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Identifying the Learning Needs of Construction Professionals for Artificial Intelligence

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Abstract

The integration of artificial intelligence (AI) in the construction industry is gaining momentum, driven by its potential to enhance project efficiency, safety, and innovation. However, the successful adoption of AI technologies relies heavily on the ability of construction professionals to understand, implement, and manage these new technologies. Despite the growing presence of AI, a significant gap remains in the preparedness of the workforce to effectively utilize these technologies. To bridge this gap, this paper aims to identify the specific learning needs and educational requirements of construction professionals regarding AI technologies.

This paper presents the findings from a research study that aims to quantify the learning needs of construction professionals in relation to the applied tools which use AI. Utilizing a survey-based methodology, data was collected from a diverse range of construction professionals, including project managers, engineers, site supervisors, project engineering staff, and other stakeholders across various sectors of the construction industry. The questionnaire for the online survey was designed to assess the current level of AI awareness, familiarity with AI applications, and the perceived need of AI in day-to-day construction activities. Furthermore, the study explores the respondents' willingness and preferences for participating in AI-focused training programs.

The findings of this research shows that while most professionals recognize the potential benefits of AI, there are widespread gaps in knowledge and technical skills. Many respondents reported limited exposure to education of AI tools and techniques and a lack of understanding about AI techniques such as machine learning, predictive models, and automation for the construction industry. This lack of familiarity has led to a cautious approach toward adopting AI, with construction industry professionals citing concerns about the complexity of AI systems, and the need for specialized training.

One of the key findings of the research is the demand for structured, industry-specific AI training programs tailored to the construction sector. Respondents emphasized the importance of practical, application-oriented AI technique training for addressing real-world challenges in construction projects. Also, there was a strong preference for flexible and accessible learning formats, such as online courses, workshops, and certification programs, that can allow professionals to upskill without interrupting their work schedules. Additionally, the study found that collaboration between academia, industry organizations, and technology providers is crucial in developing and delivering this AI education and training programs.

This paper concludes by discussing the implications of these findings for educators, industry leaders, and policymakers. It advocates for the development of targeted educational initiatives that focus on equipping construction professionals with necessary AI skills. By addressing the specific learning needs of the workforce, these initiatives can accelerate the adoption of AI technologies in the construction industry, ultimately driving improvements in efficiency, productivity, safety, and innovation. The findings of this research highlight a clear need for comprehensive, accessible, and industry-specific AI education and training for construction professionals. The findings of this research are expected to provide valuable insights into the educational needs of construction professionals for AI and offer a framework for developing effective learning strategies that can prepare the construction workforce for the future of AI-driven construction.

Introduction

AI is observed to be an emerging supportive tool in optimization, simulation, analyzing, managing, and automating the processes such as safety inspections, design optimizations, and contract document management in construction [1-4]. Many of these tools apply to applications in the construction processes[5]. There are tools ranging from automation support via robotics, risk mitigation, resource management, and many others which have also evolved over time [6]. A prominent example of a similar application is an image processing and recognition tool to detect safety violations and non-compliance [7]. However, the ingress of emerging technologies such as Building Information Modeling (BIM), Internet of Things (IoT), and AI have led to the necessity of developing new skills for the construction workforce [8].

There are ever-growing numbers of upgrade options for an average construction stakeholders to follow through from an upskilling perspective. The choice of these upgradation options or skills can be difficult to program into the learning and upgradation programs of engineering students and workforce. To further emphasize on the need of research on workforce education of emerging technologies, the global construction industry is found to be suffering from a gap between the project demands and the current workforce abilities in the form of cost and budget overruns [9-13]. The typical cause of this skill gap is inadequate training and education, lack of awareness and incentives, and other socio-economic parameters [10, 11, 14]. The global construction industry requires the workforce to be trained in the newer core competencies to tackle the skill gap and declining productivity which include technical skills and interdisciplinary applications [15].

The existing body of knowledge identifies the applications of AI and the skill gap in the construction industry. However, the aspect of skilling in these applications for industry professionals has not been widely explored yet. Taking this problem into account, this study aims to explore the thematic learning needs of industry professionals pertaining to applications and skills relevant to AI. The findings of this study are intended to serve as guidance markers for educational entities, AI technology developers, and policymakers to collaborate and address the

pressing challenges to the construction industry by tailoring the program according to the learner's needs. This study identifies areas of preference to serve as actionable insights to the relevant stakeholders.

