Empowering Future Construction Professionals by Integrating Artificial Intelligence in Construction-Management Education and Fostering Industry Collaboration

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Abstracts

Integrating Artificial Intelligence (AI) into construction management education is pivotal for equipping aspiring professionals with the necessary tools and competencies to excel in an ever-evolving construction industry. Incorporating AI in construction management education empowers students to acquire valuable skills and prepares them to address the challenges and opportunities that AI brings to the construction sector. This, in turn, can lead to more streamlined and sustainable construction practices in the years to come. This study aims to propose curriculum enhancements that equip construction management students with a deep understanding of AI and provide recommendations for academic institutions to collaborate with the industry to maximize hands-on involvement. To attain this goal, the research adopts an extensive literature review for future surveys to elaborate on the work in progress of this research. The study's findings underscore a pressing need for construction management programs to introduce dedicated courses or modules centered around AI. These courses should cover various topics, including AI applications in project scheduling, risk assessment, supply chain optimization, and predictive analytics. Fundamental AI concepts, such as machine learning, neural networks, natural language processing, and computer vision, should be integrated to demonstrate their relevance to construction management. Moreover, students should gain access to AI tools and software for practical application. Furthermore, the study recommends stronger collaboration between academia and industry, encouraging construction companies and technology firms to provide students with internships, co-op opportunities, or access to real datasets for AI-related projects.

Keywords: Construction Management, Artificial Intelligence, Industry Collaboration, Education

Background and Motivation

The design and construction processes depend on the effective transmission of information. Historically, this task has been accomplished using technical drawings and specifications based on engineering designs [1]. Technical Drawing is a form of documentation that follows set guidelines to facilitate communication among project partners in the development process [2]. Traditionally, technical drawings and specifications were created on paper and by hand, being labor-intensive and time-consuming [2]. The instruction of Technical Drawing to engineering students has evolved over the course of engineering history [2].

Leonardo da Vinci made significant contributions to the field of two-dimensional graphical representation of three-dimensional machinery. He utilized perspectives, shadows, and descriptive notes to enhance the accuracy and realism of his depictions[2]. However, due to the growing accessibility of powerful computing resources at lower prices, there is a shift towards

utilizing 3D modeling techniques incorporating subject orientation, parametric, and data modeling [1]. Over the past forty years, part of the evolution of data management has been machine learning (ML), which has significantly matured, with drastic changes to many industrial landscapes brought about by the deep learning subdomain that uses artificial neural networks. It has become a valuable tool, automating processes within the construction industry, which lags behind other sectors regarding productivity and efficiency. Adopting this paradigm change, however, is hampered by the slow progress in managing data quality and the lack of guidelines for fusing domain knowledge with data-centric assessment [3]. These difficulties come down to three main issues: the mismatch between a space rich in features and small sample sizes, the trade-off between model accuracy and usefulness, and the harmonization of machine learning results with domain-specific knowledge [3]. The need for enhanced information technology (IT) system functionality in the construction industry has skyrocketed as a result of this development [1]. Furthermore, since the late 1950s, artificial intelligence (AI), a discipline focused on creating computer systems that possess cognitive capacities similar to humans, has been present in our culture. More recently, projects and businesses in the construction sector have integrated AI to support regular work routines [4][3]. AI has numerous potential applications in the construction industry, ranging from helping with decision-making to streamlining workflows and lessening environmental effects.

The construction management industry aims to streamline the planning, designing, and building process as effectively as possible, and AI ought to be a part of the construction manager's toolkit if it can assist in achieving these efficiencies [4]. According to the United States of America Bureau of Economic Analysis report for the first quarter of 2022, the construction industry's nominal value added was 4.1 percent of the GDP and is projected to reach a Compound Annual Growth Rate of 5 percent from 2022-2026 [5]. The projected growth in the industry exacerbates the ongoing workforce shortage crisis in the U.S. construction sector. Considering the significant economic impact associated with building activities, it is logical to prioritize effective construction management in order to enhance product performance [3]. Enhancing construction productivity by 50% to 60% or more is projected to provide an additional $1.6 trillion in value for the sector annually and contribute to a further increase in global GDP[6]. The adoption of AI, which aims to instill robots with human-like intelligent behavior and thinking, has garnered considerable interest. AI approaches have significantly contributed to the construction industry's transformation, resulting in a more dependable, automated, adaptable, time-efficient, and cost-effective construction engineering and management process [6].

