complex and ambitious projects, pushing the boundaries of the industry's achievable goals.

In summary, advanced PM software like Primavera P6 and Microsoft Project is key in modern CPM in SA. While challenges in adoption and training exist, the benefits of enhanced efficiency, precise scheduling, and optimal resource management are undeniable. As the industry continues to embrace DT, these tools will remain central to the successful execution and management of construction projects, driving further innovation and growth within the sector.

Challenges and Opportunities in Integrating Advanced Project Management Technologies:

- Financial Investment and Resource Allocation: Integrating advanced project management technologies such as BIM and sophisticated software like Primavera P6 and Microsoft Project presents challenges and opportunities for the SACI. As noted by CPM5, a primary concern revolves around the significant financial investment required. "Adopting these

advanced tools requires substantial financial resources," CPM5 states, indicating that the upfront costs of acquiring licenses, upgrading hardware, and maintaining these systems can be a substantial barrier, especially for smaller firms. This financial commitment extends beyond the initial purchase and includes ongoing expenses related to updates, support, and integration with other systems.

- Training and Cultural Adaptation: Another critical challenge is the need for extensive training and cultural adaptation within organisations. As CPM8 notes, "The cost of these technologies can be prohibitive," but beyond the financial aspect, there is also the challenge of upskilling the workforce to use these tools effectively. For many companies, especially those relying on traditional methods, the shift to digital project management tools requires a significant transformation in their operational culture. It involves training employees on the technical aspects of the software but also cultivating an organisational mindset that values and embraces technological advancements.

- DD Among Firms: The challenges are particularly acute for smaller firms, as highlighted by CPM8: "For smaller companies, the cost of these technologies can create a divide in how projects are managed across the industry." This DD leads to a disparity in project management capabilities, with larger firms having a competitive advantage due to their access to and proficiency with advanced technologies. This disparity could lead to a two-tier industry, where smaller firms need help to compete or participate in more complex projects that demand high-level digital proficiency.

- Opportunities for Efficiency and Innovation: Despite these challenges, the opportunities presented by integrating advanced project management technologies are significant. They offer the potential for dramatically increased efficiency, better resource management, and more accurate project planning and forecasting. CPM7 explains, "These technologies enable us to manage projects with precision and control that was

previously impossible." This precision and control can reduce waste, cause fewer delays, and lead to more successful project outcomes.

- Bridging the DD: To bridge the DD, there is a need for industry-wide initiatives that support the adoption of these technologies across all firms, regardless of size. This could include shared training programs, group purchasing agreements to reduce costs, or partnership models where larger firms mentor smaller ones in adopting digital tools. Additionally, government interventions or industry association initiatives could provide subsidies or grants to help smaller firms invest in these technologies.

- Leveraging Technology for Competitive Advantage: Adopting advanced project management technologies offers a significant competitive advantage for firms able to overcome these challenges. It allows for more efficient and effective project management, opens opportunities for taking on more complex and lucrative projects, and positions firms as leaders in a technologically advancing industry.

In summary, while integrating advanced project management technologies in the SACI presents significant challenges, particularly in financial investment and the need for training and cultural adaptation, it also offers substantial opportunities for efficiency, innovation, and competitive advantage. Addressing these challenges requires a collaborative approach across the industry, with support mechanisms to assist smaller firms and initiatives to promote a more uniform adoption of these technologies. This approach would ensure that the benefits of technological advancements are accessible to all firms, thereby driving the industry forward.

4.5.4 Optimising Project Management (Objective 2)

Optimising project management in the SACI through digitalisation involves a multifaceted approach. Integrating advanced technologies and methodologies is an upgrade of tools and a transformation of the entire project management landscape.

- Efficiency through Digital Tools: The SACI's move towards digital tools like Primavera P6 and Microsoft Project, as mentioned by CPM2, marks a significant shift in project management practices. These software solutions are revolutionising how projects are managed, bringing a previously challenging level of precision and control.
- Advanced Scheduling and Resource Management: Primavera P6 and Microsoft Project, among other advanced project management tools, bring great sophistication to scheduling and resource management. As CPM2 puts it, "The precision in scheduling offered by Primavera P6 ensures that every phase of the construction project is carefully planned and executed. This minimises the risks of delays and helps maintain the project timeline." These tools allow project managers to foresee scheduling conflicts and resource bottlenecks, enabling proactive adjustments.

- Real-Time Tracking and Monitoring: Real-time tracking is another key feature of these tools, offering a live view of project progress. This capability allows instant identification of lagging areas, facilitating quick intervention to keep the project on track. CPM7 adds, "The real-time data we get from Microsoft Project helps us make immediate decisions, which is critical in maintaining project momentum and meeting deadlines."

- Cost Management and Forecasting: Cost management is another area where these digital tools excel. They allow for more accurate cost forecasting and tracking, essential for budget adherence. As CPM4 observes, "Using these tools, we can keep a tight rein on project costs, ensuring that we stay within budget. The detailed cost analysis helps to identify areas where costs can be cut without compromising quality."

- Enhanced Collaboration and Communication: These tools also facilitate better communication and collaboration among team members. CPM3 points out, "The collaborative features of these software solutions mean that everyone involved in the project, from architects to contractors, is on the same page. This improves overall project coordination."

- Challenges and Training Needs: However, implementing these tools does come with its set of challenges. As CPM5 notes, "The shift to such advanced software requires significant training and adjustment, especially for teams accustomed to traditional methods." Therefore, firms must invest in comprehensive training programs to ensure that their teams can fully leverage the capabilities of these tools.

In conclusion, integrating advanced PM software like Primavera P6 and Microsoft Project significantly enhances the efficiency of CPM in SA. By offering advanced scheduling, resource management, real-time tracking, and cost management, these tools enable project managers to execute projects with greater precision, control, and effectiveness. The investment in these tools, coupled with proper training, can transform the landscape of CPM, leading to more successful project outcomes.

Integration of BIM for Holistic Management:

Integrating BIM into CPM in SA has been transformative, as underscored by CPM6. BIM represents more than a technological advancement; it signifies a paradigm shift in how construction projects are conceptualised, planned, and executed.

- Revolutionising Project Planning and Execution: CPM6 elaborates on the role of BIM: "With BIM, we have moved beyond traditional 2D blueprints to a dynamic, interactive 3D modelling environment. This has enabled us to manage every project aspect more holistically." BIM's multidimensional nature allows project teams to visualise every element of a construction project in detail, leading to improved accuracy in planning and execution.

- Enhancing Collaboration across Disciplines: One of the most essential benefits of BIM is its ability to improve collaboration between different project stakeholders. BIM creates a shared platform where architects, engineers, and construction teams can collaborate seamlessly. As CPM4 observes, "BIM has bridged the gap between different disciplines,

fostering a collaborative environment where everyone works towards a unified vision of the project."

- Streamlining the Construction Process: BIM streamlines the construction process by providing a comprehensive view of the project. Its implementation enables the timely identification of possible problems, diminishing the chances of expensive mistakes and setbacks. CPM8 adds, "BIM's predictive capabilities enable us to foresee and mitigate risks before they manifest on the construction site, which is invaluable in maintaining project timelines and budgets."

- Improving Communication and Decision-making: The use of BIM also significantly improves communication and decision-making processes. As CPM7 points out, "BIM's real-time update capability ensures that any changes are immediately reflected and communicated to all stakeholders, leading to more informed decision-making." This real-time information exchange is key in maintaining project momentum and aligning with project goals.

- Facilitating Sustainable Practices: Moreover, BIM supports sustainable construction practices. CPM5 notes, "BIM helps us plan for sustainability, from material selection to waste management, contributing to greener construction practices."

- Training and Adaptation Challenges: However, integrating BIM into traditional project management processes takes much work. CPM3 mentions, "The shift to BIM requires significant training and a change in mindset. It is a leap from conventional working methods, but the long-term benefits are undeniable."

In summary, integrating BIM in CPM is proving to be a game-changer in SA. It offers a more comprehensive, accurate, and collaborative approach to project planning and execution. The adoption of BIM necessitates investment in training and cultural adaptation. However, the resultant improvements in project

outcomes, sustainability, and efficiency make it a critical tool for the future of CPM.

Data-Driven Decision-Making in CPM:

The evolution of CPM in SA towards a data-driven paradigm significantly enhances the efficacy of planning and execution phases. Integrating digital tools in project management is not just about technology adoption; it is about harnessing the power of data to make more informed, strategic decisions.

- Harnessing Predictive Analytics: CPM4 highlights the importance of data analytics in transforming decision-making processes: "The use of predictive analytics enables us to forecast potential challenges, optimise resource allocation, and streamline project timelines." By analysing historical data and current project metrics, predictive analytics tools can identify patterns and predict future outcomes, allowing project managers to address potential risks proactively.

- Enhancing Planning Accuracy and Efficiency: Data-driven strategies improve the accuracy and efficiency of project planning. As CPM2 elucidates, "Data analytics allows us to refine our planning process continually. We can adjust schedules in real-time based on data inputs, significantly reducing the likelihood of delays and budget overruns." This dynamic approach to planning ensures that projects remain agile and responsive to changing conditions.

- Facilitating Strategic Decision Making: The shift to data-driven decision-making extends beyond operational efficiencies. CPM7 explains, "We gain insights that drive strategic decision-making by analysing project data. This could range from choosing the right construction methods to identifying potential market opportunities."

- Improving Risk Management: Data analytics is instrumental in the domain of risk management. CPM5 states, "With data-driven tools, we can assess risks more accurately, which is essential in maintaining project safety and compliance standards."
- Challenges in Data Integration and Analysis: However, integrating data into everyday decision-making processes is challenging. CPM3 remarks, "The key challenge lies in effectively analysing the vast amounts of data we collect. It requires specialised skills and tools to transform this data into actionable insights."

- Training and Skill Development: Construction firms must invest in training and skill development to fully leverage data analytics. CPM8 notes, "Our teams must understand how to interpret and use data. We are focusing on upskilling our workforce to be more data-savvy."

In conclusion, data-driven decision-making is revolutionising CPM in SA. By effectively leveraging predictive analytics and real-time data, construction firms can enhance planning accuracy, improve risk management, and make strategic decisions that positively role project outcomes. The industry must continue to evolve, prioritising data analysis skills and tools to maintain this momentum and fully harness the potential of a data-driven approach.

Overcoming Implementation Challenges in Digitalising CPM:

The journey towards fully digitalised project management in the SACI is marked by several implementation challenges, particularly for smaller firms. CPM5's observation sheds light on companies' significant hurdles when integrating advanced digital tools.

- Financial Constraints and Initial Investment: One of the primary challenges is the financial aspect of adopting new technologies. CPM8 elaborates, "For smaller construction firms, the cost of advanced software like BIM or Primavera P6 can be prohibitive. It is not just the purchase cost but also the infrastructure needed to support these tools." This financial burden can

deter smaller companies from embracing digitalisation, widening the technology gap within the industry.

- Learning Curve and Skill Development: The learning curve associated with new technologies is another significant barrier. As CPM2 points out, "Adopting these tools is one thing, but ensuring our team can effectively use them is another. It requires significant training and skill development." This necessity for training underscores the need for accessible and comprehensive educational programs catering to the workforce's varying skill levels.

- Targeted Training Programs: To address this challenge, targeted training programs are essential. CPM7 suggests, "Industry-wide training initiatives, possibly supported by software providers or industry associations, could help in upskilling the workforce, making technology adoption more feasible for smaller firms."

- Financial Assistance and Incentives: Financial assistance and incentives can play a critical role in enabling smaller firms to overcome economic barriers. CPM3 mentions, "Government grants or subsidies could be a game-changer, making it more feasible for smaller players to invest in these technologies.

- Partnerships and Collaborations: Creating partnerships and collaborations between larger firms and smaller entities can also be a way forward. CPM6 states, "Larger firms could play a mentorship role, sharing resources and knowledge with smaller companies to help bridge the technology divide."

- Scalable and Flexible Solutions: Another strategy is to implement digital solutions that can be easily adjusted and personalised to meet various companies' specific requirements and capabilities. CPM4 advises, "There is a need for digital tools that can grow with the company, allowing firms to start small and scale up as they become more proficient."

In conclusion, while the potential benefits of digital project management tools are immense, their successful implementation hinges on overcoming significant financial and educational barriers, particularly for smaller firms. A collaborative approach involving industry stakeholders, government bodies, and technology providers is key to developing scalable solutions, financial support mechanisms, and comprehensive training programs. Such a collective effort can ensure that the benefits of digitalisation in CPM are accessible to all, fostering a more inclusive and technologically advanced industry.

Collaboration and Communication in Optimising Project Management:

In CPM, DTEC have profoundly transformed the role of collaboration and communication. The emphasis is now on ensuring seamless interaction and information flow among all stakeholders, an aspect that digital platforms have greatly facilitated.

- Seamless Information Sharing with Cloud-Based Tools: CPM7 highlights the role of cloud-based project management tools in enhancing collaboration. "With tools like Trello or Asta, we've seen a significant improvement in how team members communicate and collaborate. These platforms allow us to centralise project information, making it accessible to everyone involved, regardless of their location. This real-time update capability ensures everyone is on the same page, reducing misunderstandings and delays."

- Improved Stakeholder Engagement: Digital communication tools also play a critical role in stakeholder engagement. As CPM6 notes, "Platforms like Microsoft Teams or Slack have revolutionised our meetings and interactions with clients and stakeholders. They allow for more frequent and productive engagement, leading to better alignment and understanding of project goals."

- Challenges in Digital Communication: However, implementing these communication tools has its challenges. CPM5 points out, "While these tools have made communication more accessible, they require a certain

level of digital literacy. We have had to invest in training to ensure all team members can effectively use these platforms."

- Real-Time Data and Updates: Another aspect of enhanced communication is the use of real-time data and updates. CPM2 elaborates, "Integrating IoT devices on construction sites has allowed us to capture and share real-time data with the project team. This immediate flow of information aids in quick decision-making and keeps everyone informed about the site conditions."

- Virtual Collaboration Spaces: The concept of virtual collaboration spaces is also gaining traction. As CPM3 explains, "We have started using virtual reality (VR) tools for project walkthroughs, which has significantly improved our ability to collaborate with architects and designers. It is a more interactive way to review and change project plans."

In summary, integrating digital communication and collaboration tools in CPM has changed how projects are managed. These tools facilitate a more connected and transparent workflow, enabling better coordination and decision-making. However, successfully implementing these tools depends on addressing digital literacy challenges and ensuring all team members are equipped to utilise these technologies effectively. As the industry evolves, the emphasis on digital collaboration and communication will only grow, becoming a cornerstone of modern CPM practices.

Customisation and Scalability in Optimising Project Management:

Integrating digitalisation in CPM is more than just a one-size-fits-all solution. Customisation and scalability of digital tools play a role in ensuring that technology is leveraged effectively to meet the unique requirements of different projects.

- Tailoring Digital Solutions to Project Needs: CPM3 emphasises the importance of customising digital tools to align with specific project goals. "We have found that adapting tools like BIM and PM software to our

project's unique requirements significantly improves efficiency and outcomes. Customisation allows us to focus on each project's specific challenges and objectives, rather than applying a generic approach."

- Scalability for Diverse Project Sizes: Scalability is equally important, as projects can vary significantly in size and complexity. CPM4 notes, "The ability to scale digital tools up or down depending on the project size ensures that we are not over or under-utilising technology. This scalability is key to managing resources efficiently and keeping costs in check."

- Challenges in Customisation and Scalability: However, implementing customised and scalable solutions is challenging. CPM5 points out, "Developing a digital strategy that accommodates the scalability and customisation of tools requires a deep understanding of both the technology and the construction processes. It is a balance that can be difficult to strike, especially for smaller firms with limited resources."

- Adapting to Changing Project Dynamics: Adapting digital tools to the dynamic nature of construction projects is another aspect highlighted by CPM6. "Construction projects are often fluid, with changes occurring frequently. Our digital tools must be adaptable to accommodate these changes quickly and efficiently."

- Integration with Existing Systems: Integrating customised and scalable digital tools with existing systems is also a key consideration. CPM7 elaborates, "Ensuring that new digital solutions work seamlessly with our existing systems is key. This integration reduces disruption and allows for a smoother transition to more advanced digital practices."

In summary, customisation and scalability are pivotal in optimising project management within the CI. Tailoring digital tools to specific project requirements and ensuring their scalability enhances efficiency, resource management, and overall project success. However, the challenges in implementation, particularly in adapting to the unique and changing dynamics of construction projects, must

be addressed with a strategic and informed approach. By strategically prioritising these elements, construction companies can optimise their utilisation of DTEC, resulting in the implementation of creative and triumphant project management approaches.

Future Outlook in Optimising Project Management:

As the CI continues to navigate the digital landscape, the future outlook for project management optimisation appears promising, with numerous opportunities and potential for significant advancements.

- Embracing Emerging Technologies: The industry is poised to witness the introduction of more sophisticated digital tools and methodologies. CPM8 reflects on this evolution: "Emerging technologies like AI and advanced data analytics are set to redefine how we approach CPM. Adopting these technologies will be key to staying competitive."

- Continual Learning and Adaptation: The key to harnessing these new technologies lies in continuous learning and adaptation. CPM6 notes, "The landscape is constantly evolving, and so must we. Ongoing training and upskilling our workforce in these new technologies will be essential."

- Investment in Digital Infrastructure: Investment in digital infrastructure is critical. CPM3 adds, "To truly benefit from these advancements, firms must be willing to invest not just financially but also in terms of time and resources to integrate new technologies seamlessly into our existing systems."

- Challenges and Opportunities: While the future holds immense potential, it also presents challenges. CPM5 highlights, "The rapid pace of technological change can be daunting, especially for smaller firms. However, it also opens up opportunities for innovation and efficiency that were previously unimaginable."

- Strategic Approach to Digital Transformation: A strategic approach to DT will be key. As CPM4 suggests, "It is not just about adopting the latest technology. It is about strategically integrating these tools into our project management processes to enhance efficiency, accuracy, and collaboration."

- Industry Collaboration and Standardisation: Collaboration within the industry and standardisation of digital practices can accelerate adoption. CPM7 states, "Collective efforts in developing industry-wide standards for digital tool usage can create a more uniform and efficient approach to project management."