This paper proceeds to go through the literature to explore AI tools and their perceptions along with understanding the skill gap that exists in the industry. Then the learning needs assessment methodology is discussed which is followed by expansion of the findings of the survey. The findings of this study are primarily intended for the educators involved in the development of the design of technical curriculum, the policymakers to collaborate and develop supportive policies for the implementation of AI tools, and the industry stakeholders who seek to upgrade their existing workforce. These findings and their inferences were then discussed, along with possible paths for further research.

Background and Literature Review

The applications of artificial intelligence have been growing and steadily getting integrated into the global construction industry. These applications span multiple activities in construction. Some prominent construction activities that can be assisted by AI include real-time monitoring, predictive maintenance, project management, and supply chain management[6, 16]. The integration of core components of AI models has also gained traction in construction practices. These include automation and robotics, big data analytics, digital twin development, and risk management[17]. Critical activities like design optimization and document analysis are also some proposed application areas being researched[6].

The opportunities for AI's integration in the construction industry are observed in two folds. The first fold is these tools and skills will enhance efficiency and productivity, where these technologies offer forecasting support and manage repetitive tasks[17, 18]. The other fold is the innovation of new technologies and digitization of existing processes. AI is observed to be a driver of automation in construction processes, effectively digitizing the process, for example, design optimization and reduction of human intervention in manufacturing of prefabricated sections [8]. Integrating AI with other technologies such as robotics, the Internet of Things (IoT), and machine learning shows great potential for fostering innovation [5].

With literature indicating an overall positive outlook of AI's integration in the construction industry, some concerns were also identified regarding AI's reliability and the need for legal frameworks for managing the associated risks of using AI in construction processes [19, 20]. A study on AI perceptions also indicated professional's apprehension towards using AI in the Australian construction industry owing to concerns for project risks and data security[5].

A critical motivation to improve the workforce skillset for construction companies, is to develop a competitive portfolio for approaching international business opportunities [21]. Modernized practices in construction are required to be a part of the next phase in this mission of the global construction industry to skill the workforce [8]. Another study identifies emerging technologies such as BIM, IoT, Robotics, and AI to be essential for the workforce [22].

The important applications of AI in construction have been widely researched but the aspect of their value for industry professionals has not been studied so far. This study proceeds to explore the perceptions of AI applications which could serve as training material for upskilling the industry professionals.

Methodology

To answer the research question (i.e. what the learning needs of the essential AI application themes in the construction industry for the professionals are), the research team followed the learning needs assessment framework of the quantitative data collection method [23]. The questionnaire was designed to assess the value of various AI-based applications which have emerged to cater to the construction industry activities. The online survey was collected via Google Forms for distribution among the respondents. The targeted audience for this survey was professionals working in the construction industry. The respondents typically belonged to the industry roles of project manager, safety manager, quality manager, and consultant. Beyond the learners/beneficiaries of the training program, the survey was also extended to the respondents who are academicians to include stakeholder perspectives from academia. The inclusion of multiple stakeholders is a common practice in learning needs assessment research to gauge a diversified perspective [24].

The survey was shared with around 180 project teams with different personnel working in administration, quality assurance, safety personnel, and consultants. Some teams in the email list were from academia owing to the representation from academia as well. The survey was shared from the month of October 2024 to December 2024. The communique for the survey was shared with the representatives of these teams where snowball sampling took place for the data collection. The key advantage of this sampling method is the effective reach for the perceptions of practicing industry professionals while collecting more responses in a shorter period [25]. A total of 74 valid responses were received by the research team.