AI is transforming the construction sector by improving productivity, security, and project administration. One of the developments of the AI industry has been the efficient use of Productive analytics[3]. Predictive analytics is one prominent application that uses machine learning algorithms and historical data to predict future project delays, material shortages, and cost overruns [7] The construction sector has a multitude of intricate hurdles, such as exceeding budget and schedule, occupational health and safety issues, efficiency problems, and scarcity of workforce. Moreover, the sector is falling behind in terms of digitalization, which hampers its ability to tackle the difficulties properly, as mentioned earlier. The utilization of AI has the capacity to disrupt the construction industry profoundly, influencing these areas in a positive way and reducing inefficiency and risk [8] [6]. Hence, including AI education in students' curricula and offering continuous training in AI capabilities within the business will assist the construction

sector in recruiting and retaining young talent. This technique provides them with the opportunity to improve their skills and develop new ideas[3].

For more than 20 years, computers have been used in classrooms. The initial computer-assisted instruction (CAD) and computer-based training (CBT) systems were implemented in an effort to teach computer use. The instruction in these systems was not tailored to the [9]. Both CBT and CAI may be able to assist students to some extent, but they cannot offer the same level of personalized attention that a student would receive from an in-person tutor[9] The literature process requires a systematic and concerted effort[10]. The advancements in AI technology pose difficulties for educators and educational institutions to provide appropriate curricula and resources that can equip students of all ages with the necessary knowledge and abilities to thrive in the AI-driven workforce [10].

Methodology

The goal of this study aim to propose curriculum enhancements that equip construction management students with a deep understanding of AI and provide recommendations for academic institutions to collaborate with the industry to maximize hands-on involvement. In order to propose the curricular recommendations, it was essential to conduct a literature review of areas where AI skills and knowledge are important for the adequate use of tools. An exhaustive literature analysis was conducted to determine the current uses of AI in the construction sector—different sources from Google Scholar and ASEE peers were utilized. The research covered the time frame from 1960 to 2023, including six decades of AI adoption patterns in the construction industry.

Results and Discussion

Incorporating AI into construction management education can equip future professionals with the tools and skills needed to thrive in an ever-evolving industry. There is a global scarcity of AI experts with the requisite expertise to drive AI advancements across various sectors, including construction. Identifying AI experts with experience in the construction business to develop tailored solutions for industry-specific issues is challenging. To tackle this scarcity, it is imperative to allocate more resources to STEM education and foster cooperation between building specialists and AI researchers [8]. The focus of academic institutions has been on the rate at which personnel acquire new skills and knowledge, emphasizing the need to integrate AI into construction management education based on the current utilization of AI in the industry[10]. The following are some strategies for incorporating AI into construction management education:

1. **AI Curriculum Integration:**

    a. Develop specific courses or modules dedicated to AI in construction management. Topics can include AI applications in project scheduling, risk assessment, supply chain optimization, and predictive analytics[8].
    b. Cover fundamental AI concepts, including machine learning, neural networks, natural language processing, and computer vision, while also emphasizing their relevance to construction management [7].

2. **Guest Lecturers and Industry Experts:**

    a. Invite professionals and researchers in the field of AI and construction management to give guest lectures. Their real-world insights can provide students with a practical perspective on AI's role in the industry [6]. Students and industry professionals see internships as a very effective learning method for acquiring and transferring information across the academic and corporate sectors. From an academic perspective, the criticism is that university education primarily focuses on acquiring theoretical knowledge rather than practical skills[11][12].

3. **Practical Projects:**

    a. Assign projects that require students to apply AI techniques to solve real construction management problems. For example, students could develop AI models for project cost estimation, scheduling, or safety prediction[13].

4. **Access to AI Tools and Software:**

    a. Ensure that students can access AI software and tools commonly used in the construction industry. These may include AI-powered project management software, data analytics platforms, and ML libraries. The rapid growth of AI, has driven the advancement of complex Large Language Models (LLMs). Notably, instances like GPT, PaLM, and Llama, epitomize the pinnacle of achievement in AI invention [3].
    b. Facilitating access to and integrating GenAI across various courses can effectively equip students to tackle the AI challenges prevalent in the industry. GenAI is a subset of deep learning that operates within the field of AI, utilizing neural networks to its advantage. It has the impressive capacity to evaluate datasets that have been labeled or unlabeled, using a range of methodologies that include supervised, unsupervised, and semi-supervised learning. GenAI demonstrates its expertise in generating many types of material, including text, graphics, and audio, which allows for the production of unique and significant results [3].

5. **Collaboration with Industry Partners:**

    a. Foster collaboration with construction companies and technology firms to provide students with internships, co-op opportunities, or access to real datasets for AI-related projects. Hands-on experience is crucial for understanding practical AI applications [6].

6. **Research Initiatives:**

    a. Encourage students and faculty to engage in research related to AI in construction management. This can not only lead to the development of innovative AI solutions but also enhance the educational institution's reputation. The utilization

of AI and ML in various aspects of construction management, such as safety management, cost forecasting, schedule optimization, progress monitoring, quality control, supply chain management, logistics management, project risk management, dispute resolution, waste management, sustainability assessments, visualization, and overall enhancements in the construction process. Moreover, research has emphasized using AI in Building Information Modeling (BIM) to improve the extraction of information, expedite processes, and maximize efficiency in construction management [3].

