

An Investigation of the need to Incorporate Artificial Intelligence (AI) in Construction Curricula

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Abstract

Artificial Intelligence (AI) applications, such as machine learning, deep learning, natural language processing, and computer vision, have been increasingly used in the construction engineering and management (CEM) area for the past decades to enhance productivity and project performance. Recently, the rise of large language models, such as ChatGPT, has even enlarged the number of AI-powered approaches that academic researchers and industry professionals can utilize to solve CEM problems. The wide range of AI applications challenges practitioners regarding the effective selections and efficient implementations in the CEM education and training programs. The objectives of this paper are to (1) assess the readiness of the industry for the adoption of AI as a necessary instrument for solving CEM problems, (2) identify AI tools that may be best suited for inclusion in construction related curricula, and (3) provide academic programs with recommendations regarding how AI applications can be incorporated in construction curricula. The research methodology includes a comprehensive literature review of AI applications in CEM and a nationwide survey to the construction industry professionals. The results of this study are expected to leverage the understanding about AI in the industry and enhance construction workforce development. This paper contributes to the body of knowledge by investigating the effectiveness of using AI in the construction industry to advance construction curricula.

Keywords: AI, artificial intelligence, construction, education, curriculum, development

Benefits and challenges of incorporating AI in construction education and justification of study

With the overwhelming surge of AI-based applications over the past several years, industries slow to adapt may face significant consequences. The construction industry, in particular, can avoid long-term failure by taking steps today to ensure its readiness in taking full advantage of these technologies. It is not enough to simply develop AI tools to help execute construction-related tasks; adopting AI technology must be a holistic process involving all project stakeholders. Training them to use such tools not only contributes to current projects, but potentially helps in the development of future tools as well. This training should start at the most formative steps; construction engineering and management programs must embrace this burden of preparing its graduates for work in environments dominated by AI.

The benefits of the integration of AI in construction practice have been enumerated by many researchers and even labeled as indisputable [1]. According to Regona et al. [2], the benefits of the use of AI include the prevention of cost overruns, improvements in safety, increased efficiency in management of project plans, and growth of productivity on sites. They also stated that the use of AI technologies has enhanced automated processes, providing a competitive advantage. They enumerated a number of opportunities that the technology can bring to a

construction project. These include opportunities to provide AI enhanced solutions to problems in waste management and resources, estimating and scheduling, construction site analytics, job creation, supply chain management, health and safety, and construction contracts. From their perspective, Pan and Zhang [3] identified five areas where AI can benefit the construction industry: automation, risk mitigation, efficiency, digitalization, and computer vision, and gave examples of how AI can be used effectively in each one of these areas.

However, the benefits of AI will not come without cost as many challenges stand in the way of a wider implementation and adoption by the industry. One of the challenges, for example, has to do with the issue of protection of the privacy of data that may be shared in an open AI learning environment. Abioye et al. [1] provided a comprehensive analysis of the role of AI in the construction industry, including an extensive presentation of AI and its subfields describing opportunities for their application in construction. They also provided an informative analysis of key challenges facing the industry's bid to increasingly incorporate AI solutions, namely, 1) cultural issues and explainable AI, 2) security, 3) talent shortage, 4) high initial costs, 5) ethics and governance, and 6) computing power and internet connectivity. The good news is that some of these challenges can be addressed by adequately educating future professionals about AI. At a minimum, this will help alleviate the talent shortage, but beyond addressing this issue, having some knowledge of concepts used in AI will help its users better comprehend its proposed solutions and be better aware of security risks.

Research Method

This study was designed to include two main components: (a) a literature review of AI-related practices in construction education and management and (b) a nation-wide survey that targeted construction management faculty and professional organizations around the country and some students majoring in construction management. The literature review focused on identifying AI-related applications in the construction industry focusing on construction management education. It was accomplished via electronic searches in multiple online libraries and databases, followed by conducting content analysis of the reviewed papers. The objective from the survey questionnaire was mainly to gather insights into the position of the industry with respect to the incorporation of AI into the preparation of the construction professionals of the future, but it was also deemed beneficial to gain some insights into the outlook of students on the issue. Consequently, the survey was sent to two professional organizations, which provided access to professionals and educators in the various disciplines of construction, including roofing, and to construction management students in two universities. The surveys did provide some valuable insights regarding the assessment of the need to integrate AI in construction education, and they made it easier to make recommendations for incorporating AI in construction curricula.

Status of incorporation of AI in construction education

AI-related applications have been increasingly incorporated into construction management education curricula, reflecting the growing importance of AI technologies in the construction industry. For instance, California Polytechnic State University, San Luis Obispo, assessed the need of AI-related applications for their BS in Construction Management by surveying the Construction Management Advisory Council, focusing on AI adoptions in the planning,

construction, and operation and maintenance (O&M) phases. As a result, 45% of them had prior knowledge in construction AI. Therefore, despite a lack of confidence in artificial intelligence's application, learning about AI driven software and its data analysis may benefit students' careers, attract recruiters, and help in adapting to evolving industry trends [4]. Florida International University introduced AI-focused classes in its construction management program, teaching students about AI applications for efficiency and productivity [5]. Stanford University offers a graduate-level course called "CEE329: AI in Construction," which aims at building knowledge on AI's potential in construction and developing critical thinking skills for evaluating AI technologies [6]. In 2024, the University of Florida started to incorporate an AI-in-Construction module focusing on computer vision for personal protective equipment (PPE) inspection into an undergraduate construction management course BCN4252: Introduction to Building Information Modeling [7]. In 2020, the University of Illinois Urbana-Champaign started the establishment of the National Institute for AI in Construction, promoting the application of AI in design, construction and operation of buildings and infrastructure systems [8].

The current adoption of AI in construction management education typically covers project management and optimization, safety and risk management, Building Information Modeling (BIM), cost estimation, quality control and maintenance, and sustainable design [9]. The curriculum approach for integrating AI into construction management education is multifaceted, designed to provide students with a comprehensive understanding of AI applications in the industry. Many institutions have attempted to establish a solid foundation in AI and machine learning concepts relevant to construction management, focusing on introducing AI and its subfields (machine learning, deep learning, natural language processing), data science and analytics, AI algorithms commonly used in construction applications, and big data and its role in AI-driven decision-making [5, 7, 8]. Various real-world applications of AI in construction projects, such as case studies, AI-powered tools for construction planning and scheduling, and AI applications in risk assessment and safety management, have also been introduced in construction management courses [4, 6].

