Enhancing AI Literacy of Undergraduate Students Using Construction Safety Context

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ABSTRACT

The integration of artificial intelligence (AI) has the potential to address various challenges in the construction industry, including cost overruns, safety concerns, labor shortages, and productivity issues. However, the construction industry has been slow to adopt AI solutions due to a lack of construction professionals with appropriate AI understanding. Currently, very few construction programs incorporate AI literacy into their undergraduate curricula. This study aims to address this gap by developing a 2-h curriculum that teaches construction students AI literacy knowledge within the context of construction safety. The effectiveness of the curriculum was assessed through pre- and post-intervention questionnaires, which showed that the curriculum effectively enhanced construction students' AI literacy level. This research provides a valuable foundation for the future integration of AI literacy components into construction curricula, which is crucial for the construction industry to catch up with other industries in adopting AI solutions.

KEYWORDS: Artificial Intelligence (AI) literacy, Construction education, Construction safety.

INTRODUCTION

Artificial Intelligence (AI) is transforming the construction industry significantly, and it is here to stay. Research has shown that AI has the potential to revolutionize the construction industry by improving efficiency, safety, and sustainability (Kristombu Baduge et al. 2022). The literature also demonstrates that the application of AI can be found across the entire construction lifecycle and could disrupt the construction industry (Mohammadpour et al. 2019; Schober 2020). However, despite the advantages of AI in construction, research has also shown that the construction industry is lagging behind other industries in adopting AI as a solution to the challenges it is facing (Jose Luis Blanco et al. 2018; Regona et al. 2022b). This delay in incorporating AI in the construction industry could be attributed to several reasons. One of the reasons is the shortage of AI talent and know-how in the construction industry (Regona et al. 2022b). This knowledge gap about AI in construction could lead to misconception and anxiety about AI in construction and cause a lot of resistance to the adoption of AI in the industry. As such, it is critical to foster "AI literacy" among construction workers and students who will enter the construction industry in the near future, to better incorporate AI in the construction industry.

"AI literacy" is an emerging concept that emphasizes a set of essential competencies required for effective interaction with and critical evaluation of AI (Long and Magerko 2020). In recent years, researchers have focused on creating AI literacy learning interventions for kindergarten and first through 12th grade (K-12) and non-computer science students to prepare them for a future era in which AI is ubiquitous (Southworth et al. 2023; Su et al. 2023; Sulmont et al. 2019). In the construction education domain, there is limited recent literature that discusses the integration of AI into construction curricula (Naser 2022). However, there is still a knowledge gap regarding how to integrate AI into existing construction curricula, such as construction safety, and whether such integration can enhance students' AI literacy. This study aims to fill this gap by developing the 2-hour curriculum to teach basic AI literacy competencies to undergraduate construction students, with a focus on the context of construction safety, and evaluating its effectiveness in increasing students' AI literacy. This study's contribution to the body of knowledge will be a detailed development process for the curriculum that enables undergraduate students to learn about AI within the construction safety context and a better understanding of how AI integration in construction curricula affects students' AI literacy. The following sections will introduce AI applications and AI education status in construction, the methodology of this study, and a discussion of the results.

AI APPLICATIONS IN CONSTRUCTION

In response to safety concerns, labor shortages, and low productivity issues, the construction industry is beginning to explore AI to cope with these challenges (Fang et al. 2020). AI applications have been explored by industry and researchers throughout the life cycle of civil assets, namely from the pre-construction, construction, operation, and maintenance phases to assure reasonable decision making. For example, a report from Roland Berger has demonstrated AI with significant disruption potential along with the construction value chain (Schober 2020). With the substantial improvements in various AI domains, data sources from safety reports, images, audio, and videos recorded in different formats have been utilized to achieve different purposes in construction (Fang et al. 2020). For example, in pre-construction phase, AI has been applied to contract analysis, project planning and scheduling, and cost estimation (Jeong and Alikhani 2021). For the construction phase, AI has been utilized to assist in progress monitoring, quality control, and operational productivity analysis (Regona et al. 2022a). In the operation and maintenance phase, AI has been applied to assist with structural health monitoring, energy management, and security assurance (Kristombu Baduge et al. 2022). Besides these, other applications of AI in construction include cost management (Son et al. 2012) and dispute resolution (Chou and Lin 2013).

