

Transforming Construction Education through Artificial Intelligence and Simulation-Based Work Integrated Learning: A Systematic Literature Review

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DOI: 10.36108/cbpm/2026.0171

Abstract

The rapid advancement of Artificial Intelligence (AI) is transforming higher education, particularly in professionally oriented fields such as construction education. At the Central University of Technology, Work Integrated Learning (WIL) plays a vital role in preparing students for industry readiness and digital transformation. However, limited industry placements, assessment integrity, and growing digitalisation have increased interest in simulation-based and AI-enabled WIL models. This systematic literature review (SLR) investigates the integration of AI into simulation-based WIL in construction education. Using PRISMA principles, literature published between 2016 and 2026 was systematically reviewed and analysed. 38 scholarly articles were reviewed. Thematic analysis identified key themes including AI-enabled pedagogy, simulation-based WIL, assessment transformation, governance and ethics, and student readiness. Findings indicate that AI can enhance simulated WIL through reflective learning, technical report writing, problem-solving, adaptive learning, and digital collaboration. AI integration further improves student engagement, workplace preparedness, and access to construction knowledge where traditional placements are limited. Despite these benefits, concerns remain regarding assessment authenticity, overreliance on generative AI, digital literacy inequalities, ethical risks, and weak governance frameworks. The review concludes that effective AI-supported WIL requires a balanced pedagogical approach that combines authentic assessment, educator supervision, simulation-based learning, and responsible AI governance.

Keywords: Artificial Intelligence; Construction Education, Simulation-Based Learning; Work Integrated Learning;

1 Introduction

The Fourth Industrial Revolution (4IR) has transformed industries through digital technologies, automation, artificial intelligence (AI), and data-driven systems (Schwab, 2017). In construction, technologies such as Building Information Modelling (BIM), AI-assisted scheduling, Predictive Analytics (PA), Digital Twins (DT), Robotics, and automated cost estimation are improving productivity, sustainability, collaboration, and project performance (Oesterreich et al., 2016; Sawhney et al., 2020). These developments require higher education institutions to align curricula and experiential learning approaches with evolving industry demands (Hruby, 2025).

Work-Integrated Learning (WIL) remains a critical strategy for preparing students in construction-related disciplines by integrating academic knowledge with workplace experience through placements, internships, apprenticeships, and simulation-based learning (Briant et al., 2023). Simulation-based learning is increasingly adopted in higher education because it enhances conceptual understanding, inquiry, problem-solving, and decision-making while providing opportunities to practise complex professional skills in realistic

environments (Tabak et al., 2018; Chernikova et al., 2020). In construction education, simulations can replicate project delivery processes, site management activities, and collaborative workplace interactions.

Traditional WIL models face growing challenges arising from increasing enrolments, limited placement opportunities, economic constraints, health and safety requirements, and disruptions such as the COVID-19 pandemic (Dlamini et al., 2022). Consequently, simulation-based WIL has emerged as a viable alternative for providing authentic experiential learning when workplace placements are unavailable (Mogoale et al., 2025; Laverie et al., 2022). Such approaches support the development of technical and professional competencies, including communication, project coordination, teamwork, problem-solving, contract administration, and ethical decision-making (Prada et al., 2022).

Simultaneously, generative AI tools, including ChatGPT, intelligent tutoring systems, automated assessment platforms, and learning analytics, are reshaping teaching and learning practices (Bakare et al., 2023). These technologies can personalise learning, improve engagement, support technical

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communication, and strengthen reflective learning (Brugliera, 2024; Korke et al., 2023). Despite these benefits, concerns regarding academic integrity, assessment authenticity, ethical governance, data privacy, bias, and educator readiness remain significant (Al-Shamaileh et al., 2025; Chiu et al., 2023). Furthermore, limited research has examined the integration of AI within simulation-based WIL in construction education, particularly in the South African context, highlighting a critical gap for future investigation.

