

Development of a project management framework for the digitalisation of mining operations

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Background: The topics of digitalisation and project management have received increasing attention in the 21st century due to the important role they play in organisational success.

Objectives: The article makes use of an exploratory approach to determine the push factors and challenges disrupting digitalisation as well as the key success factors that influence the use of digitalisation to support project managers in a mining organisation.

Method: A qualitative approach was undertaken in this study, categorised by an interpretive lens. Twelve authoritative capacity participants were purposively selected and interviewed face-to-face to identify the subjective nature of reality and phenomena.

Results: The study findings strongly suggest that, in order to improve project management digitalisation within the organisation and improve organisational efficiency, consideration should be given to the push factors for digitalisation. However, challenges such as resistance to change and infrastructure limitations disrupt the digitalisation process. The findings also revealed that key success factors include leadership and organisational support, which should also be taken into account when implementing digitalisation.

Conclusion: It can be concluded that the aim of the study has been met and the research objective reached.

Contribution: Given the importance of project management digitalisation, especially in the mining sector, the study makes a unique and meaningful contribution through empirically determined findings. Specifically, this study contributes to the body of knowledge by providing influential factors for digitalising project management. In addition, the development of the conceptual project management framework provides sound contributions to further advance the field of study.

Keywords: digitalisation; mining industry; qualitative approach; project management; organisational performance; South Africa.

Introduction

Digitalisation has continued to gain recognition on account of its increasing importance in the business world. The 21st century has seen more attention given to the topics of digitalisation and project management because of the important role they play in business success (Branca et al. 2020). A notable number of mining companies have been quick to adopt digital technologies, but some are still showing evidence of resistance as they continue to use outdated technology. A study conducted by Duarte, Rodrigues and Baptista (2021) revealed that more than 60% of the mining companies in the United States (USA) have adopted or have plans to adopt a digital-first strategy. In addition, a study done by Tyuleneva (2020) revealed that more than 70% of the mining companies in Europe have digitalised their project management processes, harnessing Fourth Industrial Revolution (4IR) technologies such as artificial intelligence (AI), machine learning (ML) and big data analytics. Kinnunen et al.'s (2022) study revealed that most governments in Asia have started rolling out initiatives to help their mining companies fully adopt the digitalisation of project management. These studies show that the digitalisation of project management in the mining sector is unstoppable, and in order for mining-sector organisations to remain competitive and sustainable, they should move towards digitalisation.

However, the mining sectors in most developing countries are still in their infancy when it comes to the implementation of various digital technologies in managing mining projects (Pan & Zhang 2021).

According to Wilson (2019), some African mining companies have been slow in digitalising project management in their organisations because of reasons such as high capital requirements, resistance to change, a lack of senior management support, restraining government policies and poor infrastructure. Lehmann (2021) argues that big mining companies in sub-Saharan Africa have made some significant progress in digitalising their project management, but most small and medium-sized mining companies are still struggling. The major causes highlighted for this slow pace in digitalising include financial challenges and a lack of expertise because of a failure to hire the best talent in the industry (Lehmann 2021).

The digitalisation of project management has been significantly impacted by virtualisation (Barnewold & Lottermoser 2020). Virtualisation has made it possible for programmes, data and computer resources to be separated from the underlying hardware, giving project managers more adaptability, scalability and mobility (Guo & Zhang 2022). Consequently, cloud-based project management systems have been more widely used. Teams who are spread out geographically may now work together in real time, access project documents and data from any location, and use on-demand computing capacity to support complicated project processes. Virtualisation has also made it possible to use resources more effectively, manage information technology (IT) infrastructure more simply and strengthen disaster recovery capabilities (Tyuleneva 2020). These developments have all increased the general efficacy and efficiency of digital project management techniques. It is anticipated that virtualisation will play an increasingly important role in facilitating smooth, cloud-based project management as businesses continue to adopt remote and hybrid work models (Smith, Bekker & Marnewick 2021).

While significant strides have been made in understanding the digital transformation of various industries, there remains a conspicuous gap in the literature concerning the specific context of digitalisation within the mining industry of South Africa. Various studies have been conducted on the use of technology in the mining sector (Silase 2018; Smith, Bekker & Marnewick 2021; Zulu, Pretorius & Van der Lingen 2021); however, little is still known about the factors influencing the digitalisation of project management within the mining industry of South Africa. The existing body of research has primarily focussed on broader aspects of digitalisation in the mining sector, often overlooking the nuances and intricacies of this process within a South African context. This study aims to bridge this gap by specifically examining the digitalisation of project management within the South African mining sector. Based on the findings of the study, a conceptual project management framework for the digitalisation of mining operations is developed and presented.

The mining organisation examined in this study operates six large-scale, open-cast and underground thermal coal mines,

predominantly supplying Eskom power stations, and is currently developing the New Largo mine to meet the needs of the adjacent Kusile Power Station. The organisation is therefore running several megaprojects, which require a high degree of efficiency in project management in order to be successful. Some concerns among stakeholders at the mining organisation have revealed that the company is not meeting its milestones of digitalising project management. Some stakeholders have revealed challenges impeding the digitalisation process, such as a lack of senior leadership support and inadequate resources being allocated towards digitalising project management. Therefore, the problem that prompted this study is that the organisation has been slow in digitalising their project management, which has arguably led to many of the organisation's projects being delayed or overrun, costing millions of Rands. This has impacted profits and shareholder confidence in the leadership of the organisation. Should this trend continue, this will result in lower profit margins, eventually resulting in retrenchments and ultimately threatening the sustainability of the organisation. These problems are not unique to this organisation; Zulu et al. (2021) have found that it is a common concern in various mining companies in developing economies.