The existing literature shows several gaps in adopting and implementing AI-related applications in construction management education. First, while AI-driven personalized learning is common in many fields, there is a lack of studies on how AI can adaptively help teach construction-specific skills such as cost estimation, scheduling, and risk management. Second, there is a lack of guidance and many institutions are hesitant to adopt AI to transform their construction management curriculum due to the complexity of technology and fear of redundancy [1]. A potential reason is that traditional teaching methodologies dominate many construction management programs in the U.S., raising concerns that AI may overly automate teaching processes, which create slow institutional processes about AI adoption. Third, the successful implementation of AI tools in education requires instructors with a deep understanding of both construction management and AI technologies [7]. However, the lack of adequately trained educators often limits the effective integration of AI in the curriculum. Opportunities for faculty training in AI and construction management are often scarce or inadequately funded. Additionally, the fast-paced development of AI technologies requires continuous learning, which can overwhelm educators. Fourth, AI systems, such as simulation software, machine learning tools, and smart learning platforms, are expensive to acquire and maintain [4]. Many institutions, especially in developing countries, prioritize immediate educational needs over advanced

technologies, such as AI. Finally, a gap often exists between academia and industry in designing curricula that align with practical AI applications in construction management [10]. Without strong industry partnerships, students may not receive hands-on experience with cutting-edge technologies, reducing AI's impact on students' preparedness for the workforce. Among this study's aims is the reduction of that gap through the involvement of a large section of the industry in it.

Current AI tools in construction practice

There are currently a number of AI-based tools on the market to help construction professionals develop efficient solutions for their projects. The process to identify these tools actually gave the authors an opportunity to demonstrate the usefulness of AI Generative Pre-trained Transformer (GPT) bots, e.g. ChatGPT, in collecting relevant information about a given topic. In a world without AI, one would have to resort to using search engines and spending numerous hours sorting through web pages and research articles to learn about existing or emerging software applications in a given field. However, a quick query into ChatGPT about AI tools being used in the construction industry was quick to produce a comprehensive summary of results, as shown in Figure 1. Since bots such as ChatGPT can actually carry a conversation with their user, it is possible to ask for more information about any of the results from the first query. For example, asking the bot to provide references for the AI tools it came up with in the first question will point the user to an article describing the ten best construction AI software in 2024 [11]. It may also be useful to note that using ChatGPT for such queries will guarantee that one always has the most up-to-date information to work with.

Moreover, say that one is interested in learning about AI tools for construction site monitoring, which actually did not come up in the first query. Asking ChatGPT to provide information about that specific application will produce a list of available tools, listing their purpose, main features, and cases of use, such as shown in Figure 2.

ChatGPT is not the only bot of its kind as a number of them are available with varying uses. For example, a chat bot called Claude (<https://ai-pro.org/start-claude-ai/>) has the ability to summarize a given document that the user can upload into the system and answer questions about it, draft contracts and proposals, and create video scripts, among other capabilities.

Results and Discussion

Assessment of the need to integrate AI in construction education

Educational curricula in higher education are typically influenced by two major drivers: accreditation requirements and the needs of the industry that the institution serves. Optimally, of course, there should be complete harmony between accreditation requirements and the needs of the industry. To help assess the needs of the industry and establish some background principles for the development of accreditation requirements, a 21-question survey was created and shared with students in two construction management programs and with the members of two professional organizations: the American Council for Construction Education (ACCE) [12], and the Roofing Alliance, the foundation for the roofing industry [13].

<p>1. Construction Planning and Scheduling Tools</p> <ul style="list-style-type: none"> • ALICE Technologies: Optimizes construction scheduling by using AI to explore various construction scenarios, providing the most efficient project plans. • Procore + Smartvid.io: Integrates AI to automate risk assessments and streamline project planning. <hr/> <p>2. Project Management and Monitoring Tools</p> <ul style="list-style-type: none"> • PlanGrid: Uses AI to digitize blueprints and provide real-time project updates. • Buildots: Tracks project progress using AI-powered wearable cameras to compare actual work with planned schedules and detect discrepancies. <hr/> <p>3. AI-Enhanced Safety Tools</p> <ul style="list-style-type: none"> • Smartvid.io: Leverages computer vision and machine learning to identify safety risks in construction sites through video and photo analysis. • OpenSpace: Provides AI-based site documentation and progress monitoring while highlighting safety concerns. <p>4. Autonomous Construction Equipment</p> <ul style="list-style-type: none"> • Built Robotics: Converts heavy equipment like bulldozers and excavators into autonomous robots for tasks such as earthmoving and grading. • Trimble Earthworks: Uses AI to enable machine control and automate certain construction tasks. <hr/> <p>5. Predictive Maintenance Tools</p> <ul style="list-style-type: none"> • Doxel AI: Tracks and predicts equipment and material wear-and-tear, ensuring timely maintenance and reducing downtime. • Versatile: Uses AI-driven data to analyze crane performance and site activity for predictive maintenance and optimization. 	<p>6. Design and BIM Tools</p> <ul style="list-style-type: none"> • Autodesk Construction Cloud (ACC): Integrates AI to analyze Building Information Modeling (BIM) data, identifying potential design clashes and optimizing designs. • Revit with AI Plugins: Incorporates AI for automating design and detecting structural issues before construction begins. <hr/> <p>7. Workforce and Resource Optimization Tools</p> <ul style="list-style-type: none"> • Deepomatic: Utilizes AI to optimize workforce allocation based on skill sets and real-time needs. • Oracle Aconex: AI-enhanced collaboration and communication tool that optimizes resources and project execution. <hr/> <p>8. Sustainability and Energy Efficiency Tools</p> <ul style="list-style-type: none"> • Arbnco: Uses AI to analyze and improve energy efficiency in buildings during construction. • Rhumbix: Monitors and optimizes material usage to reduce waste. <p>9. Quality Control and Defect Detection</p> <ul style="list-style-type: none"> • NVIDIA Metropolis: A platform that uses AI-powered video analytics to detect defects and ensure compliance with standards. • HoloBuilder: Provides 360° AI-assisted progress tracking for quality assurance. <hr/> <p>10. Virtual and Augmented Reality Tools</p> <ul style="list-style-type: none"> • Unity Reflect: Integrates AI with VR/AR for immersive visualization of construction plans. • DAQRI Smart Helmet: Uses AI and AR to provide real-time data overlays to workers for better decision-making.
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Figure 1. Results of a ChatGPT inquiry with respect to AI tools currently used in construction