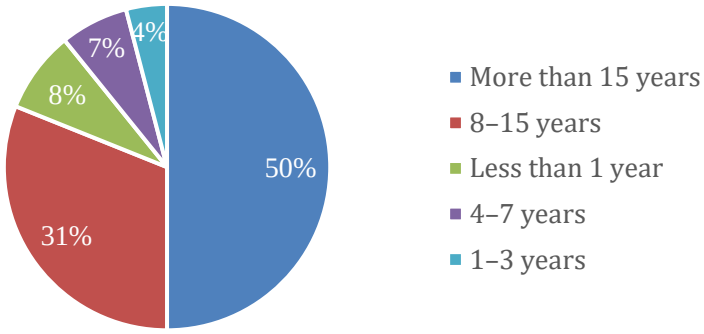

Figure 1. Respondent's Industry Experience

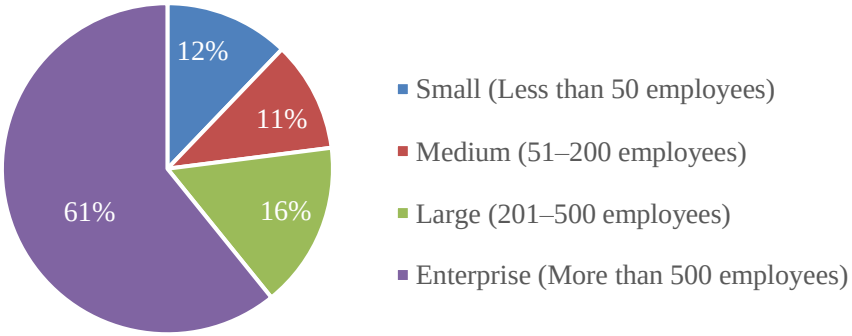

Figure 2. Respondent's Company Size

Most of these responses came from the individual with industry experience greater than 8 years with 38 of the responses having experience greater than 15 years as indicated in Figure 1. The general demographic indicates a respondent population of mid-level to senior-level management. The respondents also indicated the size of the company they work at, which is represented in Figure 2. Over 60% of them belong to an enterprise of more than 500 employees. This majority indicates that the responses are coming from a semi-organized construction sector as opposed to smaller businesses.

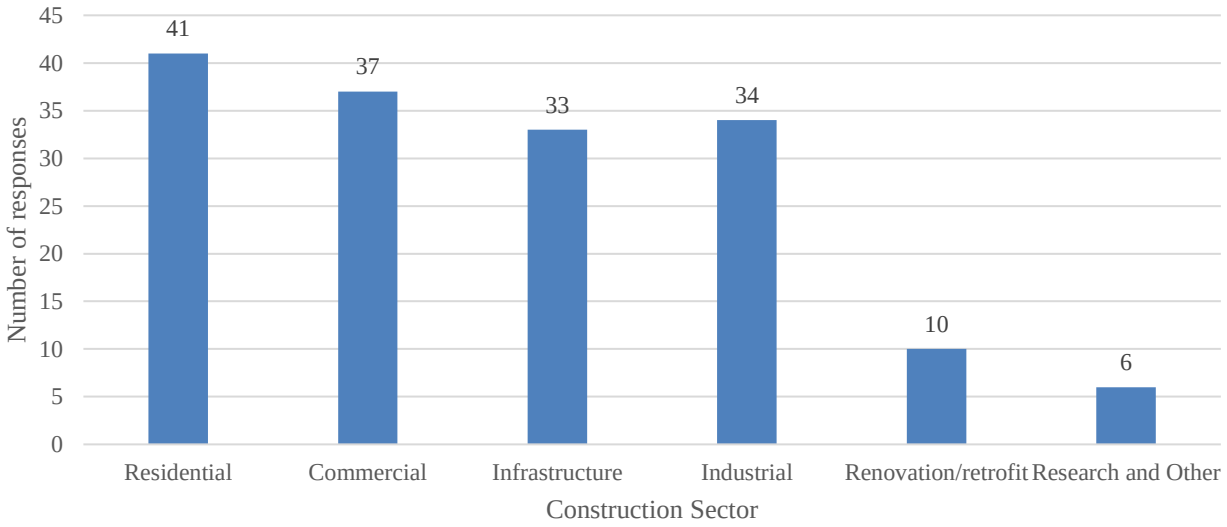

Figure 3. Respondent's Sector of Work

Figure 3 represents the construction sectors from which the respondents have filled out the survey. Most respondents were working in the residential construction sector, commercial sector, and industrial construction sector at the time of filling out the survey. Most respondents are involved in multiple sectors of the construction industry, for example, residential and commercial construction sectors. The design of the survey question was oriented toward understanding the top choices for AI applications for an average learner in the professional construction ecosystem.

The survey had four sections including the demographic section, the section on familiarity with the concept of AI, perceived learning needs, and open-ended questions on learner's expectations. The data was collected in the form of short answers, long answers, Likert scale, and multiple-choice questions. The data collected in this study was analyzed using Microsoft Excel.

Findings

AI Awareness and Familiarity

The respondents indicated varying levels of familiarity with AI across different parameters. Figure 4 indicates the overall familiarity with the idea of Artificial intelligence on a Likert scale from 1 through 5, with 1 being the least familiar and 5 being completely familiar. The response to general awareness about AI indicated a perception distribution like a normal distribution where the peak of 23 respondents (31%) presented an intermediate perception (rating 3) which can be understood as general awareness but limited technical expertise. Only 9 respondents (12%) indicated a complete awareness of AI.

