Enhancing Students' Attitudes Towards Robots Using a Virtual Site Visit on Four-Legged Robot Applications in Construction

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Abstract: The use of robotics and automation in construction has become increasingly popular in recent years, but negative attitudes toward working alongside these technologies persist. This is a significant issue, particularly for construction students who are future construction professionals. Understanding the safety challenges and countermeasures associated with working with robots on-site is essential for improving attitudes toward them. However, logistical and financial constraints present challenges in incorporating an effective robot-related learning tool or alternative into construction education. To address this issue, this study developed a virtual site visit, which integrates Virtual Reality (VR) technology and immersive storytelling to expose students to a robot-dominant construction site. The virtual site visit allows users to navigate a robot-dominant construction site and learn about four-legged robots, their applications, safety challenges, and countermeasures for working safely with them. This study aims to explore the potential relationship between students' backgrounds, specifically their construction experience and familiarity with construction robots, and the impact of virtual site visits on improving attitudes toward construction robots. The findings indicate that following the virtual site visit, there was a significant decrease in negative attitudes among students with limited construction experience and limited knowledge about robots.

Keywords: Attitudes Towards Robotics, Immersive Storytelling, Virtual Reality, Construction Robots

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1 Introduction

The construction industry has shown increasing interest in utilizing construction robots in recent years, as on-site robotic systems have the potential to revolutionize and address various shortcomings of the industry, such as stagnant productivity and safety concerns. By performing repetitive tasks such as bricklaying, finishing, and rebar-tying, construction robots can enhance productivity and allow workers to focus on more complex tasks that require human skills and capabilities [1]. Additionally, the use of automation and robotics can help reduce project costs by enabling construction work to continue during adverse weather conditions [2], [3]. Construction robots also have the potential to mitigate labor shortages and increase workforce access by enabling underrepresented groups, such as disabled individuals, to engage in construction tasks. Furthermore, these robots can execute hazardous and labor-intensive tasks like demolition, reducing injuries and fatalities in an industry known for its dangerous work environment [4]. However, a significant challenge to leveraging robots in construction is the negative attitudes that humans often present toward working alongside robots. This is especially true for new construction workers who lack experience working with robots, as they may not be familiar with dynamic working environments and collaborative working environments with robots.

Humans are less willing to work with or alongside robots when they are unfamiliar with novel technologies. Negative attitudes towards robots in construction may lead to the limited promotion of construction robots on the site and workers' negative attitudes towards learning how to operate or work with robots during safety training, affecting learning efficiency [5]. As future construction professionals, learning and adopting innovative technologies, such as construction robots, is essential for these construction students. Many studies explored learning and training contents to introduce the robot's various components, safety management, and general guidelines used for robots [6] and integrating VR technology to simulate robot-dominant construction scenarios where users can observe or interact with these robots without exposing themselves to unnecessary risks [7]. However, there is a research gap in understanding construction students' attitudes toward robots in construction. This study explores the innovative use of a virtual site visit, which integrates VR technology and immersive storytelling to expose students to virtual four-legged robots within a construction site. The aim of this study is to explore the use of the virtual site visit to understand and improve construction students' attitudes toward robots in construction. In this paper, we will develop the virtual site visit as a valuable tool for incorporating knowledge about four-legged robots in construction within the construction curriculum and help reduce students' negative attitudes toward robots' use in construction sites.