<p>1. Smartvid.io</p> <ul style="list-style-type: none"> • Purpose: Monitors site safety using AI-powered computer vision. • Features: <ul style="list-style-type: none"> • Identifies safety risks like missing personal protective equipment (PPE) or unsafe practices. • Provides a "Safety Score" to track improvements. • Generates reports to help manage safety compliance. • Use Case: Reduces accidents and ensures OSHA compliance. <hr/> <p>2. OpenSpace.ai</p> <ul style="list-style-type: none"> • Purpose: Automates construction site documentation and progress tracking. • Features: <ul style="list-style-type: none"> • Uses 360-degree cameras for site walkthroughs. • Compares current progress with project schedules. • Provides AI-generated insights to detect delays and inconsistencies. • Use Case: Enables transparent communication among stakeholders.
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Figure 2. Some results of a ChatGPT inquiry for AI tools for construction site monitoring

The ACCE has a diverse membership that includes educators and professionals from various sectors of the construction industry. The Roofing Alliance was selected as a representative

specialty sector of the industry as it has quite a bit to gain from adopting AI solutions and tools, not to minimize the gains that can possibly be achieved by other sectors. In particular, and because of the ease of access of drones to roofs, the industry has an opportunity to significantly improve the safety and accuracy of roof inspections at any height and under typically challenging conditions. It also has an opportunity to improve overall safety during roof installation activities using AI enhanced monitoring and forewarning devices. A total of 93 participants contributed to the survey and Figure 3 shows a distribution of their areas of activity.

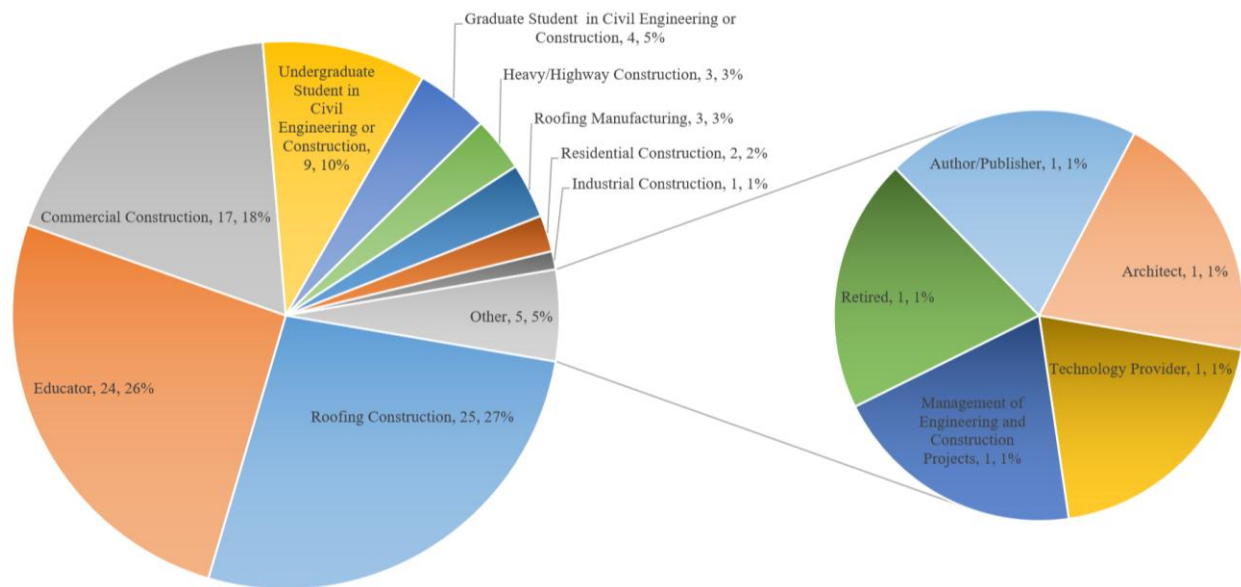


Figure 3. Survey respondents' areas of activity

A little over half of the respondents were either educators or roofing construction professionals, with the remaining part composed of construction management undergraduate (10%) and graduate (5%) students and professionals from the various sectors of the industry. Representatives from the commercial construction sector made up 18% of the respondents. There were also representatives from the heavy civil and highway construction sector (3%), roofing manufacturing (3%), residential construction (2%), industrial construction (1%) and one author/publisher, one architect, one technology provider, one representative from a management of engineering and construction projects company, and one retired professional.

Survey participants were also asked to provide some information about any AI background they may have. This survey question generated 248 entries covering nine areas of AI. While a little over one quarter of the respondents (27) indicated no prior knowledge of any AI concepts, the remaining survey participants indicated a decent level of familiarity, with the area of generative AI and large language models being selected by 46 respondents (representing 19% of all the responses), and, at the bottom of the spectrum, neural networks being selected by 14 participants (representing 6% of all responses). A summary of the results of this question is depicted in Figure 4.

There was an option for this question of the survey to add other fields of familiarity that were not included in the list but only three participants took advantage of this option. One participant

indicated familiarity with ChatGPT, another participant added image capturing, and the third participant added auto takeoff. This option was added to give participants the opportunity to add concepts that may have been overlooked by the research team and also to possibly assess the understanding of participants of the concepts that were included.