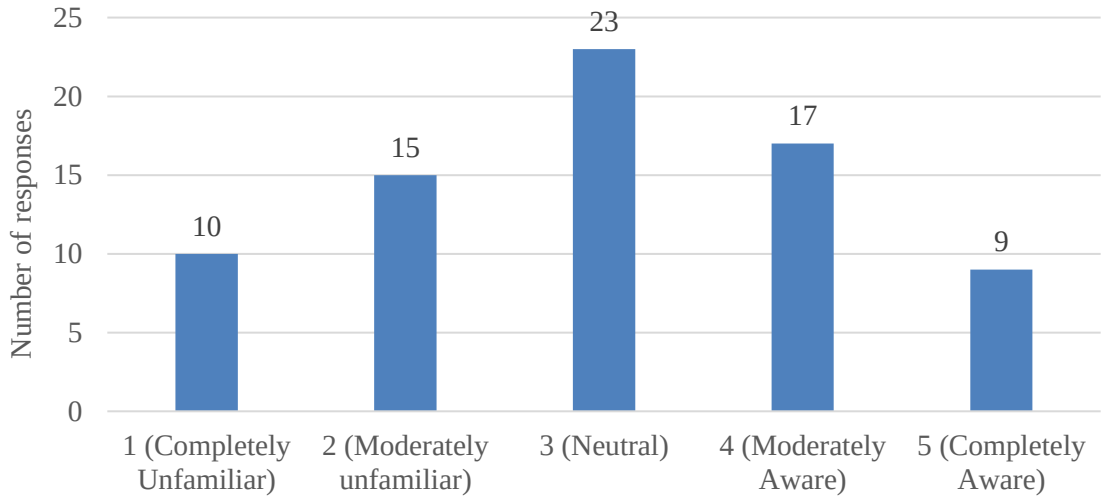

Figure 4. Perception of Overall Familiarity with AI rated on a 5-point Likert scale

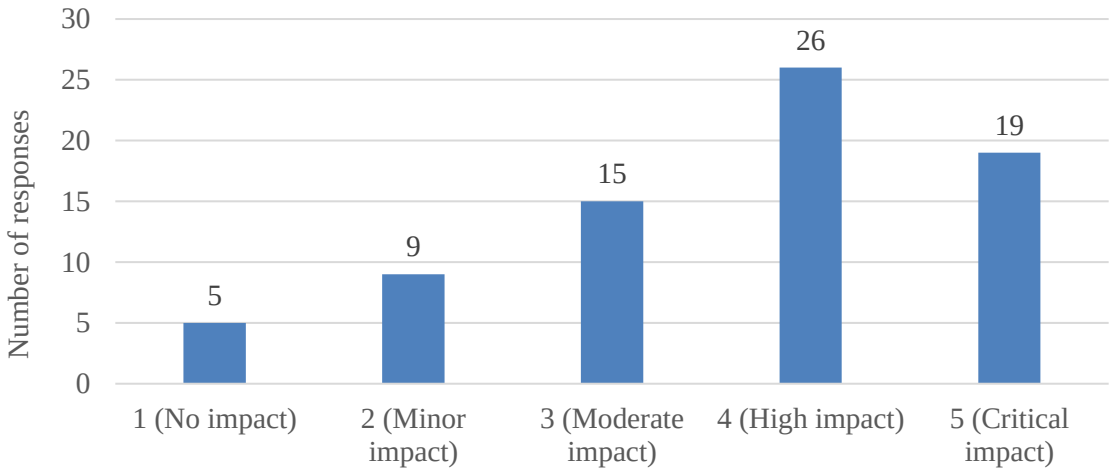

Figure 5. Perceived Impact of AI in the Construction Industry rated on a 5-point Likert scale

Figure 5 represents the perceived impact of AI in the construction industry. Most respondents (35% of 74 responses) indicated a strong impact (Likert scale rating of) of AI on the practices in the construction industry. The general trends of the perceived impact also indicate a high impact with a total of 60 responses with 3 or above rating for this question. The respondents also indicated their awareness of various segments of the construction process where AI applications are being inducted. Figure 6 represents the same, with 30 of them (41% of 74 responses) being aware of AI applications in construction safety. The other application areas include tools for planning & designing and robotics for automation with equalized high familiarity among 22 respondents (30% of 74 responses). 26 respondents (35% of 74 responses) were not familiar with AI applications in construction.