The future of PM in the CI is intrinsically linked to digital transformation. With emerging technologies continuously reshaping the landscape, firms must remain agile, open to learning, and ready to adapt. By embracing change, investing in training, and adopting a strategic approach to integrating digital tools, the industry can unlock new efficiency, precision, and innovation levels. Taking a proactive approach is key in effectively navigating the obstacles and benefiting from the opportunities brought about by the digital revolution in CPM.

Optimising project management in the CI through digitalisation requires a comprehensive approach that embraces technological advancements, optimising-driven decision-making and promotes collaboration. While challenges are inevitable in terms of investment and training, the benefits of enhanced efficiency, improved accuracy, and better project outcomes make the DT journey vital for the industry's future competitiveness and success.

4.5.5 Strategic Digital Integration (Objective 3)

Under Objective 3, which focuses on Leveraging Digitalisation for Improved Outcomes, Strategic Digital Integration emerges as a critical theme. This section delves into how CPM in SA is harnessing DTEC strategically to enhance overall project outcomes.

Integration of Digital Tools and Methodologies:

The strategic integration of digital tools and methodologies in CPM is vital for enhancing efficiency and effectiveness. CPM1's perspective emphasises the importance of a holistic approach in this integration, underlining that it is not merely about using digital tools but their seamless incorporation into the project management process.

CPM1 elaborates, "Integrating digital tools like Primavera P6 or BIM must go beyond their basic functionalities. It is about how these tools interact with each other and our traditional methods to create a more efficient, transparent, and responsive project management environment." This approach ensures that digital tools are not isolated entities but are interwoven into the project lifecycle, enhancing every phase from planning to execution.

Moreover, CPM3 notes the significance of aligning digital tools with existing PMM. "Our digital tools must complement and enhance our established methodologies rather than replace them. This integration allows us to leverage the strengths of both traditional and modern practices, leading to more robust project management." By combining traditional expertise with digital advancements, CPM can achieve greater accuracy, foresight, and adaptability.

In addition to technical integration, CPM2 points out the importance of a cultural shift towards embracing these digital tools. "Adopting new technologies also means cultivating a mindset open to change and innovation within our teams. This cultural integration is as important as the technological aspect."

According to CPMs, the importance of recognising digital tools as essential elements within a project management framework is underscored by this integration strategy. It is a strategic move towards creating a more dynamic, data-driven, and collaborative PM environment in the CI.

Developing a Digital Ecosystem:

Creating a digital ecosystem in CPM is a strategic move towards a more interconnected and streamlined approach. CPM4's vision of a digital ecosystem encapsulates an environment where various digital tools and platforms are aligned and synergistically integrated. "By developing a digital ecosystem, we aim

to create a seamless flow of information, where data from different phases of the project lifecycle are interconnected, enhancing decision-making and efficiency."

This ecosystem approach goes beyond the mere adoption of individual digital tools. It involves creating a network where data, tools, and processes are interlinked, providing a comprehensive project view. CPM2 adds, "In our digital ecosystem, tools like BIM and PM software are not standalone entities. They feed into each other, enabling us to harness the full potential of digital data for better planning, execution, and monitoring."

CPM3 emphasises the importance of stakeholder collaboration in this ecosystem. "Our digital ecosystem is designed to improve collaboration across all levels – from architects and engineers to contractors and clients. It ensures everyone can access the latest information, fostering a collaborative and transparent project environment."

Additionally, CPM5 notes the role of advanced technologies in enriching this ecosystem. "Incorporating technologies like AI and IoT into our digital ecosystem allows us to automate routine tasks, gather real-time insights, and predict potential issues before they escalate."

The development of such a digital ecosystem signifies a transformative shift in how construction projects are managed. It represents a move towards a more integrated, data-driven, and collaborative approach, leveraging the power of DTEC to optimise every aspect of project management. This ecosystem streamlines processes and opens new avenues for innovation and efficiency in the CI.

Real-Time Data Utilisation and Predictive Analytics:

In CPM, strategically integrating real-time data and predictive analytics is pivotal in enhancing decision-making and project outcomes. CPM2's insights reflect this, emphasising the transformative role of these technologies: "By integrating real-time data into our project management processes, we have shifted from a reactive to a proactive approach. This allows us to anticipate issues and make timely decisions that keep our projects on track."

Using real-time data facilitates a dynamic planning process, where adjustments can be made swiftly in response to changing on-site conditions or unforeseen challenges. CPM4 elaborates, "Real-time data from the construction site feeds directly into our planning tools, giving us the ability to adapt our schedules and resource allocations instantly."

Predictive analytics further enhances this capability by providing foresight into potential project risks and outcomes. CPM6 explains, "We use predictive analytics to analyse historical project data and identify patterns. This helps us forecast potential delays or budget overruns, allowing for pre-emptive measures to mitigate risks."

Integrating these advanced data techniques is challenging, as CPM5 states: "While the benefits are clear, the implementation requires a robust digital infrastructure and a skilled workforce capable of acting and interpreting on the data insights."

In addition, CPM7 emphasises the significance of maintaining accurate and well-managed data. The precision and integrity of real-time data holds utmost importance. We have established stringent data governance protocols to maintain the reliability of our data-driven decision-making process."

In summary, the strategic integration of real-time data and predictive analytics in CPM signifies a shift towards more informed, efficient, and effective project management. This approach enables construction firms to stay ahead of potential issues, optimise resource utilisation, and deliver projects successfully within time and budget constraints.

Innovation in Collaboration and Communication:

The strategic digital integration in CPM significantly enhances collaboration and communication, which is pivotal for the success of complex projects. CPM5's observations highlight this transformation: "The adoption of digital platforms like cloud-based project management tools and communication apps has fundamentally changed our interaction dynamics. It has enabled a more fluid,

transparent, and efficient exchange of information among team members, stakeholders, and clients."

These digital platforms provide a centralised hub for information sharing, ensuring that all parties involved in a project have access to the latest updates, documents, and data. CPM3 further elaborates, "Tools like Microsoft Teams or Slack have become essential in our daily operations. They facilitate instant messaging, file sharing, and even virtual meetings, key for maintaining continuous and effective communication, especially in remote or distributed team settings."

Beyond mere information exchange, these platforms also support collaborative decision-making. CPM2 adds, "We leverage digital dashboards that integrate data from various project aspects. This provides a real-time overview of the project's status and enables quick decision-making based on current and accurate data."

The innovation extends to client interactions as well. CPM6 states, "Digital tools have allowed us to involve clients more closely in the project process. Through platforms like BIM, clients can visualise project progress in real-time, leading to better engagement and satisfaction."

However, this shift towards digital communication and collaboration also presents challenges, as noted by CPM7: "While digital tools offer numerous advantages, they also require a cultural shift within the organisation. Employees need to be trained not only on how to use these tools but also on how to communicate efficiently in a digital environment."

In conclusion, strategic digital integration in collaboration and communication is not just about adopting new technologies; it is about reshaping how construction project teams interact, make decisions, and engage with stakeholders. This digital evolution fosters a more cohesive, transparent, and efficient project management approach, ultimately contributing to the success of construction projects.

Challenges in Digital Integration:

The journey towards achieving seamless digital integration in CPM encompasses a range of challenges, as evidenced by the experiences of the CPMs. CPM7 highlights one of the core difficulties: "Aligning our existing legacy systems with advanced digital tools is a complex task. It demands financial investment and a robust change management strategy."

One significant challenge is the technical compatibility between old and new systems. CPM3 explains, "Our legacy systems, designed decades ago, often struggle to communicate effectively with the new, more advanced digital solutions. This results in data silos and integration issues." Overcoming these technical hurdles requires IT expertise and strategic planning to ensure that new technologies can be integrated without disrupting ongoing operations.

Another challenge lies in the cultural adaptation to new technologies. As CPM5 points out, "The introduction of advanced digital tools necessitates a shift in the company culture. There is often resistance to change, particularly from those accustomed to traditional project management methods." Addressing this resistance involves comprehensive training programs and a gradual approach to implementation to ensure a smooth transition for all employees.

The cost of digital integration also poses a significant challenge, especially for smaller firms. CPM2 notes, "The financial aspect of integrating cutting-edge digital tools can be daunting. It requires not just initial investment in the technology but also ongoing expenses for maintenance and updates." This financial barrier can widen the gap between larger and smaller firms with more resources, potentially leading to disparities in the industry's digital maturity.

CPM1 further elaborates on the strategic challenges: "Developing a cohesive digital strategy that aligns with our overall business objectives is another hurdle. Without a clear strategy, digital integration efforts can become disjointed and ineffective."

In addition, CPM4 mentions the challenge of keeping pace with rapidly evolving technology: "The digital landscape is constantly changing. Staying on top of with the latest trends and tools requires continuous learning and adaptation."

In conclusion, while integrating digital tools in CPM offers numerous benefits, the path to achieving this integration is fraught with challenges. These include technical compatibility issues, cultural resistance to change, financial constraints, strategic planning difficulties, and the need for ongoing adaptation to technological advancements. Addressing these challenges is key for the CI to harness digital transformation's potential fully.

Training and Skill Development:

The successful integration of DTEC into CPM heavily relies on workforce training and skill development. As CPM3 points out, "To fully leverage new digital tools, we must ensure that our team members are adequately trained and comfortable with these technologies."

CPM5 echoes this sentiment, highlighting the need for ongoing education: "As we introduce more advanced digital solutions, we must provide continuous learning opportunities for our staff. This includes initial training sessions, regular updates, and workshops to keep pace with technological advancements."

CPM2 discusses the implementation of comprehensive training programs, "We have established structured training programs that cover everything from basic digital literacy to advanced software proficiency. These programs are tailored to meet the diverse needs of our workforce, ensuring everyone, regardless of their starting skill level, can confidently use digital tools in their daily tasks."

CPM7 also underscores the importance of leadership in driving training initiatives: "Our leaders play a critical role in advocating for and facilitating skill development. They help create an environment where learning new digital skills is considered valuable and essential for career growth."

Moreover, CPM4 mentions bridging the digital skills gap: "One of our main challenges has been bridging the gap between our experienced professionals who are more accustomed to traditional methods and our younger workforce who

are more digitally native. Balancing these differing skill sets and encouraging cross-generational learning is key to our digital integration strategy."

In conclusion, training and skill development are fundamental components of strategic digital integration in CPM. It involves equipping the workforce with the necessary digital competencies and fostering a culture of continuous learning and adaptation. This approach ensures that the entire team can effectively utilise digital tools, enhancing overall project efficiency and outcomes.

Future Direction and Sustainability:

The future direction of digital integration in CPM hinges on sustaining current digital practices and proactively seeking new technological advancements. CPM6's perspective on sustaining current practices while exploring emerging technologies reflects a strategic approach to continuous improvement and adaptation in a rapidly evolving digital landscape.

CPM1 discusses the importance of keeping pace with technological advancements: "The CI is dynamic, and staying ahead requires us to constantly evaluate and adopt new digital tools and methodologies that can enhance our efficiency and project outcomes."

CPM4 emphasises the need for a forward-looking approach: "We must not only maintain the digital systems we have integrated but also keep an eye on future trends. This includes technologies like AI and IoT, which have the potential to revolutionise how we manage construction projects."

CPM2 highlights the role of sustainability in future strategies: "As we look towards the future, sustainability will be a key focus. Leveraging digital tools to improve resource efficiency and reduce environmental role will be essential in our project management strategies."

CPM3 speaks about maintaining momentum: "The challenge is not just in adopting digital tools but in ensuring their use becomes a sustainable part of our

project management culture. Continuous training and leadership support will be key in this regard."

CPM5 addresses the need for resilience in digital strategies: "Our future direction must include building resilience into our digital systems, ensuring they can adapt to changing market conditions and client needs."

The future direction of digital integration in CPM is marked by a commitment to sustaining and enhancing current digital practices. It involves maintaining operational efficiency, exploring emerging technologies, focusing on sustainability, and fostering a culture of resilience and continuous learning. This approach ensures that the industry not only adapts to the present but is also well-prepared for the challenges and opportunities of the future.

In conclusion, strategic digital integration is a critical component in the evolution of CPM in SA. This approach goes beyond merely adopting new digital tools; it requires seamlessly integrating these technologies into every facet of project management, encompassing planning, execution, and monitoring stages.

The insights from CPMs highlight the benefits of this integrated approach, which include improved efficiency in project execution, enhanced decision-making capabilities through real-time data and predictive analytics, and superior collaboration facilitated by advanced communication platforms. These advantages underscore the transformative role of digital integration on project outcomes, driving a more efficient, agile, and responsive approach to CPM.

However, the journey towards complete digital integration has its challenges. The alignment of traditional legacy systems with new DTEC poses a significant hurdle, necessitating substantial investment and a strategic change management approach. Additionally, developing and enhancing digital skills within the workforce is vital to ensure these technologies' effective utilisation and maximisation.

Despite these challenges, the strategic integration of digital tools is essential for the future success and competitiveness of the SACI. It represents a step towards a more innovative, data-driven, and collaborative approach, aligning with global

trends and standards. As the industry continues to navigate its DT, the strategic integration of digital tools and methodologies will remain a cornerstone in achieving operational excellence and long-term sustainability in CPM.

4.5.6 Cultivating a Data-Driven and Adaptive Culture (Objective 3)

In the SACPM context, cultivating a data-driven and adaptive culture is pivotal for leveraging digitalisation to achieve improved outcomes. This objective aligns with the industry's transition towards a more nuanced and intelligent approach to project planning and execution.

Data-Driven Decision Making:

In the landscape of CPM in SA, the shift towards a data-driven culture is revolutionising the approach to project execution. As the Construction Planning Managers (CPMs) highlighted, the emphasis on data-driven decision-making significantly roles the methods employed in project planning, risk management, and resource allocation.

CPM4's experiences illustrate this transformation, where incorporating predictive analytics has marked a turning point in strategizing and executing projects. The manager shares, "The use of predictive analytics has been a game changer, allowing us to foresee potential risks and make more informed strategic decisions." This shift from relying primarily on intuition and experience to leveraging data-backed insights enables a more precise and efficient approach to managing construction projects.

Data analytics in PM is not constrained to risk assessment alone. It extends to various aspects of project planning, such as timeline estimation, budget management, and resource allocation tools, providing project managers with the ability to analyse extensive quantities of data, detect trends, and make more accurate predictions. For instance, predictive models can forecast potential delays due to environmental factors or supply chain disruptions, allowing project teams to devise contingency plans proactively.

Furthermore, this data-driven approach aids in optimising resource allocation. By thoroughly examining records and current project statistics, managers can make well-informed choices regarding the allocation of resources, leading to increased efficiency and minimal wastage. This approach is especially beneficial in large-scale projects where the complexity and scale can make resource management exceptionally challenging.

Adopting data-driven decision-making in CPM represents a significant paradigm shift. It moves the industry from traditional, heuristic-based methods towards a more analytical and evidence-based approach. This transition enhances the accuracy and efficiency of project planning and execution. However, it also positions SA construction firms to be more competitive and agile in a rapidly evolving industry landscape.

Empowering Teams with Data:

In CPM, empowering teams with real-time data and analytics tools has become a key driver of efficiency and responsiveness. As noted by CPM2, the introduction of mobile technologies has significantly enhanced the capability of teams on the ground. CPM2 shares, "Our teams are now equipped with mobile technologies that provide real-time insights, enabling on-the-spot decision-making and greater responsiveness to project dynamics." This approach represents a fundamental shift from a traditionally reactive project management style to a more proactive and agile one.

Integrating mobile technology into daily operations allows project teams to access key data on the go, from project timelines and resource allocation to immediate updates on site conditions. This instant access to information empowers team members to make informed decisions quickly, reducing delays and enhancing the project's overall efficiency.

For instance, site managers can immediately report and address issues like material shortages or unexpected site conditions. This immediate reporting and problem-solving capability can significantly reduce downtime and improve project timelines. Furthermore, these technologies facilitate better communication

between the field and the office, ensuring that all stakeholders are consistently informed and aligned with the project's status.

Using mobile data analytics tools also enables a more dynamic approach to risk management. Teams can monitor project metrics in real-time, identify potential risks early, and adjust plans accordingly. This capability is precious in large and complex projects where variables can change rapidly, and the ability to respond quickly is key.

In essence, empowering project teams with real-time data and mobile technologies cultivates a data-driven culture that enhances the adaptability and effectiveness of CPM. It allows for a more informed, collaborative, and responsive approach to handling the challenges and dynamics of modern construction projects.

Adapting to Change:

Adapting to change is paramount in today's fast-paced and technology-driven CI. This adaptability is particularly significant in a data-driven culture, where decisions are often based on real-time information. As highlighted by CPM7, integrating Internet of Things (IoT) devices plays a key role in this context. CPM7 states, "The integration of IoT devices has been key in providing us with up-to-date information, allowing for agile responses to on-site changes."

IoT devices in CPM offer many advantages, primarily enhanced data collection and monitoring capabilities. Managers can make strategic resource allocations and optimise productivity by examining past records and project metrics. This enables them to enhance efficiency and minimise unnecessary expenditure. This constant stream of data ensures that project managers can access the most current information, enabling them to make timely and informed decisions.

For instance, sensors can detect weather conditions, material quality, or structural integrity changes and relay this information instantly to the project management team. This immediate feedback allows for rapid adjustments, whether it involves rescheduling tasks, reallocating resources, or implementing

contingency plans. Such agility is invaluable in mitigating risks and preventing delays or cost overruns.

Moreover, IoT technology fosters a more proactive approach to project management. Instead of reacting to issues as they arise, project teams can anticipate and address potential challenges before they escalate into significant problems. This proactive stance is essential in managing the complexities of modern construction projects, where variables can change quickly and have far-reaching roles.

The adaptability facilitated by IoT, and other data-driven technologies also extends to how teams collaborate and communicate. The ability to instantly share data promotes synergistic collaboration between the Project managers and all the departments involved in a project, ensuring that everyone is working from the same information and working together to achieve common goals.