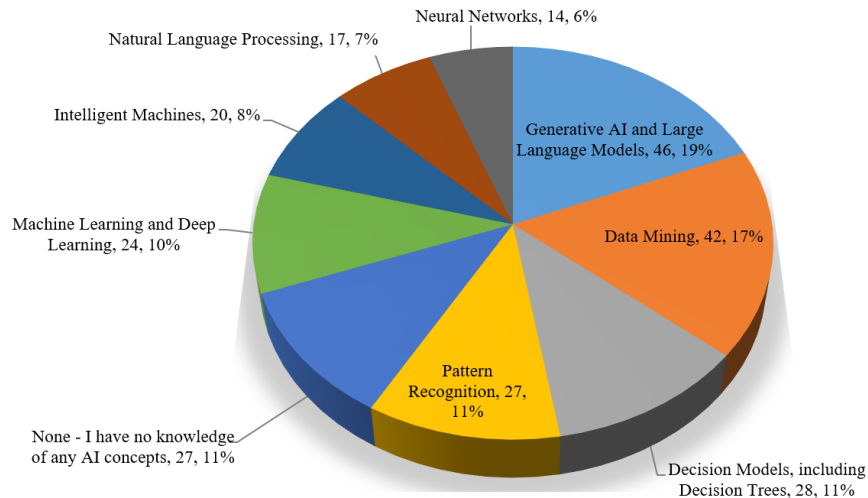


Figure 4. Familiarity of respondents with the various AI tools and concepts

The fact that only one participant added ChatGPT to the list is a good indicator that most participants actually had a good understanding of the technology behind it as most selected generative AI and large data models as an area of familiarity. Similarly, image capturing could have been included under pattern recognition, and auto takeoff is an application of AI that can typically use multiple concepts.

Survey participants were also asked about their use of AI tools, such as ChatGPT for example, in their day to day activities. Sixty-three (or 68%) of the respondents indicated that they had used AI for a purpose not directly related to their work, while the remaining 30 (or 32%) respondents did not. When asked if they have ever used an AI tool for an activity related to work, 64 (or 69%) indicated that they did and 27 (or 29%) indicated that they had not. Students who did not have any work experience were asked to not answer questions that are directly related to professional activity. Participants were then asked if AI has affected the way they work and 46 (or 50%) of them stated that it did while about 22% said that they were not sure. When asked to elaborate, respondents provided the following answers, which are being reproduced here with minor editing:

1. Idea generation/multiple design iteration studies, improved communications, advanced modeling
2. Really exploratory at this point looking for efficiencies in a lot of business modalities.
3. I have witnessed AI used to generate meeting minutes. Several estimating software are actively developing "auto takeoff" capabilities, leveraging AI to streamline estimates.
4. GenAI is fantastic for subject matter expertise, technical writing, ideation & refinement, document/process creation, analytics, process automation, proposal generation, content creation, and expediting tasks.

5. Chat GPT and Intelligent machines have assisted to cut down on time it takes to perform the traditional way. Efficiency and work quality has improved as a result.
6. Grammar checking an email
7. As a scholarship reviewer, I check to see how much of a scholarship essay was written by AI and score accordingly. As an author of certification exams, I try to use AI intelligently to help with questions.
8. It's amazing, I put in a description of what I am trying to say and it generates a response. I ask it to have the audience of say a college professor and it will word the verbiage differently than for a student or a prospective student.
9. Improved my letter writing.
10. Made my work more efficient
11. Quick summarization of information
12. Chatgpt is a perfect tool for summarizing content for classes. Also it is a powerful tool to generate step-by-step instruction for class projects and assignments.
13. Opened new research opportunities
14. Help better formulate thoughts - and brainstorming of ideas
15. Rethinking student assignments to leverage AI or make them 'AI proof'
16. Tool for developing project management strategies and support activities
17. Assists in daily writing tasks such as email drafts
18. Automation
19. Operative tasks are efficiently handled by AI, saving time. But I came to realize that for example English is my second language the more I have chatgpt writing for me, answering letters, etc I realized I was getting rusty, maybe less fluent in my ability to write.
20. It helped me make meaningful decisions by organizing/analyzing large data
21. It has helped me analyze data and answer specific questions related to that data.
22. I am more productive using AI. Also, AI is good for brainstorming and expanding ideas.
23. Mejora el proceso operativo (Author's translation: improves the operational process)
24. Used AI for educational purpose to see how the AI works. I was amazed how much time it can save and provide precise info based on the query.
25. Provides prompt responses and helps in making faster decisions.
26. It has affected the way I organize data and helped me with brainstorming. Whenever I'm stuck I use AI tool to offer me some insights about my work.
27. It makes it easier to find info. We have specific bots made by our company to do certain tasks such as proposals, data mining, etc.
28. Broaden perspective when problem solving; improve quality of written responses
29. We are seeing intelligent offerings and better suggestions
30. We now use AI for many areas of contract generation, contract executive summary creation, travel planning, expense analysis, customer acquisition, marketing, and more.
31. Automating redundant tasks, wordsmithing letters and emails, etc.
32. From time to time we use AI to generate base text for policies and procedures that we use as a starting point for these documents
33. Assist with emails and documents
34. Preparing for interviewing candidates, writing letters, publishing articles
35. It has accelerated the decision making and ability to produce content or answers to questions.
36. Using an AI app to record conversations about a project and use those notes as the meeting minutes.

37. We use AI for various tasks including an augmented knowledge base to help customers and employees quickly and efficiently find information. We also use chatbots for code generation and QA, document creation, etc.
38. It has helped me be more efficient and generate additional ideas that I may not have been aware of.
39. I often ask AI a question rather than googling now. Especially if I am trying to learn the basics of something for understanding, since I trust it is getting the right info.
40. Shortens the time in Estimates
41. It allows me to better understand the material when google doesn't give a direct answer.
42. Student ethics in completing assignments

Subsequently, survey participants were asked if they were using AI enhanced tools to complete specific construction management tasks. Interestingly, the majority of the respondents indicated that they were not using such tools, as can be seen in Table 1. Inspection and project management lead the list with 10% and 11% of respondents, respectively, indicating their use of AI tools to perform these tasks.