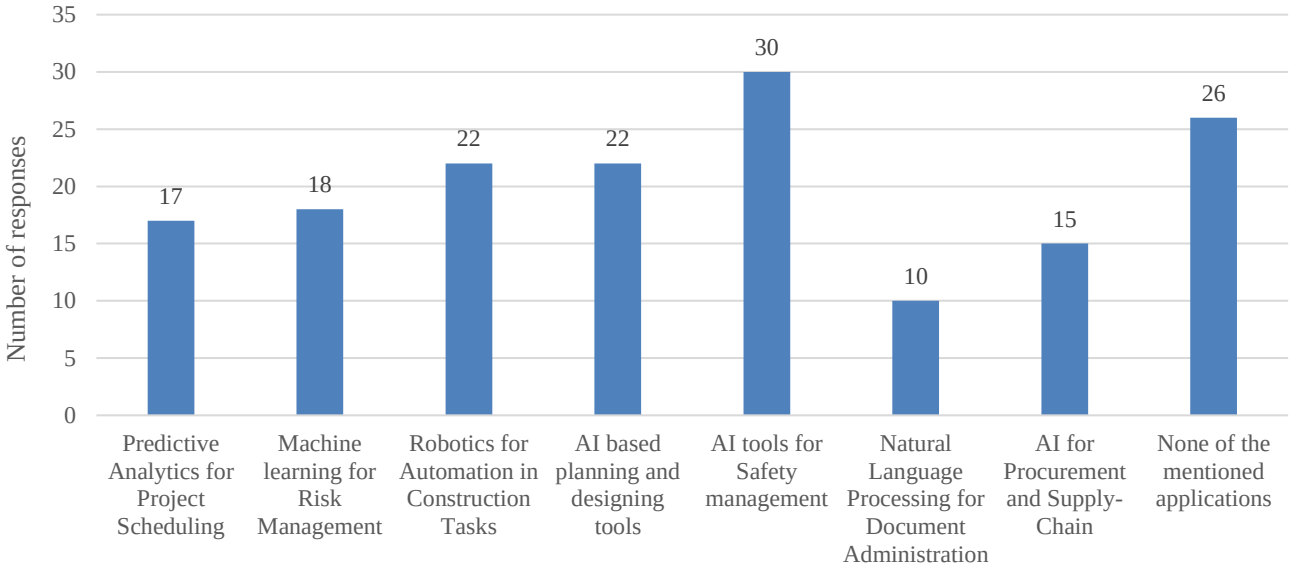

Figure 6. Familiar AI applications in current construction process

Current Usage

The professionals in the construction industry indicated a low utilization of AI tools in day-to-day work as shown in Figure 7. Only 16.2% (12 of 74 respondents) reported using AI tools occasionally (scale rating 3) whereas only 9.5% or 7 respondents reported using AI tools frequently (scale rating 5) for their work. A significant number (33.8%) have never used AI tools, which underscores the need for awareness and basic training.

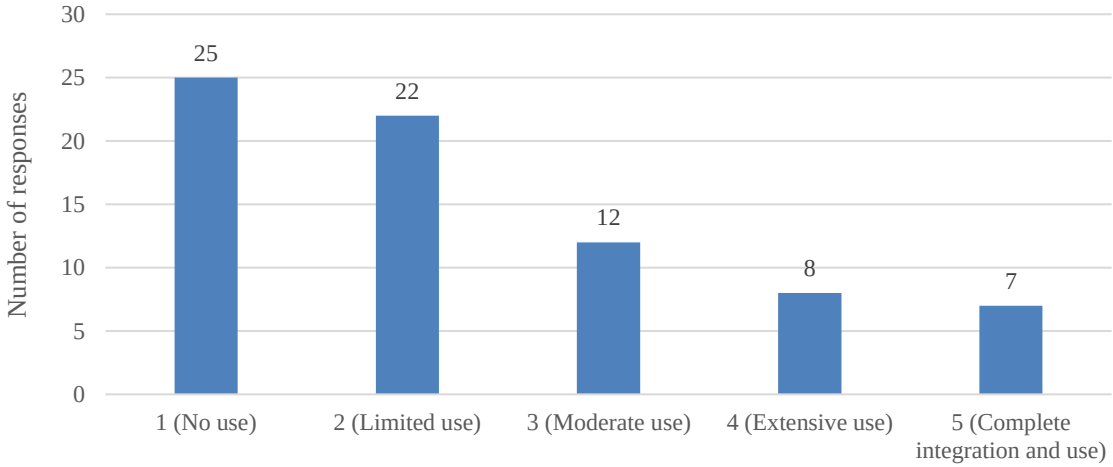

Figure 7. Current usage of AI tools rated on a 5-point Likert scale

Learning Needs

The respondents were asked about the potential areas in the construction process where AI tools can support and improve the working standards. The majority (65% of 74 responses) of the respondents visualized the improvement in project planning and scheduling with AI's ingress in the process. Figure 8 also indicates a strong vision for AI tools in the improvement of safety management processes with 58% of the respondents highlighting it. The other widely accepted areas included "Communication and Reporting", "Quality Control" and "Budgeting and Cost Estimation" with 51% of the respondents indicating the same.

