

Impediments to Readiness to Adopt Building Information Modelling for Health and Safety Among Small and Medium Contractors in KwaZulu-Natal

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Abstract

The construction industry remains one of the most hazardous economic sectors, with persistently high accident and fatality rates worldwide. Building Information Modelling (BIM) has emerged as a valuable tool for strengthening health and safety (H&S) management through improved visualisation, early hazard detection, and enhanced project collaboration. While large construction firms have progressively adopted BIM, Small and Medium Enterprises (SMEs), which constitute many South African construction companies, continue to lag in adopting digital technologies. Although SME readiness for BIM is known to depend on the alignment of strategy, leadership, culture, people, and technology, far less is known about the impediments that prevent this alignment in practice. This study, therefore, aimed to identify the impediments to SME readiness for BIM-enabled H&S management in KwaZulu-Natal (KZN), South Africa. Using a positivist, deductive, and quantitative design, a simple random sample of 130 SMEs registered with the Construction Industry Development Board (CIDB) in KZN completed questionnaires measuring 13 potential impediments. Respondents agreed that these impediments significantly constrain SME readiness for BIM-enabled H&S management (overall mean = 4.00), with limited infrastructure, restricted training, and a shortage of skilled personnel identified as the most significant. Insufficient standardisation, resistance to organisational change, software incompatibility and inadequate funding were also rated highly. Targeted initiatives, including affordable training, SME-specific implementation frameworks, leadership awareness campaigns, government incentives, and industry collaboration, are needed to address these impediments and accelerate BIM uptake for H&S management among South African SMEs.

Keywords: Building Information Modelling, Health and Safety, Impediments to Readiness, Small and Medium Contractors

1. Introduction

The construction industry plays a pivotal role in economic growth and infrastructure development across both developed and developing economies (Ofori, 2021). Despite this importance, the sector continues to be characterised by significant safety risks and recurring project management inefficiencies that undermine its performance and public standing (Tixier *et al.*, 2017). Construction remains among the most hazardous industries globally, with workers routinely exposed to physical, mechanical and organisational hazards that translate into high rates of injury and fatality. Addressing these persistent health and safety (H&S) challenges requires approaches that move beyond traditional, paper-based site management practices towards more proactive, technology-enabled risk management.

Building Information Modelling (BIM) has been widely promoted as a collaborative digital platform capable of addressing many of these challenges through improved visualisation, earlier hazard identification, and more effective coordination among project stakeholders (Succar, 2009). However, the uptake of

BIM among South African small- and medium-sized contractors, particularly for H&S purposes, remains limited. This is a concern, given that small and medium enterprises (SMEs) constitute the majority of registered construction firms in South Africa (CIDB, 2022). While BIM has been shown to enhance the competitiveness of construction firms that adopt it (Ambe *et al.*, 2020), SMEs continue to face considerable impediments, including resource constraints, limited awareness, and resistance to changing established ways of working. These obstacles are compounded by the fact that SMEs typically lack the dedicated capacity to institutionalise new technologies that larger firms can more readily absorb.

Overcoming these obstacles is essential if BIM is to make a meaningful contribution to improving H&S practices within the SME segment of the industry. Doing so requires more than a general sense of how ready SMEs are to adopt the technology. It requires a clear understanding of the specific impediments that prevent SMEs from reaching that readiness level. Bowen and Ndlovu (2017) suggested that organisational culture and leadership play a particularly important role in shaping how firms' receptiveness to

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new technology, and that readiness levels can vary considerably between provinces (Modise, 2016). Yet while the organisational factors associated with readiness are reasonably well established, the specific impediments that obstruct SMEs from developing this readiness within the KZN construction sector remain poorly understood. This study, therefore, aimed to examine the impediments to SME readiness to adopt BIM for H&S management in KZN.

To achieve this aim, the study adopted a positivist, deductive and quantitative research design, surveying a random sample of CIDB-registered SME contractors operating in KZN. The remainder of this paper is structured as follows: Section 2 reviews the literature on BIM, organisational readiness, and the impediments that shape construction H&S management; Section 3 outlines the research methodology adopted; Section 4 presents the findings and discusses their implications in relation to the existing body of knowledge; and Section 5 concludes the paper and proposes directions for further research.