2 Literature Review

2.1 Artificial Intelligence in Higher Education

Artificial Intelligence (AI) has emerged as a transformative technology in higher education, enabling computer systems to perform tasks such as learning, reasoning, problem-solving, and language processing (Walter, 2024). AI technologies in education include intelligent tutoring systems, adaptive learning platforms, chatbots, predictive analytics, automated feedback tools, and generative AI applications (Fatria, 2021; Mogoale et al. 2025). The rapid advancement of generative AI, particularly large language models, has significantly influenced educational practices by supporting writing assistance, personalised learning, assessment feedback, and access to information (Lee et al., 2024). Khoza (2026), mentions that in higher education and construction education specifically, as a result, institutions are developing ethical guidelines, governance frameworks, and responsible AI use policies.

2.2 Work Integrated Learning in Construction Education

Work Integrated Learning (WIL) is a pedagogical approach that integrates academic learning with practical workplace experience through methods such as internships, apprenticeships, cooperative education, project-based learning, and simulation-based learning (Mpofu et al., 2022). In construction education, WIL plays an important role in developing professional competence by exposing students to project environments, organisational structures, site operations, and practical application of theoretical knowledge (Adedoyin et al: 2023). As a result, WIL significantly contributes to graduate employability and industry readiness (Mabungela et al., 2024). The COVID-19 pandemic further highlighted weaknesses in conventional placement systems, encouraging institutions to adopt virtual and simulation-based experiential learning alternatives (Mhlanga et al., 2022).

2.3 Simulation-Based Pedagogy and Experiential Learning

Simulation-based pedagogy uses realistic scenarios to support experiential learning and develop practical decision-making, collaboration, and professional

judgment skills (Laverie et al., 2026). In construction education, simulations support training in project management, safety, contract administration, budgeting, communication, stakeholder negotiation, and ethical decision-making (Opesemowo et al., 2025). The integration of AI further improves simulation-based learning through adaptive environments, intelligent feedback, conversational tools, and personalised learning experiences (Kasneci et al., 2023).

2.4 AI-Enabled Pedagogical Benefits and Challenges

Although AI offers significant opportunities in higher education, it also raises important risks related to governance and academic integrity (Cheng et al, 2025. Opesemowo et al, 2025) indicate that a major concern is assessment authenticity, as Gen AI tools can produce essays, reports, and project documentation with minimal human involvement. This creates challenges regarding plagiarism, authorship, and the verification of student competencies (Lee et al., 2025). In construction education, where practical professional competence is essential, excessive reliance on AI-generated outputs may weaken critical thinking and undermine the development of industry-relevant skills (Mogoale et al. 2025).

2.5 Gap in Knowledge

Although existing studies show that AI can enhance personalised learning, feedback quality, and student engagement, concerns remain regarding its effects on critical thinking, independent problem-solving, and academic integrity. The shortage of workplace-based learning opportunities in construction education is also widely recognised as a barrier to competency development and programme completion. While simulation-based WIL offers authentic learning experiences when physical placements are unavailable, current evidence suggests that simulations cannot fully replicate the complexity of real construction sites. Consequently, a significant knowledge gap exists regarding how AI-enabled blended WIL models, combining simulation-based and traditional experiential learning, can effectively develop industry-relevant competencies and workplace readiness among construction students. Furthermore, limited empirical research has evaluated the effectiveness of these approaches within construction education, particularly in resource-constrained contexts where access to workplace placements is restricted. This gap underscores the need for research on the design, implementation, and outcomes of AI-enhanced blended WIL models.