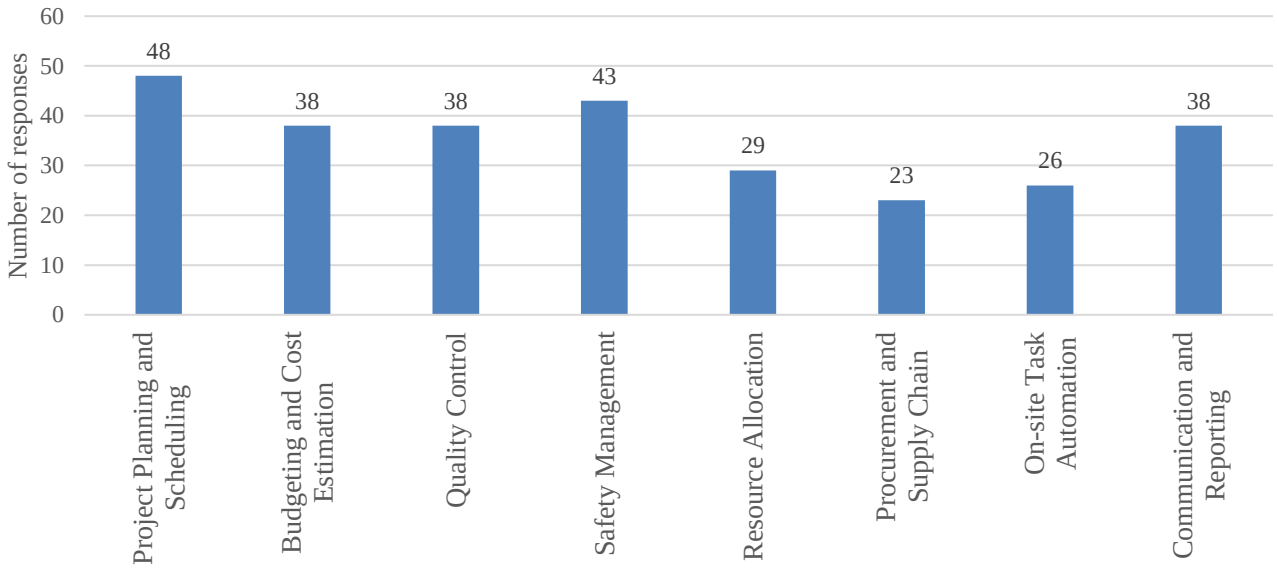

Figure 8. Potential construction areas where AI can improve the processes

Figure 9 indicates the essential areas that are seen to be the learning needs of the professionals of the Indian construction industry. While a strong majority of professionals are interested in understanding the basic tools in AI and how AI can improve safety management processes (66% and 65% of 74 responses respectively), the other areas have also received considerable interest from the respondents. These areas include 'Machine learning' (55%), 'AI in scheduling and resource optimization' (38%), 'Data analysis and Predictive modeling' (36%), 'Implementation of these tools in practice' (36%) and 'Robotics and Automation' (30%). Some respondents were also interested in learning other job-specific AI tool training for Quality Assurance and Concrete management. Some of the respondents were interested in learning all the identified areas in the survey.