Despite the literature having demonstrated the benefits of adopting AI in the construction industry, construction industry is still lagging other industries (Jose Luis Blanco et al. 2018). One recent survey shows that only 0.2% of all job postings in the construction industry are AI related, which is falling behind most of the industries (Stanford University 2021). This is because several barriers still exist hindering the widespread implementation of AI in these fields (Naser 2022). Among all the possible barriers, research has identified the shortage of AI talent (Abioye et al. 2021) or AI skill gap (Regona et al. 2022b) in the construction industry is one of the main reasons that hinder AI integration. This lack of understanding of AI could also cause negative attitude toward AI and further result in the resistance of adopting AI in construction (Maitz et al. 2022; Regona et al. 2022b). Recently, Maitz et al. (2022) interviewed 20 construction workers

from a small company in Austria and found their understanding of AI as a concept is rather superficial, diffuse, and vague, which can lead to misconceptions about AI and AI anxiety. Another research investigating Australian public sentiments toward AI in construction from Twitter posts has found that negative sentiment was mainly driven by those who has relatively limited knowledge of AI (Regona et al. 2022b). These findings underscore the importance of addressing the AI skill gap and promoting AI literacy in the construction industry. By providing construction professionals with basic AI knowledge and training, we can enhance their understanding of AI's potential benefits and reduce any resistance to its adoption. Taking a proactive approach to AI skill development in the construction sector will be crucial to fully leverage the advantages that AI technology can offer in this domain.

AI LITERACY IN CONSTRUCTION EDUCATION

The construction industry is not the only one that has the challenge of lacking AI talent within the industry. In fact, many industries have demonstrated a strong eagerness for professionals with sufficient skills to use AI as a tool to solve problems. Therefore, an emerging research topic about the concept of "AI literacy" has been growing in recent years (Tenório et al. 2023). Long and Magerko (2020) defined as "a set of competencies that enables individuals to critically evaluate AI technologies; communicate and collaborate effectively with AI; and use AI as a tool online, at home, and in the workplace." The same study also carried out an extensive review of the existing research and narrowed down a list of essential AI literacy competencies and considerations under 5 themes when creating AI literacy learning interventions (Expressive Machinery Lab 2020). Based on the concept, research has tried to integrate AI into different levels of education to an AI-ready workforce covering the essential 21st-century competencies. For example, Chiu (2021) focused on developing a model develops a model of curriculum design for AI education for K-12 school and reveals that AI knowledge, AI processes, the impact of AI (content and product), student relevance, teacher-student communication, and flexibility (process and praxis) are six key components for the curriculum. For higher education, Sulmont et al. (2019) conducted ten interviews with instructors of machine learning course for non-computer science majored students and identified the pedagogical knowledge content, barriers faced by students, and pedagogical tactics adopted by instructors. In more recent research, the University of Florida developed a model infusing AI across the curriculum and developing opportunities for student engagement within identified areas of AI literacy regardless of student discipline (Southworth et al. 2023).

Recently, there have been also calls to integrate AI into construction education to mitigate the reluctances and challenges of slow adoption of AI in the construction industry (Naser 2022). However, there is still a limited amount of research that explores how AI can be integrated into the construction curriculum. Among the limited literature, Naser (2022) provided a thought-provoking opinion on infusing AI into civil engineering education and what are the AI learning objectives in civil engineering education. Another research established a new interdisciplinary AI curriculum as a capstone course by integrating AI application case studies into undergraduate civil engineering courses (Wanyan et al. 2017). The research found that the interdisciplinary curriculum could significantly increase students' awareness of the need for knowledge acquisition and enhance the learning outcome. Chiang (2021) investigated a survey on 237 students taking civil engineering courses with AI integration in Taiwan and found that effective teaching practices are the key factor for students to learn AI in civil engineering courses. In a

recent study by Uddin et al. (2023), ChatGPT, an AI-powered language model, was introduced as an educational intervention to aid construction safety education and training. The study demonstrated its capabilities in enhancing hazard recognition tasks to students and provided guidance on how they could leverage ChatGPT to aid hazard recognition efforts. Although previous research has made efforts to integrate AI in construction or civil engineering courses and investigated the effectiveness of such integration, there is still a lack of research focused on incorporating AI literacy competencies into construction or civil engineering courses. In this regard, as an exploration study, the aim of this research is to develop the 2-hour curriculum that imparts fundamental AI literacy competencies to undergraduate construction students and understand the effectiveness of such integration on enhancing students' AI literacy.

SCOPE OF STUDY

Why a 2-hour curriculum? In this study, the integration of AI literacy into a 2-hour construction safety curriculum was driven by the goal of offering the curriculum as guest lectures in junior and senior undergraduate classes, thus reaching a broader audience of construction students. The time constraint of 2 hours allows for seamless integration into any course during the semester within two sessions. The chosen topic for the curriculum is construction safety, with a specific focus on the use and inspection of Personal Protective Equipment (PPE). The rationale behind this selection will be elucidated in the following sub-section.

