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THE ROLE OF BUILDING INFORMATION MODELING (BIM) IN CIVIL ENGINEERING EDUCATION WITHIN THE EDUCATION 5.0 FRAMEWORK

Abstract:

The digital transformation of the construction industry has reshaped the competencies required from future civil engineers. Building Information Modeling (BIM) has emerged as a key methodology supporting integrated design, collaboration, and lifecycle management of construction projects. The higher education is evolving toward the Education 5.0 paradigm, which emphasizes human-centered learning and the effective use of advanced technologies. This paper examines the role of BIM in civil engineering education within the Education 5.0 framework. Focusing on master-level students, the study investigates their awareness and exposure to BIM through a structured survey. The findings aim to support improved BIM integration in civil engineering curricula.

Keywords: building information modeling, Education 5.0, civil engineering education, digital transformation

УЛОГА BIM-а У ОБРАЗОВАЊУ ГРАЂЕВИНСКИХ ИНЖЕЊЕРА У СКЛАДУ СА ОБРАЗОВАЊЕМ 5.0

Сажетак:

Дигитализација грађевинске индустрије је преобликовала компетенције које се очекују од будућих грађевинских инжењера. Информационо моделирање објеката (БИМ) је кључна методологија која подржава интегрисано пројектовање, сарадњу и управљање животним циклусом грађевинских пројеката. Високо образовање се развија ка парадигми „Образовање 5.0”, која наглашава учење усмерено на човека и ефикасну примену напредних технологија. Овај рад разматра улогу БИМ-а у образовању грађевинских инжењера у оквиру „Образовања 5.0”. Фокусирајући се на студенте мастер студија, ово истраживање испитује њихову свест и изложеност БИМ-у путем анкете. Резултати имају за циљ да подрже унапређену интеграцију БИМ-а у наставне планове и програме студија грађевинарства.

Кључне речи: информационо моделирање објеката, образовање 5.0, образовање у грађевинарству, дигитална трансформација.

1. INTRODUCTION

The construction industry is undergoing a rapid digital transformation driven by increasing project complexity, sustainability requirements, and the demand for improved efficiency and collaboration. Traditional construction practices are being replaced by data-driven and integrated approaches that enable better coordination among project stakeholders. In this context, Building Information Modeling (BIM) has become one of the most influential methodologies shaping contemporary civil engineering practice [1].

BIM enables the creation and management of digital representations of physical and functional characteristics of construction projects throughout their entire lifecycle. Unlike conventional two-dimensional documentation, BIM supports information-rich models that facilitate coordination, visualization, and decision-making from early stages to operation and maintenance [1]. As BIM adoption continues to expand globally, civil engineers are increasingly expected to possess not only technical knowledge but also digital competencies and collaborative skills. For the Republic of Serbia, there is an important step ahead: Article 91 [9] of the Planning and building act states technical documentation for buildings over 10,000 m^2 of gross developed construction area must be prepared in BIM technology starting from January 1, 2028 [2].

Higher education institutions play a crucial role in preparing future engineers for these evolving professional demands. However, traditional engineering education has often been characterized by curricula and limited exposure to integrated digital workflows. Several studies have highlighted a growing gap between industry expectations and the competencies developed during formal education [3], [4]. As a result, the integration of BIM into civil engineering curricula has become a strategic priority for many academic institutions. Other studies emphasize that effective BIM education should be practical and workflow-oriented, enabling students to cope with a BIM-enabled project environment, and should be delivered through progressive, scaffolded learning from foundational concepts to advanced applications - rather than as isolated, software-only exposure. Consequently, curriculum-level integration (with a balanced distribution of BIM content across the program) is recommended to develop job-ready competencies without diluting essential domain knowledge [5], [6].

At the same time, educational systems are evolving toward the Education 5.0 framework. Education 5.0 represents a shift from technology-centered education toward a human-centered approach that emphasizes creativity, sustainability, ethical responsibility, and lifelong learning [7]. In this paradigm, advanced technologies are not considered ends in themselves but rather tools that enhance human capabilities and support societal well-being.