Adapting to change in a data-driven environment is a critical aspect of contemporary CPM. The integration of technologies like IoT devices not only enhances the responsiveness of project teams but also contributes to more efficient, effective, and risk-averse management practices. As the CI evolves, embracing these technological advancements will be key to maintaining competitiveness and achieving successful project outcomes.

Training and Continuous Learning:

Training and continuous learning are paramount in cultivating a data-driven and adaptive culture within CPM. CPM3's statement underscores the significance of this aspect: "Investing in training for our staff ensures that they are not only capable of using these tools but can also interpret and act on the data effectively."

The advancement of data analytics and digital tools in CPM has opened new possibilities for efficiency and precision. However, the true potential of these tools can only be realised when the workforce is proficient in their use and interpretation. Training becomes a key element in empowering teams to leverage data effectively.

Continuous learning programs should focus on several key areas:

- Technical Skills Development: Training programs must provide comprehensive instruction on using digital tools such as BIM, PM software, and data analytics platforms. This instruction should cover the basic functionalities and explore advanced features that can optimise project management processes.

- Data Interpretation and Analysis: More than having access to data is required; teams must be trained to interpret this data to accomplish actionable insights. This involves understanding data patterns, identifying potential risks, and making data-backed decisions that align with project objectives.

- Adaptability to Technological Changes: The CI continuously evolves with new technological advancements. Training programs should include modules that keep the workforce abreast of the latest developments and trends in construction technology.

- Soft Skills Development: Alongside soft skills, technical skills, such as communication, collaboration, and problem-solving are key in a data-driven environment. Training should encompass these aspects to ensure team members can effectively collaborate and communicate insights derived from data.

- Feedback and Iterative Learning: Training should be an iterative process, incorporating participant feedback to improve and update the curriculum continuously. This feedback loop ensures that training remains relevant and meets the changing needs of the industry.

Training and continuous learning are indispensable in fostering a data-driven and adaptive culture in CPM. By providing teams with the necessary skills and education, construction firms can enhance their project execution capabilities, drive innovation, and maintain a competitive edge in a rapidly evolving industry.

Investing in the ongoing education and development of staff is beneficial and essential for successfully integrating digital tools and methodologies in construction projects.

Collaboration and Knowledge Sharing:

Key aspects of collaboration and knowledge sharing in this context include:

- Seamless Information Exchange: The use of cloud-based platforms and collaborative software tools is instrumental in enabling a seamless exchange of information. These tools provide a unified space where team members can access, share, and discuss data insights, ensuring everyone is on the same page.

- Enhancing Collective Understanding: As CPM5 notes, shared data insights contribute to a collective understanding of project dynamics. When all team members have access to the same information, it leads to more informed discussions, better problem-solving, and a unified approach to decision-making.

- Fostering Transparency and Trust: Collaborative tools enhance transparency within the project management process. When team members can easily share and access information, it builds trust and a sense of collective responsibility for project outcomes.

- Encouraging Innovation and Creativity: A collaborative environment where freely sharing knowledge often leads to innovation. Team members feel more comfortable suggesting new ideas and solutions, knowing that contributions will be considered and valued.

- Accelerating Decision-Making: Quickly sharing and accessing data allows for faster decision-making. In the fast-paced environment of construction projects, making timely decisions based on the latest data is key for maintaining project timelines and budgets.

- Learning and Continuous Improvement: Collaboration and knowledge sharing create learning opportunities. The team can improve project management skills and practices by continuously gaining knowledge from one another's experiences and expertise.

- Adapting to Changes: Conditions and requirements can change rapidly in construction projects. A collaborative approach ensures that these changes are communicated quickly and efficiently, allowing the team to adapt and respond promptly.

Knowledge sharing and collaboration are essential components of a data-driven culture in CPM. By leveraging cloud-based platforms and collaborative software, teams can enhance their collective understanding, foster innovation, and make more informed decisions, ultimately leading to more successful project outcomes.

Challenges and Overcoming Barriers:

Addressing the challenges of cultivating a data-driven and adaptive culture in CPM involves navigating various barriers and implementing strategic solutions. As CPM6 points out, overcoming these hurdles demands a balanced approach that encompasses technological advancements, comprehensive training, and a fundamental shift in mindset.

Key Challenges and Strategies for Overcoming Them:

Resistance to Change:

- Strategy: Implementing targeted change management programs can help address resistance, especially among seasoned professionals. These programs should focus on demonstrating the tangible benefits of a data-driven approach, using real-life examples and case studies to illustrate the improvements in efficiency and decision-making.

- CPM6's Insight: A shift in mindset is essential. Encouraging a culture that values innovation and adaptability can gradually reduce resistance to new technologies and methods.

Integration of New Data Systems with Legacy Infrastructure:

- Strategy: Developing hybrid systems that allow new technologies to work alongside legacy systems can provide a smooth transition. This involves investing in middleware and APIs that enable seamless data exchange between old and new systems.

- CPM6's Perspective: Balancing the old with the new is critical. While legacy systems are often deeply ingrained in existing processes, introducing new systems incrementally can help manage the transition without causing significant disruptions.

Training and Skill Development:

- Strategy: Continuous learning opportunities and training programs can equip teams with the necessary skills to adapt to new data-driven methods. This includes training in data analysis, software usage, and adapting to new operational workflows.
- CPM6's Recommendation: Training should not be a one-off event but an ongoing process that evolves with technological advancements and changing project requirements.

Data Governance and Security:

- Strategy: Establishing robust data governance frameworks and security protocols is key to ensure the integrity and confidentiality of project data.

- CPM6's Advice: A proactive approach to data management, including regular audits and compliance checks, is essential to maintain trust and reliability in data-driven processes.

Budget Constraints and Resource Allocation:

- Strategy: Careful planning and justification of investments in digital tools and training are needed. Demonstrating the long-term cost savings and efficiency gains can help secure the necessary budget allocations.

- CPM6's Observation: Investment in DT should be viewed as a strategic move that yields long-term benefits rather than a short-term expense.

While there are challenges in fostering a data-driven and adaptive culture in CPM, these can be effectively addressed through strategic technology integration, comprehensive training, robust data governance, and a shift in organisational mindset. Embracing these changes can significantly improve project outcomes and position firms for continued success in a digitally evolving landscape.

In conclusion, cultivating a data-driven and adaptive culture within SA's CPM sector is challenging and necessary. This shift involves more than just adopting new technologies; it requires a fundamental change in mindset and operations. To undergo this transformation, it is key to adopt a data-driven approach to decision-making, provide teams with appropriate training and tools, and cultivate a collaborative and continuous learning culture.

Overcoming the challenges associated with this shift, such as resistance to change, integrating new systems with legacy infrastructure, and ensuring data security and governance, is key. By successfully navigating these hurdles, the industry can unlock significant improvements in project outcomes, enhance operational efficiencies, and maintain its competitive edge in a rapidly evolving digital landscape.

Ultimately, this transition will lead to more informed and strategic decision-making, greater agility in project management, and a robust, innovative industry capable of meeting the demands of the modern construction environment.

4.5.7 Proposition 1 conclusion

Proposition 1 of the study demonstrates that formulating a robust digital strategy is essential for successful DT within the SACPM industry. This strategy should

define the organisation's vision and strategic intent in the digital realm and establish a clear understanding of what DT means.

The research findings highlight the significance of fostering an enabling culture that supports DT. This involves adopting new technologies and a fundamental shift in organisational culture, operational models, and leadership approaches. The transformation journey necessitates strong leadership to steer the change effectively, ensuring that the workforce has the required knowledge, skills, and dexterity to adapt to new digital methods and technologies.

An adaptable and digitally fit operating model is key. This model should facilitate the implementation of digital strategies, accommodating new technologies and methodologies emerging as pivotal in the CPM sector. Such a model would be instrumental in integrating digital tools like BIM, advanced PM software, and real-time data analytics into everyday operations, enhancing efficiency and decision-making processes.

Furthermore, the research underscores the importance of clear custodianship and defined organisational roles for driving digital change. Every team member, from leadership to frontline staff, should understand their role in this transformation journey. This collective responsibility is vital for a cohesive and coordinated approach towards digital adoption.

However, it is also evident that legacy systems pose a significant challenge to enabling the digital agenda. Often outdated and inflexible, these systems can inhibit the smooth integration of new technologies and impede the overall DT process. Therefore, addressing the limitations of legacy systems, either through modernisation or strategic integration with newer technologies, is critical for successfully realising digital strategies.

The journey towards DT in CPM is multi-dimensional, requiring concerted efforts in culture change, operational model restructuring, leadership, and technology integration. By navigating these aspects effectively, the industry can achieve a comprehensive and sustainable digital transformation, leading to enhanced project outcomes and sustained competitiveness in an increasingly digital world.

4.6 Results Of Proposition 2

The thematic analysis of CPM interviews provides a nuanced perspective on the modernisation strategies employed within the CPM sector in SA. Each element of the DT strategy serves a specific function in addressing the challenges presented by legacy systems and the pursuit of digital innovation.

4.6.1 Abstraction Layer:

Incorporating abstraction layers within CPM is pivotal for simplifying intricate project data and facilitating comprehensive understanding and engagement among all project stakeholders. CPM6's insights regarding the use of BIM epitomise the essence of such abstraction. BIM transcends its role as a mere design tool to act as a medium that abstracts complex construction data into more intelligible visual formats. This capability is instrumental in enabling stakeholders to visualise a project's spatial and functional aspects with greater clarity, irrespective of their technical background.

BIM's effectiveness as an abstraction layer lies in its ability to model various construction elements digitally, thus providing a virtual representation of a building or structure before its physical realisation. Through BIM, project managers can foresee potential design conflicts, workflow disruptions, and other project-related issues that may take time to be apparent in two-dimensional plans. CPM6 elaborates on this, noting that BIM's role in digital abstraction extends to enhancing communication across disciplines, improving decision-making, and ultimately streamlining the project management process.

BIM facilitates a collaborative environment as an abstraction layer where architects, engineers, contractors, and clients can converge on a unified platform. The shared visual model acts as a singular source of truth, reducing the possibility of misinterpretations and miscommunications arising from complex project documentation. This collaborative aspect of BIM, as highlighted by CPM6, is central to the DT strategies employed within modern CPM, serving as a cornerstone for improved project outcomes.

In conclusion, the strategic implementation of BIM as an abstraction layer represents a transformative step in digitising CPM. It encapsulates a shift towards more interactive, precise, and accessible project planning and execution. As the CI evolves, adopting such digital tools will be integral to addressing the complexities inherent in modern construction projects, thereby driving efficiency, innovation, and success.

4.6.2 Orchestration Layer:

The orchestration layer in CPM plays a key role in harmonising the multitude of tasks, resources, and timelines that constitute a construction project. Advanced PM software such as Primavera P6, as noted by CPM2, exemplifies an orchestration layer's functionality by providing a robust framework that facilitates seamless interaction among various project components. This software platform enables PMs to integrate disparate elements, such as resource allocation, scheduling, and workflow management, into a cohesive operational strategy.

Primavera P6, renowned for its comprehensive features, allows for meticulously planning and tracking every stage of the construction process. It supports the simultaneous management of multiple projects, ensuring that resources are efficiently utilised, and project milestones are met within the stipulated timeframes. CPM2's acknowledgement of Primavera P6's efficacy underscores its ability to enhance communication and collaboration across the project team, improving project control and execution.

The orchestration layer provided by such software is essential in modern CPM, where the complexity and scale of projects often necessitate a high degree of coordination and precision. By enabling a centralised view of project progress, potential bottlenecks and scheduling conflicts can be pre-emptively identified and addressed, mitigating risks, and reducing the likelihood of delays and cost overruns.

Moreover, the data-driven insights offered by the orchestration layer aid in strategic decision-making. Project managers can leverage comprehensive data analytics to forecast project trajectories, adjust plans in real-time, and ensure that

the project adheres to its strategic objectives. CPM2's experience reflects a broader industry trend where the integration of digital tools is transforming PMM, moving away from reactive approaches to proactive, informed management practices.

In essence, the orchestration layer represents a nexus of DT in CPM, enabling the industry to meet the evolving demands for greater efficiency, transparency, and accountability. As construction companies navigate the complexities of digital integration, the orchestration layer will remain an indispensable aspect of their strategic digital framework, driving innovation and ensuring the success of construction projects in an increasingly dynamic industry.

4.6.3 Agile and Waterfall Squads:

In the CPM domain, the convergence of Agile and Waterfall methodologies has been increasingly recognised as a strategic approach to handling the multifaceted nature of construction projects. This hybrid model, which CPM7 references, capitalises on the strengths of both Agile adaptability and Waterfall structured planning to construct a robust project management framework that caters to the diverse demands of modern construction projects.

With an iterative and incremental approach, Agile methodologies provide the flexibility to respond swiftly to changes, allowing for adaptation and continuous improvement throughout the project lifecycle. This responsiveness is particularly beneficial in managing complex, unpredictable aspects of construction projects where requirements, scope, and stakeholder inputs might evolve. CPM7's insights suggest that Agile techniques, such as scrum sessions, sprints, and stand-ups, are incorporated into construction management to enhance team collaboration and ensure rapid delivery of high-priority tasks.

On the other hand, the Waterfall model offers a systematic and orderly progression through the project phases, from conception to completion. This method's sequential nature lends well to the CI, where specific tasks must follow a predetermined order due to technical or regulatory requirements. By employing Waterfall squads, construction managers can ensure that each project phase,

such as design, planning, and construction, is thoroughly completed before proceeding to the next, thereby maintaining a high level of quality control and risk management.

CPM7's mention of the hybrid approach underscores the recognition that no single project management methodology is one-size-fits-all. Each construction project presents unique challenges and requirements that may necessitate different management styles. By integrating Agile and Waterfall squads, project managers can create a dynamic and flexible project environment that maintains the necessary structure and discipline to meet project deliverables and deadlines.

Fusing these two methodologies into a cohesive management strategy represents a progressive step in CPM. It allows for a more tailored and nuanced approach that aligns with specific project needs, client expectations and the dynamic nature of the CI. As such, deploying Agile and Waterfall squads is not merely a combination of methodologies but a strategic decision reflecting a deep understanding of the project demands and the available management tools.

In conclusion, using Agile and Waterfall squads in CPM exemplifies the industry's evolution towards more sophisticated and responsive project management practices. As construction firms strive for increased efficiency and better outcomes, the hybrid approach offers a pathway to balance flexibility with the requirement for order and precision, ultimately leading to successful project delivery.

4.6.4 APIs and Middleware:

The CPM landscape increasingly relies on integrating various software systems to ensure seamless operation and communication across platforms. CPM3's insights into the use of Application Programming Interfaces (APIs) and middleware technologies underscore this trend, highlighting their role as vital conduits for interoperability within the digital ecosystem of construction projects.

APIs are the binding agent for different software systems, enabling them to exchange and communicate information. This interaction is essential in modern

construction projects, where various tools and platforms are used for PM, such as resource allocation, scheduling, contracting, and budget tracking. Implementing APIs facilitates seamless data exchange between these systems, eliminating the necessity of manual data input and significantly decreasing the likelihood of errors. This API-enabled interoperability improves efficiency and gives project managers a comprehensive view of project status, enabling more informed decision-making.

Middleware, on the other hand, acts as a mediator that bridges the gap between different technologies within a network, especially where legacy systems are involved. It enables newer, more agile digital solutions to function alongside older, more rigid systems without extensive overhauls. This is particularly relevant in the CI, where the cost and complexity of completely replacing legacy systems can be prohibitive. Middleware offers a more cost-effective solution by allowing businesses to maintain the value of existing systems while benefiting from the capabilities of the latest technologies.

CPM3's commentary on deploying APIs and middleware demonstrates a forward-thinking approach that acknowledges the complexities of DT in CPM. By leveraging these technologies, construction firms can modernise their operations in a manner that is both scalable and sustainable. This strategic use of APIs and middleware addresses the immediate need for integration and lays the groundwork for future technological advancements, ensuring that the project management systems can evolve as innovations emerge.

Integrating APIs and middleware indicates the CI 's recognition that DT is not a destination but an ongoing journey. As construction projects become more complex and the digital landscape continues to expand, the strategic use of these technologies will become increasingly important. They enable construction firms to build a resilient digital infrastructure capable of adapting to new challenges and opportunities, ensuring their project management practices' long-term success and sustainability.

In summary, using APIs and middleware in CPM is a testament to the industry's commitment to embracing digitalisation. It reflects a nuanced understanding of

the need to create a flexible, integrated, and future-proof digital environment that supports construction projects' complex, multifaceted nature. As the industry continues to navigate the digital era, the strategic application of these technologies will play a critical role in driving efficiency, innovation, and competitive advantage.

4.6.5 Drive Digital Whilst Running Legacy:

A critical challenge in CPM is balancing adopting new DTEC and maintaining legacy systems. As CPM5 elucidates, construction firms are adopting a pragmatic strategy that allows digital innovation to be driven forward while ensuring the existing legacy systems continue to function without disruption.

This approach requires a delicate balance, as legacy systems often form the backbone of a firm's operational capabilities, storing invaluable data and running core processes essential to the day-to-day management of construction projects. Completely overhauling these systems in one go can be risky and impractical, potentially leading to significant operational downtime and financial implications.

Instead, by driving digital innovations in a phased manner, firms can introduce new technologies and processes that complement and gradually replace the functions of the legacy systems. This might involve deploying new software for specific tasks, such as data analytics or project visualisation, while the core data processing still runs on the legacy platforms. Over time, as confidence in the digital systems grows and their capabilities are proven, more and more functions can be transitioned away from the legacy systems.

The key to successfully driving digital while running legacy systems, as suggested by CPM5, lies in the construction firms' ability to innovate without causing instability in their operations. It requires a strategic approach to technology adoption, where introducing new digital tools is carefully planned and executed to ensure seamless integration with the existing infrastructure.

This strategy minimises disruption to ongoing projects and allows firms to leverage legacy systems' stability and reliability while exploring and adopting new

digital solutions. It enables the gradual upskilling of the workforce, allowing employees to adapt to new technologies at a manageable pace. Furthermore, it allows firms to test and evaluate digital solutions in real-world scenarios, ensuring that investments in new technologies deliver tangible benefits.