Table 1. Frequency of use of AI tools in Construction Management Practice

Description	Yes	No	Not Sure	N/A
Using an AI enhanced software for producing Project Cost Estimates	4 (4%)	75 (81%)	3 (3%)	11 (12%)
Using an AI enhanced software for producing Project Schedules	5 (5%)	73 (79%)	2 (2%)	13 (14%)
Using an AI enhanced software for managing projects	9 (10%)	70 (75%)	2 (2%)	12 (13%)
Using any AI enhanced tools for Safety monitoring	5 (5%)	71 (76%)	4 (4%)	13 (14%)
Using any AI enhanced tools for inspection	10 (11%)	67 (72%)	2 (2%)	14 (15%)

When asked to briefly describe the tools they use that are enhanced with AI, respondents provided the information below. Again, the information is being provided with minimal editing. One of the respondents refrained to answer because of confidentiality.

1. We do not yet depend on AI for day-to-day tasks but I could see an application for AI assisted takeoffs taking hold in the near future
2. Everything. AI as a virtual assistant and on demand subject matter expert for any major piece of software or task.
3. ChatGPT
4. Machine Learning for failure detection in facade inspections
5. Used to develop student response to ASC regional project competition
6. ANOVA and SPSS
7. Microsoft Excel
8. Writing emails, recommendation letters.
9. Planning to use AI for safety checks, procedures and compliance as well as lesson learned base model. Will be using AI to track the schedule and material integration. List goes on.
10. It's confidential
11. DroneDeploy Safety AI, and experimentation with survey AI data. Both with poor results.

12. We use Motive for our fleet. They have the ability to create warnings based on driver's behaviors.
13. Help read pdf's
14. ML/AI drone based damage detection
15. 360 camera and OpenSpace AI

Subsequent questions in the survey were focused on generating information that could provide guidance for revisions of educational programs and program accreditation requirements. Below are each question and a summary of the answers associated with it.

Q13. (Figure 5) If an Introduction to AI course to introduce the main concepts of AI and its various uses is to be offered in an undergraduate construction program, should this course be required, elective, or should there be no course offered?

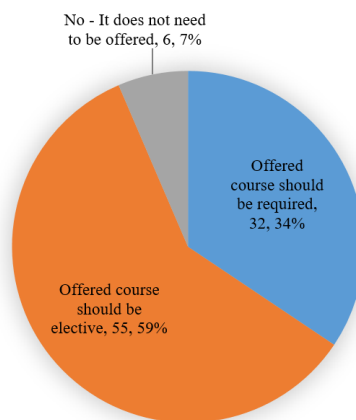


Figure 5. Options for offering an introductory AI course in construction

Q14. (Figure 6) Many courses in construction include the introduction of appropriate software (estimating, scheduling, ...). In these courses would it be preferred to focus on AI enhanced software, non AI enhanced software, or other.?

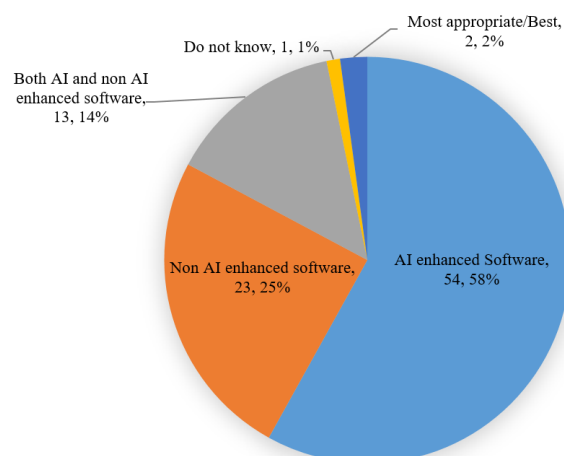


Figure 6. Type of software to introduce in construction management courses

Q15. (Figure 7) Should Construction Management students still be required to learn the basics of construction graphics and how to read drawings and blueprints?

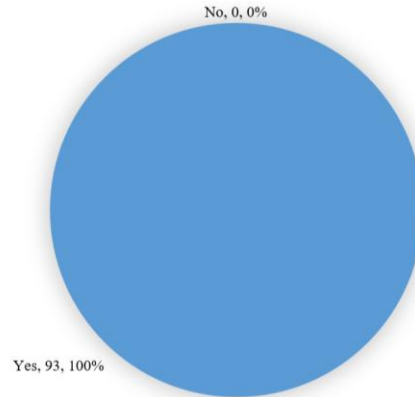


Figure 7. Preference for making a construction graphics course required

Q16. (Figure 8) Should Construction Management students still be required to learn how to estimate quantities of different materials directly from project documents?

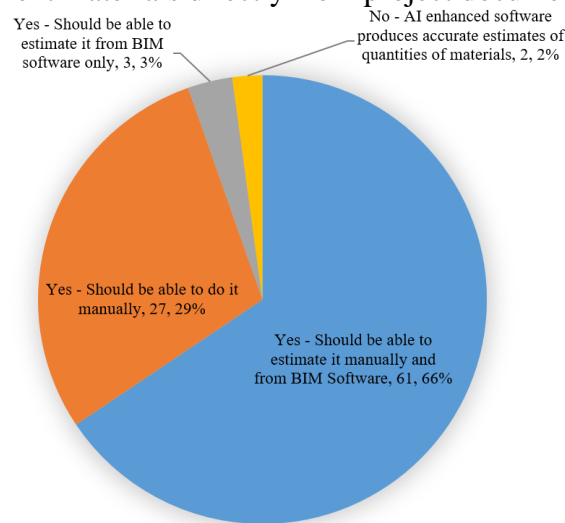


Figure 8. Options for learning how to estimate quantities

Q17. (Figure 9) Currently, accredited construction management programs must assess the ability of their graduates to create a Cost Estimate for a given project. Given that AI enhanced software can now expertly produce a complete cost estimate, going forward, should construction programs:

- Continue to ensure graduates can create a cost estimate for a given project
- Just ensure that graduates can analyze a cost estimate and confirm its validity
- No need to continue to teach cost estimating; just ensure that graduates understand how to use the results of a cost estimate