Within the Education 5.0 framework, BIM can be understood as more than a technical tool. It represents a pedagogical approach that supports experiential learning [8]. Experiential Learning Theory (experience as the source of learning and development) conceptualizes learning as a cyclical process in which concrete experience and active experimentation play central roles. Also, it supports interdisciplinary collaboration, and systems thinking. BIM-based learning environments allow students to engage with realistic project scenarios, fostering problem-solving skills and professional competencies aligned with contemporary engineering practice [9]. Despite its recognized importance, BIM integration in civil engineering education remains uneven. In many study programs, BIM is introduced through isolated lectures or software-focused courses, without systematic alignment with learning outcomes and curricular objectives [10]. Substantial regional differences persist, and deeper BIM adoption remains constrained by limited resources, insufficient faculty training, institutional resistance, and weak industry collaboration [11]. Understanding students' awareness, perceptions, and educational experiences related to BIM is therefore essential for evaluating the current state of BIM education and identifying opportunities for improvement.

This paper investigates the role of BIM in civil engineering education within the Education 5.0 framework, with a focus on 4 different modules of one master study program. Through a survey-based study, the research aims to assess students' familiarity with BIM concepts, their exposure to BIM during formal education, and the alignment between current educational practices and the principles of digital transformation.

Education 5.0 has emerged as a response to the challenges posed by rapid technological development, societal change, and sustainability concerns. Building upon earlier educational paradigms, Education 5.0 emphasizes a human-centered approach that integrates advanced technologies with ethical responsibility and social values [7].

Key principles of Education 5.0 include learner-centered education, interdisciplinary collaboration, development of digital and transversal competencies, and lifelong learning. In engineering

education, these principles require a shift from passive knowledge transfer toward active, project-based, and experiential learning environments.

Digital transformation in higher education involves not only the adoption of new technologies but also fundamental changes in teaching methodologies and curriculum design. Engineering students are increasingly expected to work in collaborative digital environments, solve complex real-world problems, and adapt to rapidly changing professional contexts [3].

Within this framework, digital tools such as BIM play a crucial role in bridging the gap between theoretical knowledge and professional practice. By integrating BIM into education, institutions can support learning experiences that reflect real engineering workflows and promote the development of competencies aligned with the principles of Education 5.0.

2. BIM IN CIVIL ENGINEERING EDUCATION

Building Information Modeling has become a central component of modern civil engineering practice, influencing design, construction, and project management processes. BIM is commonly defined as a collaborative process for generating and managing digital representations of the physical and functional characteristics of built assets [1].

In civil engineering education, BIM offers significant pedagogical benefits. It enables visualization of complex structural systems, supports interdisciplinary coordination, and facilitates understanding of construction sequencing and project lifecycle management. BIM-based learning activities allow students to integrate knowledge from multiple disciplines, including structural engineering, construction technology, and project management [9].

Despite these advantages, the level of BIM integration within civil engineering curricula varies widely. In many cases, BIM is introduced as an optional or elective subject, with a primary focus on software operation rather than on collaborative processes and information management [10]. Such approaches may limit students' understanding of BIM as a comprehensive methodology.

Research indicates that the systematic, curriculum-wide integration of BIM is more effective at developing professional competencies than isolated courses or short-term training [4]. Consequently, there is a growing need to evaluate how BIM is currently taught and perceived by students to inform educational strategies.

2.1. BIM WITHIN THE EDUCATION 5.0 FRAMEWORK

BIM aligns strongly with the principles of Education 5.0 by supporting active, collaborative, and experiential learning. BIM-based educational environments encourage students to work in teams, solve complex problems, and engage with realistic project scenarios that reflect professional practice.

Through BIM, students can develop not only technical skills but also transversal competencies such as communication, collaboration, and critical thinking. These competencies are essential for addressing the challenges of sustainable development and digital transformation in the construction industry [8].

However, effective BIM integration requires more than access to software tools. It demands appropriate pedagogical approaches, educated professors, and institutional support. Without these elements, BIM education risks being reduced to technical training rather than serving as a transformative educational methodology aligned with Education 5.0.