7. **AI Ethics and Sustainability:**

    a. Teach students about the ethical considerations of AI in construction, including data privacy, bias mitigation, and responsible AI deployment. Emphasize the importance of AI in promoting sustainability in the construction industry. Ensuring ethical considerations is crucial in order to mitigate any hazards and prevent any instances of unfair benefits[8].
    b. Regulations should encompass matters such as the process of making decisions in crucial circumstances and guarantee impartiality within the building sector. Incorporating ethical principles into AI systems and adopting AI safety engineering methods are crucial measures for tackling these difficulties[8].

8. **Interdisciplinary Approach:**

    a. Facilitate multidisciplinary education by fostering collaboration with departments specializing in computer science, data science, and engineering. This can offer a more thorough comprehension of AI and its possible influence on the building industry[14].

9. **Certifications and Competitions:**

    a. Encourage students to pursue AI-related certifications and participate in AI competitions to further develop their AI skills and demonstrate their expertise to potential employers[15] AI is a rapidly evolving field; therefore, ensuring that the curriculum is updated regularly to keep pace with the latest developments and trends in AI technology and its applications in construction is crucial. Furthermore, certification is a powerful mechanism for addressing disparities in knowledge and motivating improved conduct, offering insights into the AI systems, associated entities, and humans. AI-related projects may encompass voluntary adherence to ethical ideals as well as mandatory compliance with regulatory regulations[15].

By integrating AI into construction management education, students can acquire valuable skills and become better prepared to address the challenges and opportunities presented by using AI in the construction industry. This can lead to more efficient and sustainable construction practices in the future.

Limitation and Future Work

The study recommendations based on the literary review are preliminary, warranting further investigation to understand the implications and potential applications comprehensively. The research primarily centers on suggesting improvements to the curriculum and providing proposals for integrating AI into construction management education. Nevertheless, the generalizability of the suggestions may be limited to certain academic institutions or construction management programs since variances in resources, curriculum structures, and institutional agendas might affect their applicability.

The recommendations outlined in the study reflect the synthesis of the literature review and insights contributed by both the writers and experts involved in the research process. Therefore, the selection of AI applications, curricular components, and cooperation methodologies may be influenced by biases or subjectivity, potentially affecting the comprehensiveness and success of the proposed initiatives. The study primarily focuses on urgent recommendations for incorporating AI into construction management education. Nevertheless, the long-term impacts of these interventions on student learning outcomes, industry-academia collaborations, and the broader construction sector remain unclear, requiring further longitudinal research and evaluations. The rapid advancements in AI technology and its applications may render certain suggestions from the research outdated or not insufficiently adaptable to new trends and discoveries. Regularly monitoring and adjusting training curriculum and collaboration frameworks is essential to staying informed about the ever-changing landscape of AI technology and industrial practices.

Conclusions

Integrating AI into construction management education is crucial for equipping future workers with the necessary skills to thrive in a fast-changing sector. AI has a wide range of uses in the construction industry, including assisting with decision-making and improving workflow efficiency. AI has the potential to change the construction industry despite the constraints associated with data management and knowledge fusion. Traditionally, the construction industry has been slower than other sectors in embracing technological progress. However, AI offers a chance to narrow this disparity and enhance efficiency and effectiveness. Predictive analytics, ML algorithms, and 3D modeling are AI techniques revolutionizing project management and administration. The existing construction management education must be modified to include AI literacy and practical skills in its curriculum. This involves creating specialized courses or modules that focus on the implementation of AI in several areas of construction management, such as project scheduling, risk evaluation, and supply chain enhancement.

It is important to incorporate essential AI ideas such as ML and neural networks into the construction management curriculum, highlighting their practical applications. To improve learning results, educational establishments should include professionals from the industry through guest lectures, enable the execution of practical projects applying AI approaches, and grant access to AI tools and software. Partnerships with construction industries and technology

enterprises can provide students with practical experience through internships and research activities. By engaging with industry partners, academic institutions can ensure that their AI education initiatives align with industry needs and practices, enhancing the employability of graduates and driving innovation in the construction sector. Moreover, it is crucial to highlight the ethical aspects and sustainability implications of AI in construction to guarantee responsible implementation and foster sustainable practices. Integrating AI into construction management education enables students to acquire the requisite skills and knowledge to navigate the dynamic terrain of the construction business effectively. Through cultivating a more profound comprehension of AI and its practical implementations, educational institutions have the opportunity to enable upcoming professionals to spearhead innovation and sustainability in building methodologies.

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