2 Related Works

2.1 Applications of four-legged robots and their safety challenges in construction

The construction industry is currently facing a significant skilled labor shortage, which has led to the integration of robots becoming inevitable. One increasingly popular type of robot in construction is the four-legged robot, also known as the quadruped robot. These robots offer adaptability and mobility that is ideal for various construction applications [8], [9]. They are commonly used for monitoring and inspection activities, as they are capable of traversing and scanning job sites more frequently than humans. This enhances the effectiveness of the inspection and monitoring process by generating digital replicas of job sites that can be used for manual or automated assessments [10], [11]. Several recent studies have demonstrated the effectiveness of using four-legged robots for various construction applications. For example, [10] [11] utilized BIM-enabled automated reality capture and GPS technology to enable four-legged robots to autonomously capture 360-degree images for frequent construction inspections, reducing the need for manual labor. Another study proposed the use of a 3D LiDAR-equipped four-legged robot for monitoring scaffolding operations from a safety perspective by collecting 3D point cloud data of the scaffolds [12]. Additionally, Kolvenbach's research group deployed the ANYmal four-legged robot to inspect concrete deterioration in sewer systems, providing deterioration levels through their autonomous inspection system [13]. Furthermore, four-legged robots have been proposed for transporting materials and tools on job sites, constructing building elements, and assisting in the building process. For example, a study used employed a four-legged robot equipped with a robotic arm to facilitate safe interaction between humans and robots in collaborative tasks, such as opening doors and carrying payloads [8]. With the rapid advancements in robotic technology, such applications may soon become more prevalent in the construction industry.

However, as the deployment of four-legged robots increases in construction, there will be more interactions between human workers and robots on job sites. Safety concerns have been highlighted regarding the rising interactions between humans and robots in shared workplaces. These safety concerns can be classified into three categories: physical risks, attentional costs, and psychological impacts [14]. Physical injury to humans is one of the primary safety challenges in human-robot interaction in construction. Such injury can result from collisions with robots or contact with robot components, including their moving parts. The National Institute for Occupational Safety and Health [15] has noted that "falls" are the primary cause of work-related deaths in construction, which could be worsened by the introduction of four-legged robots to construction sites. This risk may arise from various factors, including robots colliding with workers on scaffolding or ladders or the harsh conditions of construction environments that can cause robotic navigation systems to fail in detecting accurate walking paths, resulting in collisions with humans [8], [16]. Apart from the direct physical dangers brought about by robots, the presence of robots on a construction site could also influence the way workers typically carry out tasks, which may lead to new safety hazards. For instance, robots could serve as a distraction to workers, causing them to constantly switch their focus between executing hazardous tasks and monitoring the robots [17]. Besides, the implementation of robots in construction sites can have a psychological impact on workers as most robots are equipped with cameras or other sensors to capture worker activities. This could lead to a sense of "being watched" among workers, causing feelings of anxiety and stress.

To manage the risks posed by these robots, measures such as regulatory and administrative interventions, technological interventions, training interventions, and cyber and privacy interventions have been developed [18]. Morris and Cannady proposed that controls can be implemented to abate workplace hazards and protect construction workers [18]. The primary approach to ensure workplace safety is to eliminate hazards completely to prevent accidents or fatalities. The second approach involves the substitution or replacement of the hazardous source with a non-risky alternative. The third strategy is to implement engineering controls that can isolate people from potential hazards that cannot be eliminated or substituted. For instance, this can be achieved by placing physical barriers, like safety fences, around workers who operate in close proximity to four-legged robots or by cordoning off the area where robots are working. The next strategy is administrative control, which involves modifying the way workers perform their tasks to minimize the risk exposure while accommodating robots. This may include the introduction of safety guidelines or precautions for workers to follow while working with or around robots. The final strategy is to provide appropriate Personal Protective Equipment (PPE), such as hard hats, safety glasses, steel-toed shoes, and safety gloves when working with four-legged robots. This information is essential for construction students to understand and become familiar with the use of four-legged robots in construction [19]. This study will use the above information about four-legged robots to develop the virtual site visit.