2. Literature Review

This section reviews the literature on BIM, construction H&S, and SME development in South Africa, moving from an overview of BIM to its application in H&S management, the role of SMEs in the South African construction economy, the organisational factors associated with BIM readiness, and finally, the specific impediments that prevent SMEs from developing this readiness.

2.1. BIM Overview

Building Information Modelling (BIM) is a technology-driven approach that supports the design, construction and operation of the built environment throughout the asset lifecycle. Rather than functioning merely as a three-dimensional drawing tool, BIM operates as a digital model of a facility's physical and functional characteristics, providing project stakeholders with a shared, continuously updated information resource from inception through to deconstruction (Park & Park, 2015). This shared model underpins construction-phase simulation, advanced visualisation, and resource management, which in turn enhance both safety performance and cost-estimation accuracy (Toyin & Mewomo, 2023). BIM also fosters more effective collaboration and project management across an asset's lifecycle, extending well beyond traditional 3D modelling by embedding intelligent data within the model and improving communication among architects, engineers, contractors and clients (Wang *et al.*, 2024). For SMEs, these capabilities are potentially transformative, provided the technology can be implemented in a manner that is affordable, accessible and compatible with existing ways of working.

2.2. BIM for Health and Safety in Construction SMEs

Construction safety encompasses a wide range of procedures intended to manage physical risks such as falls and unguarded machinery, chemical hazards, biological threats such as exposure to harmful bacteria, and psychosocial issues such as stress and harassment. Effective H&S management requires strict adherence to safety regulations and active employee participation in identifying and mitigating risks (Labaran *et al.*, 2024). The technologies associated with the Fourth Industrial Revolution, which combine digital, physical and biological systems, have introduced tools such as smart personal protective equipment (helmets, gloves and high-visibility clothing) and immersive training methods that further enhance site safety (Abina *et al.*, 2024). Sound safety management, supported by regular reviews and continuous improvement, has been shown to enhance workplace quality and reduce accident rates. Within this context, BIM serves as a collaborative digital tool for project planning, design, construction, and management, enabling better systems integration, more proactive risk management, and real-time hazard tracking on-site (Azhari *et al.*, 2011). Despite these documented benefits, BIM has not been widely adopted by construction SMEs operating in KZN. This study examines the impediments to SMEs' readiness to adopt BIM for H&S management in KZN.

2.3. The Role of SMEs in the South African Construction Economy

SMEs occupy a critical position within the South African construction economy. Hove (2016) emphasises the importance of small-scale emerging contractors for the country's economic development, noting that government support programmes have historically sought to foster their growth and create employment opportunities for previously disadvantaged groups. SMEs are estimated to contribute a substantial share of national GDP while simultaneously creating jobs, stimulating economic growth, and expanding infrastructure delivery capacity (CIDB, 2022). Beyond their direct economic contribution, SMEs empower marginalised communities through entrepreneurship and skills development, although they continue to face persistent challenges, including financial constraints, skills shortages, and intense competition from larger, more established firms (Hove, 2016), while also indirectly increasing household incomes and broader economic activity through the infrastructure they help to deliver. Given this combination of economic importance and structural vulnerability, understanding how SMEs can be supported to adopt safety-enhancing technologies such as BIM is of practical significance.

2.4. Readiness to Adopt BIM for Health and Safety

BIM adoption in the construction industry has been consistently linked to improvements in project

efficiency, cost control and H&S outcomes; however, the readiness of South African SMEs to adopt the technology remains comparatively under-researched. Chen *et al.* (2013) propose that readiness for BIM adoption can be conceptualised as the degree to which an organisation's strategy, people, processes and technology are aligned and capable of supporting implementation, a framework that has informed how the present study operationalised readiness. Existing evidence suggests that SMEs in KZN face a combination of financial, skills, and training-related constraints that limit their readiness (Olatunji, 2022), a pattern that echoes earlier South African findings indicating that mandatory or incentivised initiatives may be needed to accelerate adoption (Chimhundu, 2015). The literature further indicates that successful BIM adoption depends on the alignment of five interrelated organisational factors, namely strategy, leadership, culture, people and technology (Abbasnejad, *et al.*, 2021; Bowen & Ndlovu, 2017), with anticipated benefits including improved H&S compliance once these factors are adequately developed (Sila *et al.*, 2024). These five factors provided the conceptual basis for the present study, which offers little insight into the specific impediments that prevent South African SMEs from developing them in practice, a gap addressed next.