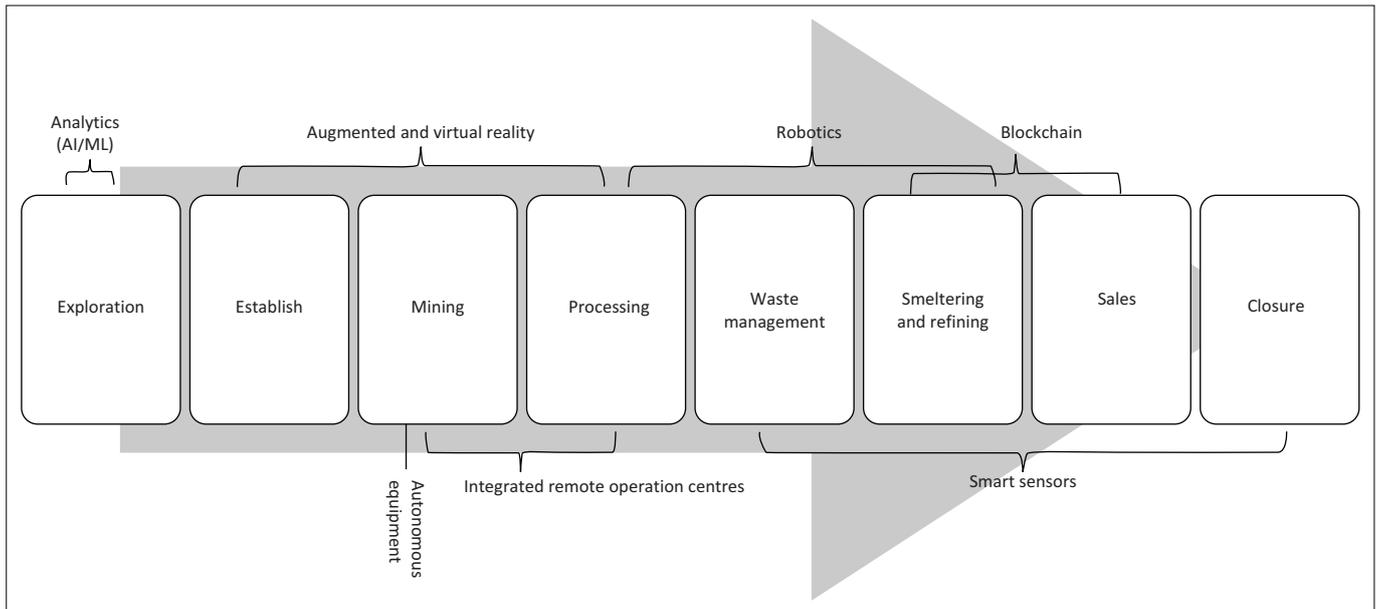
Literature review

In an era defined by rapid technological advancements, the integration of digitalisation into various industries, including the mining industry, has become imperative for sustaining competitiveness and operational excellence.

Digital project management

According to Lehmann (2021), project management can be described as the application of processes, methods, skills, knowledge and experience to achieve defined project objectives based on project acceptance criteria within agreed parameters. The final deliverables of project management are constrained by a finite timescale and budget. According to Sarc et al. (2019), digital project management refers to a streamlined process of managing projects using digital technologies. Digital project management starts with the concept and ends with the total project completion within the defined budget and using the allocated amount of resources (Sarc et al. 2019). Figure 1 depicts how modern digital technologies have impacted and will continue to impact different areas of business in the mining sector.

As shown in Figure 1, new technologies are producing operational changes across the mining value chain, and their use is not necessarily specific to certain activities. For example, smart operations centres are being implemented for extraction and processing operations. Likewise, augmented reality (AR), virtual reality (VR) and digital twins are tools that can enhance the design and construction of mining projects as well as extraction and processing operations (Silase 2018).



Source: Pan, Y. & Zhang, L., 2021, 'A BIM-data mining integrated digital twin framework for advanced project management', *Automation in Construction* 124, 103564. <https://doi.org/10.1016/j.autcon.2021.103564>

AI, Artificial Intelligence; ML, Machine Learning.

FIGURE 1: Digital technologies in the different stages of the mining value chain.

Push factors for the digitalisation of project management within the mining industry

Research has shown that there are several factors that are pushing towards the digitalisation of project management within the mining sector (Aghimien et al. 2021). These factors include the following:

Enhanced competitiveness

Martinez (2019) posits that, in order for mining organisations to remain competitive and sustain their businesses, they need to make sure they update their technology to include 4IR technologies such as the Internet of Things (IoT), robotics, big data and AI. Tyuleneva (2020) argues that an important factor in enhancing competitiveness in this digital era is connectivity, and mining companies must therefore digitalise their project management to enhance connectivity and remain competitive.

Efficient and strategic communication

Cross-team communication is one of the key areas where contemporary digital technologies are reinventing project management (Pan & Zhang 2021). Communication has been described by Guo and Zhang (2022) as the lifeblood of any project. This means that, in order for a project to be successful, there is a strong need for communication to be effective and efficient, which involves embracing digital communication technology (Storey et al. 2024).