Understanding students' experiences and perceptions of BIM is therefore crucial for assessing the effectiveness of current educational practices and identifying opportunities for improvement within the Education 5.0 framework.

3. RESEARCH METHODOLOGY

3.1. RESEARCH AIM

This research aims to examine the level of awareness, understanding, and educational exposure to BIM among master-level civil engineering students within the context of Education 5.0. Master's level students at one higher education institution in Serbia were selected because they are closest to entering professional practice and have completed undergraduate studies, making them well positioned to evaluate their exposure to BIM.

3.2. RESEARCH SAMPLE

The research sample comprises master's students enrolled in civil engineering studies. The research was conducted during the 2022 and 2025 winter semesters. The inclusion of students from different school years enables comparative analysis of BIM exposure during formal education.

3.3. RESEARCH INSTRUMENT

Research instruments are tools used to gather, measure, and analyze data in research studies. These instruments are crucial for obtaining accurate and reliable information, which forms the basis for drawing valid conclusions and making informed decisions.
For this research, the chosen research instrument is a questionnaire. Data was collected using a structured questionnaire designed to assess students' familiarity with BIM concepts, sources of information, experience with BIM software, and perceptions of BIM-related education. The questionnaire included both closed-ended and open-ended questions:

Survey Questionnaire on BIM Awareness and Education

1. Have you ever heard of the term *Building Information Modeling (BIM)*?
☐ Yes
☐ No

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2. Where did you hear about BIM?
☐ University courses
☐ Student conference
☐ Self-directed research

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3. What do you think BIM represents?
(Open-ended question)

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4. How often was the term *BIM* mentioned during undergraduate courses?
☐ A few times
☐ Occasionally
☐ Frequently

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5. Have you independently shown interest in learning more about BIM?
☐ Yes
☐ No

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6. Is a 3D model the same as a BIM model?
☐ Yes
☐ No

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7. Does using BIM software alone imply working in a BIM environment?
☐ Yes
☐ No

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8. Which BIM software tools have you heard of?
(Open-ended question)

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9. Have you attended any BIM software training courses?
☐ Yes
☐ No

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10. If yes, which software tools were included in the training?
(Open-ended question)

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11. Have you independently learned to work with any BIM software?
☐ Yes
☐ No

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12. If yes, which BIM software did you learn to use?
(Open-ended question)

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13. Have you received recommendations from senior students to engage in BIM?
☐ Yes
☐ No

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14. Have you received recommendations to use specific BIM software?
☐ Yes
☐ No

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15. If you received a recommendation, please specify the source
(e.g., senior students, social media, parents, etc.)
(Open-ended question)

3.4. DATA COLLECTION AND ANALYSIS

The questionnaire, which was created for this research, was distributed in person and was anonymous. The collected data was prepared for descriptive statistical analysis and qualitative interpretation. The detailed results of the analysis are presented in the following section.

4. RESULTS AND DISCUSSION

This section presents the survey results and discusses the findings in relation to existing literature and the principles of Education 5.0.

The results are presented using descriptive statistics and graphical representations to illustrate students' awareness of BIM, their educational exposure, and learning pathways. The discussion focuses on identifying patterns, gaps, and opportunities to improve BIM integration within civil engineering curricula. The survey conducted among 39 master's students in 2022 and 29 master's students in 2025 indicate a clear improvement in the level of awareness and interest in BIM technology. While in 2022 a total of 95% of respondents reported being familiar with the term BIM, in 2025 all surveyed students (100%) stated that they had heard of the concept (Figure 1).

