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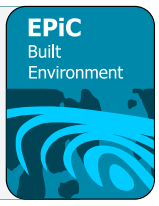

Digital Technologies Readiness Among Undergraduate Construction Management Students: An Exploratory Study

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This research explores the readiness of construction management students regarding their familiarity levels, their perception in the future, and barriers in learning of digital technologies in construction. This study utilized a mixed-methods approach to perform a comprehensive survey of construction management students focused on junior and senior levels. Digital technologies such as Building Information Modeling (BIM), Artificial Intelligence (AI), Virtual/Augmented Reality (VR/AR), Drones, Lidar 3D scan, and Internet of Things (IoT) were emphasized and utilized in the survey questionnaire. Data was collected from 108 students and the results are summarized with analysis. The findings indicated varying levels of familiarity with BIM/VDC, and drones perceived as highly significant for future industry applications. However, substantial barriers, such as lack of formal training, high costs, time constraints, and limited emphasis by institutions, were identified as key challenges to technology adoption. A Spearman correlation heatmap highlighted the relationships between students' self-interest, perception of the necessity of technology, and their preference for traditional methods. This study emphasized the need for a systematic approach to reduce barriers, better align the curriculum with current industries digital transformation requirements and foster a culture of technological adoption among future industry experts.

Keywords: Construction, Digital Technologies, Education, Barriers

Introduction

The construction industry, which contributes over $10 trillion annually to the global economy, is undergoing digital transformation driven by technologies such as BIM/VDC, AR/VR/XR, AI, Lidar 3D scan, Drone, Robotics and automation, and IoT. With the emergence of advanced technology and digital transformation, the industry is now recognized for its importance in pre-construction, construction, and facility management stages, despite its historical sluggishness in embracing digital technologies (Gunduz et al., 2024). These technologies are transforming traditional practices, potentially reducing project costs by 15-20% and improving productivity by up to 25% (McKinsey, 2024).

At present, major construction companies in the United States have integrated digital technology, emerging technology or automation divisions separately inside their organizational frameworks to

investigate and implement digital technologies for project visualization, client collaboration, site surveillance and for repetitive tasks (Whitley, 2021; DPR, 2024; McCarthy, 2024; Suffolk, 2020; Turner, 2024). To prepare students for the ever-changing nature of the construction industry, it has been essential to include these technical advances into construction management curricula. The construction industry encounters challenges with technology adoption, notably in terms of labor preparedness and skill development. A gap exists between industry skill demands and the offerings of educational institutions (Murzi et al., 2023).

This study explores the readiness of construction management students to adopt digital technologies by addressing the following research questions: (1) What is the current level of familiarity with digital technologies among construction management students? (2) How do construction management students perceive the significance of these technologies for their future careers? (3) What are the main barriers to the adoption of digital technologies in construction management education? (4) How do students' self-reported interest in, and perception of, technology correlate with their preference for traditional methods? (5) How can educational institutions better align their curricula with the digital transformation requirements of the construction industry? (6) What strategies can be employed to foster a culture of technological adoption among future construction management professionals? By examining these questions, the study aims to interpret critical factors influencing technology adoption, provide insights for curriculum development, and offer practical recommendations to enhance collaboration between academia and industry. It is crucial to understand these aspects to develop effective teaching strategies and improve industry-academia cooperation.