2.2 Attitudes toward robotics in construction

New-generation technologies, including robotics, have demonstrated significant potential for widespread use in the construction industry. However, construction workers and students often exhibit reluctance to trust or harbor negative attitudes toward these new technologies. Research has shown that building a culture of trust and positive attitudes regarding the potential and reliability of new technologies can play a critical role in enhancing adoption levels within the construction industry [20]. Moreover, the adoption of robotic technologies in construction sites is increasing human-robot interaction, which necessitates trust in the new technologies. Therefore, it is crucial to improve the attitudes of construction workers and future professionals toward robots in construction. Construction robots belong to interdisciplinary fields such as computer science, engineering, mathematics, statistics, and psychology, which enable them to learn from existing data and past experience and perform tasks that typically require human intellectual processes [21]. The complexity of this interdisciplinary nature may reinforce concerns among users or future users of this new technology regarding operational complexity and hazards. Latikka indicated that advanced new-generation technologies, when deployed well, should provide transparency and interpretability to reduce human bias [22]. Particularly in robotics, learning or training agents are capable of providing explanations for robotic actions and rationale. Several studies have explored the use of virtual site visits to study and enhance trust and positive attitudes toward robotics and automation in various fields [23]–[25]. In construction applications, Adami's study used a virtual learning environment to enable trainees to remotely operate construction robots and measure workers' trust in the robot [6]. Results showed that the virtual environment significantly increased trust in the robot compared with traditional in-person training. However, no study has focused on understanding the impact of the virtual environment on construction students' attitudes toward robots. Particularly investigating the knowledge gap in students' backgrounds, such as their construction experience and familiarity with construction robots, could be associated with the effects of the virtual environment on improving attitudes toward construction robots. This study proposed the virtual site visit, which incorporates storytelling content related to four-legged robot technologies, applications, safety challenges, and countermeasures in a VR environment. This approach provides an opportunity for students to fully understand and enhance their positive attitudes toward four-legged robots in construction.

3 Methods

This study aims to develop a virtual site visit platform that integrates immersive storytelling and virtual site visit technologies to provide an opportunity for students to understand and enhance their positive attitudes towards four-legged robots in construction, as well as to investigate the association between students' professional backgrounds and their attitudes towards robots in construction. The study will present the creation of immersive storytelling and technological design of the virtual site visits (See figure 1), followed by a pre-and post-survey on students' attitudes towards robots [26]. The following sections will discuss the development of the virtual site visit and the study metrics used for attitudes assessment. During the analysis phase, the participants were divided into groups based on their professional backgrounds, and their attitudes toward robots were compared between groups using statistical methods to investigate their association.