Why safety? The decision to use construction safety as the context for integrating AI literacy was driven by the critical importance of safety topics in the construction industry. Statistics indicate that the construction industry accounts for approximately 20% of all workplace fatalities in the United States (U.S. BLS 2022). Given the gravity of construction safety, it holds great significance as a subject in construction education and training. Due to the time constraints of the proposed curriculum, we narrow our focus to one specific topic within the construction safety domain. Specifically, the curriculum centered on the use and inspection of PPE, a vital component in ensuring worker safety. Furthermore, the use of AI technologies to enhance construction safety has emerged as a popular research topic within the industry (Fang et al. 2020). This widespread adoption of AI in construction safety presents an excellent opportunity to expose students to practical examples that bridge the gap between AI knowledge and its application to address construction challenges.

Selection of AI technology for demonstration. Given the multitude of AI technologies used to enhance construction safety, attempting to cover the full aspects of AI would be challenging. Therefore, this study narrowed its focus to a specific aspect of AI. Specifically, we explored the application of AI in the context of PPE inspection. For this purpose, we selected computer vision techniques, a subfield of AI that relies on images as sensory inputs and is commonly employed in PPE inspection (Fang et al. 2020), as the specific AI technology that was used for demonstration. The choice of computer vision techniques also allows for visual demonstrations, enabling students to better comprehend how AI works.

RESEARCH METHODOLOGY

To achieve the research goal, the research was completed in 4 steps (see Figure 1), namely, (1) identify AI and safety learning objectives; (2) develop AI4Safety curriculum; (3) implement curriculum; and (4) assessment. Each step will be explained in the following sections.

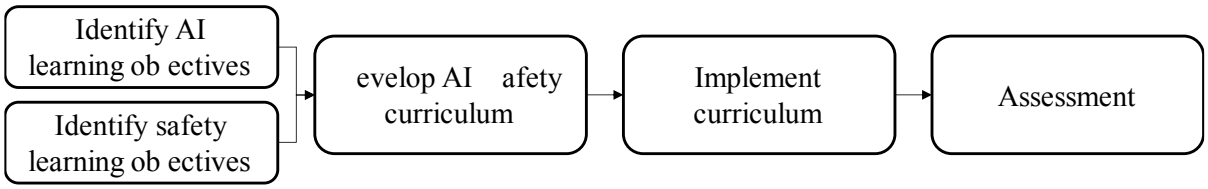

Figure 1. Research methodology

Identify AI and safety learning objectives. In this step, AI and construction safety learning objectives were identified. The AI learning objectives were identified adapted from the framework proposed by Long and Magerko (2020). The framework suggested the design of AI literacy intervention could cover 17 competencies and 15 design considerations in the proposed curriculum, and categorized them into 5 major themes: (1) What is AI? (2) What can AI do? (3) How does AI work? (4) What should AI do? and (5) How do people perceive AI? Based on the framework's defined 5 major themes, we set the AI learning objectives for students to understand (1) how AI can assist with PPE inspection; (2) the basics of AI; (3) general steps to create an AI model; and discuss about (4) the ethical issues of AI. On the other hand, the safety learning objectives were focused on the topic of PPE and PPE inspection. The safety learning objectives were set for students to understand (1) the basics of PPE; (2) the importance and challenges of PPE inspection; (3) the applications of AI in practical projects. In this part, the AI and safety components were connected to each other while discussing the AI application in PPE inspection.

Develop AI4Safety curriculum. After identifying the learning objectives, the curriculum was divided into 5 sections: introduction to PPE, PPE inspection, introduction to AI, hands-on activity, and conclusion. Corresponding topics were established under each learning objective (see Table 1). The curriculum began with the topic of PPE and its inspection, which is related to the students' major, and introduced the concept of AI when discussing the challenges faced by the industry during PPE inspection. The curriculum is designed to motivate students to learn about AI by presenting real-world problems faced by the industry. AI literacy knowledge was then introduced to provide students with sufficient knowledge to understand the components involved in the hands-on project. This section also introduced different types of AI that could be used in the industry. A simple hands-on project with Google Teachable Machine was then presented (see Figure 2), as the user-friendly interface enables them to understand how AI works without requiring programming skills. Finally, the curriculum concluded with a discussion of ethical issues related to AI and other examples of AI for construction safety.