As the CI continues to evolve, the ability to drive digital innovation while maintaining legacy systems will be a defining factor in a firm's adaptability and competitiveness. By adopting this approach, firms can ensure a smooth transition into the digital age, harnessing the power of new technologies to enhance their project management capabilities while preserving the integrity of their core operations.

4.6.6 Multi Squads:

In the dynamic field of CPM, the concept of multi-squads, as highlighted by CPM4, is pivotal for driving DT efficiently and effectively. These multi-disciplinary teams are assembled to tackle distinct aspects of the digital shift, ensuring that experts in each area address all facets of the transformation process.

These squads often comprise a mix of individuals with expertise in various domains, such as software development, data analytics, project management, and construction operations. By having diverse skills and knowledge bases within each team, firms can ensure that the solutions they implement are technically sound and practically applicable within the unique context of CPM.

The multi-squad approach allows for a more agile and responsive implementation of digital strategies. These teams can operate semi-autonomously, making quick decisions and adapting to new information or changes in project requirements without being bogged down by traditional hierarchical decision-making processes. They are often empowered to experiment with new ideas and iterate rapidly, which is key in a landscape where DTEC and construction practices continually evolve.

CPM4's mention of such teams underscores the recognition within the industry that successful DT is not just about the technology itself but also about how it is

implemented and managed. Multi squads can bridge the gap between high-level strategic goals and on-the-ground operational realities, ensuring that digital initiatives are relevant, practical, and effectively integrated into daily workflows.

This approach also encourages collaboration and knowledge sharing across different disciplines and departments, breaking down silos that can often hinder innovation. By working together in multiple squads, individuals from various backgrounds can share insights and develop more comprehensive and holistic solutions to the challenges posed by digital transformation.

In essence, multi-squads represent a modern approach to organisational structure and project management suited to today's CI 's complex, fast-paced, and technology-driven nature. They enable firms to leverage a wide range of expertise and perspectives, ensuring that the transition to digital tools and processes is as smooth, efficient, and effective as possible.

In conclusion, the findings from the CPM interviews strongly support the proposition that modernisation and strategic management of legacy systems are key for the evolution of the SACPM sector. The practical applications and strategies discussed by the CPMs—from implementing abstraction layers and orchestration tools to integrating hybrid project management methods and APIs—illustrate a clear path towards digital transformation.

The CI 's move towards a more digitised and efficient operational model is complex. However, adopting these strategies is essential for navigating legacy systems' inherent challenges. The strategic use of modern technological tools and methodologies and restructuring teams into multi-disciplinary squads facilitates a smoother transition towards digital integration. This approach enhances operational efficiency and ensures the industry stays competitive and agile in a rapidly changing technological landscape.

Moreover, the insights gained from these interviews highlight the necessity for a broader approach to DT encompassing technological and human aspects of change. The industry needs to implement new tools and cultivate a culture that embraces change, encourages continuous learning, and fosters collaboration across various functional areas.

Ultimately, the successful modernisation of legacy systems in the SACPM sector hinges on a balanced combination of innovative technological solutions, strategic planning, and a workforce adept at navigating the digital landscape. This holistic approach to DT is key to ensuring long-term sustainability and competitiveness in the global construction market.

4.6.7 Proposition 2 conclusion

Addressing the challenges posed by legacy systems in SACPM requires a nuanced and strategic approach. The complexity of these systems, characterised by intricate architecture, sluggish execution speeds, and high operational costs, demands innovative solutions and a shift in operational mentality.

The findings within the thematic analysis indicate that organisations contending with legacy systems must develop clear architectural strategies. This involves understanding the limitations and risks associated with legacy systems and identifying and implementing modernisation solutions that can bridge the gap between old and new technologies. Interim solutions such as developing orchestration layers, utilising APIs, and creating standard rails have emerged as practical approaches to alleviate the burden of legacy systems. These strategies offer a way to enhance system interoperability and flexibility, allowing for more efficient integration of advanced digital tools while maintaining the stability and reliability of existing systems.

However, the success of these modernisation efforts extends beyond technical implementations. It necessitates a change in traditional working methods within the CPM sector. Fostering an environment that supports skill development and continuous learning is key. Building a workforce proficient in both legacy and new technologies is key to driving successful digital transformation. This dual competency ensures that teams can operate and maintain existing systems and effectively leverage new digital solutions to optimise project outcomes.

In essence, the journey towards successfully navigating legacy system challenges is multifaceted. It requires a balanced approach that combines technical innovation with strategic planning and workforce development. By

adopting this holistic approach, the SACPM industry can effectively modernise legacy systems, enhancing operational efficiency, reducing costs, and better positioning itself in a rapidly evolving digital landscape.

4.7 Summary of the findings

The research conducted on DT in the SACPM industry has yielded insightful findings, particularly addressing the two propositions that were the focal point of this study.

Proposition 1: DT Beyond Technological Enablement

The first proposition explored the notion that DT in CPM transcends the mere adoption of new technologies. The findings reveal that this transformation comprehensively rethinks the business model and how organisations function operationally. Key themes emerged from the interviews:

- Holistic Approach to DT: DT is not confined to technological advancements but encompasses a broader scope. It necessitates changing the organisational culture, operational models, and overall strategic direction.

- Culture and Leadership: The successful implementation of digital strategies relies heavily on organisational culture and leadership. There is a need for strong leadership to drive an enabling culture and for teams to embrace new ways of working that align with digital objectives.

- Skills and Competencies: The findings highlight the importance of having the necessary skills and competencies to execute digital plans. Training and skill development are vital in bridging the digital skills gap and ensuring successful digital adoption.

- Operational Model Adaptation: The operating model of organisations plays a key role in successfully executing digital strategies. It needs to be flexible and adaptable to integrate new digital methodologies effectively.

Proposition 2: Legacy Modernisation in Digital Transformation

The second proposition focused on the need for traditional institutions to explore legacy modernisation strategies as part of their DT journey. The findings from this proposition include:

- Challenges of Legacy Infrastructure: Legacy systems present significant challenges, including slow delivery pace, high maintenance costs, and a skill gap due to outdated programming languages. The complexity and risk of replacing these systems make modernisation challenging yet key.

- Strategies for Legacy Modernisation: Organisations have adopted various strategies to mitigate the role of legacy systems. These include using abstraction and orchestration layers that facilitate standard development rails, enhancing flexibility and reducing delivery times. This approach signifies a bimodal strategy where different technological modes coexist during the digitisation process.

- Navigating Digital and Legacy Systems: Managing the coexistence of digital innovation and legacy systems is a notable inhibitor to digital transformation. The balance between driving digital initiatives while running legacy infrastructure necessitates careful planning and strategic execution.

In conclusion the findings from this study emphasise that DT in the CPM industry is a multifaceted journey. It involves not just adopting new technologies but also significant changes in organisational culture, operational models, and the upskilling of teams. Furthermore, managing legacy systems and integrating them into the DT strategy is a complex but essential part of this journey. These elements together shape the pathway for a successful transition to a more digitally advanced and efficient CPM sector in SA.

CHAPTER 5. DISCUSSION OF THE RESULTS OR FINDINGS

5.1 Introduction

Chapter 5 serves as a analysis of the research findings delineated in Chapter 4, focusing on synthesising, and interpreting the collected data. This chapter delves deeper into the themes that have emerged, connecting them cohesively to the study's underlying research objectives and propositions. The analysis has been methodically structured to provide a clear and insightful understanding of how DT manifests within the SACPM sector.

The ensuing discussion in this chapter is anchored around Table 9, which encapsulates the core themes identified during the research. These themes have been meticulously formulated to correspond with the research objectives and propositions at the study's outset. This alignment ensures that the analysis addresses the fundamental questions driving this research and offers a nuanced understanding of digital transformation's broader implications and intricacies in CPM.

Table 9 thus acts as a foundational framework for this chapter, guiding the discussion and analysis towards a understanding of how traditional construction management practices are evolving in response to digital advancements and the challenges and opportunities these present. Through this analytical lens, the chapter aims to provide a detailed exploration of the themes, elucidating their significance and role on the overarching goals of digitalisation in the CI.

Table 7: Research questions, Table 9: Research objectives, propositions, and final themes

Research Objective	Proposition	Themes
Objective 1: Challenges of Digitalisation	Proposition 1: DT in the SACI extends beyond mere technological enablement and encompasses a rethinking of traditional business models and operational functions. The successful implementation of digital strategies requires not only the integration of digital tools into CPM but also a holistic approach. This approach includes fostering a data-driven culture, strategically embedding digital methodologies, and proactively addressing the various challenges that arise during the digital integration process.	1. Embracing Digital Evolution
		2. Economic and Technical Divides
Objective 2: Opportunities for Digitalisation		3. Technological Innovation in Construction
		4. Optimising Project Management
Objective 3: Leveraging Digitalisation for Improved Outcomes	Proposition 2: Traditional organisations need to explore existing system modernisation strategies and manage existing systems according to a clear digital plan.	5. Strategic Digital Integration
		6. Cultivating a Data-Driven and Adaptive Culture

In this section, we will carefully examine the results outlined in Chapter 4 using a systematic approach that closely corresponds with the theoretical foundation laid out in Chapter 2. The primary focus of this chapter is to draw out key insights from the earlier theoretical framework and juxtapose these with the empirical data gathered during the study. This comparative analysis is key in understanding how theoretical concepts are manifested in practical scenarios within the SACPM context.

The results are methodically organised and discussed about the propositions, each correlating directly with the research objectives delineated earlier in the study. This structure ensures a thorough and cohesive exploration of the themes, providing a clear link between theoretical knowledge and empirical findings. Through this approach, the chapter offers a synthesis of insights, bridging the gap between academic theory and the practical realities of DT in CPM. The goal is to provide a nuanced understanding of how digital strategies are formulated, implemented, and integrated within the industry, considering the challenges and opportunities that emerge in this dynamic environment.

5.2 Discussion pertaining to Proposition 1

Proposition 1 of the study reveals that DT in SACPM goes beyond simply incorporating DTEC. It necessitates a fundamental re-evaluation of business models and operational processes. To successfully implement this all-encompassing transformation, businesses must go beyond simply incorporating digital tools and instead make a strategic change in how they function and strategies, establishing a profound incorporation of DTEC at the heart of their operational methods.

5.2.1 Embracing Digital Evolution

Exploring DT within SACPM reveals a multifaceted and complex phenomenon. The findings from the research, particularly under the theme 'Embracing Digital Evolution', highlight that DT needs to be more understood and conceptualised within the industry.

One critical insight from the literature review is the emphasis on viewing DT as more than technological enablement. Scholars such as (Ismail et al., 2017) note that organisations frequently place disproportionate focus on the technological aspects, overlooking the broader strategic and operational shifts necessary for a truly transformative digital journey. This aligns with the empirical data, which shows that the term 'digital' is frequently used in a limited sense within the construction sector, often equated merely with the digitisation of technology infrastructure or the implementation of specific digital tools like BIM.

However, as discussed by (Matt, Hess, & Benlian, 2015) DT involves a change that reshapes the entire business model and operational processes of an organisation. This broader understanding of DT encompasses not only the integration of new technologies but also a fundamental re-evaluation of business practices, organisational structures, and revenue models.

In the SACPM context, embracing this view of digital evolution is imperative. The industry faces a rapidly changing landscape, with evolving customer needs and increasing competition. As such, firms need to move beyond a narrow focus on

technology and consider how digital strategies can fundamentally alter their approach to project management. This includes rethinking business processes, enhancing agility, and improving customer experiences through digital channels.

The research findings suggest that while there is an awareness of the need for digital evolution in some pockets of the industry, a shared understanding and strategic approach to DT still need to be improved. The need for leadership steer and a change in the organisational culture is key in navigating this DT journey. Therefore, firms in the construction sector must cultivate a digital-first mindset and align their digital strategies with their overall business goals to remain competitive and responsive to the changes in the industry.

In summary, the theme 'Embracing Digital Evolution' underlines the importance of a holistic approach to DT in CPM. This approach should integrate technological advancements with strategic changes in business models, operational processes, and organisational culture to achieve successful and sustainable DT.

5.2.2 Economic and Technical Divides

The theme of 'Economic and Technical Divides' within the context of SACPM provides significant insights into the challenges and disparities faced in the journey towards digital transformation. The empirical data from this study, in conjunction with the literature review, underscores the complex interplay between economic resources and technical capabilities in shaping the digital landscape of the CI.

A key observation from the literature is the varying levels of digital adoption across different firms, influenced by economic factors and technical proficiency. Studies by authors like (Ismail et al., 2017) highlight how economic constraints and technical limitations can create significant gaps in digital capabilities among construction firms. Smaller companies often need more financial resources and technical expertise, hindering their ability to fully embrace digital tools and methodologies.

This economic and technical divide becomes evident when examining the implementation of technologies such as BIM and advanced PM software. While larger firms with more resources can invest in these technologies and the necessary training, smaller firms may need help to keep pace, creating a DD within the industry. This disparity affects the operational efficiency of individual firms and the overall competitiveness of the SA construction sector.

Moreover, the research findings suggest that the DD is not solely an issue of financial resources but also involves the availability and development of technical skills. The CI faces a skills gap, particularly in adapting to new digital tools and methodologies. This gap underscores the need for focused training programs and educational initiatives to equip professionals with digital competencies.

There is a need for collaborative efforts within the industry to bridge these economic and technical divides. This can include shared resource platforms, knowledge exchange initiatives, and cooperative training programs. Additionally, government and industry associations can play a pivotal role in facilitating access to DTEC and supporting skill development through incentives and regulatory reforms.

In conclusion, the theme 'Economic and Technical Divides' highlights the key challenges that should be addressed to achieve equitable and DT in SACPM. Addressing these divides requires a concerted effort from all industry stakeholders, including firms, government bodies, and educational institutions, to ensure that all companies, regardless of size and resources, can participate in and benefit from the digital revolution.

5.2.3 Technological Innovation in Construction

The theme of Technological Innovation in Construction under Proposition 1 captures the essence of DT within the SACPM landscape. This transformation is primarily driven by integrating advanced tools and methodologies, revolutionising traditional construction practices.

A critical aspect of this transformation is the adoption of BIM. As a digital representation of a construction project in three dimensions, BIM facilitates better visualisation and understanding than traditional 2D methods (Azhar et al., 2011). It enhances data management, communication, and stakeholder collaboration throughout the project lifecycle (Eastman et al., 2011), fostering interdisciplinary teamwork and improved coordination.

Additionally, incorporating advanced PM software like Primavera P6 and Microsoft Project has enhanced project management efficiency (Aghimien, Aigbavboa, Oke, Thwala, & Moripe, 2022). These tools allow for intricate scheduling and resource management, offering a level of control and precision previously unattainable. This evolution in project management tools reflects a broader trend towards more sophisticated, technology-driven project management solutions.

However, the journey towards integrating these technological innovations is fraught with challenges. There is a need for significant investment in the technologies and the training and cultural adaptation within organisations. Integrating these tools into the fabric of project management necessitates a approach that addresses these challenges while capitalising on the opportunities they present.

In conclusion, under Proposition 1, the Technological Innovation in Construction theme emphasises the transformative role of DTEC in the SACI. It highlights the need for a holistic approach that includes not only the adoption of these technologies but also strategic and operational adjustments within organisations. By successfully navigating these changes, the industry can leverage these technological advancements to enhance efficiency, improve project outcomes, and maintain its competitive edge in a rapidly evolving digital landscape.

5.2.4 Optimising Project Management

The 'Optimising Project Management' theme in SACPM encapsulates the transition towards advanced digital tools and methodologies. This shift enhances project efficiency, accuracy, and overall outcomes.

Integrating sophisticated PM software like Primavera P6 and Microsoft Project exemplifies this move towards optimisation. These tools have revolutionised project management by enabling intricate scheduling, resource management, and real-time tracking. Adopting such software aligns with the industry's need for precision and efficiency, as it significantly mitigates delays and cost overruns. This echoes the sentiments of (Agboola et al., 2019) who highlight the transformative role of digital tools in streamlining project management processes.

BIM has also emerged as a cornerstone in modern project management. BIM's ability to provide a more integrated approach to PM, from planning to execution, aligns with (Azhar, Nadeem, Mok, & Leung, 2008; Chen & Lu, 2019) findings. They emphasise that BIM facilitates enhanced visualisation, improved collaboration, and more effective communication among project stakeholders, leading to more cohesive project development.

The emphasis on data-driven decision-making further exemplifies the shift towards optimisation. Harnessing digital tools to analyse project data allows for predictive analytics and strategic planning. As noted by CPM4, this approach enables construction firms to anticipate potential issues and make informed decisions, leading to better project outcomes. This aligns with (Dallasega et al., 2018), who stress the importance of leveraging real-time data for proactive project management.

However, transitioning to optimised project management through digital tools takes time and effort. The need for significant investment in both financial and training resources, particularly for smaller firms, is a notable barrier. This reflects the concerns raised by (Aghimien, Aigbavboa, Oke, & Koloko, 2018) regarding the challenges smaller firms face in adopting new technologies.

In conclusion, the 'Optimising Project Management' theme under Proposition 1 highlights the critical role of digital tools in transforming project management practices within the SA construction sector. By embracing these tools, the industry can achieve enhanced efficiency, improved decision-making, and superior project outcomes, aligning with the evolving demands of the digital age.

5.3 Discussion pertaining to Proposition 2

For Proposition 2, traditional institutions in the context of SACPM must consider in-depth legacy modernisation strategies. These strategies are imperative for effectively handling legacy systems and must be underpinned by a clear and digitisation plan. This approach is key for facilitating strategic digital integration and fostering a data-driven and adaptive culture, ensuring that these institutions can efficiently adapt to and thrive in a rapidly evolving digital environment.

5.3.1 Strategic Digital Integration

Strategic digital integration is a critical theme in addressing the challenges posed by legacy systems within SACPM, as highlighted under Proposition 2. This theme emphasises the need for a well-coordinated approach that combines modern digital solutions with legacy infrastructures.

The essence of strategic digital integration lies in its capacity to bridge traditional methods with contemporary digital advancements. It involves the meticulous alignment of new digital tools and methodologies with the entrenched systems, ensuring both compatibility and continuity in operations. This strategic approach is vital for maintaining operational stability while transitioning to more sophisticated digital platforms, reflecting insights similar to those of (Matt et al., 2015; Nikmehr, Hosseini, Martek, Zavadskas, & Antucheviciene, 2021), who underscored the transformative potential of digital technology in reshaping business models and operational processes.