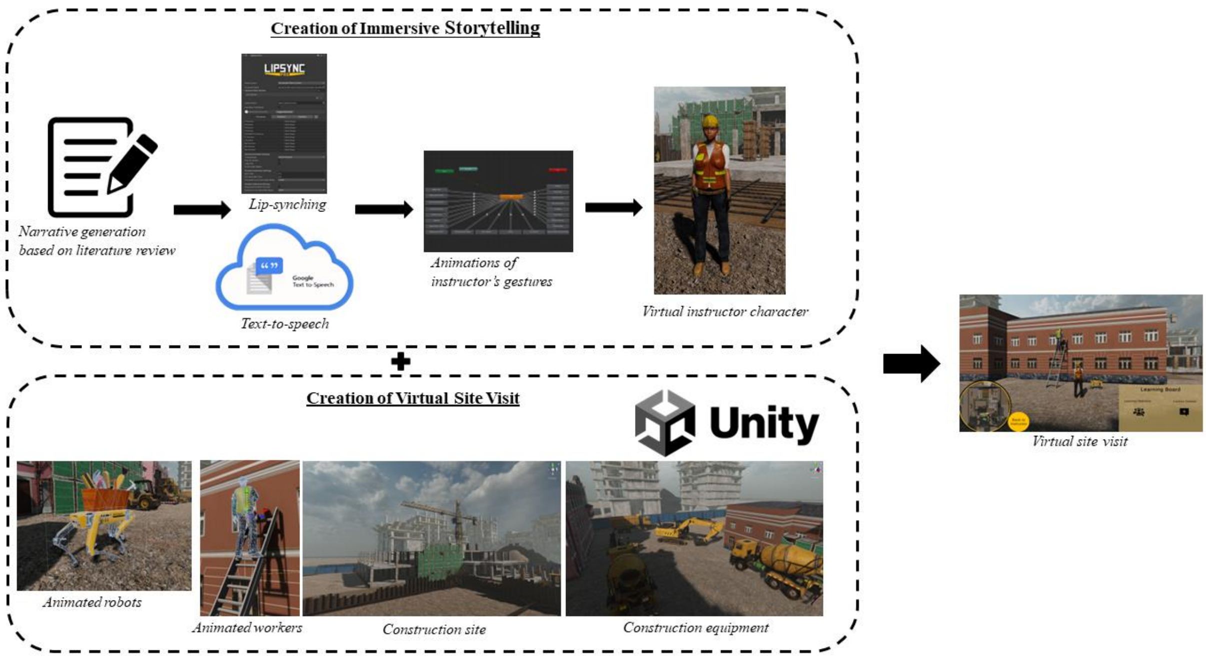
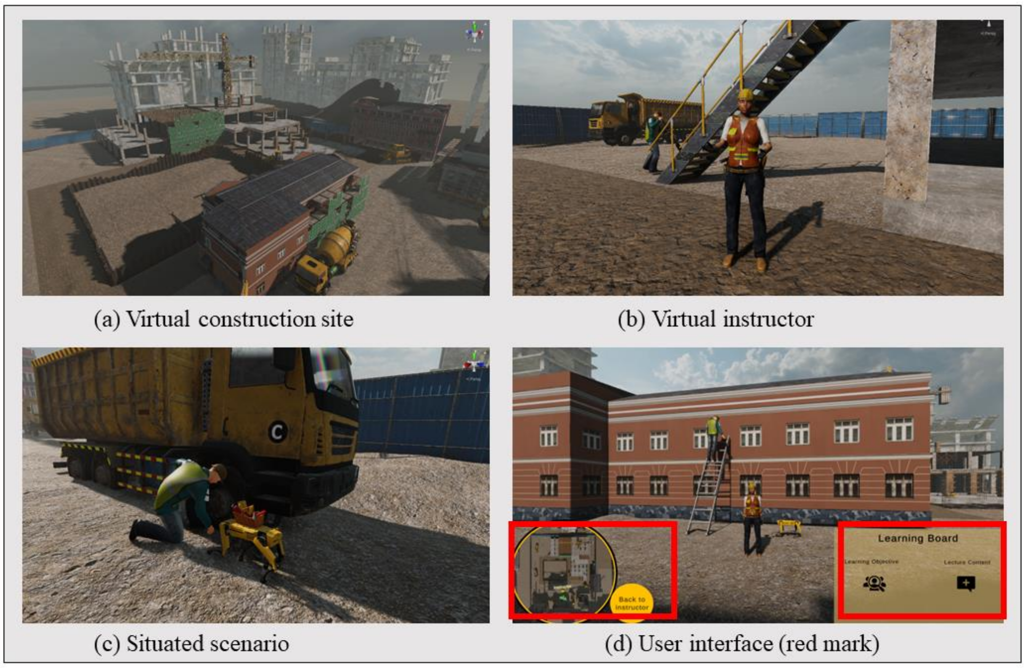


Figure 1. Creation of immersive storytelling and virtual site visit

4 Technical Development

The development of the virtual site visit can be divided into two main sections: narrative generation and technical development. The primary purpose of the narrative in virtual site visits is to help construction students understand the potential applications of four-legged robots in construction sites, the safety challenges associated with their use, and the countermeasures to address those safety concerns. According to the narrative content, a virtual site visit comprises three primary elements: the virtual construction site, virtual instructor, situated scenarios, and user interfaces (see Figure 2). The Unity® game engine was utilized to build the construction environment in VR. To create the virtual robot-dominant construction site, construction equipment, workers, and four-legged robots were arranged and animated in the virtual environment. Next, several technologies were used to develop a virtual instructor who uses natural verbal and nonverbal language, including text-to-speech, lip-synching, and animation technologies. Situated scenarios were animated in accordance with the project narratives. Finally, user interfaces were developed, including a virtual learning board, a "Back to Instructor" button, and a Mini Map, enabling users to track learning objectives, return to the instructor's location, and locate themselves and the instructor in the virtual environment. These elements were required to successfully integrate and correctly place them at designated positions in the immersive environments, considering the narrative contents at that time.