Environmental sustainability

Digitalising project management is not only important when it comes to cost and operational efficiency but also for environmental sustainability (Martinez 2019). This includes aiming towards the United Nations Sustainable Development Goals (SDGs), which organisations across the world are

increasingly taking into consideration (Silase 2018). Ribeiro, Amaral and Barros (2021) assert that digital tools in projects can optimise energy usage, minimise waste and emissions, and support responsible resource extraction and management practices.

Challenges disrupting the digitalisation of project management within the mining industry

In spite of the massive adoption of digital project management, there are still various challenges being faced by mining-sector organisations that are affecting the digitalisation of project management (Smith et al. 2021). The most prominent of these challenges are discussed in the following sections.

Shortage of resources

Ribeiro et al. (2021) argue that the technology needed to fully digitalise project management requires high capital investments, which some mining companies in developing countries might not be able to afford. This shortage of resources, according to Guo and Zhang (2022), can be a result of various factors, including poor economic conditions and inequitable allocation of financial resources.

Lack of top leadership support

According to Tyuleneva (2020), some mining companies' failure to digitalise project management is a result of the decisions being made by top leaders who do not support digitalisation. Silase (2018) and Storey (2023) believe that some leaders still think that digital technologies are here to take away their jobs or replace them; hence, they try to resist them by all means.

Lack of industry standards

Tanga et al. (2021) opine that, as with any industry development, the mining sector needs a new generation of

standards that are implemented, together with training and widespread adoption to meet these standards. In Africa, the implementation of standards and regulations for project management in the mining sector has proven to be a major challenge (Naidoo & Govender 2023; Ribeiro et al. 2021).

Skills gap and workforce readiness

According to Uteshov et al. (2021), there is a skills gap in most developing countries in terms of the use of technology, and those countries that have been able to train their people are suffering from brain drain, as the technologically proficient workforce often leaves in search of greener pastures in developed countries (Mahlo & Spencer 2022). Ribeiro et al. (2021) argue that developing countries are also being affected by workforce readiness, as some employees are yet to fully embrace new technologies. The major reason highlighted for this is that the employees are afraid of losing their jobs to technology, and therefore they tend to resist it (Kinnunen et al. 2022; Naidoo 2022).

Cyber-security risks

Hargaden et al. (2019) posit that cyber security is one of the major challenges disrupting the digitalisation of project management within the mining industry. The growth in the use of technology has also led to a growth in cybercrime, and this has become a huge risk for organisations (Grooss 2024; Zhironkin & Ezdina 2023). This challenge has also led to organisations hesitating to invest in digitalisation (Dall'omo 2022).

Key success factors for the digitalisation of project management within the mining industry

In order for the digitalisation of project management within mining-sector organisations to be successful, there are certain requirements that need to be in place (Wilson 2019). Some of these key success factors for the digitalisation of project management within mining-sector organisations are discussed in the following sections.

Agile implementation

Kinnunen et al. (2022) and Naidoo (2022) purport that, at times, digital products fail to meet users' expectations and timelines are then delayed. When a digital product fails to meet the expectations of its users, it faces resistance, leading to the wastage of resources (Naidoo & Govender 2023; Tyuleneva 2020). It is thus important for mining-sector organisations to remain up to date with the latest technology and implement it with agility (Naidoo 2022; Zhironkina & Zhironkin 2023).

Customised solutions

According to Branca et al. (2020) and Naidoo and Govender (2023), every organisation has different characteristics in terms of the ore body, mining processes, required technical capabilities and quality of raw materials needed (Naidoo & Govender 2023), as well as the skill of the operators themselves. As a result, there is a need for digital project

management solutions to be tailor-made so that they can suit the needs of each individual mining organisation (Tanga et al. 2021, El Bazi et al. 2023).

Sustaining digital solutions

Digital leaders have established digital centres of excellence and are upskilling shop-floor operators to help design and maintain solutions over the long term (Naidoo & Ramphal 2020; Silase 2018). At a large coal-mining plant, operators not only provide input to build the model but are also trained to change key parameters and improve parts of the code when necessary. As a result, the operator maintains the solution and deploys the model to other departments within the company, helping to build a strong, operator-centric digital culture (Hargaden et al. 2019; Naidoo 2022).

Leadership and organisational commitment

Silase (2018) and Naidoo (2022) stress the importance of having all stakeholders on board through engagement. Getting the buy-in of all the relevant stakeholders, together with leadership and organisational commitment, will minimise resistance to the digitalisation of project management (Martinez 2019; Naidoo 2022). Principle 10 of the project management knowledge areas (PMBOK) says that project stakeholders must be managed properly in order to keep them happy and well informed (Silase 2018).

Research methods and design

This cross-sectional case study adopted an exploratory research design with an interpretivist paradigm. It utilised 12 semi-structured, face-to-face interviews to explore the push factors affecting and the challenges disrupting the digitalisation of project management within a South African mining organisation.

The target population for this study consists of the employees at the mining organisation's head office in Sandton, Johannesburg. Considering the chosen research approach, a non-probability purposive sampling technique was used to select a sample.

The sample framework that was used in selecting the sample from the population was a list of all the employees of the mining organisation working at the head office in Sandton. The following inclusion criteria were adopted:

- The participant must be employed at the mining organisation's head office and be based in South Africa.
- The participant must be a manager or hold a senior decision-making position in the organisation.
- The employee must possess at least 5 years' knowledge and experience in terms of digitalising project management within the mining industry.
- The employee must be willing to participate in the study.