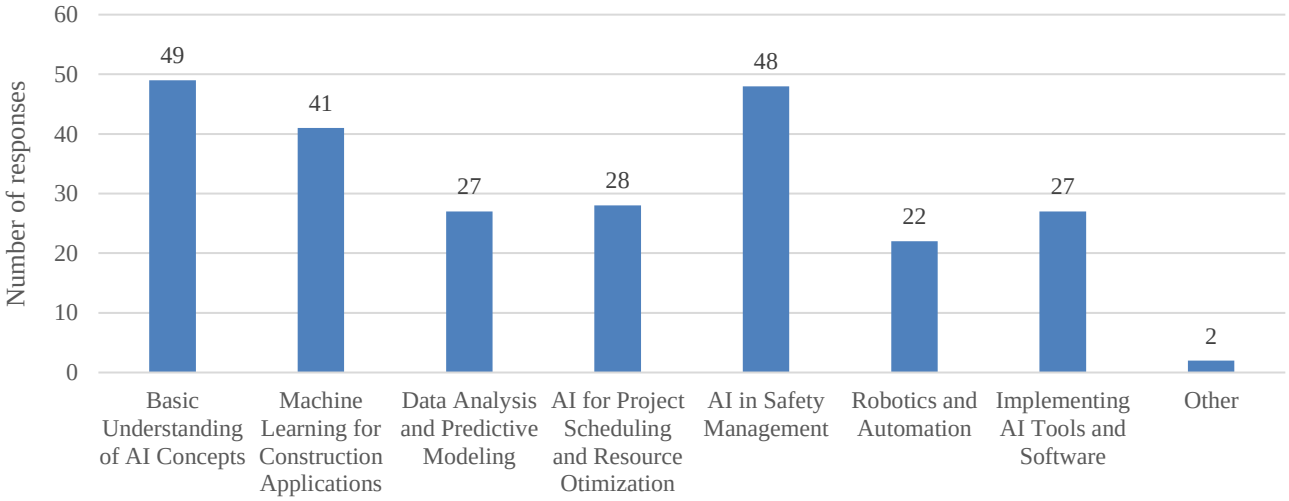

Figure 9. Perceived learning interests for AI-related skills in construction process

Preferences for Learning Formats

While 32% of the respondents were interested in the in-person workshops and training for learning these concepts, 26% of the respondents preferred online self-paced courses owing to the demand for on-site work progress. This is also observed for 20% of respondents who wish for On-site training and demonstrations for ensuring that no interruptions are caused to work. A small fraction (4%) of respondents preferred short webinars or seminars for these educational purposes as represented in Figure 10. Other respondents were seeking either live virtual workshops (10%) or reading materials such as articles or e-books (8%). While only 34% of the respondents would go for self-taught learning mode, 66% would prefer instruction by an expert faculty through the indicated formats.

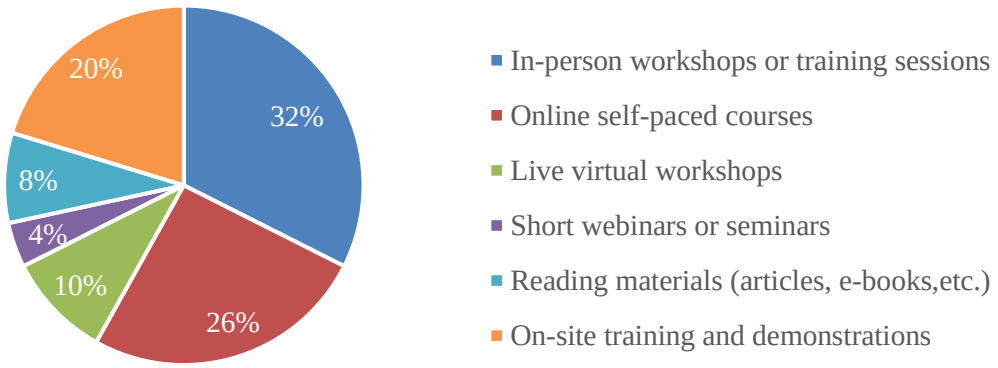

Figure 10. Learning format preferences

Most respondents (58%) would like to go for short-duration courses of about less than 4 hours. Some respondents (13%) preferred a full work-day program while only 11% selected a multi-day workshop. 18% of the respondents preferred ongoing, modular courses spanning more than a week. The majority seeking shorter span courses indicates a need for designing these courses which allow the learners to manage their work commitments as well.