(a) Virtual construction site (b) Virtual instructor (c) Situated scenario (d) User interface (red mark)

Figure 1. Primary elements within the virtual site visit

5 Attitudes Towards Robots in Construction Between Different Backgrounds

To achieve the research goal of this paper, an experiment was conducted aimed at construction students with varied working experience and familiarity with construction robots. Forty-one males and fifteen females participated in the survey and used desktop computers to individually experience the virtual site. Participants were recruited from the College of Design, Construction, and Planning at the University of Florida, and they had an academic or working background in construction, architecture, civil engineering, or landscape. The experiment was exempted from the UF Institutional Review Board (IRB). Prior to the survey, participants responded to a demographic survey that included questions about their gender, working experience, and familiarity with construction robots. Table 1 provides the demographic details of the study participants.

Table 1. Participant study grouping based on their background (experience and familiarity with robots)

Parameters		Group Code	Number (Percentage)
Experience in Construction Industry	Less 1 year	A0	33 (59%)
	Over 1 year	A1	23 (41%)
Familiarity with Construction Robotics	None and Some Knowledge of	B0	42 (74%)
	Fair and Competent	B1	15 (26%)

To measure whether people generally have a positive or negative attitude towards robots, the Negative Attitudes Toward Robots Scale (NARS) was used. The NARS includes 12 five-point Likert-scale questions, with a focus on the extent to which one would be reluctant to interact with robots, which reflects negative attitudes towards interacting with robots, the social influence of robots, and emotions in interaction with robots. The NARS scale has been validated in previous studies, such as Nomura's study [5] investigated the relationships between negative attitudes, anxiety towards, and allowable distance from a robot. A higher score on the NARS indicates more negative attitudes toward robots. In this study, students participated in pre- and post-NARS questionnaires, and the results reveal that after experiencing virtual site visits, participants' negative attitudes towards robots significantly reduced (from 2.74 to 2.53), indicating the effectiveness of the proposed virtual site visit in improving students' attitudes towards robots. Furthermore, participants were divided into different groups according to their experience in the construction industry and familiarity with construction robotics. An independent sample t-test was used to compare the means of pre- and post-NARS scores among the diverse groups of students, as determined by the Shapiro-Wilk normalization test [27] (all, p>0.05). As shown in Table 2, there was no significant difference between groups with different construction industry experiences in both pre-and post-NARS scores, while there were significant differences between groups with different familiarity with construction robotics in pre- and post-NARS scores. Therefore, it was found that prior experience in the construction industry does not result in a different level of attitudes towards robots in construction, while students' familiarity with construction robotics significantly impacts their attitudes towards robots. Students who have fair and competent familiarity with construction robotics presented lower negative attitudes towards robots than students with no or some knowledge of familiarity.

Table 2. Results based on different professional backgrounds

Professional Background	Pre-NARS Mean (SD)				Post-NARS Mean (SD)			
Experience in Construction Industry	A0	A1	Difference of mean (SE)	P-value	A0	A1	Difference of mean (SE)	P-value
	2.82 (0.49)	2.62 (0.50)	0.20 (0.14)	0.14	2.57 (0.38)	2.45 (0.45)	0.12 (0.11)	0.29
Familiarity with Construction Robotics	B0	B1	Difference of mean (SE)	P-value	B0	B1	Difference of mean (SE)	P-value
	2.84 (0.47)	2.44 (0.48)	0.39 (0.14)	0.01*	2.61 (0.38)	2.29 (0.40)	0.32 (0.12)	0.02*