Literature Review

Digital Technologies in Construction

Digital technologies have been recognized as critical in contemporary construction, enhancing efficiency, resource management, and safety (Lu et al., 2024). BIM provides comprehensive digital representations of projects, accelerating real-time collaboration and reducing error (Zavari et al., 2022). VDC tools on the other hand combine data from various sources for synchronized visualization, aiding in practical planning and stakeholder commitment (Del Savio et al., 2022). As construction technology advances, AR/VR have recently emerged as innovative solutions in construction management by improving progress monitoring, facilitating complex training, and enhancing safety management through real-time risk visualization (Li et al., 2018). Lidar technology facilitates the acquisition of three-dimensional geometric high-precision data collection and site monitoring capabilities, which are increasingly essential for surveying, inspection, and progress tracking (Puri & Turkan, 2020). The integration of AR and lidar technologies has recently been demonstrated in indoor navigation applications, representing significant progress in practical construction solutions (Sharma Bhattarai & Kisi, 2024). This integration, however, primarily reflects experimental or exploratory phases rather than widespread industry practice. AI/ML has considerably enhanced the construction sector by providing automation and competitive benefits. It assists in optimizing contractor selection, mitigate bias, and promotes efficiency through the rapid analysis of extensive data sets (Regona et al., 2022). Drone technology's practical benefits for site surveying, safety inspection, and construction monitoring are well documented (Mahajan, 2021). Nonetheless, previous studies often overlook educational implications and students' preparedness to utilize drone technologies professionally. Further, Robotics and automation in construction have become crucial for enhancing operational efficiency, worker safety, and overall quality of the work environment (Gharbia et al., 2020). Lastly, Internet of Things (IoT) technologies offer extensive benefits in enhancing site safety, environmental monitoring, and real-time data collection (Kanan et al., 2018).

Existing literature extensively documents technical benefits and barriers to various digital technologies in construction yet notably lacks comprehensive analysis on educational readiness and integration within construction management programs. This study fills this critical gap by examining students' perceptions, familiarity, and readiness to adopt digital technologies, thereby offering unique insights for curriculum development.

Digital Technologies in Construction Education

BIM has emerged as a fundamental component of construction education owing to its extensive Industry utilization, allowing students to cultivate essential skills in modeling, project visualization, and lifecycle management (Sacks & Pikas, 2013). However, Leite et al. (2016) argue that most programs focus primarily on basic modeling skills rather than advanced applications such as 4D scheduling and 5D cost estimation, which are increasingly demanded by industry. Dang et al. (2024) highlights the significance of BIM education and offers suggestions for the instruction of BIM courses within construction management curricula. Although many educational institutions have started integrating these technologies, significant challenges remain to be addressed.

Disparity between Academy and Industry

A study shows nearly half of all construction companies (42.2%) are struggling with a lack of skilled workers with digital technology skills (Deloitte, 2024). The demand for CM graduates has shifted due to digital transformation, necessitating a combination of traditional skills and digital technologies (Wang, 2024). To prepare future industry experts, it is crucial to incorporate digital technologies in construction management education. This integration can create an effective learning environment, develop advanced technical skills, and improve safety training protocols (Zoleykani et al., 2024). The industry's adoption of digital technologies has led to the need for a combination of traditional skills and digital technologies in education.

The disparity between industry requirements and graduate capabilities has emerged as a critical concern in construction education. However academic institutions often lack digital technology integration, leaving students without hands-on experience. This disconnect affects their readiness for industry roles and calls for academic programs that reflect modern construction demands. There are skills gaps in graduates and industry expectations, and educational institutions must adapt while maintaining fundamental principles (Radermacher et al., 2014). Educational obstacles include inadequate faculty proficiency and limited access to contemporary software and hardware, hindering successful technology instruction (Haleem et al., 2022).

Methodology

This study seeks to address a gap in knowledge between academia and industry about the perspectives of future professionals in the field of construction management on digital technologies and their level of preparedness for the industry's evolution. The study aimed to explore the perception of undergraduate students about adoption readiness of digital technology in construction. This study is a pilot study targeting only one leading US institution which has been teaching construction management for more than four decades. Students in their junior and senior years who have internship experience or who are currently thinking about their career paths were invited to participate since they were the most likely to provide useful information.

An online questionnaire was designed using the Qualtrics platform, hosted by the university, for the purpose of conducting the survey. The questionnaire was carefully structured into sections, with the

first section dedicated to gathering demographic information of the respondents, including their level, whether they have industry experience and their future area to be involved. The second section was designed to delve into the specific level of familiarity of digital technologies, any formal training on those technologies and their preference on future perspective on traditional method or application of digital technology as well as the barriers in learning those technologies.