2.5. Impediments to BIM Readiness for Health and Safety

Despite its considerable benefits, BIM implementation continues to be constrained by high costs, organisational resistance, skills shortages and inadequate digital infrastructure (Bowen & Ndlovu, 2017), challenges that are particularly pronounced among SMEs, where regulatory enforcement and institutional support remain limited. Comparable findings have been reported among SMEs in other developing-country contexts, including Nigeria (Saka, 2022), suggesting that the constraints facing KZN SMEs reflect a broader pattern affecting resource-constrained contractors rather than a uniquely local problem. Financial constraints, reluctance to change established practices, insufficient training opportunities (Olatunji, 2022), and the absence of clear implementation standards collectively hinder the adoption of BIM-enabled H&S measures, underscoring the need for more supportive government and industry policies, particularly for SMEs that may otherwise be left behind as larger firms continue to digitalise.

Overcoming these impediments is vital if the sector is to realise BIM's full potential for improving safety outcomes. Chen *et al.* (2024) note that BIM improves construction performance and H&S by enabling design optimisation, advanced visualisation and early hazard detection. The technology assists architects, engineers and contractors in assessing sites and identifying hazards before construction begins (Azhar, 2017), thereby strengthening overall risk management

practices. This is particularly relevant for KZN construction firms, including SMEs, which continue to record high rates of occupational injury (Federated Employers Mutual Assurance Company [FEM], 2024); for these firms, BIM offers tangible benefits in terms of hazard detection, safety testing and risk management (Chen *et al.*, 2024). Taken together, the literature suggests that while the benefits of BIM for SME health and safety management, and the organisational factors associated with readiness, are well established, the specific impediments that prevent South African SMEs from translating this potential into practice remain insufficiently understood. Identifying these impediments forms the empirical focus of the present study.

3. Research Methodology

This study adopted a positivist research philosophy, on the basis that the impediments to SME readiness for BIM adoption can be objectively measured through a structured, replicable instrument. A deductive approach was followed, whereby existing theory on organisational readiness and BIM adoption (Chen *et al.*, 2013) informed the variables measured, rather than allowing themes to emerge inductively from the data. Data collection followed a mono-method quantitative approach, as recommended by Creswell & Creswell (2017).

The research strategy was a cross-sectional questionnaire survey, as suggested by Saunders *et al.* (2019), which collects data at a single point in time rather than tracking change longitudinally (Bryman & Bell, 2015). This strategy was considered appropriate given the exploratory, baseline nature of the investigation and the practical constraints of surveying a geographically dispersed population of SME contractors. Simple random sampling was used to facilitate efficient and representative data collection. The target population comprised CIDB-registered general building contractors in grades 1 to 6 operating in KZN, a category dominated by SMEs (CIDB, 2022). From a population of 1,634 such contractors, a sample size of 180 SMEs was established. 130 SMEs participated using a simple random sampling method, yielding a sample considered adequate for the descriptive statistical analysis undertaken. An electronic questionnaire was distributed via email, with follow-up reminders sent to non-respondents to improve the response rate.

The questionnaire measured perceived impediments to BIM adoption for H&S management using a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). Mean scores (MS) were interpreted using the following ranges: strongly disagree (≥ 1.00 – ≤ 1.80), disagree (≥ 1.81 – ≤ 2.60), neutral (≥ 2.61 – ≤ 3.40), agree (≥ 3.41 – ≤ 4.20), and strongly agree (≥ 4.21 – ≤ 5.00), adopted from the study of Renault *et al.*, (2018). Data

were analysed using SPSS version 29, with descriptive statistics, including frequencies, means, and standard deviations, computed for each impediment item. Content validity was established by having the questionnaire reviewed by experts familiar with BIM and construction H&S management prior to distribution, while internal consistency reliability was assessed using Cronbach's alpha, with a coefficient of 0.70 or higher regarded as acceptable for newly developed multi-item constructs (Nunnally, 1978).