**P-value < 0.05*

To determine whether the virtual site visit has a different impact on students with various professional backgrounds (i.e., construction industry experience and familiarity with construction robotics) in enhancing their attitudes towards robots, dependent t-tests were used to compare means between pre- and post- NARS based on the different professional backgrounds, as determined by the Shapiro-Wilk normality test (all, p>0.05). The results showed that there were significant differences between pre-and post-NARS for students who had less than 1 year of construction industry experience and none to some familiarity with construction robots. As shown in Table 3, these students' negative attitudes towards robots in construction were considerably reduced after experiencing the virtual site visit. In contrast, no significant difference was found between pre- and post-NARS for students who had over 1 year of construction industry experience and fair to competent familiarity with construction robots. Thus, students with different professional backgrounds may require different learning or training methods to improve their attitudes toward robots in construction. It is suggested that students with more years of experience in the construction industry and higher familiarity with construction robotics could receive a shortened version of the virtual site visits or learning content, while those with less experience in the construction industry and lower familiarity with construction robotics may benefit more from the full virtual site visit.

Table 3. Differences between pre- and post-NARS based on different professional backgrounds

	Professional Background	Difference of means (SE)	95% CI	P-value
Pre - NARS vs. Post - NARS	A0	0.24 (0.06)	(0.13, 0.36)	0.00*
	A1	0.16 (0.08)	(-0.00, 0.33)	0.06
	B0	0.23 (0.05)	(0.12, 0.34)	0.00*
	B1	0.15 (0.10)	(-0.06, 0.36)	0.14

**P-value < 0.05*

6 Conclusion and Future Work

As an increasing number of construction projects adopt construction robots on-site, it is crucial for future construction professionals to be familiar with these technologies and have positive attitudes towards working with them. This study proposes a virtual site visit that incorporates storytelling content related to four-legged robot technologies, applications, safety challenges, and countermeasures into a VR environment. This study also provides an opportunity for students to learn about four-legged robots in construction, enhance their positive attitudes toward them, and investigate the association between students' professional backgrounds and their attitudes toward robots in construction. The virtual site visit platform enables students to navigate a robot-dominant construction site and learn about four-legged robots, their applications, safety challenges, and countermeasures for working safely with robots. Four main components were established in the virtual site visit: virtual construction site, virtual instructor, situated scenarios, and user interfaces. An experiment was conducted during the virtual site visit to understand students' attitudes towards robots in construction and investigate whether students' construction experience and familiarity with construction robots could be associated with their attitudes towards robots. A total of 56 participants were surveyed to collect data and analyze their attitudes toward robots in construction before and after experiencing the virtual site visit. The results indicated the effectiveness of the proposed virtual site visit in improving students' attitudes toward robots. Furthermore, students' prior experience in the construction industry did not result in a different level of attitudes towards robots in construction, while students' familiarity with construction robots significantly impacts their attitudes towards construction robots. Students with fair and competent familiarity with construction robots presented lower negative attitudes towards robots than students with no or some knowledge of familiarity. On the other hand, the results revealed that students with different professional backgrounds might require different learning or training methods to improve their attitudes toward robots in construction. It is suggested that students with more years of experience in the construction industry and higher familiarity with construction robotics could receive a shortened version of the virtual site visit or learning content, while those with less experience in the construction industry and lower familiarity with construction robotics may benefit more from the full virtual site visit. Furthermore, to enhance the understanding of the effectiveness of the virtual site visit in improving students' positive attitudes toward construction robots, future studies should consider gathering a larger sample size to improve the generalization of the results. Also, this study did not focus on how the virtual site visit would influence students' learning outcomes and experiences with construction robots, and future studies could focus on this topic to gain more insights into the effectiveness of the virtual site visit.