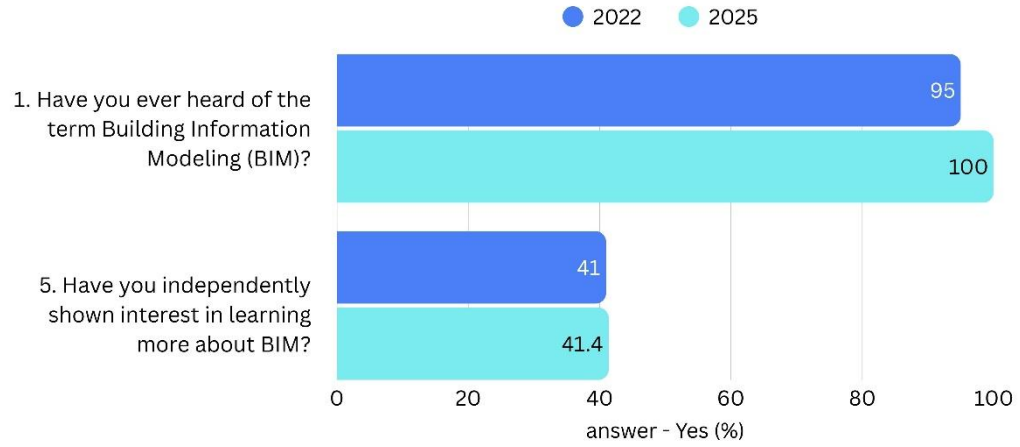

Figure 2. Descriptive comparison of BIM awareness (Q1) and independent motivation to learn more about BIM (Q5), expressed as the percentage of "Yes" responses in 2022 and 2025 (created by author).

University courses remain the primary source of information about BIM, although the importance of other sources, such as student conferences and informal learning environments, has increased.

The results also suggest that BIM is being mentioned more frequently during undergraduate studies, indicating its gradual integration into the educational process (Figure 2).

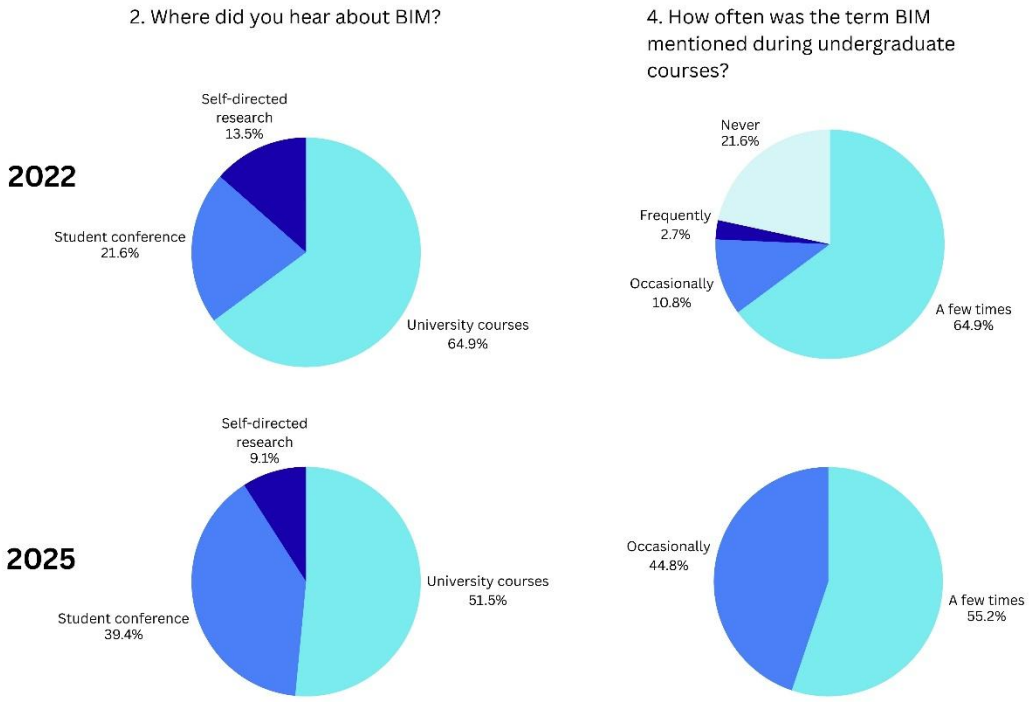

Figure 3. Survey results for Questions 2 and 4 (2022 vs. 2025) (created by author).

Students were able to identify a wider range of BIM software tools compared to the earlier survey, although Allplan (Nemetschek Company) and Autodesk Revit remain among the most widely recognized software tools (Figure 3). At the same time, the proportion of students who have attended BIM-related training courses or independently learned to use BIM software has increased (Figure 4).