Q18. (Figure 10) Currently, accredited construction management programs must assess the ability of their graduates to create a Schedule for a given project. Given that AI enhanced software can now expertly produce a complete project schedule, going forward, should construction programs:

- Continue to ensure graduates can create a schedule for a given project
- Just ensure that graduates can analyze a project schedule and confirm its validity

- No need to continue to teach scheduling; just ensure that graduates understand how to work with a project schedule

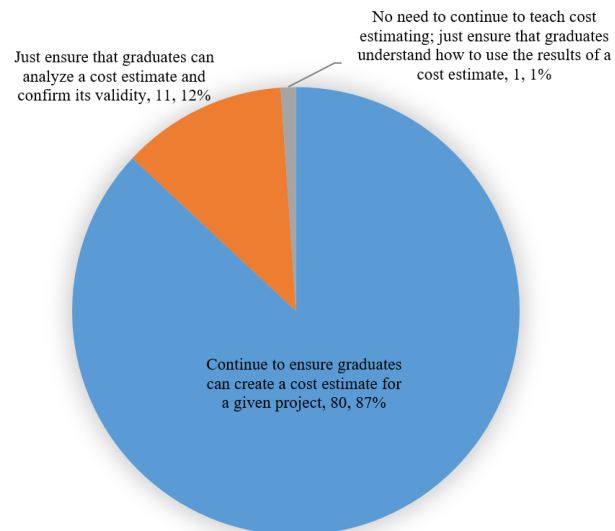


Figure 9. Options for learning how to produce a project cost estimate

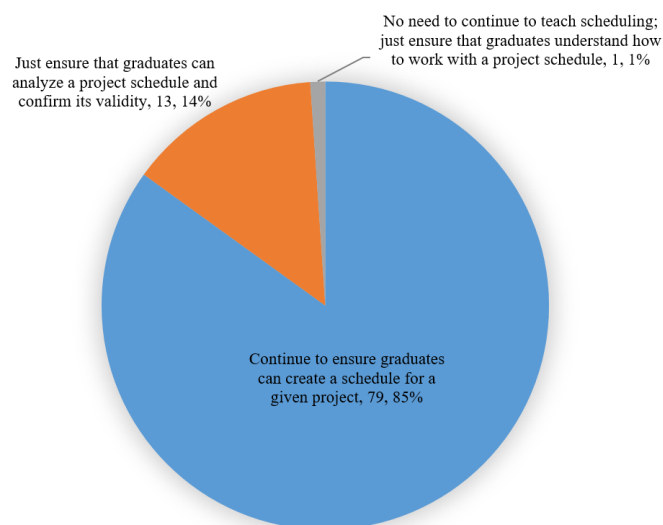


Figure 10. Options for learning how to produce a project schedule

Q19. (Figure 11) Currently, accredited construction management programs must assess the ability of their graduates to create a Safety Plan for a given project. Given that AI enhanced software can now expertly produce a complete safety plan, going forward, should construction programs:

- Continue to ensure graduates can create a safety plan for a given project
- Just ensure that graduates can analyze a project safety plan and confirm its completeness and validity
- No need to continue to teach safety; just ensure that graduates understand how to work with a safety plan and AI enhanced safety tools and equipment

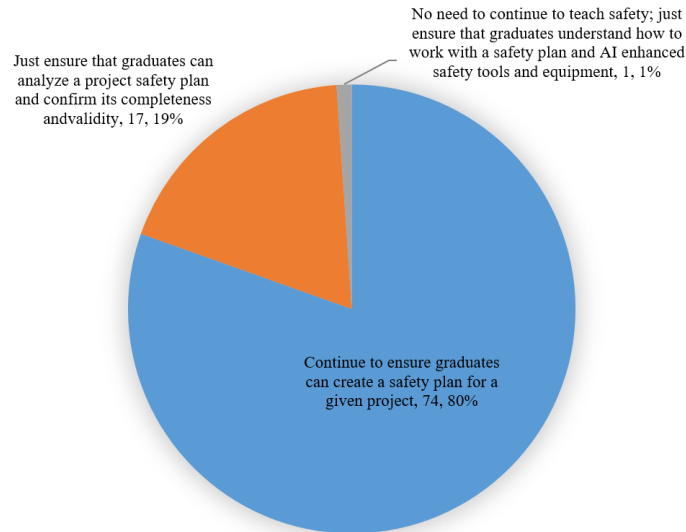


Figure 11. Options for learning how to produce a project safety plan

Q20. (Figure 12) This question is to assess the overall impact of AI on the industry whether you are or you are not using it. In general, AI is:

- Making it easier to secure and successfully complete projects
- Making it harder to secure and successfully complete projects
- Does not seem to be making a difference
- Not able to assess its impact
- Not applicable

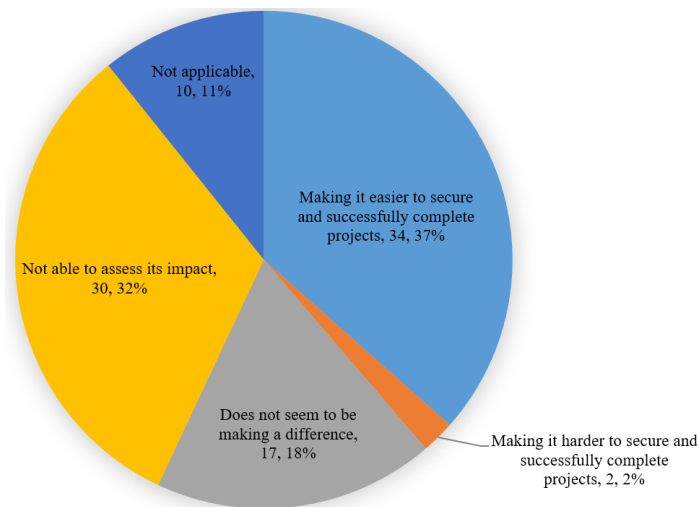


Figure 12. Current impact of AI on participants' ability to secure and complete projects

The answers summarized in Figures 5 through 12 engender the following observations:

1. The construction industry is ready to embrace AI and make it work to enhance its processes and output. However, this readiness is being expressed with a lot of caution as overwhelmingly respondents expect construction professionals to be able to carry out their duties with or without the use of AI. The message is clear that while the use of AI may be beneficial, construction managers should have the adequate background and skills to verify the validity of solutions that are obtained using AI.