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References

[1] A. J. Madsen, "The SAM100: Analyzing Labor Productivity," 2019, Accessed: Jul. 21, 2021. [Online]. Available: https://digitalcommons.calpoly.edu/cmsp/243/.

[2] K. Iturralde *et al.*, "A Cable Driven Parallel Robot with a Modular End Effector for the Installation of Curtain Wall Modules," 2020.

[3] Z. Dakhli and Z. Lafhaj, "Robotic mechanical design for brick-laying automation," *Cogent Eng.*, vol. 4, no. 1, Jan. 2017, doi: 10.1080/23311916.2017.1361600.

[4] A. Balzan, C. C. Aparicio, and D. Trabucco, "Robotics in construction: State-of-art of on-site advanced devices," *Int. J. High-Rise Build.*, vol. 9, no. 1, pp. 95–104, 2020, doi: 10.21022/IJHRB.2020.9.1.95.

[5] T. Nomura, T. Shintani, K. Fujii, and K. Hokabe, "Experimental investigation of relationships between anxiety, negative attitudes, and allowable distance of robots," in *Proceedings of the 2nd IASTED International Conference on Human-Computer Interaction, HCI 2007*, 2007, pp. 13–18, Accessed: Apr. 17, 2023. [Online]. Available: http://www.vstone.co.jp/e/rt01e.htm.

[6] P. Adami, B. Becerik-Gerber, L. Soibelman, T. Doleck, Y. Copur-Gencturk, and G. Lucas, "An Immersive Virtual Learning Environment for Worker-Robot Collaboration on Construction Sites," *Proc. - Winter Simul. Conf.*, vol. 2020-December, pp. 2400–2411, Dec. 2020, doi: 10.1109/WSC48552.2020.9383944.

[7] P. Adami *et al.*, "Impact of VR-Based Training on Human–Robot Interaction for Remote Operating Construction Robots," *J. Comput. Civ. Eng.*, vol. 36, no. 3, p. 04022006, Feb. 2022, doi: 10.1061/(ASCE)CP.1943-5487.0001016.

[8] C. D. Bellicoso *et al.*, "Advances in real-world applications for legged robots," *J. F. Robot.*, vol. 35, no. 8, pp. 1311–1326, 2018, doi: 10.1002/rob.21839.

[9] M. Safeea and P. Neto, "Minimum distance calculation using laser scanner and IMUs for safe human-robot interaction," *Robot. Comput. Integr. Manuf.*, vol. 58, pp. 33–42, Aug. 2019, doi: 10.1016/j.rcim.2019.01.008.

[10] S. Halder, K. Afsari, ; John Serdakowski, S. Devito, and R. King, "Accuracy Estimation for Autonomous Navigation of a Quadruped Robot in Construction Progress Monitoring," in