2 Research Methodology

3.1 Research Design

The study adopted a Systematic Literature Review (SLR) approach guided by the Preferred Reporting

Items for Systematic Reviews and Meta-Analyses (PRISMA) framework. PRISMA provides a structured process comprising four stages: identification, screening, eligibility, and inclusion (Page et al., 2021). A search strategy was developed from the research topic, *Transforming Construction Education through Artificial Intelligence and Simulation-Based Work-Integrated Learning*. Key search terms included “Work-Integrated Learning”, “Artificial Intelligence”, “Digital Technologies”, “Simulation-Based Learning”, and “Construction Education”. Boolean operators (“AND” and “OR”), wildcards (*, ?), and quotation marks (“”) were used to refine and broaden the search. The review employed a rigorous and systematic process to identify, evaluate, and synthesise relevant literature on AI and simulation-based WIL in construction education between 2016 and 2026. Searches were conducted across major academic databases, including,

Emerald Insight, ScienceDirect, IEEE Xplore, and SpringerLink. Retrieved publications underwent title, abstract, and full-text screening in accordance with the PRISMA protocol. Following the application of inclusion and exclusion criteria, 38 peer-reviewed publications were selected for critical review. The selected studies were subsequently analysed using thematic analysis to identify recurring themes, research trends, challenges, opportunities, and knowledge gaps relating to AI-enabled simulation-based WIL in construction education. An inductive coding approach was adopted. Figure 1 presents the publication retrieval and selection process.

3 Findings

Based on the literature synthesis, the study proposes various themes seen in Table 1. The themes are

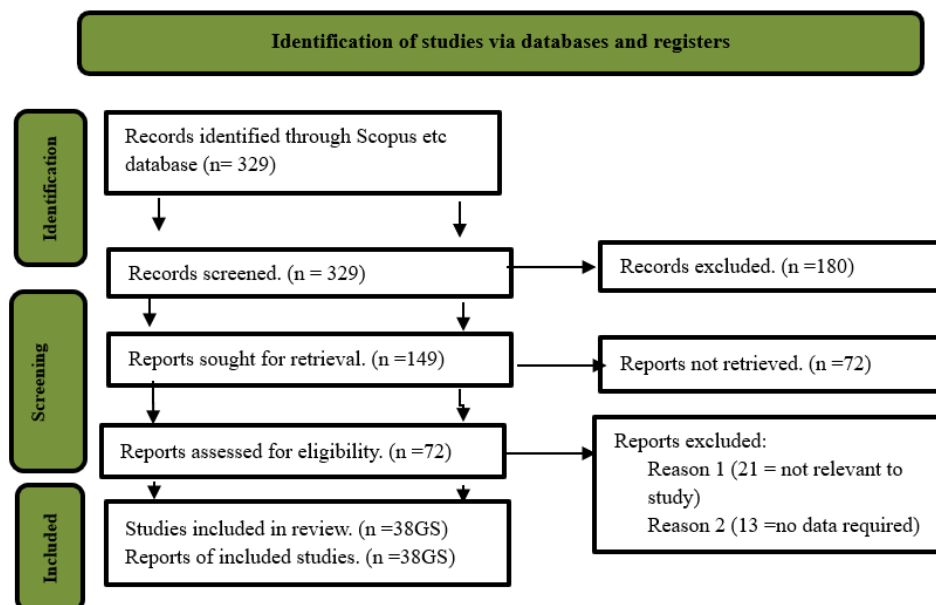


Figure 1: Publication retrieval process

Table 1: Key Themes and Findings from the Literature Review

THEME	KEY FINDINGS	RECENT SUPPORTING CITATIONS
AI-enabled pedagogy	AI tools support personalised learning, technical report writing, adaptive learning, and reflective learning in construction education.	Kizilcec et al., (2025); Khoza et al (2025); Al-Shamaileh et al (2026); Bakare et al (2023). Briant et al, (2023).
Simulation-based WIL	Simulation environments provide alternative experiential learning opportunities where physical placements are limited.	Laverie et al., (2026); Kingston et al, (2025); Dittrich et al, (2025); Chernikova et al, (2020)
Assessment Transformation	AI is forcing institutions to redesign assessments towards authentic, oral, collaborative, and scenario-based evaluations.	Cheng et al, (2025); Mogoale et al. (2025); Lee et al (2025); (Chiu et al., 2023). Tabak et al., (2018);
Student readiness and employability	AI-supported learning improves workplace readiness, digital collaboration, and industry preparedness.	Cheng et al., (2025); Opesemowo et al., (2025); Mogoale et al. (2025).; Briant et al, (2023).