Middleware and APIs are at the forefront of this integration as critical enablers facilitating the smooth interplay between old and new systems. Their role is particularly significant in mitigating the challenges posed by legacy systems, which are often characterised by inflexibility and incompatibility with newer technologies. This aligns with the observations of (Davis, Granić, & Marangunić, 2023), who emphasised the necessity of change in business processes and systems for effective digital transformation.

Furthermore, the theme underscores the pivotal role of data-driven approaches in the integration process. Leveraging data analytics and real-time information empowers construction firms to make informed, strategic decisions, enhancing both the efficiency and the effectiveness of project outcomes. This approach echoes the findings of researchers like (Davis et al., 2023), who highlighted the critical role of real-time data in proactive project management.

However, the journey towards strategic digital integration is challenging, particularly for smaller firms facing resource constraints. Significant infrastructure, training, and resource investments are required to align digital solutions with legacy systems effectively. These challenges mirror the concerns raised in the broader CI discourse, where integrating new technologies with existing infrastructures has been a consistent point of discussion and deliberation.

In conclusion, the strategic integration of digital tools within legacy systems is a complex yet essential endeavour for the SACPM sector. This approach enables the industry to transcend the limitations of outdated systems, harnessing the full potential of modern DTEC to remain competitive and responsive in a rapidly evolving digital landscape.

5.3.2 Cultivating a Data-Driven and Adaptive Culture

The theme 'Cultivating a Data-Driven and Adaptive Culture' is key under Proposition 2, especially in managing legacy systems within SACPM. This theme underscores the importance of establishing an organisational culture that deeply values data analytics and adaptability amidst evolving DTEC.

A significant aspect of this theme is the transformation toward a data-driven culture, which involves empowering project management teams with the necessary tools and the skills to effectively harness data for insightful decision-making. This shift is aligned with the insights from (Agboola et al., 2019), who emphasise the transformative role of digital tools in PM. These tools empower extracting valuable knowledge from data, enhancing predictive analytics, and facilitating strategic decision-making. Intelligent data utilisation is key for

improving operational efficiency and making informed decisions in construction projects.

Additionally, fostering adaptability within the organisational culture is essential for addressing the challenges posed by legacy systems. As construction projects increasingly integrate DTEC, the ability to rapidly adapt to new tools and methodologies becomes critical. This mirrors the findings of (Azhar et al., 2011), who highlighted the necessity of an adaptive mindset in the face of technological advancements in CPM. A culture that champions continuous learning and flexibility is vital for adapting to the changing digital landscape and successfully integrating modern digital tools with existing legacy systems.

However, building such a culture presents challenges, notably in overcoming resistance to change, especially among seasoned professionals accustomed to conventional methods. Addressing this requires robust training and skill development programs, as (Davis et al., 2023) suggested. These initiatives ensure that all team members are adequately prepared to embrace and effectively utilise emerging digital tools.

In conclusion, 'Cultivating a Data-Driven and Adaptive Culture' as a theme under Proposition 2, highlights the necessity for a strategic approach in fostering an organisational culture that values data analytics and adaptability. Such a culture is essential for SACPM firms to successfully navigate the complexities of integrating digital tools with legacy systems, enhancing overall operational efficiency and success in a digitally evolving landscape.

5.4 Conclusion

The findings and discussions from Chapter 5, it is apparent that the legacy of traditional practices and systems significantly influences the DT journey within the SACPM sector. This legacy manifests in various forms, including established operational methods, organisational culture, and technological infrastructure. The complexity of navigating DT in this context lies in the need for a deep

understanding of the current landscape to develop feasible and practical digital strategies.

The journey towards digitalisation in CPM differs from initiating digital strategies in a new entity. It necessitates considering available financial resources, prioritisation based on current realities, and the existing constraints. Building digital solutions parallel to legacy systems emerges as a pragmatic method to facilitate transformation while maintaining operational continuity. This method enables construction firms to remain competitive while gradually transitioning to more advanced digital practices.

The discussions from the themes in Chapter 5 reflect the multifaceted nature of DT in this sector. An essential aspect is the recognition of the significance of integrating new technologies and transforming business models, operational processes, and organisational culture. Mastering this strategy is key for effectively navigating the intricacies of digital transformation, enhancing project management methods, and retaining a competitive advantage in a swiftly evolving digital environment.

The DT journey in SACPM is a balancing act. It involves strategically managing legacy systems while progressively integrating digital innovations to enhance efficiency, decision-making, and project outcomes. This balanced approach is vital to achieving DT that aligns with the industry's evolving demands and future aspirations.

CHAPTER 6. CONCLUSIONS & RECOMMENDATIONS

6.1 Introduction

Chapter 6 concludes this study by drawing conclusions based on research objectives that are outlined in Chapter 1 and providing recommendations, including opportunities for future research. This research was primarily aimed at exploring how SACPM firms navigate DT, along with the role of legacy systems on this journey.

This study's literature and empirical findings have revealed that DT in the construction sector encompasses far more than merely digitising existing processes. It involves a holistic re-evaluation and potential restructuring of the entire business ecosystem and operational models. A critical insight that has emerged is the tendency of some traditional organisations to focus narrowly on technological upgrades while neglecting the requisite changes in their operating and business models. This oversight often leads to a superficial transformation needing more sustainability.

Despite the centrality of technology in digital transformation, the challenges posed by legacy systems are particularly pronounced in the construction sector. These systems, often deeply ingrained and fundamental to current operations, present significant hurdles due to their age, complexity, and the specific skill sets required for maintenance and upgrade. Consequently, the path to DT is not straightforward and involves navigating the intricacies of modernising or replacing these legacy systems. Moreover, it necessitates reimagining the business model to align with the demands and opportunities of the digital era.

Therefore, Chapter 6 aims to synthesise these findings, providing a understanding of the DT landscape in the SACPM industry. It will also propose practical strategies for overcoming the identified challenges and suggest future research directions to enhance the sector's digital maturity further.

6.2 Conclusions regarding research questions

6.2.1 Formulating DT Strategies in CPM

The study's examination of the challenges of digitalisation in SACPM reveals several key insights:

- Understanding and Embracing DT: One of the primary challenges identified is the understanding and embrace of DT within the construction sector. It extends beyond technological adoption, requiring reevaluating business models and operational processes. This necessitates a shift in the organisation's mindset and culture to leverage digital tools and methodologies fully.
- Navigating Economic and Technical Divides: The research highlights a significant divide between larger and smaller firms regarding resources available for digital adoption. Larger firms often have the capacity for comprehensive digital strategies, while smaller firms face challenges due to resource constraints. This divide creates disparities in the adoption and integration of digital tools, potentially leading to competitive imbalances within the industry.
- Integrating Technological Innovations: Integrating technologies like BIM and advanced PM software presents opportunities and challenges. While these technologies promise enhanced efficiency and accuracy, integrating them into existing project management frameworks requires strategic planning and adaptation.
- Optimising Project Management through Digital Tools: The transition to using advanced digital tools is key for optimising project management. This transition involves significant investment in technology and training, especially for smaller firms, and requires cultural adaptation to new working methods.
- Strategic Digital Integration and Culture Shift: Effective integrating digital tools into project management involves more than just technology adoption; it requires a strategic and holistic approach. Cultivating a data-

driven and adaptive culture is essential, as it empowers teams with real-time data and the flexibility to respond to project dynamics.

- Overcoming Implementation Challenges: Implementing DT is challenged by the need to balance legacy systems with new technologies. This requires careful planning, investment in infrastructure and human capital and a change in organisational mindset towards a more dynamic, data-centric operation.

In summary, the challenges of digitalisation in SACPM are multifaceted and complex. They encompass technological, cultural, and operational aspects. Successfully overcoming these challenges requires a concerted effort towards integrating new technologies and fostering a culture conducive to digital innovation and adaptation. The construction sector can enhance its efficiency, competitiveness, and capability to deliver successful projects in an increasingly digital world by addressing these challenges.

6.2.2 Harnessing Opportunities for Digitalisation

Addressing Objective 2: Opportunities for Digitalisation, this study has uncovered vital insights into leveraging the potential of DT within the SACPM (CPM) sector. These conclusions highlight the pivotal role of digitalisation in enhancing project outcomes and operational efficiency.

- Technological Innovation in Construction: The study highlights the significance of adopting technological advancements like cutting-edge PM software and BIM. These tools have revolutionised the CPM landscape by enabling precise scheduling, effective resource management, and improved collaboration, thereby contributing to the streamlining, and optimising of construction projects.

- Optimising Project Management with Digital Tools: The study emphasises adopting sophisticated digital tools for optimising project management. These tools not only aid in better project planning and execution but also significantly reduce delays and cost overruns. Adopting such technologies

demonstrates a proactive approach towards enhancing project efficiency and accuracy.

- Strategic Digital Integration: Integrating digital tools into the project management processes requires a strategic and holistic approach. The findings indicate that successful digital integration extends beyond mere tool adoption; it fundamentally rethinks PMM and practices. This strategic integration ensures that digital tools are effectively embedded into the operational fabric of construction projects, leading to more streamlined and cohesive project management.

- Cultivating a Data-Driven and Adaptive Culture: Moving towards a data-driven and adaptive culture within construction firms is key for leveraging digitalisation. This cultural shift empowers project teams with real-time data and analytics tools, facilitating on-the-spot decision-making and enhancing responsiveness to project dynamics. Such a culture promotes proactive rather than reactive project management, enabling firms to better adapt to the fast-paced changes and complexities of the CI.

- Addressing Challenges in Digital Integration: While the opportunities presented by digital tools are significant, the study also acknowledges the challenges faced in achieving seamless digital integration. These challenges include aligning legacy systems with new digital tools, requiring substantial infrastructure and change management investment. Overcoming these barriers is essential for the successful implementation of digital strategies.

In conclusion, the opportunities for digitalisation in SACPM are extensive and transformative. The construction sector can significantly enhance its project management capabilities by embracing technological innovations, strategically integrating digital tools, fostering a data-driven culture, and addressing the inherent challenges of digital integration. This will improve operational efficiencies and position SA construction firms more competitively in the global market, ready to meet the demands and complexities of modern construction projects.

6.2.3 Leveraging Digitalisation for Improved Outcomes in SACPM

Addressing Objective 3: Leveraging Digitalisation for Improved Outcomes, this study has illuminated the critical aspects of effectively utilising DT to enhance project management outcomes in the SACI.

- Strategic Digital Integration: The research identifies the strategic integration of digital tools as a critical factor in leveraging digitalisation. This involves not just adopting new technologies but their seamless incorporation into every aspect of project management. This strategic approach ensures that digital tools are not merely add-ons but integral components that enhance efficiency, collaboration, and decision-making processes.

- Cultivating a Data-Driven and Adaptive Culture: Central to leveraging digitalisation is cultivating a data-driven culture within construction firms. This cultural shift allows for a more analytical and evidence-based approach to project management. Empowering teams with real-time data and advanced analytics tools facilitates more informed decision-making, improving project outcomes.

- Navigating the Digital and Legacy Systems Divide: A significant challenge in leveraging digitalisation is managing the coexistence of digital innovations with legacy systems. The study highlights the need for a balanced approach that combines the maintenance of legacy systems with the progressive implementation of digital solutions. This balance is key for ensuring continuity in operations while capitalising on the benefits of modern technologies.

- Modernisation Strategies for Legacy Systems: Addressing legacy systems through modernisation strategies is identified as a vital step in leveraging digitalisation. This involves updating or replacing outdated systems with more flexible and efficient digital solutions. Such strategies can reduce

operational costs, increase efficiency, and enhance the capacity to integrate advanced digital tools.

- Emphasising Leadership and Skill Development: Effective DT requires strong leadership and a skilled workforce. Leaders play a key role in guiding the DT journey, while a skilled workforce is essential for successfully adopting and utilising DTEC. Investing in training and skill development is, therefore, key for achieving improved outcomes through digitalisation.

In summary, leveraging digitalisation for improved outcomes in the SACPM sector involves a multifaceted approach. It requires strategic digital integration, cultivating a data-driven culture, navigating the divide between digital and legacy systems, modernising legacy infrastructure, and emphasising leadership and skill development. By addressing these aspects, the CI can maximise the benefits of digitalisation, leading to enhanced project efficiency, reduced costs, and better project outcomes in an increasingly digital world.

6.3 Recommendations

Given the insights and conclusions drawn from the study on digitalisation in SACPM, the following recommendations are put forth to aid in the industry's ongoing digital transformation:

Promote the Understanding of DT: Expanding on the Necessity

The critical need to promote the understanding of DT in the CPM sector extends far beyond the mere adoption of new technologies. It involves a paradigm shift in how professionals perceive and engage with digital changes at various levels. To effectively address this, the sector needs to focus on several key areas:

- Educational Initiatives: Tailored educational programs should be developed to elucidate the full spectrum of digital transformation. These programs must go beyond technical training to include modules on how DTEC can revolutionise business models, alter operational processes,

and redefine customer engagement strategies. Universities, vocational training institutions, and industry bodies could collaborate to design curricula that blend theoretical knowledge with practical insights.

- Strategic Awareness: Professionals must understand that DT is not just an IT issue but a strategic business concern. Workshops and seminars led by industry experts can show how digital strategies align with broader business goals and can be leveraged for competitive advantage.

- Cultural Shift Training: The human aspect of DT is often the most challenging. Training sessions focusing on change management, leadership in digital transitions, and fostering a culture open to innovation and adaptability are key. These sessions should equip leaders and employees with the skills to effectively manage and adapt to change.

- Operational Integration Workshops: Practical workshops that demonstrate the integration of digital tools into daily operational activities can be highly effective. These workshops could showcase case studies of successful digital integration, offering insights into overcoming common challenges and maximising the benefits of digital tools.

- Regular Industry Forums and Conferences: Regularly scheduled forums and conferences can provide platforms for sharing experiences, challenges, and best practices in digital transformation. These events offer networking opportunities and insights into the industry's latest trends and technologies.

- Cross-Industry Learning: Learning from other sectors that have successfully navigated DT can provide valuable lessons. Inviting speakers from different industries to share their experiences can provide a fresh perspective and innovative ideas applicable to the construction sector.

- Online Resources and Learning Platforms: Developing online resources, such as webinars, podcasts, and e-learning modules, can make learning about DT more accessible to a wider audience. These resources should cater to various expertise levels, from beginners to advanced professionals.

- Mentorship Programs: Establishing mentorship programs where seasoned professionals guide younger employees through the nuances of DT can foster a culture of continuous learning and knowledge sharing.

Bridge Economic and Technical Divides: Enhancing Equitability in Digital Transformation

Addressing the economic and technical divides within the CI, particularly in aiding smaller firms in their digital journey, is a multifaceted challenge that requires targeted and inclusive strategies. To bridge these divides, several initiatives can be implemented:

- Financial Incentives and Support Programs: Establishing financial incentives such as grants, subsidies, or low-interest loans can significantly assist smaller firms in acquiring digital tools and technologies. Government bodies, industry associations, or through public-private partnerships could provide this financial aid. Tailoring these incentives to smaller firms' specific needs and capabilities is key for their effectiveness.
- Access to Affordable Digital Tools: Collaborations with technology providers to offer cost-effective or scaled versions of digital tools can make technology more accessible for smaller firms. Negotiating bulk purchasing agreements or offering shared licenses can reduce costs. Furthermore, encouraging the development of open-source digital tools can provide cost-effective alternatives.

- Knowledge Sharing Platforms: Creating platforms for knowledge exchange, such as online forums, webinars, and workshops, can facilitate the transfer of digital skills and expertise from larger to smaller firms.

These platforms can be a hub for sharing best practices, troubleshooting common challenges, and fostering a collaborative learning environment.

- Mentorship and Collaboration Programs: Establishing mentorship programs where larger firms guide smaller ones through the DT process can be beneficial. These mentorship relationships can provide practical insights and hands-on assistance and foster a sense of community within the industry.

- Streamlined Access to Training and Resources: Providing streamlined access to training programs, especially those focusing on digital skills and literacy, is essential. Collaborating with educational institutions and technology providers to offer tailored training sessions can equip more minor firm employees with the necessary skills for digital adoption.

- Policy Advocacy for Equal Opportunities: Advocating for policies that promote equal opportunities in digital access is vital. This could involve lobbying for regulatory changes that support small and medium-sized enterprises (SMEs) in the construction sector, ensuring they are not disadvantaged in the digital landscape.

- Incentivising Innovation and Adaptation: Encouraging smaller firms to innovate by providing awards, recognitions, or additional support for those who adopt and adapt DTEC effectively can be a motivational factor. Showcasing their success stories can inspire other small firms to embark on their digital journey.

- Customisable and Scalable Solutions: Promoting the development and adoption of custom and scalable digital solutions ensures that smaller firms can start with basic functionalities and scale up as their proficiency and needs grow.

- Building a Supportive Ecosystem: Cultivating a supportive ecosystem that includes government bodies, technology providers, industry associations, and educational institutions can create a more inclusive environment. This ecosystem can provide the necessary support structure for smaller firms to navigate the DT journey.

By implementing these initiatives, the CI can work towards mitigating the economic and technical divides, fostering a more inclusive and equitable DT landscape. This benefits smaller firms and strengthens the industry, driving innovation and competitiveness.

Enhance Strategic Integration of Digital Tools: Facilitating Seamless Technology Adoption in Construction

Integrating digital tools such as BIM and advanced PM software is essential in effectively utilising DTEC for CPM. This strategic integration entails a detailed approach:

- Developing an Integration Framework: Create a framework that outlines how digital tools will be integrated into existing workflows and processes. This framework should identify critical areas where digital tools can add value, such as planning, design, execution, and monitoring. It should also establish clear objectives and measurable outcomes for integrating these technologies.

- Regular Training and Workshops: Conduct regular training sessions and workshops to ensure that all staff members, from project managers to frontline workers, are proficient in using these digital tools. Training should be tailored to cater to different skill levels and updated regularly to keep pace with technological advancements.