A sample of 12 participants was reviewed and purposively selected to participate in the study. Before embarking on the

main data collection phase of the research, a pilot study was conducted to refine the research instruments, test the feasibility of data collection methods and identify any potential challenges. The pilot study was carried out and the results were excluded from the main study.

Qualitative data analysis techniques were used in this study, in the form of content and thematic analysis. The data were arranged into different themes. Table 1 shows how the content was analysed (Clark et al. 2021).

Ethical considerations

The study obtained ethical clearance via the University of South Africa (UNISA), as part of a Master's study on 28 August 2023. The reference number is 2023_SBL_MBA_028_FA-1474. Confidentiality and anonymity were ensured by not gathering any data that could identify the participants. Furthermore, raw data was securely saved on the cloud with a password protection. Hard copies of the data were kept in a locked cabinet and not accessed by anyone outside the research team.

Results

In this section, the results of the thematic analysis that was conducted using the data gathered through semi-structured interviews conducted with 12 participants are presented.

The participant demographics, as shown in Table 2, have two implications for the study. Firstly, the gender distribution of the participants, with four males and eight females, indicates a relatively balanced representation of gender within the organisation. Secondly this, is important because it allows for a diverse range of perspectives and experiences to be captured in the study, potentially leading to more comprehensive and nuanced findings.

Development of themes

To analyse the collected data, a six-step thematic analysis approach (as per Table 1) as outlined by Clarke et al. (2021) was employed.

TABLE 1: Steps in content analysis.

Phase	Procedures for each step
Familiarising oneself with the data	Transcribing data; reading and re-reading; noting down initial codes
Generating initial codes	Coding interesting features of the data in a systematic fashion across the data set; collating data relevant to each code
Searching for themes	Collating codes into potential themes; gathering all data relevant to each potential theme
Involved reviewing of the themes	Checking if the themes work in relation to the coded extracts and the entire data set; generating a thematic map
Defining and naming themes	Ongoing analysis to refine the specifics of each theme; generation of clear names for each theme
Producing the report	Final opportunity for analysis; selecting appropriate extracts; discussion of the analysis; relating back to research question or literature; producing report

Source: Clarke, T., Foster, L., Bryman, A. & Sloan, L., 2021, *Bryman's social research methods*, Oxford University Press, Oxford

Main theme 1: Push factors for digitalisation of project management

According to Guo and Zhang (2022), push factors refer to the external factors or stimuli that compel or motivate individuals, organisations or industries to adopt or pursue a particular course of action, such as the digitalisation of project management. Table 3 shows the development of the first emerging main theme: push factors for the digitalisation of project management.

Sub-theme 1.1: Technological advancements

The findings reveal how emerging technologies, such as advanced project management software, cloud-based solutions, IoT integration, AI and ML applications, and VR, are transforming project management practices in the mining sector. The participants said the following:

'The advanced project management software being implemented in the mining industry has been a game-changer for us. It automates repetitive tasks, improves collaboration, and provides real-time project insights.' (Participant 1, Female, Bachelor's)

'The use of AI and ML applications has transformed decision-making processes. Mining companies can analyse historical data, predict project risks and make informed decisions to mitigate uncertainties.' (Participant 12, Female, Bachelor's)

These findings align with the results of the literature review by indicating the importance of digitalisation in project management within the mining industry (Sarc et al. 2019).

Sub-theme 1.2: Competitive pressure

The findings show that there are external factors in the form of competitive pressure that drive the digitalisation of project management within the South African mining industry. This is supported by the following participant statements:

TABLE 2: Demographic details of participants.

Participant	Gender	Highest qualification
1	Female	Bachelor's
2	Male	Diploma
3	Female	Bachelor's
4	Female	Master's
5	Female	Bachelor's
6	Female	Diploma
7	Male	Diploma
8	Male	Master's
9	Female	Master's
10	Male	Diploma
11	Female	Bachelor's
12	Female	Bachelor's

TABLE 3: Development of main theme 1: Push factors for digitalisation of project management.

Motivators for digitalisation	Emerging theme
1.1 Technological advancements	Push factors for digitalisation of project management
1.2 Competitive pressure	
1.3 Regulatory and compliance requirements	
1.4 Industry best practice and benchmarking	
1.5 Enhanced data analytics and decision-making	

'In today's competitive landscape, digitalisation is crucial for maintaining a competitive edge. It allows us to streamline operations, reduce costs, and deliver projects more efficiently, giving us an advantage over competitors.' (Participant 3, Female, Bachelor's)

'Competitive pressure drives us to continuously improve our project management practices. Digitalisation enables us to optimise resource utilisation, reduce project timelines, and deliver quality outcomes, positioning us as leaders in the industry.' (Participant 11, Female, Bachelor's)

The participants' responses highlight the influence of competitive pressures on the digitalisation of project management in South Africa's mining industry. To remain competitive, mining companies must recognise the importance of digitalisation in streamlining operations, reducing costs and improving project efficiency.

To enhance competitiveness, mining organisations need to adopt 4IR technologies and ensure maximum connectivity. Efficient and strategic communication facilitated by digital tools is crucial for project success and responding to competitive pressures (Guo & Zhang 2022; Pan & Zhang 2021; Smith et al. 2021).