Ethical approval for the study was obtained from the Tshwane University of Technology Research Ethics Committee prior to data collection, ensuring that the research was conducted with due regard for integrity, respect for participants, and trust between researchers and the SMEs who responded. Participation was voluntary, and respondents were assured of the confidentiality and anonymity of their responses.

4. Findings and Discussion

This section presents the empirical findings of the survey of 130 KZN-based SME contractors and discusses their implications in relation to the literature reviewed in Section 2. The discussion is organised around the reliability of the measurement instrument, the specific impediments identified, and the broader factors that explain why these impediments continue to constrain SME readiness to adopt BIM for H&S management.

4.1. Reliability of the BIM Readiness Impediments Construct

Reliability was assessed using SPSS to compute Cronbach's alpha for the thirteen items comprising the impediments construct. As shown in Table 1, the construct returned an unstandardised alpha of 0.919 and a standardised alpha of 0.920, both comfortably exceeding the 0.70 threshold generally regarded as acceptable for multi-item scales (Nunnally, 1978). This high level of internal consistency indicates that the thirteen impediment items measured a coherent underlying construct and that the subsequent mean scores can be interpreted with confidence.

4.2. Impediments to the Adoption of BIM Technology for Health and Safety

Table 2 presents the descriptive results for the thirteen impediments to BIM adoption for H&S management among KZN SMEs. Overall, respondents agreed that these impediments significantly hinder SME readiness, with an overall mean score of 4.00 and a standard deviation of 0.761, placing the construct firmly within the 'agree' band of the interpretation scale. The most strongly endorsed impediments were limited access to the infrastructure and technological resources required for effective BIM use (mean = 4.16), limited access to BIM-specific training and education (mean = 4.14), and a shortage of personnel skilled in using BIM for H&S purposes (mean = 4.11). Insufficient standardisation and the absence of clear implementation protocols

Table 1: Internal Reliability Test for the Impediments Construct

Factor	N	Unstandardised Cronbach's Alpha	Standardised Cronbach's Alpha
Impediments to BIM readiness for H&S	13	0.919	0.920

Source: Authors' construction, 2026

Table 2: Impediments to the Adoption of BIM Technology for H&S

Item	Mean	Std. Dev.	Ranking
Limited infrastructure and technological resources	4.16	0.724	1
Limited access to BIM-specific training and education	4.14	0.723	2
Shortage of personnel skilled in BIM for health and safety	4.11	0.760	3
Lack of standardisation and clear H&S protocols	4.08	0.743	4
Resistance to changing organisational culture	4.07	0.759	5
Incompatibility of BIM software with existing systems	4.03	0.777	6
Insufficient financial resources for BIM investment and training	4.00	0.807	7
Regulatory barriers and lack of government incentives	3.96	0.772	8
Limited awareness of BIM benefits for health and safety	3.92	0.832	9
Data security and privacy concerns	3.92	0.743	10
Interoperability and compatibility concerns with existing software	3.90	0.714	11
Perceived complexity of integrating BIM into project processes	3.88	0.722	12
Difficulty identifying information for transfer to FM software	3.86	0.814	13
Overall mean and std. dev.	4.00	0.761	

Source: Authors' construction, 2026 (n = 130). SD = Strongly Disagree; D = Disagree; N = Neutral; A = Agree; SA = Strongly Agree.

(mean = 4.08), resistance to changing established organisational practices (mean = 4.07), and incompatibility between BIM software and existing systems (mean = 4.03) were also rated highly. The comparatively low standard deviations recorded across most items, generally below 0.83, indicate a strong degree of consensus among respondents rather than polarised views.

4.3. Discussion: Impediments to SME Readiness for BIM Adoption

Seven of the thirteen impediments returned mean scores of 4.00 or higher, including limited infrastructure, limited training, and a shortage of skilled personnel, as well as insufficient standardisation, resistance to change, software incompatibility, and insufficient funds. This pattern corroborates research by Olatunji (2022), who found that South African SMEs face considerable compliance challenges with H&S regulations that BIM could help mitigate through better documentation, compliance tracking and project management once the underlying impediments are addressed. The prominence of infrastructure and training-related impediments is also consistent with international evidence: comparable studies among SMEs in Nigeria (Saka, 2022) likewise identify cost, skills shortages and limited access to enabling infrastructure as the dominant constraints on BIM uptake, suggesting that the impediments facing KZN SMEs are not unique to the local context but reflect a broader pattern affecting resource-constrained contractors internationally.