developed into a conceptual framework for responsible AI-supported simulated Work-Integrated Learning (WIL) in construction education. The framework consists of four interconnected dimensions which have been developed into themes: (1) AI-enabled pedagogy; (2) Simulation-based WIL; (3) Assessment Transformation; and (4) Student readiness and employability. The conceptual framework proposes that AI should serve as a supportive educational tool that enhances teaching and learning rather than replacing human instruction, professional judgment, or experiential learning processes. Furthermore, AI is proposed as the link to a digitally simulated learning environment for WIL outcomes, given the challenges within higher education institutions, such as placement challenges due to few active construction sites amid a construction industry recession. This blended WIL model triggers assessment transformation, which as a result will realise more students meeting the necessary exit level outcomes and increasing the employability and work place readiness.

4 Discussion of the findings

4.1 Theme 1: AI-enabled pedagogy

AI-enabled pedagogy is transforming higher education by reshaping teaching, learning, and student engagement. In construction education, AI technologies support personalised learning, adaptive content delivery, intelligent tutoring systems, automated feedback, and simulation-based learning environments that enhance student learning experiences and outcomes (Kizilcec et al., 2025). These technologies enable educators to identify learning gaps, provide timely support, and tailor instructional approaches to diverse learner needs, thereby fostering more effective and inclusive learning environments.

The integration of AI into pedagogy also necessitates curriculum transformation. Al-Shamaileh et al. (2025) argues that construction programmes should incorporate AI literacy, digital competencies, and simulation-based experiential learning to align with evolving industry requirements. Similarly, Mogoale et al. (2025) emphasise that embedding these competencies within teaching and learning processes promotes responsive education while preparing graduates for technologically advanced workplaces. Consequently, future construction professionals will require competencies in AI-assisted problem-solving, digital collaboration, data interpretation, ethical technology use, construction informatics, and effective human-AI interaction, reinforcing the relevance of Construction 5.0 in construction education

4.2 Theme 2: Simulation-based WIL

Simulation-based Work-Integrated Learning (WIL) has increasingly emerged as a transformative pedagogical strategy within higher education, particularly in addressing industry readiness, employability, and

experiential learning gaps (Mhlanga et al; 2025). There are notable successful case studies in medicine where simulation-based WIL has addressed the aforementioned (Kizilcec et al, (2025); Brugliera (2024); Chernikova et al. (2020); Cheng et al., 2025). Curriculum transformation through simulation-based WIL aligns with contemporary shifts toward digitally enhanced and practice-oriented learning environments. Recent studies indicate that simulation-based learning fosters student engagement with multiple forms of knowledge and authentic professional decision-making processes (Dittrich, et al., (2025); Mhlanga et al; (2025). Similarly, Kingston et al. (2025) highlight that simulation-based experiences strengthen reflective learning, professional confidence, and collaborative competencies among students. Within technologically advanced learning environments, virtual simulation experiments have further demonstrated positive impacts on student motivation, technology acceptance, and learning outcomes (Cheng et al, (2025). In the broader WIL discourse, Mhlanga (2025) and Walter (2024), argues that simulation-driven WIL models provide strategic opportunities for universities to improve graduate employability while responding to industry demands and placement constraints.