Results

108 total responses were collected out of the 298 junior and senior students. They were thoroughly analyzed, forming the foundation for the data analysis and subsequent outcomes of this research. The response rate of 36% (108 out of 298) effectively makes the sample size sufficient for this kind of pilot study analysis.

Demographic Responses

Table 1 shows demographic data for junior and senior year students, categorized by their interest and experience in the construction industry. Junior year students had 37% job experience, with commercial and residential categories being the most common. Heavy civil was chosen exclusively by students without experience. Senior-level students had 39% job experience, with commercial and residential interests. Heavy civil had a 50-50 split between those with and without experience, while other sectors showed 83% with experience. Senior year students had more work experience than juniors, and those with experience reported higher interest in multiple fields.

Table 1. Demographic information

		Previous Work Experience		**Total**
Students	**Interested Area of Industry**	**Yes**	**No**	
Junior Year	Commercial	35%	65%	14
	Residential	50%	50%	10
	Heavy Civil	0	100%	4
	Total	**37%**	**63%**	**28**
Senior Year	Commercial	35%	65%	48
	Residential	30%	70%	20
	Heavy Civil	50%	50%	6
	Others	83%	17%	6
	Total	**39%**	**61%**	**80**

Familiarity of Different Digital Technologies

Students were asked about their familiarity towards their knowledge on digital technologies. Figure 1 shows that students' familiarity with various digital technologies, such as BIM/VDC, AR/VR, AI, drones, lidar 3D scanning, robotics and automation, and IoT and sensors, varies significantly. BIM/VDC has the highest combined familiarity, with 35% being moderately familiar and 31% very familiar. AI also shows notable familiarity, with 38% being moderately familiar and 25% very familiar. However, IoT and sensors have the highest percentage of respondents who are not familiar, while lidar 3D scan and robotics and automation have a significant number of respondents who are not familiar or only slightly familiar.

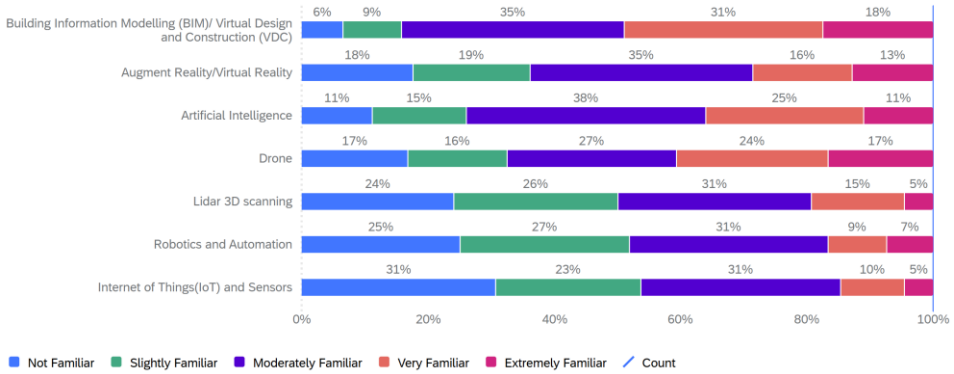

Figure 1. Familiarity with different digital technologies

Training Taken Outside University

In this section, we asked students whether they had enrolled in any digital technologies courses or participated in training sessions beyond their usual curriculum. As detailed in Figure 2, BIM/VDC is the most prevalent, with 33% of respondents enrolled, followed by Drone technology at 14%. AR/VR constituted 7%, while AI represented 4%, and Lidar 3D Scanning together with other technologies each included 3%. Notably, 38% of respondents said that they have not pursued any courses in new technologies outside their standard curriculum.