Implement curriculum. In this study, we implemented the curriculum by delivering guest lectures to undergraduate students enrolled in the Rinker School of Construction Management at the University of Florida. To ensure such implementation, we collaborated with instructors teaching required undergraduate courses and inquired whether they could allocate two sessions of their courses for guest lectures. Subsequently, we implemented the AI4Safety curriculum in two junior- level courses and one senior-level course as guest lectures. A total of 67 junior and 31 senior construction students participated in these guest lectures. All guest lectures were delivered in person. The students completed an assessment survey before and after the 2-hour guest lecture. The assessment tool and process will be explained in the following section.

Assessment. To evaluate the effectiveness of the curriculum on enhancing students' AI literacy, we employed the AI Literacy Scale (AILS) developed by Wang et al. (2022). This scale

has been validated and consists of 12 items that effectively measure the AI literacy of ordinary users. The AILS was designed around four constructs to evaluate users' AI literacy: (1) Awareness: Measuring individuals' capability to recognize and understand AI when using applications related to AI; (2) Usage: Assessing individuals' competence in applying and utilizing AI to successfully complete tasks; (3) Evaluation: Analyzing individuals' aptitude to assess, choose, and critically analyze AI applications and their results; and (4) Ethics: Investigating individuals' awareness of the responsibilities and potential risks linked to the use of AI (Wang et al. 2022). Participants rated their level of agreement with a 7-point Likert scale, where a rating of 1 indicates a " tr ongly disagree", while a rating of 7 indicates " tr ongly agree." The specific statements asked in this survey can be found in the original paper (Wang et al. 2022). We administered the survey to students before and after the intervention to gauge any changes in their AI literacy. The assessment process is detailed in Figure 3. Before the guest lecture began, we asked students to complete the demographic and AILS surveys, which took approximately 5 minutes. After the intervention, students were asked to complete the AILS survey again. We utilized the paired t-test to analyze the data and assess the curriculum's effectiveness in enhancing construction students' AI literacy.

Table 1. Curriculum development

Sections	Learning objectives (LOs)
Introduction to PPE (35 mins)	AI LO: N/A Safety LO: Understand the basics of PPE. Topics: (1) What is PPE? (2) When should PPE be used? (3) Different types of PPE
PPE inspection (10 mins)	AI LO: Understand how AI can assist with PPE inspection. Topics: How can AI be applied to improve PPE inspection? Safety LO: Understand the importance and challenges of PPE inspection. Topics: (1) Current issues of PPE appliance; (2) Challenges of PPE inspection
Introduction to AI (20 mins)	AI LO: Understand the basics of AI. Topics: (1) What is AI? (2) What can AI do? (3) Different types of AI. Safety LO: N/A
Hands-on activity (45 mins)	AI LO: Understand general steps to create an AI model. Topics: (1) How does AI work? (2) Google Teachable Machine Safety LO: Understand the applications of AI in practical projects. Topics: How to apply the AI model to practical projects?
Conclusion (10 mins)	AI LO: Discuss the ethical issues of AI. Topics: (1) What should AI do? (2) Strength and weakness of AI; (3) How can we perceive AI? Safety LO: Understand the applications of AI in practical projects. Topics: Other examples of AI application to improve construction safety.

RESULTS AND DISCUSSION

A total of 98 students, consisting of 67 juniors and 31 seniors, participated in the guest lecture and completed the AILS survey. Among these students, 79.6% of them were males, and

19.4% of them were females. The students were also asked to rate their understanding of the topic of safety and AI. According to the self-reported result, most of the students (71.4%) reported themselves to have adequate knowledge of safety, on the other hand, most of the students considered themselves only to have minimal (50.0%) or basic (39.8%) knowledge of AI.