Sub-theme 1.3: Regulatory and compliance requirements

The participants highlighted how regulatory and compliance requirements such as environmental regulations, health and safety standards, and reporting obligations compel mining companies to adopt digital project management practices. This is supported by the following quotations from study participants:

'Meeting regulatory and compliance requirements is a top priority for us. Digital project management allows us to track and report on environmental impact, health and safety measures and other compliance-related aspects efficiently and accurately.' (Participant 2, Male, Diploma)

'Regulatory and compliance requirements are becoming increasingly complex. Digitalisation streamlines our reporting processes, automates data collection and provides a centralised platform for storing and retrieving compliance-related information.' (Participant 11, Female, Bachelor's)

The above-mentioned findings correspond to those of the literature review; by leveraging digital technologies such as data analytics, information management systems and automation, mining companies can enhance transparency, traceability and accountability in their operations (Sarc et al. 2019). The integration of digital tools enables real-time monitoring, reporting and documentation, supporting compliance with environmental regulations, health and safety standards, and social responsibility commitments (Sarc et al. 2019).

Sub-theme 1.4: Industry best practices and benchmarking

The findings also highlight industry best practices and benchmarking as key drivers for the digitalisation of project management within the mining industry in South Africa.

This is supported by the following quotations from the participants:

'Benchmarking against our industry peers helps us identify areas for improvement. Digitalisation allows us to gather and analyse data, compare performance metrics and implement strategies that align with or surpass industry benchmarks.' (Participant 4, Female, Master's)

'Digital project management provides us with valuable insights into industry trends and emerging practices. It enables us to adapt quickly, innovate and implement cutting-edge technologies to match or exceed industry standards.' (Participant 9, Female, Master's)

Digitalisation also enables benchmarking against industry standards and key performance indicators (KPIs), allowing mining organisations to compare their performance and identify areas for improvement.

Sub-theme 1.5: Enhanced data analytics and decision-making

The findings showed that enhanced data analytics and decision-making are significant internal factors that drive the digitalisation of project management within South Africa's mining industry. This is evidenced by the following participant statements:

'Digital project management enables us to gather and analyse vast amounts of data. Enhanced data analytics help us identify patterns, trends and insights that guide our decision-making and improve project outcomes.' (Participant 3, Female, Bachelor's)

'Enhanced data analytics through digital project management enable us to identify bottlenecks, optimise workflows and improve overall project efficiency. It helps us make proactive decisions that reduce costs and improve project outcomes.' (Participant 10, Male, Diploma)

The findings suggest that digitalisation plays a crucial role in enhancing data analytics capabilities (Sarc et al. 2019) and enabling informed decision-making processes (Martinez 2019; Tyuleneva 2020), leading to improved operational performance and outcomes in the mining industry (Zulu et al. 2021).

Main theme 2: Challenges disrupting the digitalisation of project management

The second objective of the study sought to establish the challenges disrupting the digitalisation of project management within the mining industry of South Africa. Table 4 shows the development of the emerging main

TABLE 4: Development of main theme 2: Challenges disrupting the digitalisation of project management.

Challenges in digitalisation	Emerging theme
2.1 Resistance to change	Challenges disrupting the digitalisation of project management
2.2 Infrastructure limitations	
2.3 Data security and privacy concerns	
2.4 Legacy systems integration	
2.5 Change management and employee buy-in	

theme 2: challenges disrupting the digitalisation of project management.

The sub-themes are discussed in detail in the following sections:

Sub-theme 2.1: Resistance to change

The findings of the study revealed resistance to change as one of the challenges that hinder the digitalisation of project management within South Africa's mining industry. This is indicated by the following participant quotations:

'Management buy-in is crucial for successful digitalisation. However, resistance from higher levels can delay or undermine the implementation of digital project management practices.' (Participant 5, Female, Bachelor's)

'Organisational culture plays a critical role in shaping attitudes towards change. If the culture doesn't value innovation and digital transformation, it can create resistance and hinder the adoption of digital project management.' (Participant 8, Male, Master's)

The findings thus align with those of the literature review, highlighting the challenges faced by mining-sector organisations that hinder the digitalisation of project management. A key challenge related to resistance to change is a shortage of resources (Martinez 2019; Smith et al. 2021), as high capital investments are required for full digitalisation, which may be unaffordable for some mining companies, especially those in developing countries. Another related challenge is a lack of top leadership support, as some leaders may resist digitalisation because of fears of job displacement or a reluctance to learn new skills (Guo & Zhang 2022; Tyuleneva 2020).

Sub-theme 2.2: Infrastructure limitations

The findings highlighted infrastructure limitations as another challenge that hinders the digitalisation of project management within the mining industry in South Africa. This is supported by the following statements from the participants:

'In remote mining locations, poor Internet connectivity poses a significant hurdle to digitalisation. Limited access to reliable internet services affects the real-time collaboration and data exchange required for effective digital project management.' (Participant 1, Female, Bachelor's)

'Outdated hardware and legacy systems hamper the adoption of digital project management. Without modern technology, it becomes challenging to leverage digital tools and platforms for efficient project management practices.' (Participant 2, Male, Diploma)

'Insufficient IT systems and outdated infrastructure create bottlenecks in the digitalisation process. Without robust systems in place, it's difficult to handle the large volumes of data, implement data analytics and ensure seamless integration of digital project management practices.' (Participant 3, Female, Bachelor's)

The study findings are in alignment with the findings of the literature review, highlighting the challenges posed by

inadequate infrastructure in the digitalisation of project management within the mining industry. Limited infrastructure, especially in developing countries, can impede the implementation of digital technologies because of constraints such as unreliable Internet connectivity, insufficient power supply and outdated communication networks (Smith et al. 2021).