- Customising Tools to Fit Project Needs: Customising digital tools is essential to tailor them to the unique requirements of every individual project. This could involve tailoring software settings, developing custom

modules, or integrating tools with existing systems to ensure that they align with the unique requirements of different projects.

- Promoting a Culture of Continuous Learning: Encourage continuous learning and experimentation. Employees should be motivated to explore new digital tools and techniques and share their findings with their peers. This culture can be fostered through incentives, recognition programs, or internal knowledge-sharing events.

- Facilitating Cross-Functional Collaboration: Digital tool integration often requires collaboration across different departments and teams. Facilitate cross-functional teams to work together in integrating and utilising these tools. This partnership has the potential to generate groundbreaking solutions and a detailed strategy for project management.

- Establishing a Feedback Loop: Implement a feedback loop where users of these digital tools can report on their effectiveness, ease of use, and any challenges encountered. This feedback is key for continuous improvement of the integration process.

- Leveraging Data for Decision-Making: Use the data generated by these digital tools for informed decision-making. This involves collecting and analysing data to gain insights to guide project planning, execution, and risk management.

- Ensuring Scalability and Flexibility: Digital tools and their integration methods must be scalable and flexible to meet construction projects' growth and changing needs. This adaptability is critical to ensuring digital investments' long-term usability and value.

- Reviewing and Updating Integration Strategies: Regularly review and update the strategies for integrating digital tools to keep them aligned with

the latest industry trends, technological advancements, and project requirements.

- Partnering with Technology Providers: It is key to forge strategic alliances with technology providers to remain current with new advancements and effectively incorporate innovative tools and features. Companies can benefit from the latest developments and receive support in the integration process.

By enhancing the strategic integration of digital tools in CPM, firms can improve efficiency, accuracy, and collaboration, leading to better project outcomes and a competitive edge in the industry.

Foster a Data-Driven Culture: Cultivating an Environment for Informed Decision-Making

Fostering a data-driven culture is paramount to drive success in CPM. This approach centres on data to inform decision-making processes, enhance efficiency, and drive innovation. Here is a strategic plan to cultivate such a culture.

- Data Literacy Training: Implement training programs focused on data literacy for all employees. This training should cover the basics of data collection, analysis, interpretation, and application in decision-making processes. Tailor the training to different organisational roles to ensure relevance and practical application.

- Invest in Data Analytics Tools: Equip teams with advanced data analytics tools that can handle large volumes of project data, providing insights into performance, risks, and opportunities. Ensure these tools are user-friendly and integrate seamlessly with existing project management systems.

- Encourage Data-Centric Decision Making: Promote a culture where decisions are based on data rather than intuition. This involves leadership setting an example by using data to justify their decisions and encouraging their teams to do the same.

- Establish Clear Data Policies: Develop clear policies regarding data collection, storage, usage, and sharing. Ensure these policies comply with data privacy laws and are communicated effectively across the organisation.

- Create Data-Driven Teams: Form dedicated teams responsible for data analysis and reporting. These teams should work closely with project managers and other stakeholders to provide data-driven insights that can guide project execution and strategy.

- Regular Data Reviews: Schedule meetings where teams review project data, discuss insights, and make informed decisions. This routine ensures continuous attention to data and its role in project management.

- Recognise and Reward Data-Driven Achievements: Establish recognition and reward systems for teams or individuals who effectively use data to achieve project objectives or innovate processes. This recognition can motivate others to adopt similar practices.

- Foster a Collaborative Environment: Encourage collaboration between different departments and teams in sharing and interpreting data. A collaborative environment ensures that diverse perspectives are considered, leading to more comprehensive data analysis.

- Invest in Continuous Improvement: Regularly evaluate the effectiveness of data-driven practices and make improvements. Stay abreast of emerging data analytics technologies and methodologies to enhance data-driven practices continually.

- Share Success Stories: Publicise success stories where data-driven decision-making led to significant project improvements. These stories can

serve as powerful examples to further encourage a data-driven approach within the organisation.

By fostering a data-driven culture, CPM can achieve higher accuracy, efficiency, and innovation levels. This approach empowers teams to make informed decisions, anticipate challenges, and capitalise on opportunities, leading to more successful project outcomes.

Address Legacy System Challenges: Developing Effective Modernisation Strategies

To address the obstacles presented by outdated systems in CPM, companies must implement strategic methods for modernisation. This strategy should focus on enhancing system efficiency and compatibility with new digital solutions without causing significant disruptions to ongoing operations. Here is a comprehensive plan:

- Incremental Modernisation Approach: Instead of undertaking a complete overhaul, which can be costly and disruptive, adopt an incremental approach to modernising legacy systems. Focus on updating one component at a time, ensuring each upgrade integrates well with the existing system.

- Implement Hybrid Solutions: Develop hybrid systems that coexist with legacy and modern digital tools. This approach enables firms to leverage the stability of existing systems while gradually introducing new technologies.

- Utilise APIs and Middleware: Integrate Application Programming Interfaces (APIs) and middleware to create seamless connections between old and new systems. This ensures data consistency and facilitates smoother operations during the transition period.

- Conduct Thorough System Assessments: Regularly evaluate legacy systems to identify components that need immediate upgrades or can be

phased out gradually. This assessment should also include identifying any potential risks associated with modernisation.

- Invest in Training and Support: Provide extensive training and support to employees to aid in adapting to new systems or upgraded components. Continuous education guarantees that staff members are adequately prepared to navigate changes effectively.

- Engage in Stakeholder Collaboration: Involve all relevant stakeholders, including IT professionals, project managers, and end-users, in the modernisation process. IT is input is invaluable in understanding the nuances of legacy systems and ensuring new technologies meet user needs and industry practices.

- Customisation and Integration: Tailor digital solutions to a firm's specific needs. This customisation should focus on enhancing the functionality of legacy systems without compromising their core capabilities.

- Perform Cost-Benefit Analysis: Conduct a cost-benefit analysis to justify the investment in legacy modernisation. This analysis should clearly outline the potential efficiency gains, cost savings, and improvements in operational capability.

- Focus on Data Preservation and Utilisation: Ensure that modernisation efforts include strategies for extracting and preserving valuable data from legacy systems. Integrate this data into new systems to maintain historical insights and inform future decision-making.

- Monitor and Evaluate Progress: Regularly monitor the progress of the modernisation efforts and evaluate their role on business operations. This ongoing evaluation will help in making necessary adjustments and improvements.

By addressing legacy system challenges through these strategic actions, construction firms can enhance their operational efficiency, reduce costs, and better position themselves in a rapidly evolving digital landscape. This approach ensures a smoother transition to modern digital platforms while leveraging the value of existing systems.

Invest in Leadership and Workforce Development: Cultivating DT Champions

To successfully navigate DT in CPM, investing in leadership and workforce development is key. Strong leadership and a skilled workforce are indispensable in implementing and sustaining digital initiatives. Here are some strategies to foster leadership and workforce proficiency in digital transformation:

- Leadership Development Programs: Implement leadership development programs specifically tailored to DT. These programs should focus on training leaders to understand and embrace DTEC, manage change effectively, and foster a culture of innovation. Leaders should have the skills to strategise digital initiatives, inspire their teams, and drive the digital agenda forward.

- Continuous Skill Development for Employees: Establish continuous learning opportunities for employees to keep them updated with the latest digital tools and methodologies. This could include workshops, online courses, and hands-on training sessions. Investing in the digital education of the workforce ensures that employees are proficient in using new technologies and understand their strategic importance.

- Promote Digital Literacy: Enhance digital literacy across the organisation. Continual education guarantees that employees are well-prepared to manage any changes that arise effectively. This holistic approach to digital literacy helps create a unified vision and approach towards DT.

- Mentorship and Coaching: Develop a mentorship program where experienced digital leaders coach and guide less experienced staff. This

mentorship can help transfer knowledge, address concerns, and build confidence in using DTEC.

- Foster a Learning Culture: Cultivate a culture that values continuous learning and adaptation. Encourage experimentation, allow for calculated risks, and learn from failures. This environment supports innovation and helps the workforce to adapt to changing digital landscapes.

- Recognise and Reward Digital Initiatives: Recognise and incentivise employees who proactively gain knowledge and utilise digital tools. Recognition can be a powerful motivator for others to engage in digital learning and application.

- Cross-functional Training: Promote cross-functional training where employees from different departments are trained in various digital tools and methodologies. This approach encourages collaboration, and a more integrated understanding of how DT roles different aspects of the business.

- Align Training with Business Goals: Ensure the training programs align with the business's digital strategy and objectives. This alignment helps create a skilled workforce that is technically proficient and strategically aligned with the company's digital goals.

- Leverage External Partnerships: Collaborate with external partners, such as universities, tech companies, and industry experts, for specialised training and insights. These partnerships can provide access to cutting-edge knowledge and technologies.

- Evaluate Training Effectiveness: Continuously evaluate the efficiency of training programs to guarantee they align with the business's and its employees' changing requirements. Use feedback to improve the training initiatives continually.

Investing in leadership and workforce development is a strategic move that positions construction firms to embrace and implement DT effectively. Companies can ensure a successful and sustainable DT by building a leadership team that understands and champions digital initiatives and a workforce skilled in digital methodologies.

Encourage Collaboration and Knowledge Sharing: Fostering a Digitally Connected Community

In CPM, prioritising the facilitation of teamwork and information exchange using digital platforms is key. Here are strategies to create a collaborative environment that leverages digital tools:

- Online Forums and Communities: Develop online forums and communities where professionals can share insights, ask questions, and discuss challenges. These platforms function as a centralised hub for the exchange of knowledge, facilitating the open sharing of experiences and best practices.

- Industry-Specific Digital Events: Organise digital conferences, webinars, and workshops focusing on the latest trends, technologies, and challenges in CPM. These events can bring together experts, practitioners, and academics to share knowledge and foster a culture of continuous learning.
- Digital Collaboration Tools: Implement digital collaboration tools such as cloud-based PM software, which facilitate real-time communication and information sharing. Tools like BIM, Slack, Microsoft Teams, or Asta can enhance team coordination and project tracking.

- Joint Ventures and Partnerships: Encourage joint ventures between companies to work on projects using digital tools. These partnerships can lead to knowledge transfer, shared resources, and a broader understanding of various digital practices.

- Case Studies and Best Practice Sharing: Regularly publish and disseminate case studies highlighting successful DT projects. Sharing

these success stories can provide practical insights and inspire others in the industry.

- Community-Led Initiatives: Support community-led initiatives where CI members come together to address common challenges or develop new solutions. These initiatives can drive innovation and collective problem-solving.

- Mentorship Programs: Establish mentorship programs where experienced professionals can guide and support those new to digital tools and methodologies. This can be valuable in closing the knowledge divide and speeding up the learning journey for individuals entering the field.

- Interactive Training Sessions: Conduct engaging training sessions to provide educational value and foster a collaborative environment for participants to exchange their insights and gain knowledge from one another. These sessions can be a blend of formal training and peer-to-peer learning.

- Cross-Industry Learning: Foster learning opportunities with other industries successfully implementing digital transformation. This cross-industry learning can provide fresh perspectives and innovative approaches that can be adapted for CPM.

- Feedback Mechanisms: Create mechanisms for feedback and suggestions for improving collaboration and knowledge sharing. Encourage an open dialogue where individuals can express their ideas and feedback on digital tools and collaborative practices.

- Standardisation of Data and Processes: Work towards standardising data formats and processes to ensure compatibility and ease of sharing across different digital platforms and among various stakeholders.

- Knowledge Repositories: Build and maintain knowledge repositories that store and organise valuable information, best practices, and learnings. Make these resources easily accessible to all members of the industry.

The CPM sector can create a more unified, efficient, and innovative industry by encouraging collaboration and knowledge sharing through digital platforms. This collaborative approach not only enhances individual projects but also contributes to the overall advancement of the industry.

Develop and Implement Policy and Regulatory Frameworks: Nurturing a Conducive Environment for Digital Adoption

In the CI, developing and implementing policy and regulatory frameworks that support digital adoption are critical. Here are steps policymakers can take to establish a conducive environment for digital transformation:

- Assess Current Regulatory Landscape: Conduct a review of existing laws and regulations related to construction and DTEC. Identify areas where current policies may hinder digital adoption or gaps that need addressing.

- Stakeholder Consultation: Engage with various stakeholders, including industry professionals, technology experts, legal advisors, and academics. Gather insights and feedback to ensure the regulatory framework is practical, relevant, and beneficial for the industry.

- Incorporate International Best Practices: Look to international standards and best practices in construction digitalisation. Adapt and adopt policies that have been successful in other countries, customising them to fit the local context.

- Clear Guidelines for Digital Tool Usage: Develop guidelines and standards for using digital tools like BIM, drones, and AR/VR in construction. Ensure these guidelines are accessible and understandable to practitioners at all levels.

- Data Privacy and Security Regulations: Develop rules and regulations that effectively tackle concerns related to the privacy and security of data associated with digital tools. Ensure that data collection, storage, and use comply with privacy laws and industry standards.

- Supportive Policies for Small and Medium Enterprises (SMEs): Create policies that support SMEs adopting DTEC. This could include financial incentives, grants, or subsidies to offset the cost of digital tool adoption.

- Continuous Regulatory Updates: Regularly update the regulatory framework to keep pace with technological advancements. Create a system that routinely evaluates and adjusts regulations to guarantee their continued applicability and effectiveness.

- Promote Interoperability Standards: Encourage developing and adopting interoperability standards to ensure different digital tools and systems can work seamlessly together. This is key for efficient data exchange and collaboration among various stakeholders.

- Educational Initiatives and Training: Complement regulatory frameworks with educational initiatives and training programs. Rewrite this text intelligently: The task requires concentration and careful attention. Provide professionals with the necessary knowledge and abilities to adhere to new regulations while efficiently utilising digital tools.

- Public-Private Partnerships (PPPs): Foster PPPs to develop and implement policies collaboratively. Utilise the public and private sectors' knowledge and assets to develop broad and impactful regulations.

- Pilot Projects and Case Studies: Initiate pilot projects to test the feasibility and role of proposed regulations. Use the findings from these pilots to refine policies and demonstrate the benefits of digital adoption in a controlled environment.

- Feedback and Continuous Improvement: Establish mechanisms for ongoing feedback from industry participants on the effectiveness and role of regulations. Use this feedback for continuous improvement of the regulatory framework.

Policymakers can significantly contribute to a more digitally advanced CI by developing and implementing supportive policy and regulatory frameworks. These frameworks aim to enable, rather than hinder, the adoption of digital tools and practices, fostering innovation, efficiency, and competitiveness in the sector.

6.4 Limitations of the Study

The research conducted on DT within the CPM sector in SA has several limitations:

- Focused Sample Scope: The sample primarily included construction professionals from various firms, which may not fully represent the diversity of the broader CI in SA.

- Sector-Specific Findings: The conclusions drawn are specific to the construction sector and might not directly apply to other industries with different dynamics and challenges.

- Digital Maturity Variance: The study reflects the experiences of firms at certain levels of digital maturity. Firms at different stages of DT may encounter diverse challenges and opportunities.

- Architectural Complexity: The complexity of digital systems within the construction firms was not a central focus of the study, which could role the interpretation and applicability of the findings.

- Skills and Leadership Variance: The variance in skills and leadership styles across different firms was not extensively explored, yet these factors are key in driving successful digital transformation.

- Single Industry Focus: The study is centred on the CI, limiting the generalisability of its findings to other sectors undergoing DT.

- Temporal Limitations: The rapidly evolving nature of DTEC means that the findings, based on data from a specific period, may need more applicability over time.

- Subjectivity in Responses: The reliance on interviews and surveys introduces a degree of subjectivity, as individual biases or organisational contexts might influence participants' responses.

Considering these limitations, the study's findings should be contextualised within the research's specific scope and time frame. Future studies could expand the research scope to include a broader range of industries and participant profiles to enhance the generalisability of the findings.

6.5 Suggestions for further research

Considering the current study's findings, the following areas are proposed for further investigation to enhance the understanding of DT in CPM and related fields:

- Development of DT Frameworks for Legacy Institutions: Future research should focus on developing frameworks to guide legacy institutions through digital transformation. This would offer a structured approach for organisations navigating the complexities of integrating new digital strategies with legacy systems.

- Role of Digitisation without Business Model Transformation: Investigating the outcomes of digitising operations without corresponding changes in

the business model would provide valuable insights. This research could examine whether such an approach affects the successful implementation of digitisation strategies.

- Exploring Effective Operating Models for DT: A broader study into various operating models that facilitate successful digital strategy implementation is needed. This research should include guidelines on crafting effective operating models tailored for organisations undergoing DT.

- Role of Organisational Culture in Digital Transformation: Examining how organisational culture can act as an enabler or barrier in the DT process would be beneficial. This research could explore strategies to cultivate a culture conducive to digital innovation and adaptation.

- Cost Analysis of Incremental Legacy Modernisation: A study dedicated to understanding the actual costs associated with incremental legacy modernisation in digitally transforming organisations is key. This would help organisations better plan and allocate resources for their DT.

These suggested research areas aim to address gaps identified in the current study and contribute to a more extensive understanding of the challenges and strategies for DT in the CI and beyond.

REFERENCES

Agboola, M. G., Awobajo, K. A., Oluwatobi, S. O., Akinbode, M. O., Fagbohun, M. O., Esse, U. C., . . . Betek, C. M. (2019). *Effect of digitalization on the performance of commercial banks in Nigeria.* Paper presented at the IOP Conference Series: Earth and Environmental Science.

Aghimien, D., Aigbavboa, C., Oke, A., & Koloko, N. (2018). *Digitalisation in construction industry: Construction professionals perspective.* Paper presented at the Proceedings of the Fourth Australasia and South-East Asia Structural Engineering and Construction Conference, Brisbane, Australia.

Aghimien, D., Aigbavboa, C., Oke, A., Thwala, W., & Moripe, P. (2022). Digitalization of construction organisations – a case for digital partnering. *International Journal of Construction Management, 22*(10), 1950-1959. doi:10.1080/15623599.2020.1745134

Arayici, Y., Egbu, C., & Coates, S. (2012). Building information modelling (BIM) implementation and remote construction projects: issues, challenges, and critiques. *Journal of information technology in construction, 17*, 75-92.