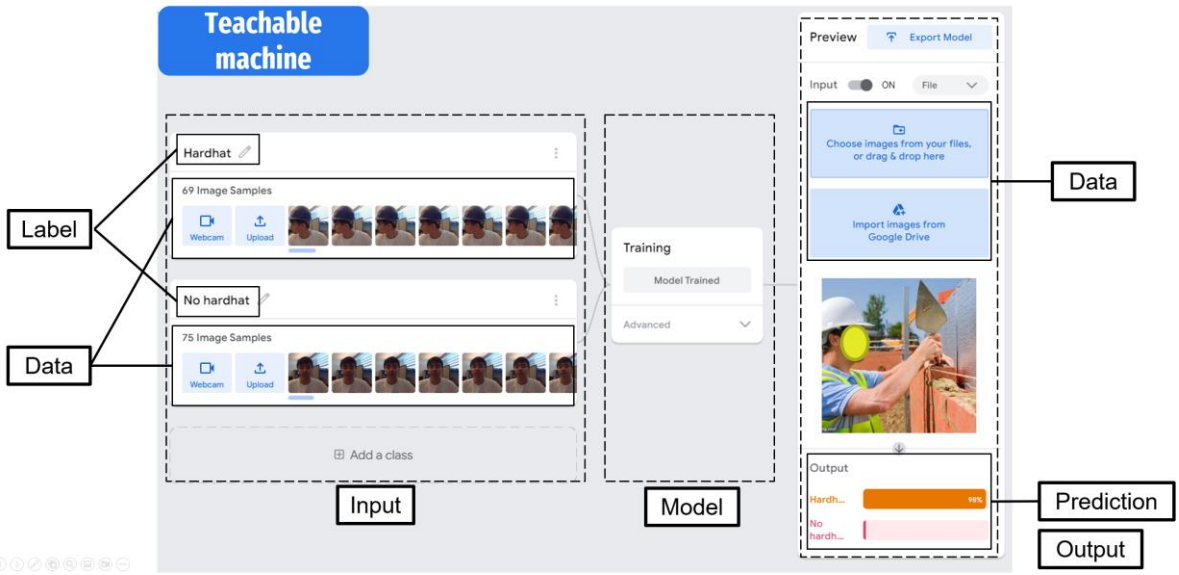

Figure 2. Hands-on project with Google Teachable Machine

Figure 3. AI literacy assessment process

A descriptive statistical analysis was performed and is shown in Table 2. Average scores for each aspect and the overall score were calculated assess the impact of the intervention on students' AI literacy. The results demonstrate that, following the intervention, students' AI literacy improved significantly in all aspects. Specifically, their overall score on the AI Literacy Scale increased from 4.41 (with a standard deviation of 0.60) before the intervention to 4.91 (with a standard deviation of 0.61) after the intervention. These findings indicate that the proposed curriculum effectively enhanced AI literacy among undergraduate construction students. However, it is worth noting that the minor change observed in students' AI literacy might be attributed to the time limitation of the curriculum. Despite this limitation, the curriculum development process undertaken in this research offers valuable insights for future studies, enabling the creation of more comprehensive AI literacy learning interventions tailored for construction students. Furthermore, the results reveal a reduction in the variability of students' scores in the "Awareness," "Usage," and "Evaluation" aspects after the intervention. This indicates that the intervention successfully minimized the differences in AI literacy levels

among the students in these areas. However, in the case of the "Ethics" aspect, the standard deviation increased after the intervention, suggesting that the effectiveness of the intervention might have varied among students. The reason behind this increase in standard deviation could be related to the limited discussion time on the complex topic of ethical issues in AI applications in construction. Consequently, some students may have experienced confusion or uncertainty regarding this aspect. Further attention to ethical considerations and dedicating more time to discussing ethical issues in AI applications could potentially lead to a more consistent improvement in students' knowledge across all aspects.

Table 2. Assessment result of AI literacy

AI Literacy Scale Constructs	Pre-intervention Mean (SD)	Post-intervention Mean (SD)	P-value
Awareness	4.70 (0.90)	5.15 (0.84)	<0.001
Usage	4.32 (0.83)	4.72 (0.75)	<0.001
Evaluation	4.28 (0.91)	4.93 (0.90)	<0.001
Ethics	4.33 (0.83)	4.82 (0.95)	<0.001
Overall Score	4.41 (0.60)	4.91 (0.61)	<0.001

CONCLUSION AND FUTURE RESEARCH

The construction industry can benefit from AI's potential to overcome various challenges, including cost and time overruns, safety concerns, productivity, and labor shortages. However, the industry is behind in adopting AI solutions, and one of the reasons is due to the shortage of AI talent within the industry. To address this issue, enhancing the AI literacy of construction students is a viable solution. This research aims to develop a 2-hour curriculum to teach construction students AI literacy competencies in the context of construction safety and evaluate the effectiveness of the curriculum on improving their AI literacy. The pre- and post-curriculum surveys demonstrate that the curriculum can effectively enhance construction students' AI literacy. Therefore, this study can serve as a valuable basis for integrating AI literacy into construction curricula, ensuring that the next generation of construction professionals is prepared to leverage AI's potential.

This study is limited by its time frame, and future research could address this by developing a more comprehensive module or curriculum that extends over a longer period to evaluate the effectiveness of such intervention. Additionally, while this research focused on changes in students' AI literacy, it is also important to examine how this intervention can impact their attitudes towards AI. Therefore, further experimental studies should measure the influence of similar AI literacy interventions in the construction context on construction students' attitudes towards AI. Furthermore, gathering students' feedback regarding the challenges they faced when learning about AI in similar learning opportunities can provide valuable insights to develop more comprehensive frameworks and strategies for integrating AI literacy into construction curricula.

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