The strong endorsement of training and skills-related impediments is particularly noteworthy given that most South African SMEs lack documented strategies for technology adoption, largely owing to limited managerial knowledge of what such strategies should entail. Without a clear strategic intent, it becomes considerably more difficult for SMEs to justify the investment required to implement BIM-enabled H&S measures, even where leadership recognises their potential value. This is compounded by evidence that a lack of leadership capacity and managerial competence contributes to high SME failure rates in their first five years of operation (Hove, 2016), leaving many firms without the leadership continuity needed to drive technology adoption to completion. Resistance to change, the fifth highest rated impediment in this study, further underscores the cultural dimension of readiness: Ghaffarianhoseini *et al.* (2016) emphasise the need for a culture of innovation within SME construction firms, yet such firms typically retain traditional, paper-based workflows that actively resist the introduction of digital tools.

The high ratings for software incompatibility and a lack of standardisation point to a further structural impediment: the absence of sector-wide BIM protocols tailored to SMEs' scale and capacity. Where standards

and guidance exist, they are often designed with large contractors in mind, leaving many smaller firms to navigate implementation largely alone. For H&S management specifically, this is a wasted opportunity, since BIM-enabled hazard detection and risk visualisation have been shown to directly support compliance and reduce site-level injury rates when properly implemented (Azhar, 2017), benefits that are especially relevant given the elevated occupational injury rates recorded among KZN's construction workforce (FEM, 2024).

Taken together, the findings show that SME readiness for BIM-enabled H&S management in KZN is constrained by a specific, identifiable set of impediments spanning resource limitations, underdeveloped strategy and leadership capacity, persistent cultural resistance, and structural gaps in standardisation and infrastructure. These impediments map closely onto the five-factor readiness framework by Chen *et al.* (2013), suggesting that readiness is unlikely to improve until relevant factors corresponding to impediments are directly addressed. This reinforces the case for SME-specific, rather than one-size-fits-all, interventions to overcome these impediments to BIM readiness for H&S management (Chimhundu, 2015).

5. Conclusion and Further Research

The construction sector remains one of the most dangerous industries in which to work, and BIM continues to offer considerable promise for improving health and safety (H&S) outcomes through better visualisation, earlier hazard identification, and more collaborative planning. While large firms have progressively adopted BIM, most South African SMEs continue to face substantial impediments to its adoption. This study set out to identify the impediments to SME readiness to adopt BIM for H&S management in KwaZulu-Natal and found 13 such impediments spanning strategy, leadership, culture, people, and technology, 7 of which were rated by respondents as particularly significant constraints on readiness.

BIM's benefits for SME health and safety management, including improved risk management and project efficiency, are widely acknowledged but remain largely unrealised in practice. The most significant impediments identified, namely limited infrastructure, restricted access to training, a shortage of skilled personnel, insufficient standardisation, resistance to change, software incompatibility, and inadequate funding, mirror challenges documented among SMEs in other developing-country contexts, suggesting that the constraints facing KZN contractors are structural rather than unique to the province.

To overcome these impediments and raise readiness levels, SMEs require affordable training programmes,

implementation frameworks tailored to their scale, leadership awareness campaigns, government incentives that lower the cost of entry, and stronger industry partnerships that allow smaller firms to learn from early adopters. Software vendors and industry bodies also have a role to play in providing accessible education, technical support and SME appropriate licensing models.

This study is not without limitations. The cross-sectional design captures impediments to readiness at a single point in time, while the focus on KZN limits the

extent to which the findings can be generalised to other provinces. Further research should consider longitudinal designs that track how these impediments evolve over time, comparative studies across provinces, and qualitative investigation of the leadership and cultural dimensions of BIM adoption identified here. Future work could also evaluate the effectiveness of specific interventions, such as subsidised training or government incentives, in reducing these impediments and strengthening SME readiness

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