Sub-theme 2.3: Data security and privacy concerns

The findings showed data security and privacy concerns as one of the challenges that hinder the digitalisation of project management within the South African mining industry. This is indicated by the following quotations from the participants:

'Data privacy regulations impose strict requirements on how we handle and store project data. Complying with these regulations adds complexity to the digitalisation process and requires robust data protection measures.' (Participant 6, Female, Diploma)

'Data security breaches can have severe consequences, including reputational damage and legal liabilities. These concerns often result in hesitation to embrace digital project management, as organisations prioritise safeguarding sensitive information.' (Participant 11, Female, Bachelor's)

Overcoming these challenges requires implementing robust cybersecurity protocols, (Smith et al. 2021), adopting encryption techniques (Hargaden et al. 2019; Uteshov et al. 2021) and ensuring compliance with data protection regulations to safeguard data security and privacy (Hargaden et al. 2019) throughout the digitalisation process.

Sub-theme 2.4: Legacy systems integration

The findings reveal that legacy systems integration also hinders the digitalisation of project management within the mining industry in South Africa. This is supported by the following participant statements:

'Integrating legacy systems with modern digital project management tools is a significant challenge. Outdated software and incompatible technologies may not seamlessly align with new systems, slowing down the digitalisation process.' (Participant 4, Female, Master's)

'Legacy systems often lack the necessary interoperability to integrate with modern project management solutions. This can lead to data fragmentation, inefficiencies and hindered collaboration across different systems.' (Participant 8, Male, Master's)

The literature suggests that mining organisations face challenges in migrating data and functionalities from legacy systems to new digital platforms. The co-existence of different systems may result in data fragmentation, inconsistencies and inefficiencies in project management processes (Ribeiro et al. 2021).

Sub-theme 2.5: Change management and employee buy-in

The participants revealed how effectively managing change and gaining employee buy-in are crucial for the successful

adoption and implementation of digital project management practices. This is evidenced by the following participant statements:

‘Employee buy-in plays a pivotal role in the success of digitalisation initiatives. Engaging employees early on, addressing their concerns and highlighting the benefits of digital project management can foster support and enthusiasm.’ (Participant 8, Male, Master’s)

‘Change can be met with resistance if employees perceive digitalisation as a threat to their job security or job roles. Clear communication and reassurance about the purpose and benefits of digital project management are essential to overcome such concerns.’ (Participant 10, Male, Diploma)

The participants’ responses shed light on the challenges of change management and employee buy-in within the South African mining industry’s digitalisation of project management. Overcoming these challenges therefore requires proactive change management practices (Silase 2018), including clear communication, training programmes, and fostering a culture that embraces innovation (Tyuleneva 2020) and digital transformation (Duarte et al. 2021; Tyuleneva 2020).

Main theme 3: Key success factors for the digitalisation of project management

The third objective of the study sought to ascertain the key success factors for the digitalisation of project management within the South African mining industry. Table 5 illustrates the development of the emerging main theme 3: key success factors for the digitalisation of project management.

The sub-themes are discussed in detail next.

Sub-theme 3.1: Leadership and organisational support

The findings show that leadership and organisational support are important for the digitalisation of project management within the mining industry in South Africa. This is shown by the following participant statements:

‘Strong leadership is critical for driving digitalisation efforts. Leaders who champion digital project management, provide resources and set clear objectives and expectations can create a culture of support and commitment to digitalisation.’ (Participant 1, Female, Bachelor’s)

‘Organisational support is vital to ensure the success of digital project management. This includes allocating sufficient budget, investing in necessary technology and infrastructure, and fostering a supportive environment for experimentation and learning.’ (Participant 3, Female, Bachelor’s)

TABLE 5: Development of main theme 3: Key success factors for the digitalisation of project management.

Requirements for digitalisation	Emerging theme
3.1 Leadership and organisational support	Key success factors for the digitalisation of project management
3.2 Training and skills development	
3.3 Collaboration and stakeholder engagement	
3.4 Scalability and flexibility of digital solutions	
3.5 Continuous monitoring and evaluation	

‘Leaders should play an active role in promoting the benefits of digitalisation to employees. By communicating the strategic importance, sharing success stories and addressing concerns, leaders can generate enthusiasm and gain buy-in from the workforce.’ (Participant 5, Female, Bachelor’s)

Bazaluk et al. (2022) emphasise the importance of agile implementation, customised solutions, sustaining digital solutions and leadership and organisational commitment.

Sub-theme 3.2: Training and skills development

The primary study findings also show training and skill development as a necessity for the digitalisation of project management within South Africa’s mining industry. This is evidenced by the following quotations from the participants:

‘Training is essential for equipping employees with the necessary skills and knowledge to effectively utilise digital project management tools. It enables them to leverage the full potential of digitalisation and contribute to improved project outcomes.’ (Participant 2, Male, Diploma)

‘Investing in training and skills development demonstrates the organisation’s commitment to digitalisation. It not only enhances employee motivation and engagement but also builds a talent pool of digitally savvy project management professionals who can drive successful digital initiatives.’ (Participant 12, Female, Bachelor’s)

By investing in comprehensive and customised training programmes (Hargaden et al. 2019; Ribeiro et al. 2020), mining companies can equip their workforce with the necessary skills and knowledge to embrace digitalisation and effectively navigate the challenges and opportunities it presents.