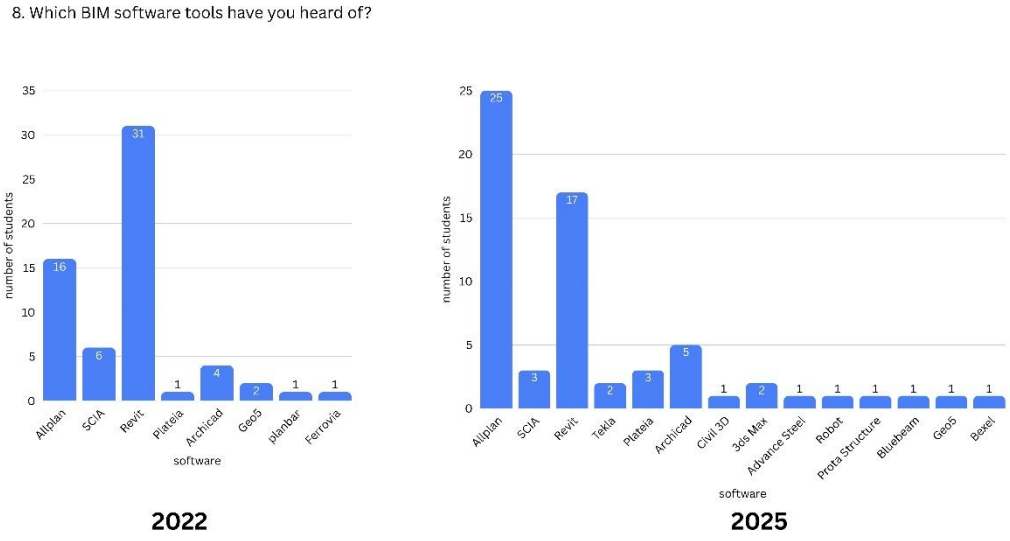

Figure 4. Survey results for Question 8 (2022 vs. 2025) (created by author).

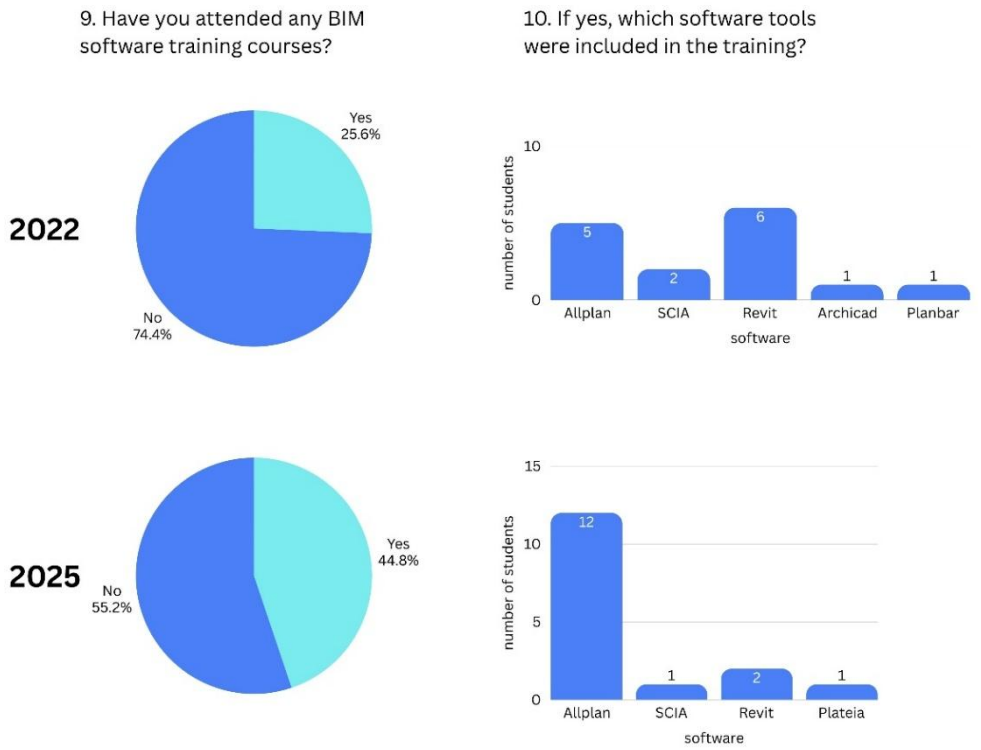

Figure 5. Survey results for Questions 9 and 10 (2022 vs. 2025) (created by author).