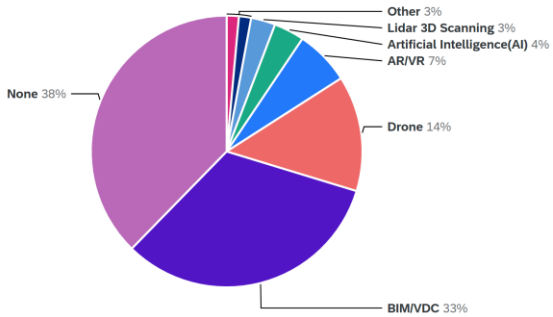

Figure 2. Training outside university courses

Significance of Digital Technologies in the Future

Many students are knowingly or unknowingly aware of digital technologies in certain ways hence, we asked students about the importance of each technology for the future in the construction industry. The relatively important index (RII) value, which may range from 0 to 1, was utilized to quantify the perceived significance of each technology. Values that are closer to 1 indicate a higher level of importance being associated with technology. Formula for RII as shown below is used to determine the relative ranking (Ahmadi, Sharma Bhattarai & Kim, 2024).

$$RII = \frac{\sum W}{AN}$$

Table 2. summarize essential insights into the objectives and preferences of students about digital technologies. The RII values and rankings facilitate the identification of the technologies deemed most influential. BIM/VDC possesses the highest RII score of 0.887, signifying its critical importance in improving project planning, cooperation, and design precision. Drones and lidar 3D scan are highly ranked, indicating their increasing use in surveying and building oversight. In contrast, AR/VR had the lowest ranking, indicating that although it possesses promise, respondents do not regard it as urgently critical in comparison to other technologies.

Table 2. Significance of digital technologies in the future

Digital Technologies	**Frequency**					**Overall**	
	1	2	3	4	5	RII	Rank
BIM/VDC	0	5	10	26	67	0.887	1
Drone	2	3	11	35	57	0.863	2
Lidar 3D Scan	2	6	16	33	51	0.832	3
AI	4	6	28	27	43	0.783	4
Robotics and Automation	2	9	28	29	40	0.778	5
IoT and Sensor	3	8	27	31	39	0.776	6
AR/VR	5	6	30	29	38	0.764	7

Analysis

Correlation Between Traditional Method and Learning Digital Technologies

A Spearman correlation analysis was conducted to understand students' perceptions of traditional methods for job security and learning new technologies.

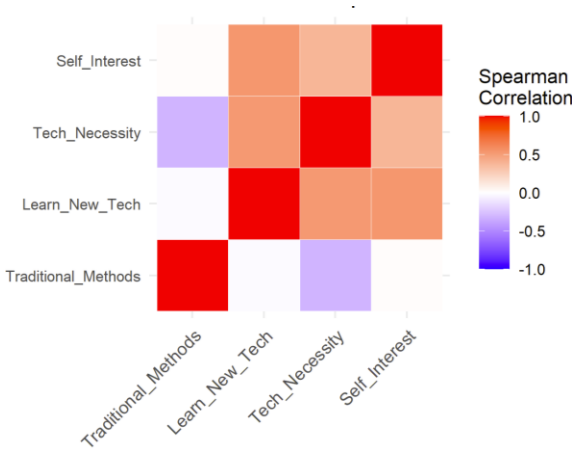

Figure 3. Spearman correlation heatmap

The results as shown in figure 3 indicate a strong positive correlation between self-interest in learning new technologies and their necessity for long-term career growth. Students who are more interested in learning new technologies are more likely to see them as beneficial for career progression. Conversely, those who prefer traditional methods are less inclined to see new technologies as beneficial. This highlights the differing attitudes towards technology adoption in the construction

industry, with those who embrace new technologies seeing them as crucial and those who favor traditional approaches seeing less value in adopting digital tools.

Barriers in Learning Digital Technologies

In the subsequent phase of the study, students were prompted to choose the barriers in learning digital technologies. The students were given six options to choose multiple answers from their perspectives. Upset plot analysis was performed to view their perception (Lex et al., 2014). The Upset Plot analysis as shown in figure 3 indicates that the primary barrier to adopting digital technologies in the Construction Management curriculum is the lack of formal courses which is responded for sixty times either individually or in combination with other barriers. Key combinations involve time constraint and higher cost barriers obstacles, suggesting that these issues are frequently interconnected. Thirty respondents make up the most common intersection of barriers, which shows a common mix of difficulties; several smaller connections show how student's perceptions of obstacles vary.