Arditi, D., & Pulket, T. (2010). Predicting the Outcome of Construction Litigation Using an Integrated Artificial Intelligence Model. *Journal of computing in civil engineering, 24*(1), 73-80. doi:10.1061/(ASCE)0887-3801(2010)24:1(73)

Azhar, S., Carlton, W. A., Olsen, D., & Ahmad, I. (2011). Building information modeling for sustainable design and LEED® rating analysis. *Automation in Construction, 20*(2), 217-224.

Azhar, S., Nadeem, A., Mok, J. Y., & Leung, B. H. (2008). *Building Information Modeling (BIM): A new paradigm for visual interactive modeling and simulation for construction projects.* Paper presented at the Proc., First International Conference on Construction in Developing Countries.

Becker, S., Bryman, A., & Ferguson, H. (2012). *Understanding research for social policy and social work: themes, methods and approaches*: policy press.

Benbasat, I., Goldstein, D. K., and Mead, M. (1987). he Case Research Strategy in Studies of Informatioin Systems. *MIS Quarterly*, 369-386.

Bloomberg, J. (Producer). (2018, April 29). forbes.com. *digitization-digitalization-and-digital-transformation-confuse-them-at-your-peril*. Retrieved from https://www.forbes.com/sites/jasonbloomberg/2018/04/29/digitization-digitalization-and-digital-transformation-confuse-them-at-your-peril/?sh=715435882f2c

Bowen, G. A. (2009). Document analysis as a qualitative research method. *Qualitative research journal, 9*(2), 27-40.

Chen, K., & Lu, W. (2019). Bridging BIM and building (BBB) for information management in construction: The underlying mechanism and implementation. *Engineering, Construction and Architectural Management*.

Clarke, V., & Braun, V. (2017). Thematic analysis. *The journal of positive psychology, 12*(3), 297-298.

Cost, A. I. P. I. (2012). Problem Statement.

Dallasega, P., Rauch, E., & Frosolini, M. (2018). A Lean Approach for Real-Time Planning and Monitoring in Engineer-to-Order Construction Projects. *Buildings, 8*(3), 38. Retrieved from https://www.mdpi.com/2075-5309/8/3/38

Davis, F. D., Granić, A., & Marangunić, N. (2023). The technology acceptance model 30 years of TAM. *Technology*.

De Reuver, M., Sørensen, C., & Basole, R. C. (2018). The digital platform: a research agenda. *Journal of information technology, 33*(2), 124-135.

Denzin, N. K., & Lincoln, Y. S. (2011). *The Sage handbook of qualitative research*: sage.

Denzin, N. K., Lincoln, Y. S., & Giardina, M. D. (2006). Disciplining qualitative research. *International journal of qualitative studies in education, 19*(6), 769-782.

Eastman, C. M., Teicholz, P., Sacks, R., & Liston, K. (2011). *BIM handbook: A guide to building information modeling for owners, managers, designers, engineers and contractors*: John Wiley & Sons.

Edition, P. S. (2018). A guide to the project management body of knowledge. *Project Management Institute. Pensylvania*.

Feise, P., & Graf von Hatzfeldt Trachenberg, P. P. M. (2019). The Effects of Digitalization on Managing Project Teams. In.

Fitzgerald, M., Kruschwitz, N., Bonnet, D., & Welch, M. (2014). Embracing digital technology: A new strategic imperative. *MIT sloan management review, 55*(2), 1.

Gabriele Hofinger, J., Alfnes, E., Kjersem, K., & Andersen, B. (2019). Lean project planning and control: empirical investigation of ETO projects. [Lean project planning and control]. *International journal of managing projects in business, 12*(4), 1120-1145. doi:https://doi.org/10.1108/IJMPB-08-2018-0170

Grant, C., & Osanloo, A. (2014). Understanding, selecting, and integrating a theoretical framework in dissertation research: Creating the blueprint for your “house”. *Administrative Issues Journal, 4*(2), 4.

https://www.gartner.com. *Gartner Glossary*. Retrieved from https://www.gartner.com/en/glossary

Ikuabe, M., Aghimien, D., Aigbavboa, C., & Oke, A. (2020). *Exploring the adoption of digital technology at the different phases of construction projects in South Africa.* Paper presented at the Proceedings of the International Conference on Industrial Engineering and Operations Management.

Ismail, M. H., Khater, M., & Zaki, M. (2017). Digital business transformation and strategy: What do we know so far. *Cambridge Service Alliance, 10*(1), 1-35.

Kallinikos, J., Aaltonen, A., & Marton, A. (2013). The ambivalent ontology of digital artifacts. *MIS Quarterly*, 357-370.

Kim, C., Park, T., Lim, H., & Kim, H. (2013). On-site construction management using mobile computing technology. *Automation in Construction, 35*, 415-423.

Koskela, L. (2000). *An exploration towards a production theory and its application to construction*: VTT Technical Research Centre of Finland.

Köster, K. (2009). *International project management*: Sage.

Kozarkiewicz, A. (2020). General and Specific: The Impact of Digital Transformation on Project Processes and Management Methods. *Foundations of Management, 12*(1), 237-248. doi:doi:10.2478/fman-2020-0018

Kozarkiewicz, A. (2020). General and Specific: The Impact of Digital Transformation on Project Processes and Management Methods. *Foundations of Management, Vol.12*, 237-248. .

Lamacchia, D., Chowdhury, Khairul, and Omar Sharif. (2020). "A Novel Way of Project Management to Ensure Engagement for Successful Digital Transformation..". *https://onepetro.org*. Retrieved from https://doi.org/10.4043/30860-MS

Lee, K.-T., Park, S.-J., & Kim, J.-H. (2023). Comparative analysis of managers' perception in overseas construction project risks and cost overrun in actual cases: A perspective of the Republic of Korea. *Journal of Asian Architecture and Building Engineering, 22*(4), 2291-2308.

Malacarne, G., Toller, G., Marcher, C., Riedl, M., & Matt, D. T. (2018). INVESTIGATING BENEFITS AND CRITICISMS OF BIM FOR CONSTRUCTION SCHEDULING IN SMES: AN ITALIAN CASE STUDY. *International Journal of Sustainable Development and Planning, 13*(1), 139-150. doi:https://doi.org/10.2495/SDP-V13-N1-139-150

Marnewick, C., & Marnewick, A. L. (2022). Digitalization of project management: Opportunities in research and practice. *Project Leadership and Society, 3*, 100061.

Matt, C., Hess, T., & Benlian, A. (2015). Digital transformation strategies. *Business & information systems engineering, 57*, 339-343.

Moroz, M. (2018). Acceleration of digital transformation as a result of launching programs financed from public funds: Assessment of the implementation of the operational program digital Poland. *Foundations of Management, 10*(1), 59-74.

Newman, C., Edwards, D., Martek, I., Lai, J., Thwala, W. D., & Rillie, I. (2021). Industry 4.0 deployment in the construction industry: a bibliometric literature review and UK-based case study. *Smart and Sustainable Built Environment, 10*(4), 557-580.

Nicholas, J. M., & Steyn, H. (2017). *Project management for engineering, business and technology*: Taylor & Francis.

Nikmehr, B., Hosseini, M. R., Martek, I., Zavadskas, E. K., & Antucheviciene, J. (2021). Digitalization as a strategic means of achieving sustainable efficiencies in construction management: A critical review. *Sustainability, 13*(9), 5040.

Oesterreich, T. D., & Teuteberg, F. (2016). Understanding the implications of digitisation and automation in the context of Industry 4.0: A triangulation approach and elements of a research agenda for the construction industry. *Computers in industry, 83*, 121-139. doi:10.1016/j.compind.2016.09.006

Pan, Y., & Zhang, L. (2021). Roles of artificial intelligence in construction engineering and management: A critical review and future trends. *Automation in Construction, 122*, 103517.

Parviainen, P., Tihinen, M., Kääriäinen, J., & Teppola, S. (2017). Tackling the digitalization challenge: how to benefit from digitalization in practice. *International journal of information systems and project management, 5*(1), 63-77.

Prebanić, K. R., & Vukomanović, M. (2021). Realizing the need for digital transformation of stakeholder management: A systematic review in the construction industry. *Sustainability, 13*(22), 12690.

Projectmanager.com. *Projectmanager.comguides/project-management*. Retrieved from https://www.projectmanager.com/guides/project-management

Rahman, M. M. (2023). Sample Size Determination for Survey Research and Non-Probability Sampling Techniques: A Review and Set of Recommendations. *Journal of Entrepreneurship, Business and Economics, 11*(1), 42-62.

Reis, J., Amorim, M., Melão, N., & Matos, P. (2018). Digital transformation: a literature review and guidelines for future research. *Trends and Advances in Information Systems and Technologies: Volume 1 6*, 411-421.

Rowley, J., & Slack, F. (2004). Conducting a literature review. *Management research news, 27*(6), 31-39.

Sacks, R., Koskela, L., Dave, B. A., & Owen, R. (2010). Interaction of lean and building information modeling in construction. *Journal of construction engineering and management, 136*(9), 968-980.

Snyman, P. (2022). Digitisation Process. In *Digitisation Process; Digital Governance*. Hartebeespoort, North West, South Africa: Pierre Snyman.

Tariq, J., & Gardezi, S. S. S. (2023). Study the delays and conflicts for construction projects and their mutual relationship: A review. *Ain Shams Engineering Journal, 14*(1), 101815.

Um, S., Yoo, Y., Wattal, S., Kulathinal, R., & Zhang, B. (2013). The architecture of generativity in a digital ecosystem: A network biology perspective.

Union, A. (2020). The Digital Transformation Strategy for Africa (2020-30).

Walker, A. (2015). *Project management in construction*: John Wiley & Sons.

Windapo, A. O. (2021). The construction industry transformation and the digital divide: Bridging the gap. *South African Journal of Science, 117*(7-8), 1-4.

Yoo, Y., Boland Jr, R. J., Lyytinen, K., & Majchrzak, A. (2012). Organizing for innovation in the digitized world. *Organization science, 23*(5), 1398-1408.

Zhang, Z. (2022). The Influence of Digital Transformation on Intelligent Design of Architecture. *Wireless communications and mobile computing, 2022*, 1-6. doi:10.1155/2022/2469364

APPENDIX A PARTICIPANT INFORMATION SHEET

Dear Sir / Madam,

My name is Pierre Snyman, and I am pursuing a master's degree in MMDB at the University of the Witwatersrand in Johannesburg. Dr Tebogo Sethibe guided me as my academic supervisor. My research focuses on qualitative aspects of Digital Transformation Technologies.

The study title: The role of digital transformation within construction project management in South Africa

I am inviting you to participate in an interview or complete a questionnaire related to this study. To help you prepare, I will send the interview questions in advance. If you choose to participate, the expected duration of this activity will be approximately 10 to 20 minutes. The interview or research activity will be conducted online, through Google Meet or Teams, at a time that aligns with your availability.

With your consent, I plan to audio/video record the interview session. I assure you that this data will be securely stored on a hard drive, which will be kept in a secure location, and will be retained for a maximum of four years, after which it will be deleted. I will be the sole individual with access to this data.

As part of the interview, I will need to enquire about personal details, such as your professional experience and current role. Please be assured that all aspects of the interview will be kept confidential and anonymous. In any published results or shared data, your identity will remain protected. Additionally, with your consent, anonymised data may be made available to other researchers, but it will not contain your name or any identifying information.

Participation in this research is entirely voluntary. You have the freedom to decide whether to participate, to decline any questions you are uncomfortable answering, and to withdraw at any point without penalty. There will be no direct benefits to you for participating in this study, and you will not incur any costs nor be compensated for your time.

The risks associated with this study are minimal and equivalent to those encountered in everyday life. You may stop and resume the interview at any time, based on your comfort.

Upon completion, this study will be compiled into a research report that will be made publicly available through the university library's website. Should you be interested, I would be more than happy to provide you with a summary of this report?

If you have any questions or would like further information, either now or in the future, please feel free to reach out to Dr Tebogo Sethibe or me at the contact details provided below. The University Human Research Ethics Committee (non-medical) is available for consultation if you have any ethical concerns regarding this research study.

Thank you for considering this invitation.

Yours sincerely,

Pierre Snyman
Master's Student, MMDB
University of the Witwatersrand, Johannesburg

telephone +27(0) 11 717 1408, email hrecnon-medical@wits.ac.za.

Researcher:
Pierre Snyman 2527205@stdents.wits.ac.za / +27645185887

Supervisor:
Dr. Tebogo Sethibe tebogo.sethibe@wits.ac.za / +27765107529

APENDIX B PARTICIPANT AGREEMENT FORM

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

Title of Project: The role of digital transformation within construction project management in South Africa

Name of Researcher: Pierre Snyman

I, _____, agree to participate in this research project conducted by Pierre Snyman, a Master's student at the University of the Witwatersrand, Johannesburg.

I agree to the following:

(Please circle the relevant options below)

The research study was explained to me. I understand what this study is about.

YES / NO

I understand that I can volunteer to take part in the study.

YES / NO

I agree that the interview may be audio/video recorded by Pierre Snyman.

YES / NO

I agree that direct quotations from my interview may be used by Pierre Snyman in his research report/manuscript/thesis, while maintaining my anonymity.

YES / NO

I agree that my participation will remain anonymous (Pierre Snyman will not use my name or other identifying data in his research report/manuscript/thesis).

YES / NO

I agree that other researchers may use the information I provide in my interview (pending their own ethics clearance being obtained), but my name and any personal information will not be used or passed on.

YES / NO

_____ (signature)

_____ (name of participant)

_____ (date)

PSnyman_____ (signature)

Pierre Snyman_____ (name of researcher/person seeking consent: Pierre Snyman)

18August 2023_____ (date)

Please note: By signing this consent form, you are not waiving any of your legal rights as a participant in this research study.

APENDIX C INTERVIEW GUIDE

Main Objective: Current State of Digitalisation
Extent of Digital Integration
- How extensively is digitalisation integrated into the construction PMP phase in SA?
- Specifically, what planning software tools, such as CCS MSP and Primavera P6, are commonly used?
- How do these tools contribute to enhancing efficiency and effectiveness?
Potential for Further Digitisation
- In what ways can further digitisation be implemented in the planning phase to enhance efficiency and effectiveness?
- Are there specific areas or processes that benefit most from additional digitalisation?
Objective 1: Challenges of Digitalisation
Cultural Adjustments for Digitalisation
- What cultural adjustments are required within construction organisations to successfully implement digitalisation in the planning phase?
- How do project managers navigate and overcome any resistance to change related to digital adoption?
Role of Regulatory Reforms
- How do regulatory reforms role the implementation of digital tools and techniques in construction project planning?
- What measures are taken to ensure compliance and alignment with regulatory requirements?
Advanced Collaboration Methods and Challenges
- What advanced collaboration methods have been adopted during the DT process?
- What challenges do they present in the planning phase of construction projects?
- How are these challenges addressed to foster effective collaboration among project stakeholders?
Addressing the DD
- How does the DD affect the successful implementation of digitalisation in the planning phase?
- What strategies are employed to bridge the gap and ensure equitable access to digital tools and technologies among all project stakeholders?
Objective 2: Opportunities for Digitalisation
Improved Communication via Digitalisation
- How does digitalisation in the planning phase improve communication among project stakeholders?
- What tools or platforms have successfully facilitated seamless communication and information sharing?
Enhanced Decision-Making Processes
- In what ways does digitalisation enhance decision-making processes in construction project planning?
- Can you explain how real-time data and analytics have contributed to more informed and strategic decision-making?
Increased Productivity
- How has digitalisation increased productivity during the planning phase of construction projects?
- What practices or tools have been adopted to streamline workflows and optimise resource allocation?
Accuracy and Efficiency in Planning
- How does digitalisation contribute to more accurate and efficient planning in construction projects?
- What techniques or software features have proven particularly beneficial in improving planning accuracy and minimising potential disruptions?
Objective 3: Leveraging Digitalisation for Improved Outcomes
Strategies for Improved Project Outcomes
- Based on experiences in the SACI, what successful strategies have been employed to leverage the opportunities presented by digitalisation for improved project outcomes?
- How can these strategies be adapted and applied in various project contexts?
Key Learnings and Best Practices
- What key learnings or best practices can be drawn from successful implementation stories in the construction PMP phase?
- How can these lessons be integrated into future projects to maximise the benefits of digitalisation?

APENDIX D LIST OF CODE

Table 8: Appendix D List of code

Code Number	Code Title	Description
1	Digital Tool Adoption	Adoption of digital tools like CCS MSP, Primavera P6, BIM, etc., in CPM.
2	Efficiency Improvement	Instances where DT has led to increased efficiency in project management.
3	Effectiveness Enhancement	How digital tools have enhanced the effectiveness of project management.
4	Cultural Resistance	Resistance to DT due to cultural factors within organisations.
5	Age-Related Adaptation	Adaptation to DT across different age groups in the CI.
6	Training and Skill Development	Need for and role of training programs in facilitating the use of digital tools.
7	Policy and Regulatory Frameworks	Role of policies and regulations in shaping DT in construction.
8	DD Role	Role of the DD, influenced by age, socioeconomic status, and skill gaps.
9	Collaboration Methods	Use of advanced collaboration methods like VR/AR, cloud-based tools in projects.
10	Stakeholder Communication	Role of DT on communication with stakeholders.
11	Project Success Factors	Factors contributing to the success of construction projects in the context of digital transformation.
12	Legacy Systems Challenges	Challenges posed by existing legacy systems in embracing digital transformation.
13	Innovation in Construction	Instances where digital tools have led to innovative practices in project management.
14	Resource Management	Role of digital tools on the management of resources in construction projects.
15	Risk Management	Role of digital tools in managing and mitigating risks in construction projects.
16	User Experience with Digital Tools	Personal experiences and opinions regarding the use of digital tools.
17	Future Trends in Digital Transformation	Predictions about future developments in digital transformation.
18	Sustainability and Digital Tools	How DT aligns with sustainability goals in construction.
19	Barriers to Digital Adoption	Barriers faced by organisations in adopting DTEC.
20	Role of COVID-19	Role of the COVID-19 pandemic on DT in construction, if relevant.