2. There is a significant support for seeing a dedicated AI course be offered for the benefit of construction engineering and management students, but at this point in time most survey participants prefer that the course be offered as an elective. However, this may change in the future when the use of AI becomes more common.
3. There is a unanimous agreement that a course in construction graphics should still be required, and programs that are contemplating dropping such a course from their requirements should rethink their strategy so as not to jeopardize the preparedness and marketability of their students. Fifty-six (or 60%) of the survey respondents were from the industry, and they all indicated that such a course must be kept as a requirement. Also, all of the students and the educators who participated in the survey said so as well.
4. Academic programs must continue to insure that their graduates have the ability to create a cost estimate, create a schedule, and create a safety plan for a construction project. Even if an AI tool is used to help produce any one of these important construction documents, a student must still have the ability to verify the accuracy and validity of the document, which cannot be done if the student does not have the ability to create the information in the first place.
5. The positive impact AI is making on the ability of industry professionals to secure and successfully complete projects is still not overwhelmingly evident as only 37% of the respondents stated that it was. Two of the respondents were of the opinion that AI was making it harder for them to secure and complete jobs but the majority of the respondents stated that either it was not making a difference or they were not able to tell.

Recommendations for incorporating AI in construction curricula

The last question in the survey asked participants to provide ideas with respect to what construction management programs should do to better prepare students for serving the industry in a world where the incorporation of AI is rapidly gaining ground on all fronts. The answers that survey participants provided were very insightful, and they would be very valuable in helping establishing a direction for the integration of AI in construction engineering and management curricula. The answers are provided below, again with little editing to convey the actual thoughts of survey participants:

1. When computerized estimating and scheduling became a norm in the construction industry, contractors and educators quickly learned that if students were not able to first learn how to create schedules and estimates manually, they were not able to successfully analyze, estimates and schedules that resulted from computer rated sources. This will absolutely be a similar situation if not even more so once AI is introduced.
2. Don't forget to always teach students the basics.
3. Incorporate AI in current lesson plans
4. Reinforce the use of AI broadly as a problem solving tool.
5. Incorporate AI into the latter two years of the curriculum throughout each course once the fundamentals have been taught and students have performed them manually.
6. Students need to understand how to complete the aforementioned tasks themselves and then understand the tools they can use to simplify the task, ensuring that they can accurately validate the data. If they don't understand how to do the work themselves, they will never be able to validate whether results are accurate.

7. Have the knowledge and skills to know how to put together schedules cost estimates etc., but also be able to use AI. If technical issues arise or service outages arise knowing how to perform the work the traditional way ensures work still gets completed.
8. AI may be able to do the functions of a CM (schedule, estimate, etc.) but it cannot deeply problem solve an issue that would bear in mind the best interests of the client, project, and design intent all in one. It cannot replace that client, coworker, tradesperson interaction that builds relationship and knowledge in someone. CM students need deep problem solving capabilities using the information they have from drawings, logistics, and understanding client needs/restrictions
9. CM programs are teaching people who will spend the next 40 years in the industry. Teaching them AI and other cutting edge technologies is important but at the same time they need to understand the theory behind how this information is created and used.
10. The students need to be able to use their own brain and thought process and not rely on a machine that doesn't take into factor an imperfect jobsite. Safety for example has to be ingrained into your soul to be successful.
11. Ensure all graduates enter industry with a sound fundamental knowledge of all CM practices
12. Provide review of AI impacts to construction
13. Discuss how companies are integrating AI.
14. Students must first understand how and why cost, schedule and safety plans are created and used. They need to understand and be able to create the logic behind them because every project, no matter how complex, is different, and AI will not be able to evaluate every possible variant on ALL projects. AI is a great tool, but it's reports need to be reviewed and verified prior to approval and execution.
15. the concept should be introduced, but it is vital today's students understand basic blocking and tackling and that can only be done by doing the work yourself. I would never trust an AI generated estimate.
16. Incorporate Artificial Intelligence (AI) in Construction Education and ensure ethical and responsible use of AI is strongly covered.
17. Teaching critical thinking skills and leadership education will be an essential area of focus. Increased collaboration with industry will be essential.
18. Provide training to all faculty members first!
19. Make sure students are familiar with the applications available
20. Keep an eye on innovations, but it is still too early to assess the overall impact.
21. Just teach some of the software that incorporates AI. Part of the instruction about the software can cover selected AI technicalities. Doubtful anyone I have encountered so far in higher education will make a leading difference in applying AI to construction management. The leaders in application of AI are in the industry, where time and value-creation are essential. Higher education can tag along behind and learn to use the features effectively, and we owe it to our students to introduce them to AI.
22. Keep on top of trends and where practical incorporation of AI is being done in our industry.
23. Yes, but developing core skills and knowledge should not be replaced. AI should be used to augment this knowledge and the skills.
24. Educate students on appropriate use, pitfalls. I helped write the guidelines at our institution which are broadly applicable: (see 'faculty guidelines section')
<https://nau.edu/provost/academic-operations/resources-policies/artificial-intelligence/>
25. Development of rules of engagement for student use of AI in an ethical manner