Sub-theme 3.3: Collaboration and stakeholder engagement

The participants indicated that effective collaboration and active engagement with stakeholders are essential for achieving successful digitalisation outcomes in project management:

‘Collaboration is crucial for the success of digital project management. It involves fostering cross-functional teamwork, breaking down silos, and leveraging digital tools to enable real-time communication and collaboration among project stakeholders.’ (Participant 5, Female, Bachelor’s)

‘Collaboration and stakeholder engagement require effective communication and relationship-building. Regular updates, clear project objectives and involving stakeholders in decision-making processes create a shared understanding and alignment, enabling smoother digitalisation efforts.’ (Participant 12, Female, Bachelor’s)

Through prioritising collaboration and stakeholder engagement, mining organisations can foster a culture of cooperation (Branca et al. 2020; Uteshov et al. 2021), harness collective expertise and ensure the successful implementation and adoption of digital solutions in the industry (Kinnunen et al. 2022; Vrchota et al. 2020).

Sub-theme 3.4: Scalability and flexibility of digital solutions

The findings highlighted the scalability and flexibility of digital solutions as other key success factors for the digitalisation of project management within the mining industry in South Africa. This is shown by the following participant statements:

'Scalability is essential for digital solutions to accommodate the evolving needs and complexity of projects. Solutions should be able to handle large volumes of data, support increased user demand and scale up as projects grow in size and scope.' (Participant 1, Female, Bachelor's)

'Digital solutions should be future-proof, capable of evolving alongside technological advancements. They should be designed with modular architectures and open interfaces, enabling easy integration of new functionalities and technologies as they emerge.' (Participant 9, Female, Master's)

Tanga et al. (2021) and Uteshov et al. (2021) emphasise the need for digital solutions that can adapt and scale to accommodate the evolving needs of mining operations. Scalable solutions allow for seamless integration with existing systems and processes while also providing the ability to handle increasing data volumes and complexity. Flexibility in digital solutions, as highlighted by Branca et al. (2020) and Tyuleneva (2020), is crucial to address the unique requirements and challenges of different mining operations. Solutions that can be customised and configured for specific mining contexts enable organisations to optimise their digital project management processes. Moreover, the literature suggests the use of open architecture and interoperability (Guo & Zhang 2022; Hargaden et al. 2019) to ensure compatibility and integration with other digital tools and systems.

Sub-theme 3.5: Continuous monitoring and evaluation

The findings highlighted continuous monitoring and evaluation as another key success factor for the digitalisation of project management within the mining industry in South Africa. This is supported by the following quotations:

'Continuous monitoring and evaluation provide valuable insights into the performance of digital project management initiatives. Regular assessment of key metrics and indicators allows for timely identification of issues, enabling proactive decision-making and corrective actions.' (Participant 1, Female, Bachelor's)

'Monitoring and evaluation should be an ongoing process throughout the project lifecycle. It allows for real-time tracking of progress, identification of bottlenecks and adjustment of strategies to ensure that digital project management initiatives stay on track and deliver the desired results.' (Participant 8, Male, Master's)

Ribeiro et al. (2020) and Smith et al. (2021) emphasise the need for regular monitoring of digital project management initiatives to assess their effectiveness and identify areas for improvement. By prioritising continuous monitoring and evaluation, mining organisations can drive continuous

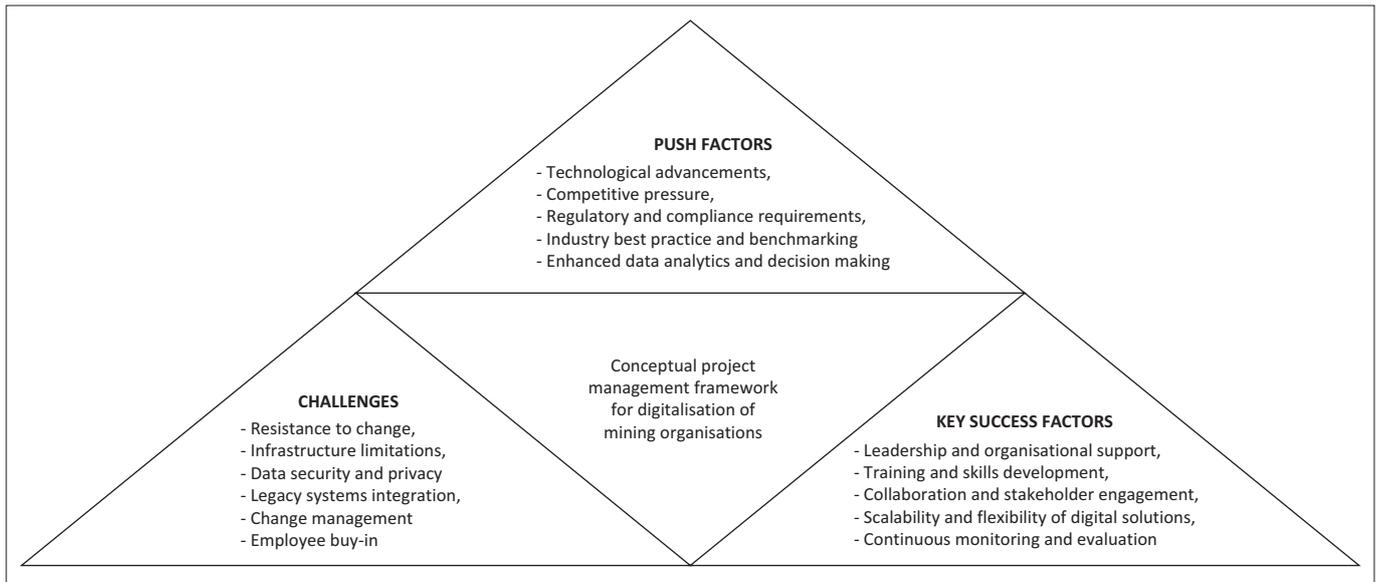
improvement, optimise the benefits of digitalisation and sustain long-term success in the industry.