4.3 Theme 3: Assessment Transformation

Walter (2024) argue that AI is reshaping assessment practices by supporting adaptive feedback, learner autonomy, and more personalised learning experiences within professional education. In the context of WIL, both Cheng et al; (2025) and Mhlanga (2025) advocate for assessment designs that prioritise reflective practice, problem-solving, and process-oriented learning over traditional content recall and AI detection methods. Mogoale et al. (2025); further demonstrate that participatory co-design approaches can strengthen AI-integrated assessment by involving both educators and students in developing meaningful and industry-relevant learning activities. This will transform currently how WIL assessments are undertaken which is primarily currently being based physically on a live construction site. This current practice is a major deterrent in graduate throughput due to a limited number of placement opportunities.

4.4 Theme 4: Student readiness and employability

The literature indicates a growing consensus that student readiness and employability are increasingly influenced by Work-Integrated Learning (WIL), digital competence, adaptability, and AI-related capabilities in rapidly evolving labour markets (Briant, 2024; Kizilcec et al., 2025; Brugliera, 2024; Chernikova et al., 2020; Cheng et al., 2025). Cheng et al. (2025) found that employability skills play a significant role in improving employment outcomes within AI-driven economies, particularly when reinforced by academic achievement and learner motivation. Furthermore, Fitria (2021) showed that predictive analytics can be used to identify

employability trends among graduates, enabling institutions to make informed decisions that strengthen student readiness and improve alignment between educational outcomes and labour market demands.

5 Implications for Construction Education

Reviewed scholarship demonstrates that Artificial Intelligence (AI), simulation technologies, and digital pedagogies are transforming construction education and reshaping the delivery of Work-Integrated Learning (WIL). The literature suggests that construction graduates increasingly require competencies beyond traditional technical knowledge, including digital literacy, AI fluency, adaptability, collaboration, and critical problem-solving skills to remain employable within the current construction environment. These developments have significant implications for construction education, particularly in contexts where access to traditional workplace placements is limited. Consequently, higher education institutions should develop simulated WIL environments that incorporate technologies such as Building Information Modelling (BIM), Virtual Construction Simulations which are integrated with AI-assisted decision-making tools. By replicating workplace challenges, collaborative practices, and project decision-making processes, simulated WIL environments can enhance student readiness, strengthen employability skills, and bridge the gap between academic learning and industry expectations.

6 Conclusion and Further Research

This systematic literature review examined the integration of Artificial Intelligence (AI) within simulation-based Work-Integrated Learning (WIL) in construction education. The findings indicate that AI-enabled simulations have significant potential to enhance experiential learning by developing students' reflective learning, technical communication, problem-solving, digital collaboration, and workplace readiness. These competencies are increasingly important for graduate employability in the digitally driven construction industry. The review also highlights a persistent challenge within construction education: limited access to workplace placements. Insufficient opportunities for site-based WIL often constrain

student progression and reduce programme throughput. In this context, simulation-based WIL offers a practical alternative by creating authentic virtual construction environments that replicate real-world project activities, stakeholder interactions, and decision-making processes. The integration of AI with other identified technologies can provide students with meaningful experiential learning opportunities when traditional placements are unavailable. Furthermore, the study contributes to simulation-based WIL literature by introducing a Construction 5.0 perspective that emphasises human-centred learning, ethical AI use, and industry-aligned digital competencies. The proposed framework highlights how AI-enhanced simulations can support personalised learning, real-time feedback, and competency development while maintaining the human, ethical, and sustainability principles underpinning Construction 5.0. In doing so, the study provides a foundation for curriculum redesign and future empirical research on AI-driven experiential learning in construction education.

The review therefore supports the development of a conceptual model that integrates AI, simulation-based learning, and authentic assessment to improve student readiness and employability in construction education. Future research should focus on designing and empirically validating such models, while evaluating the effectiveness of AI-enabled simulated construction site environments in developing technical and professional competencies. Further studies should also investigate how these environments can be implemented at scale to address the shortage of workplace placements and improve graduate preparedness for the evolving demands of the construction sector. By doing so, construction education institutions can expand access to experiential learning and better align graduate capabilities with industry expectations

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