Computing in Civil Engineering 2021, May 2022, pp. 1092–1100, doi: 10.1061/9780784483893.134.
[11] K. Afsari, S. Halder, M. Ensafi, S. DeVito, and J. Serdakowski, "Fundamentals and Prospects of Four-Legged Robot Application in Construction Progress Monitoring," in *EPiC Series in Built Environment*, 2021, vol. 2, pp. 274–263, doi: 10.29007/cdpd.
[12] N. J. Kim, B. R. Belland, and A. E. Walker, "Effectiveness of Computer-Based Scaffolding in the Context of Problem-Based Learning for Stem Education: Bayesian Meta-analysis," *Educ. Psychol. Rev.*, vol. 30, no. 2, pp. 397–429, Jun. 2018, doi: 10.1007/S10648-017-9419-1/TABLES/6.
[13] H. Kolvenbach *et al.*, "Towards autonomous inspection of concrete deterioration in sewers with legged robots," *J. F. Robot.*, vol. 37, no. 8, pp. 1314–1327, 2020, doi: 10.1002/rob.21964.
[14] I. Jeelani and M. Gheisari, "Safety challenges of UAV integration in construction: Conceptual analysis and future research roadmap," *Saf. Sci.*, vol. 144, no. July 2020, p. 105473, 2021, doi: 10.1016/j.ssci.2021.105473.
[15] NIOSH, "Construction Statistics," *NIOSH Directory of Construction Resources*, 2021. https://www.cdc.gov/niosh/construction/statistics.html (accessed Jan. 12, 2022).
[16] S. M. S. Elattar, "Automation and Robotics in Construction: Opportunities and Challenges," *Emirates J. Eng. Res.*, vol. 13, no. 2, pp. 21–26, 2008, Accessed: Jan. 11, 2022. [Online]. Available: https://www.bostondynamics.com/solutions/public-safety.
[17] I. S. Kim, Y. Choi, and K. M. Jeong, "A new approach to quantify safety benefits of disaster robots," *Nucl. Eng. Technol.*, vol. 49, no. 7, pp. 1414–1422, Oct. 2017, doi: 10.1016/j.net.2017.06.008.
[18] G. A. Morris and R. Cannady, "Proper Use of the HIERARCHY OF CONTROLS," *Prof. Saf.*, vol. 64, no. 8, pp. 37–40, Aug. 2019, Accessed: Mar. 28, 2023. [Online]. Available: https://www.jstor.org/stable/pdf/48689862.pdf.
[19] X. Xu and B. Garcia de Soto, "On-site Autonomous Construction Robots: A review of Research Areas, Technologies, and Suggestions for Advancement," *Proc. 37th Int. Symp. Autom. Robot. Constr.*, no. October, 2020, doi: 10.22260/isarc2020/0055.
[20] M. H. Schia, "The Introduction of AI in the Construction Industry and its Impact on Human Behavior," 2019, Accessed: May 03, 2023. [Online]. Available: https://ntnuopen.ntnu.no/ntnu-xmlui/handle/11250/2634040.
[21] M. Hild and B. Stemmer, "Can Evolution Produce Robots?," *Conscious. Cogn. Fragm. Mind Brain*, pp. 53–67, Jan. 2007, doi: 10.1016/B978-012373734-2/50006-6.
[22] R. Latikka, N. Savela, A. Koivula, and A. Oksanen, "Attitudes Toward Robots as Equipment and Coworkers and the Impact of Robot Autonomy Level," *Int. J. Soc. Robot.*, vol. 13, no. 7, pp. 1747–1759, 2021, doi: 10.1007/s12369-020-00743-9.
[23] S. Shayesteh, A. Ojha, and H. Jebelli, "Workers' Trust in Collaborative Construction Robots: EEG-Based Trust Recognition in an Immersive Environment," in *Automation and Robotics in the Architecture, Engineering, and Construction Industry*, H. Jebelli, M. Habibnezhad, S. Shayesteh, S. Asadi, and S. Lee, Eds. Springer, Cham, 2022, pp. 201–215.
[24] N. Emaminejad and R. Akhavian, "Trustworthy AI and robotics : Implications for the AEC industry," *Autom. Constr.*, vol. 139, no. March, p. 104298, 2022, doi: 10.1016/j.autcon.2022.104298.
[25] P. Adami *et al.*, "Advanced Engineering Informatics Participants matter : Effectiveness of VR-based training on the knowledge , trust in the robot , and self-efficacy of construction workers and university students," *Adv. Eng. Informatics*, vol. 55, no. November 2022, p. 101837, 2023, doi: 10.1016/j.aei.2022.101837.
[26] M. Joosse *et al.*, "BEHAVE-II: The Revised Set of Measures to Assess Users' Attitudinal and Behavioral Responses to a Social Robot," *Int. J. Soc. Robot.*, vol. 5, pp. 379–388, 2013, doi: 10.1007/s12369-013-0191-1.
[27] S. S. Shapiro and M. B. Wilk, "An Analysis of Variance Test for Normality (Complete Samples)," *Biometrika*, vol. 52, no. 3/4, p. 591, Dec. 1965, doi: 10.2307/2333709.