Additionally, the results reveal a growing influence of peer recommendations regarding engagement with BIM technologies and the use of specific software tools, with senior students and professors identified as the most common sources of such recommendations (Figure 5).

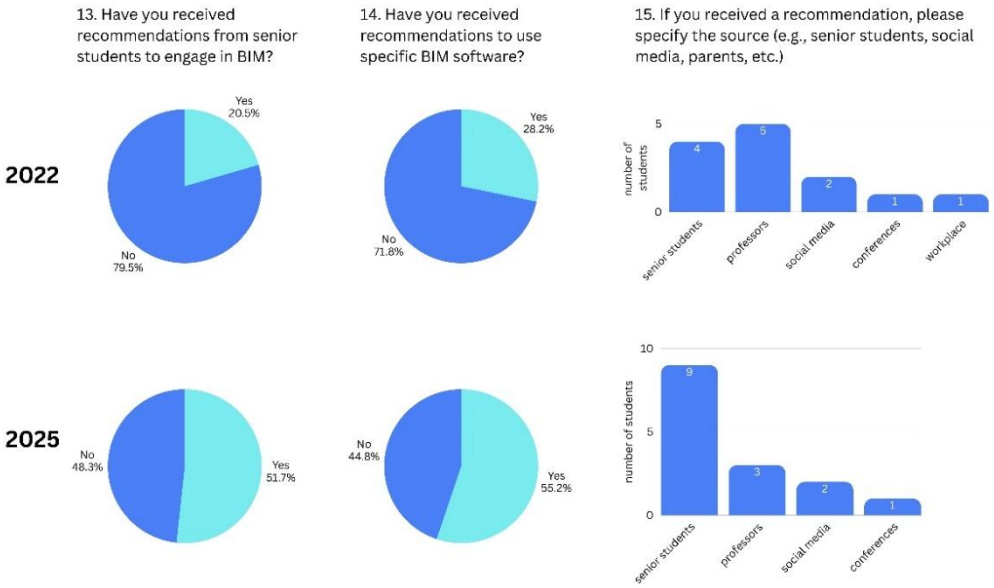

Figure 6. Survey results for Questions 13, 14 and 15 (2022 vs. 2025) (created by author).

Overall, the findings suggest an increasing presence and relevance of BIM technology within the education of civil engineering students, as well as a gradual rise in their awareness, interest, and engagement with this field. Although the results indicate higher awareness and interest, civil engineering curricula should still embed learning activities in a BIM-enabled environment so that

BIM knowledge and professional practice are developed progressively and through practical, workflow-oriented tasks.

5. CONCLUSION

The integration of Building Information Modeling into civil engineering education is a critical component of digital transformation aligned with the principles of Education 5.0. BIM supports human-centered, collaborative, and experiential learning environments that reflect contemporary engineering practice.

Although the survey results indicate a noticeable improvement in students' awareness of BIM methodology in 2025 compared to the cohort surveyed in 2022, the findings also suggest that higher education still lags behind the pace of change in the digitalization of the construction sector. Considering the forthcoming challenges related to the implementation of regulatory frameworks and the rapid advancement of digital technologies, the study indicates that both the teaching and practical application of BIM within higher education require further development in order to align with emerging industry trends.

This study provides a foundation for understanding students' awareness and experiences with BIM. The findings are expected to contribute to ongoing discussions on curriculum development and to support the design of educational strategies that better prepare future civil engineers for professional practice in a digitally driven construction industry.

Future research may expand the scope of this study by including multiple institutions, comparative international analyses, and perspectives from educators and industry professionals.

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