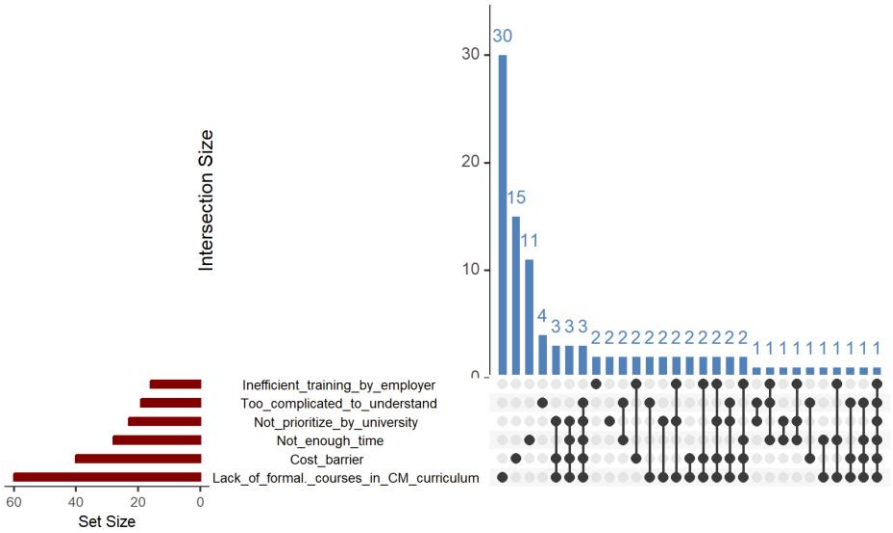

Figure 3. Upset plot analysis of barriers

Conclusion

The study highlighted that students' work experience, interest in specific construction sectors, and openness to digital technologies influence their professional aspirations. While junior and senior-level students prefer commercial and residential work, those with practical industry exposure have broader interests across multiple fields. However, there is an uneven distribution of knowledge about digital technologies, with well-known tools like BIM/VDC and AI being more widely known, while emerging applications like AR/VR, lidar scanning, and robotics are less understood.

The necessity for more accessible and organized learning opportunities is further underscored by the fact that a significant number of students are not actively seeking out extracurricular training in digital technology. BIM/VDC tends to attract the most students, indicating its high demand in the industry and the academic community. When it comes to importance ranking, BIM/VDC is at the top, followed closely by drones and lidar, which are becoming more and more useful for surveying and

oversight. Despite its promise, AR/VR scores lower, maybe because students don't have much experience with it or don't see any practical uses for it right away in the workplace.

A key insight is the strong correlation between students' self-reported enthusiasm for learning new technologies and the perceived value of these tools in advancing their careers. Conversely, those who favor traditional methods show less inclination to view digital solutions as beneficial. This attitudinal gap underscores the importance of proactive interventions—ranging from curriculum enhancements to on-site demonstrations and internships—to shift perceptions and encourage wider adoption.

Finally, the analysis of barriers reveals that the absence of formal courses stands out as the most frequently mentioned obstacle to embracing digital tools. Time constraints and cost further complicate these challenges, often appearing in tandem. To overcome these interconnected issues, universities and industry stakeholders must collaborate on targeted strategies: expanding course offerings, integrating hands-on modules, and addressing financial or scheduling hurdles. By doing so, programs can better equip future construction professionals with the skills and mindset necessary to thrive in an increasingly digitalized sector.

This pilot study on digital technologies readiness among construction management students was conducted to provide preliminary insights. However, it has limitations, such as potential bias due to data collected from a single US institution and concerns about the sample size's ability to represent the entire range of programs. Future research should include diverse colleges from all 50 states, use longitudinal methodologies to track student attitudes, and seek input from academics and business leaders. This comprehensive approach would strengthen the validity of the findings and align academic curricula with the changing needs of the construction industry.

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