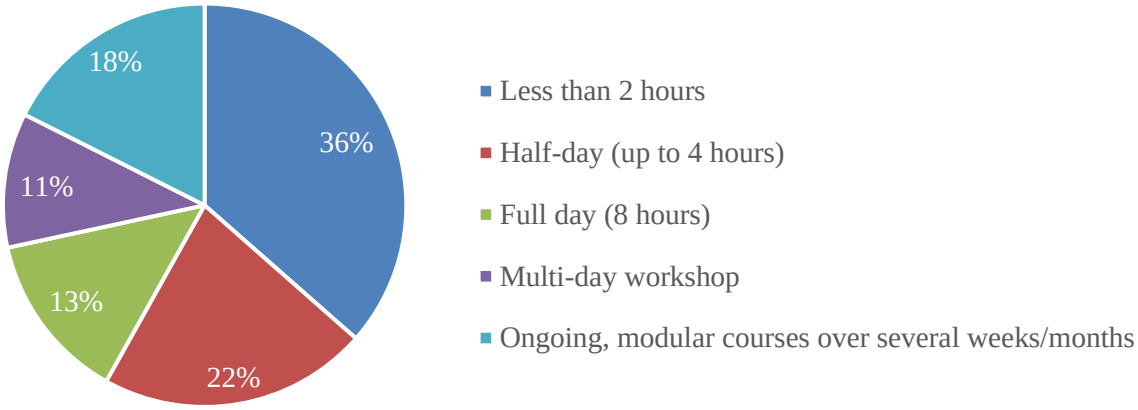

Figure 11. Respondent's preferred training duration

Discussions

The low to moderate awareness and familiarity of AI among the stakeholders in the construction industry implies a huge challenge in the adoption and implementation of the said technologies. This can be owed to the resistant to change nature of this industry as a whole [26]. This lack of awareness underscores the need for educational and awareness campaigns to support the ingress of AI and optimize construction practices. These campaigns will yield increased usage of AI tools by professionals. The finding of this study about the perceived impact of AI in construction and visualized areas for potential improvement indicate a possible trend for a welcoming ingress of AI in construction professional trainings.

Not only findings of this study can help the education industry, but the AI programming entities can also come up with some potential tailored solutions for the construction practice. For educators, the findings of low awareness serve as a strong indicator of learning needs in the industry professionals. The responses to the survey recommend the top choices for the AI programs in construction to be the course content for industry professionals. As the general trend of the construction industry, safety is always seen as a vital component of a project’s success. Any tool that improves this aspect is valued the most by industry professionals. The same was observed for

AI tools for Schedule and resource management. These responses reflect the trends of the preference for operations.

The learning format and preferred duration also indicate a requirement for a properly structured program design while allowing the learners to balance technical education with professional obligations. The preference was predominantly seen for shorter courses of less than 4 hours and online self-paced courses which shed light on the importance of flexibility for the learners to attend these programs. Based on the responses, the courses can be offered in multiple tiers ranging from basic aspects of AI in construction all the way to advanced applications of AI to optimize the construction process. Policymakers for education and governance in construction should also take part in augmenting the educational curriculum for both short-term training and proper modular courses to best suit the industry's needs while producing a workforce that has more relevant skills to the practice.

The role of technology providers is also vital for the endeavor of improving workforce skills as the products update and improve frequently. Their contribution to these programs may be critical for ensuring the best learning outcome. These programs can serve as emerging opportunities for all the involved stakeholders which could be economical or employment-based.

Conclusion

This study evaluates the thematic learning needs of the construction stakeholders which are based in India. The research team followed the learning needs assessment protocol for collecting the data. The responses to the survey indicated an emerging learning need for the professionals who are involved with the construction industry. The respondent's perceived awareness levels were on the lower side which motivates the question on the possible learning needs of these professionals. Most respondents were interested in learning the basic applications of AI to begin their upgrade journey. Most respondents also preferred flexible training or educational programs to ensure uninterrupted professional work.

This study presents the founding steps in the direction of formalized thematic training of AI skills for the professionals of the construction industry. However, there are limitations to this study. The first limitation is the limited sampling of the professionals and the possibility of sampling bias since all the perspectives are taken from the Indian Construction Industry. The perspectives and the findings may represent the professionals who are familiar with the construction practices that are limited to India only. This study is only an exploratory study that can be replicated at a larger scale to research for generalizable results. The snowball sampling done for data collection may cause a collective view of respondents belonging to similar working conditions, to dominate and may further the sampling bias.

The second limitation to be considered is the legal aspects of the use of AI applications and the current non-standardized regulations surrounding the use and education of the same. The involvement of policy-making entities in the research phase of AI program development may help in clearly defining the ambiguity in legal and socio-political frameworks. Although this involvement may lead to regulatory challenges, where complexity in understanding of AI application and co-regulating the said applications, may impede one another.

Another limitation of this study is the limited scope of the survey where this study could be expanded to assess the barriers to learning as well. Understanding the industry's needs and their preferred method for undergoing the relevant training may not be sufficient information to develop successful educational programs. It is essential for the educational program developers to overcome the barriers to the ingress and learning of AI applications for a successful program.

Exploration of the detailed content of these training programs, scalability of these training programs, implementation of AI tools, and evaluation of learning outcomes of these training programs can serve as recommendations for future research projects in this area of research. The future research can explore the broader scope of learning needs where a larger and relatively more diverse respondent population and the barriers to the learning process may also be assessed. The findings of this learning needs can yield into the development of a pilot education program which can be studied to improve learning outcomes. By expanding in these research directions, academia can create many opportunities for the stakeholders of the global construction industry.

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