26. Incorporate it as it evolves. Training of the educators (professors and GTAs) is needed.
27. Learn to work with and without IA, and always critical thinking
28. Teach basics and AI-integrated software so students understand well both worlds. Any improvements are always based on the deep understanding of the basics, hence the hands-on/manual knowledge is always a good benchmark.
29. Incorporate it into teaching.
30. At the present time students should be proficient using generative AI LLM. Going forward students will need to learn new AI technologies that are relevant to construction.
31. Understand the concepts manually first and then how AI helps in making it easier.
32. Existing BIM software will probably evolve using AI. Curriculum should follow the evolution.
33. Basic construction knowledge is a must. AI can give a precise load for crane lift but visual inspection of a crane and its components will be needed by humans. AI can successfully create multi-level fail safe contingencies but humans will be needed to validate the final decision. The knowledge still will be needed to build ground up, through experience.
34. Introduce them to use AI, but practically not just theoretically.
35. I would say students still need to learn everything and use AI to help them and not think for them. Because they will not be able to understand the errors AI may make.
36. teaching them how to learn new tools, or basically "Teaching them how to learn". it's very important skills. we don't know what is next going to affect the industry. They must be prepared to adapt any new trends.
37. Continue to teach the fundamentals coupled with AI enhancements so students know how to use both. Trust but verify.
38. AI should be a feature across the curriculum same as math, physics and systems thinking, which I would place an even heavier emphasis on given the emergence of AI. Seeing the big picture is more important than ever as AI can help you perfect a sub-optimal solution.
39. Understand how AI works, how to use and how to determine when the model is inaccurate and modify it
40. I think yes, however, I also feel that students should still know how to perform all tasks without AI. What happens if AI fails or an EMP is detonated, etc. Never place all faith in one technological source of truth.
41. Teach the basics. You must know where AI grabbed the info from so you can detect garbage when AI screws up.
42. Be able to think, analyze, change and adapt to the real world dynamics of a job site without anything to assist their minds. They need to develop common sense
43. Given the speed of technology implementation, not teaching students the latest trends and tools is setting them up for failure.
44. Understand the applicability of AI. It is not a magic button that completes the work for you, but rather is an expert assistant able to make you perform better. It is important to be able to still understand how to do the job manually, so that you understand when and where the AI model goes off the rails.
45. Explain to them what it means, explain how it can be implemented, and show them what it looks like.
46. As AI tools become more common, it makes sense to incorporate the use/familiarity of these tools into educational programs
47. AI is not going anywhere and needs to be used appropriately

48. Teach more of the direct trade worker circumstances, work environment and work techniques. learn how to build a building, not just send emails.
49. expose students to the pros and cons of AI usage.
50. Don't depend on AI to do your work
51. Make sure that students understand how to do everything by hand as well as using AI as the human element will be a long time coming for the actual construction of building for people to use.
52. Make sure that the students understand the basics and how AI might be a benefit to them.
53. Prepare students to perform work manually so that anything generated by AI can be appropriately assessed by an individual. AI is a tool. AI is NOT a replacement for thought, logic, comprehension, ability to think, creativity, intelligence, common sense, ability to assess one's context. AI should not be allowed to be a substitute for thinking.
54. Ensure they have access and exposure to changing dynamics and opportunities with AI
55. To become and remain relevant and competitive a comprehensive understanding of AI-enabled tools should be required.
56. Absolutely. AI is a tool that should be used with all of the other tools we currently use within our industry.
57. Incorporating how AI could help perform a function would be useful to learn. i.e. how can estimating be helped by AI and how can project scheduling be helped by AI.
58. Teach what needs to be taught. If AI is being used for cost estimates, scheduling and more, students should know how to use both AI and how to check AI's work
59. Allow students to learn the material the traditional ways, but also inform/teach students of the powers of AI in the industry.
60. Teach the students how to use the new AI systems and oversee its work in a project.
61. Understand the implications, abilities and safeguards when using AI.

Conclusion and Recommendations

In this paper, the results of an investigation into the necessity of incorporating AI into construction engineering and management programs was conducted. The effort included a survey of relevant literature and the administration of a survey to a diverse group of constituents of the construction industry. The group of 93 respondents included undergraduate and graduate students pursuing degrees in construction management, educators, and a diverse group of professionals from various sectors of the construction industry. The following observations and recommendations provide a concise summary of the findings of the study:

1. The industry is still not ready to see a modification in the educational requirements for construction management students and students must continue to be taught the basics of construction management at the appropriate levels of learning. More specifically, students must continue to be able to demonstrate an ability to create a cost estimate, create a schedule, and create a safety plan for a construction project. Other learning outcomes that are currently required to be assessed at the create or analyze level were not included in the study, but there is no reason to believe that they can be modified either.
2. Construction engineering and management programs should incorporate AI by adding a dedicated course or at least incorporating AI in current lesson plans, including providing hands on experience. AI should be introduced as a problem solving tool, and students should

be provided with a comprehensive review of its basics, areas of applicability, benefits, challenges, pitfalls, and impact on the industry. Students should also be exposed to how the industry is incorporating it in real practice, and be trained in using it in an ethical and responsible manner.

3. Academic programs should seek to increase collaboration with the industry to allow their students to be exposed to the latest developments in the field and benefit from the interaction. The industry is currently leading the AI integration effort and most faculty are not well versed in AI technology and its vast field of application. Moreover, most institutions of higher learning do not have the resources to secure and maintain up-to-date costly AI software and equipment.
4. Academic programs should make an effort to train their faculty on the use of AI. This can be done by securing the necessary resources for them to become fully engaged in AI or by encouraging them to become involved with the industry and making it easier for them to do so by giving them incentives and helping them in securing internships.
5. Academic programs must develop clearly articulated rules for the use of AI in academic and extracurricular activities.

The key findings of this paper recommend that construction management programs should offer introductory AI courses that cover machine learning, natural language processing, data analytics, and automation and advanced courses focusing on construction-specific AI applications, including Building Information Modeling-driven AI, AI-based scheduling, and risk assessment. Construction management programs should also include segments regarding soft skills, such as leadership, collaboration, conflict resolution, using AI-powered simulations and chatbots. AI-driven tutors should provide real-time assistance and guidance in areas such as structural design calculations, material selection optimization, and project planning strategies. Finally, universities should establish AI labs that allow students to experiment with AI-based project management tools (e.g., PlanGrid, Procore AI, AutoML for scheduling), AI-enhanced robotics for automated construction site analysis, and drone-based AI for site monitoring and safety compliance.

Future work of this study includes performing in-depth inferential testing focusing on multiple groups of AI-focused practices and construction students. Furthermore, further data collection with assessment outcomes from AI-integrated courses will be conducted to enhance AI adoption rates and lessons learned in the construction management curricula.

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