APENDIX D- ETHICS APPROVAL

Graduate School of Business Administration
University of the Witwatersrand, Johannesburg

Wits Business School Ethics Committee
Constituted under the University Human Research Ethics Committee (Non-Medical)

Ethics Clearance Certificate

Ethics protocol number: WBS/DB2527205/997
This certificate is only valid with a legitimate ethics protocol number and signed by the Researcher (below)

Project title	The Influence of Digital Transformation within Construction Project Management in South Africa
Investigator / Researcher	Mr Pierre Snyman
Nature of Project	MM (Digital Business)
Decision of the Committee	Approved, provided stakeholders and participants are guaranteed confidentialty.
Issue Date of Certificate	22/08/2023
Expiry date	Date of submission of the project / research report
Chairperson	Dr Pius Oba ☎ +27 11 717 3976 +27 82 733 6587 pius.oba@wits.ac.za

Declaration by Researcher

One copy must be signed by the Researcher and returned to the Chairperson of the Wits Business School Ethics Committee.

I fully understand the conditions under which I am authorized to carry out the abovementioned research and I guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I undertake to resubmit the protocol to the Committee.

Signature Pierre Snyman 2527205 — Date: 11 Sept 2023

APENDIX E- TURNITIN REPORT

The role of digital transformation within construction project management in South Africa-2.docx

ORIGINALITY REPORT

8%	7%	5%	%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	wiredspace.wits.ac.za Internet Source	1%
2	iceb.johogo.com Internet Source	<1%
3	stec.univ-ovidius.ro Internet Source	<1%
4	umpir.ump.edu.my Internet Source	<1%
5	asocsa.org Internet Source	<1%
6	bilselkongreleri.com Internet Source	<1%
7	www.citcglobal.com Internet Source	<1%
8	libweb.kpfu.ru Internet Source	<1%
9	repository.nwu.ac.za Internet Source	<1%

10	www.researchgate.net Internet Source	<1 %
11	www.iieta.org Internet Source	<1 %
12	savoirs.usherbrooke.ca Internet Source	<1 %
13	trepo.tuni.fi Internet Source	<1 %
14	jultika.oulu.fi Internet Source	<1 %
15	journals.uj.ac.za Internet Source	<1 %
16	www2.uwe.ac.uk Internet Source	<1 %
17	Kyung-Tae Lee, Jin-Bin Im, Sang-Jun Park, Ju-Hyung Kim. "Identifying improvements priorities in daycare centre space performance from teachers' perspectives: application of importance–performance analysis and structural equation modelling", Engineering, Construction and Architectural Management, 2023 Publication	<1 %
18	iglc.net Internet Source	<1 %

19	strategicjournals.com Internet Source	<1 %
20	s3-ap-southeast-2.amazonaws.com Internet Source	<1 %
21	Dawes, Daniel Henry. "A Qualitative Exploration of the Transformational Learning Experiences of Educational Leaders Who Transitioned From Traditional to Non-Traditional Higher Education and Training Programs", Delaware State University, 2023 Publication	<1 %
22	core.ac.uk Internet Source	<1 %
23	sciendo.com Internet Source	<1 %
24	www.aubea.org Internet Source	<1 %
25	nzbers.massey.ac.nz Internet Source	<1 %
26	Temidayo Adefioye. "Chapter 5 The Engineering Culture", Springer Science and Business Media LLC, 2023 Publication	<1 %
27	dora.dmu.ac.uk Internet Source	<1 %

28	eprints.nottingham.ac.uk Internet Source	<1 %
29	eprints.utm.my Internet Source	<1 %
30	usir.salford.ac.uk Internet Source	<1 %
31	www.tandfonline.com Internet Source	<1 %
32	eprints.utar.edu.my Internet Source	<1 %
33	scholar.mzumbe.ac.tz Internet Source	<1 %
34	"Intelligent Systems, Business, and Innovation Research", Springer Science and Business Media LLC, 2024 Publication	<1 %
35	researchspace.ukzn.ac.za Internet Source	<1 %
36	di.uqo.ca Internet Source	<1 %
37	oapub.org Internet Source	<1 %
38	uir.unisa.ac.za Internet Source	<1 %

39	www.diva-portal.se Internet Source	<1 %
40	5dok.net Internet Source	<1 %
41	ideas.repec.org Internet Source	<1 %
42	oresta.org Internet Source	<1 %
43	prism.ucalgary.ca Internet Source	<1 %
44	www.alexandria.unisg.ch Internet Source	<1 %
45	cibworld.org Internet Source	<1 %
46	jemi.edu.pl Internet Source	<1 %
47	dspace.plymouth.ac.uk Internet Source	<1 %
48	journals.bilpubgroup.com Internet Source	<1 %
49	pure.uvt.nl Internet Source	<1 %
50	samples.freshessays.com Internet Source	<1 %

51	spiral.imperial.ac.uk Internet Source	<1 %
52	www.amazoniainvestiga.info Internet Source	<1 %
53	www.tara.tcd.ie Internet Source	<1 %
54	Emelogu, Charles Ikechi. "Digital Strategies to Manage and Transform Maritime Business Operation in Lagos, Nigeria", Walden University, 2022 Publication	<1 %
55	Samuel Chukwujindu Nwokolo, Rubee Singh, Shahbaz Khan, Anil Kumar, Sunil Luthra. "Africa's Path to Net-Zero", Springer Science and Business Media LLC, 2023 Publication	<1 %
56	hdl.handle.net Internet Source	<1 %
57	lucris.lub.lu.se Internet Source	<1 %
58	erepository.uonbi.ac.ke:8080 Internet Source	<1 %
59	publikasi.mercubuana.ac.id Internet Source	<1 %

60	Gonzalo Go´ mez-Bengoechea, Juan Jung. "The Matthew effect: Evidence on firms' digitalization distributional effects", Technology in Society, 2023 Publication	<1 %
61	cdr.lib.unc.edu Internet Source	<1 %
62	lutpub.lut.fi Internet Source	<1 %
63	onepetro.org Internet Source	<1 %
64	Josefine Ernestine Latupeirissa, Hermin Arrang. "Sustainability factors of building information modeling (BIM) for a successful construction project management life cycle in Indonesia", Journal of Building Pathology and Rehabilitation, 2024 Publication	<1 %
65	ris.utwente.nl Internet Source	<1 %
66	ted.uek.krakow.pl Internet Source	<1 %
67	www.cream.my Internet Source	<1 %
68	KHRITISH SWARGIARY. "Digital Transformation and Economic Growth in	<1 %

	Post-Pandemic India: A Comprehensive Study", Research Square Platform LLC, 2023 Publication	
69	amazoniainvestiga.info Internet Source	<1 %
70	cebr.vse.cz Internet Source	<1 %
71	mdpi-res.com Internet Source	<1 %
72	opus.lib.uts.edu.au Internet Source	<1 %
73	repository.up.ac.za Internet Source	<1 %
74	salford-repository.worktribe.com Internet Source	<1 %
75	vdoc.pub Internet Source	<1 %
76	www.leanconstruction.dk Internet Source	<1 %
77	Pohmalay, Saanthi. "Optimum Time Management of First Pre-Flight Departure by LCC Operators at KLIA2", University of Malaya (Malaysia), 2023 Publication	<1 %

78	Stout, Blaine David. "Big and Small Data for Value Creation and Delivery: Case for Manufacturing Firms.", The University of Toledo, 2021 Publication	<1 %
79	etd.hu.edu.et Internet Source	<1 %
80	www.coursehero.com Internet Source	<1 %
81	Samra, Rasha Mohamed Naser Abou. "Project Complexity, Project Managers' Knowledge Creation Styles, and Project Performance", The British University in Dubai, 2023 Publication	<1 %
82	netviz.com Internet Source	<1 %
83	Harding, Nuala | Trowler, Paul. "Reframing Pedagogic Practices Using a Social Practice Perspective to Explain and Inform Change in the Irish Technological Higher Education Sector", Lancaster University (United Kingdom), 2023 Publication	<1 %
84	etheses.lib.ntust.edu.tw Internet Source	<1 %
85	research.bangor.ac.uk Internet Source	

		<1%
86	Harper, Alison. "A Hybrid Modelling Framework for Real-Time Decision-Support for Urgent and Emergency Healthcare", University of Exeter (United Kingdom), 2023 Publication	<1%
87	ro.ecu.edu.au Internet Source	<1%
88	scholar.ufs.ac.za Internet Source	<1%
89	tml.nul.ls Internet Source	<1%
90	Ahmed, Sahra. "Choosing a Life One Has Reason to Value: The Role of Education in Cultivating Educational Capabilities in Kakuma Refugee Camp in Northwestern Kenya", The Ohio State University, 2023 Publication	<1%
91	Omar, Hany Salah. "Solutions for the UAE Architecture, Engineering, and Construction (AEC) Industry to Mandate Building Information Modeling (BIM)", The British University in Dubai, 2023 Publication	<1%
92	phd.lib.uni-corvinus.hu Internet Source	<1%

93	www.futurelinkgroup.co.uk Internet Source	<1 %
94	www.researchpublish.com Internet Source	<1 %
95	Alhyari, Anas Mohammad Ahmad. "The Integration of Sustainability in Project Management and its Impact on UAE Construction Projects Performance", The British University in Dubai, 2023 Publication	<1 %
96	content.sciendo.com Internet Source	<1 %
97	ijpsat.ijsht-journals.org Internet Source	<1 %
98	jssidoi.org Internet Source	<1 %
99	repositorio.iscte-iul.pt Internet Source	<1 %
100	science.osti.gov Internet Source	<1 %
101	www.legalkitabevi.com Internet Source	<1 %
102	www.theseus.fi Internet Source	<1 %

103	"Proceedings of the 3rd International Civil Engineering and Architecture Conference", Springer Science and Business Media LLC, 2024 Publication	<1 %
104	Asmita Pendse, Arpana G. Inman. "International student-focused counseling research: A 34-year content analysis", Counselling Psychology Quarterly, 2016 Publication	<1 %
105	aubea.org Internet Source	<1 %
106	dergipark.org.tr Internet Source	<1 %
107	edepositireland.ie Internet Source	<1 %
108	espace.curtin.edu.au Internet Source	<1 %
109	etalpykla.vilniustech.lt Internet Source	<1 %
110	libserv5.tut.ac.za:7780 Internet Source	<1 %
111	odr.chalmers.se Internet Source	<1 %
112	pearl-prod.plymouth.ac.uk Internet Source	

		<1 %
113	propertibazar.com Internet Source	<1 %
114	repository.nida.ac.th Internet Source	<1 %
115	studenttheses.uu.nl Internet Source	<1 %
116	vital.seals.ac.za:8080 Internet Source	<1 %
117	www.mdpi.com Internet Source	<1 %
118	www.ros-test.hw.ac.uk Internet Source	<1 %
119	1library.net Internet Source	<1 %
120	Alan Brown, Jerry Fishenden, Mark Thompson. "Digitizing Government", Springer Science and Business Media LLC, 2014 Publication	<1 %
121	Bernardo Nicoletti. "Insurance 4.0", Springer Science and Business Media LLC, 2021 Publication	<1 %
122	Bogdan Ubiparipović, Predrag Matković, Veselin Pavlićević. "Key activities of digital	<1 %

business transformation process", Strategic Management, 2022
Publication

123 Gono, Owen P.. "Sustainable Land Management and Smallholder Farmers in Zimbabwe", Walden University, 2020 <1%
Publication

124 Hart, Andrew John. "A Critical Analysis of Sustainable Resettlement in the Context of International Development and Hydropower", University of Johannesburg (South Africa), 2022 <1%
Publication

125 Kangala, Anand. "Toward a Synergetic Organization: The Role of Dynamic Capabilities, Social Capital, and Digital Maturity in Organizational Resilience during Disruption", The University of North Carolina at Charlotte, 2023 <1%
Publication

126 Khalid K. Naji, Murat Gunduz, Fahid Alhenzab, Hamed Al-Hababi, Abdulla Al-Qahtani. "A Systematic Review of the Digital Transformation of the Building Construction Industry", IEEE Access, 2024 <1%
Publication

127 Le, Ngoc Quyet. "Building Information Modelling (BIM) Adoption and <1%

Implementation: Interaction Between BIM Specialists and Non-BIM Specialists in Vietnam", University of Technology Sydney (Australia), 2023
Publication

128	Marcos A. M. Primo, Frank L. DuBois, Maria de L. M. C. de Oliveira, Elidiane S. D. de M. Amaro, Daniela D. N. Moser. " Lean manufacturing implementation in time of crisis: the case of ", Production Planning & Control, 2020 Publication	<1 %
129	Maulana, Fauzan Reza. "A Study on the Current State and Success Factors of Construction Technology Startups", Stanford University, 2023 Publication	<1 %
130	Mohammad Omar Aburumman, Rateb Sweis, Ghaleb J. Sweis. "Investigating building information modelling (BIM) and lean construction: the potential BIM-lean interactions synergy and integration in the Jordanian construction industry", International Journal of Lean Six Sigma, 2023 Publication	<1 %
131	Peter C. Verhoef, Thijs Broekhuizen, Yakov Bart, Abhi Bhattacharya, John Qi Dong, Nicolai Fabian, Michael Haenlein. "Digital	<1 %

transformation: A multidisciplinary reflection and research agenda", Journal of Business Research, 2021
Publication

132	Raksha Agrawal, Alok Yadav, Rajiv Kumar Garg, Anish Sachdeva. "Chapter 12 Building a Greener Supply Chain with Blockchain: A Review and Future Research Directions", Springer Science and Business Media LLC, 2024 Publication	<1 %
133	Sloan-Wilhelmi, LaMonica. "More Benefits Than Barriers: Multigenerational Mentoring and the Impact on Career Advancement and Leadership Development", North Carolina Agricultural and Technical State University, 2023 Publication	<1 %
134	Stewart, Cheryl P.. "Evaluating Organizational Success of an AI-Based Recommender System at a Two-Year Higher Education Institution", Franklin University, 2023 Publication	<1 %
135	Sutap Kumar Ghosh. "A search of investors' trading practices in the Bangladesh capital market", LBS Journal of Management & Research, 2023 Publication	<1 %

136	Thuy Duong Oesterreich, Frank Teuteberg. "Understanding the implications of digitisation and automation in the context of Industry 4.0: A triangulation approach and elements of a research agenda for the construction industry", Computers in Industry, 2016 Publication	<1 %
137	Yücel Erol, Gülşen Kirpik. "Sustainable Digital Business Strategies", Emerald, 2022 Publication	<1 %
138	arno.uvt.nl Internet Source	<1 %
139	balsa.man.poznan.pl Internet Source	<1 %
140	beta.emiratesnbd.com Internet Source	<1 %
141	bia.unibz.it Internet Source	<1 %
142	birmingham.elsevierpure.com Internet Source	<1 %
143	collab.northumbria.ac.uk Internet Source	<1 %
144	dk.um.si Internet Source	<1 %

145	dl.lib.uom.lk Internet Source	<1 %
146	dokumen.pub Internet Source	<1 %
147	dspace.nwu.ac.za Internet Source	<1 %
148	eprints.brighton.ac.uk Internet Source	<1 %
149	eprints.uklo.edu.mk Internet Source	<1 %
150	epubs.scu.edu.au Internet Source	<1 %
151	erepository.uonbi.ac.ke Internet Source	<1 %
152	etd.cput.ac.za Internet Source	<1 %
153	etd.uwc.ac.za Internet Source	<1 %
154	icitee.asu.edu.bh Internet Source	<1 %
155	ijaems.com Internet Source	<1 %
156	ims.atu.ac.ir Internet Source	<1 %

157	ir.lib.uwo.ca Internet Source	<1 %
158	kclpure.kcl.ac.uk Internet Source	<1 %
159	myassignmenthelp.com Internet Source	<1 %
160	open.uct.ac.za Internet Source	<1 %
161	orca.cardiff.ac.uk Internet Source	<1 %
162	press.um.si Internet Source	<1 %
163	repositorio.uninove.br Internet Source	<1 %
164	research-information.bris.ac.uk Internet Source	<1 %
165	research-repository.griffith.edu.au Internet Source	<1 %
166	researchmgt.monash.edu Internet Source	<1 %
167	s3-ap-southeast-1.amazonaws.com Internet Source	<1 %
168	ue-varna.bg Internet Source	<1 %

169	uis.brage.unit.no Internet Source	<1 %
170	ww.jemi.edu.pl Internet Source	<1 %
171	www.emeraldinsight.com Internet Source	<1 %
172	www.ros.hw.ac.uk Internet Source	<1 %
173	www.scielo.br Internet Source	<1 %
174	Agyeman Addai, Daniel. "A Cloud Based Framework for Managing Requirements Change in Global Software Development.", University of Cincinnati, 2020 Publication	<1 %
175	Bartlett, Trisha. "Privacy and Security Management Practices of Emerging Technologies: Internet of Things.", Robert Morris University, 2020 Publication	<1 %
176	Reem Alshahrani, Manideep Yenugula, Haneen Algethami, Fares Alharbi et al. "Establishing the fuzzy integrated hybrid MCDM framework to identify the key barriers to implementing artificial intelligence-enabled	<1 %

sustainable cloud system in an IT industry", Expert Systems with Applications, 2024
Publication

177	scholarworks.waldenu.edu Internet Source	<1 %
178	uwe-repository.worktribe.com Internet Source	<1 %
179	"Creating a Roadmap Towards Circularity in the Built Environment", Springer Science and Business Media LLC, 2024 Publication	<1 %
180	Faro, Benjamin. "Continuous Transformation of Government Agencies in the Digital Era: A Technological and Non-Technological Assessment", University of Technology Sydney (Australia), 2023 Publication	<1 %
181	Horton, Stephanie Michelle. "Educator's Perceptions of the Role of Students' Dialect Density in Mastering Foundational Skills: A Qualitative Case Study", Northcentral University, 2023 Publication	<1 %
182	Yasir Tanveer, Qi Jiayin, Umair Akram, Anum Tariq. "Antecedents of frontline manager handling relationship conflicts", International Journal of Conflict Management, 2017 Publication	<1 %