Discussion

Key points emerged from the literature review regarding the push factors, challenges and key success factors of project management digitalisation. The push factors emphasise the need for enhanced productivity, cost reduction and improved decision-making through the adoption of digital technologies (Bazaluk et al. 2022; Uteshov et al. 2021; Vrchota et al. 2020; Wang et al. 2022; Whyte 2019). However, challenges such as resistance to change, a lack of skills and cybersecurity risks were identified as disruptors to successful digitalisation (Branca et al. 2020; Guo & Zhang 2022; Uteshov et al. 2021; Vrchota et al. 2020). Key success factors include agile implementation, customised solutions, sustaining digital solutions, leadership and organisational commitment, training and skills development, collaboration and stakeholder engagement, scalability and flexibility of digital solutions and continuous monitoring and evaluation (Hargaden et al. 2019; Kinnunen et al. 2022; Martinez 2019).

The study's findings show that the push factors for digitalisation include technological advancements, competitive pressure, regulatory and compliance requirements, industry best practices and benchmarking, and enhanced data analytics and decision-making. The South African mining industry is experiencing a significant shift towards digitalisation, driven by technological advancements such as advanced project management software, cloud-based solutions, IoT integration, AI, ML and VR and/or AR. These technologies streamline processes, enhance collaboration and provide real-time insights. The integration of digital technologies across the mining value chain is evident, enabling operational changes and tools like smart operations centres, AR, VR and digital twins. Competitive pressure drives the adoption of digital project management practices in the mining industry. This enables organisations to streamline operations, reduce costs and improve project efficiency. The coronavirus disease 2019 (COVID-19) pandemic has further highlighted the urgency of digitalisation, as teams were able to continue working remotely. Regulatory and compliance requirements, such as environmental regulations and health and safety standards, also drive the adoption of digital project management practices. By leveraging digital technologies, mining companies can enhance transparency, traceability and accountability. In conclusion, digitalisation plays a crucial role in enhancing data analytics capabilities and enabling informed decision-making processes, leading to improved operational performance and outcomes in the mining industry.

The study found that the challenges that disrupt the digitalisation process include resistance to change, infrastructure limitations, data security and privacy concerns, legacy systems integration and change management, and employee buy-in. The South African mining industry faces



Source: Research findings

FIGURE 2: Conceptual project management framework for the digitalisation of mining operations.

significant challenges in adopting digital project management, including resistance from employees, management and organisational culture. These challenges include a lack of resources, top leadership support, industry standards, a skills gap and cyber-security risks. Infrastructure limitations, such as limited Internet connectivity and outdated hardware, can impede real-time collaboration and data exchange. Data security and privacy concerns are also significant, necessitating robust security measures and compliance with regulations. Building trust in digitalisation requires addressing these concerns. The integration of legacy systems, including outdated software and incompatible technologies, can hinder the digitalisation of project management. Upgrading these systems can be costly and time-consuming, requiring data migration and employee retraining. Change management and employee buy-in are also crucial for successful digitalisation efforts. A culture that values change and innovation, supported by training, incentives and recognition, can foster a positive attitude towards digital project management. By focussing on change management and gaining employee buy-in, mining companies can facilitate a smoother transition to digital project management practices and harness the full potential of digitalisation for improved project outcomes.

The empirically developed project management framework for the digitalisation of mining organisations is represented in Figure 2.

It is evident from Figure 2 that the challenges for the digitalisation of project management within the mining industry of South Africa include leadership and organisational support, while disruptors include resistance to change and a lack of employee buy-in. However, there is sufficient evidence that the push factors outweigh the disruptors and challenges, as these can be overcome by introducing digitalised solutions evidenced through the empirically developed framework.

Conclusion

This article made use of an exploratory approach to determine the push factors and challenges of the digitalisation of project management within the South African mining industry. The study successfully achieved the research objectives and further contributed to the body of knowledge on project management and the mining industry by developing a unique conceptual project management framework for the digitalisation of mining operations.

Potential bias

Purposive sampling and interview-based data collection can introduce biases that affect research findings' validity and reliability. Examples include selection bias and social desirability bias which can lead to unrepresentative samples. Interviewer bias and preconceptions can also influence data collection. To mitigate these biases, the researchers triangulated data sources, trained interviewer, and critically reflected on their biases.

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Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

Authors' contributions

Both the authors, M.Q.M.B. and S.N., contributed equally to this work.

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Data availability

The data that support the findings of this study are available from M.Q.M.B., upon reasonable request.

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