Artificial Intelligence-Enhanced Virtual Reality for Health and Safety Training in Construction

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Abstract

The construction industry continues to face significant challenges in ensuring the health and safety (H&S) of its workers. Traditional training methods are often insufficient in preparing workers for the complexities of real-world scenarios. This paper explores the application of Artificial Intelligence (AI) and Virtual Reality (VR) technologies in H&S training within the construction sector. By using AI to personalise and adapt VR training experiences, these technologies can significantly enhance learning outcomes, improve safety behaviour, and ultimately reduce workplace accidents.

Keywords

AI, Virtual Reality, Health and Safety Training, Construction, Immersive Learning,

1. Introduction

Health and safety challenges remain a major concern within the construction industry, a sector that shapes our physical environment. Recent UK data reveal that 51 construction workers tragically lost their lives in accidents between January and March 2024, with an alarming increase in number over time as fatality rates among construction workers are now 70% higher than they were five years ago based on data from 2018/19, and the average number of deaths within the industry over the past two years has been reported as much worse than figures from the pre-COVID period [1]. Despite advancements in safety measures, particularly in preventing falls from height, such incidents continue to be the leading cause of fatalities on construction sites in the UK, accounting for 36% of all construction-related deaths in 2023 [2]. Traditional training methods appear increasingly inadequate in addressing the diverse hazards present on construction sites, such as working at height, operating heavy machinery, and exposure to hazardous substances. The construction industry is slow in adopting new technologies compared to other sectors, such as banking, healthcare, and IT, and it is overdue for a technological overhaul in its approach to health and safety training [3].

Artificial Intelligence (AI) and Virtual Reality (VR) present promising opportunities to enhance health and safety training. These technologies can generate immersive, engaging, and personalised training experiences that surpass conventional methods. AI and VR can simulate realistic scenarios, allowing workers to practise critical skills and decision-making in a safe, controlled environment. Recent research has demonstrated the effectiveness of VR in enhancing hazard recognition, improving safety behaviour, and increasing training satisfaction [4]. Similarly, AI can be utilised to tailor training content to individual needs and monitor learner progress, thereby optimising the overall learning experience [5]. This paper examines the potential of AI and VR to enhance health and safety training in the construction industry, with an analysis supported by a case study.

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1.1. Immersive Training

Immersive training, defined as "a set of active phenomenological experiences that are based on presence", represents an innovative approach to learning and development. By combining emerging technologies such as Augmented Reality (AR) and Virtual Reality (VR), immersive training creates highly engaging and realistic experiences, offering users a higher sense of presence and engagement compared to traditional training methods [6]. This approach is different from conventional methods, such as lectures, role-playing, or viewing safety training videos, which often lack the realism and interactivity essential for effective learning and skill transfer. With the simulation of real-world scenarios in a virtual environment, immersive training let the learners to practice skills and make decisions in a safe, controlled setting, bridging the gap between theoretical knowledge and practical application. This method provides a more engaging learning experience and makes the process more enjoyable for the workers.

Research has shown the effectiveness of immersive training across different fields. VR-based training can significantly influence user's ability to perform complex procedures [7]. This goes to the potential of immersive training in developing practical skills within a risk-free environment. Studies have also shown that immersive training increases motivation and engagement, leading to improved information retention and performance [8].

1.2. Extended Reality

Extended Reality (XR), which includes Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR), is changing the way we access and interact with information [9]. VR offers users a fully immersive and safe digital environment with controlled training scenarios, providing an ideal platform for practising skills without having to face the risks of a real-world environment. AR superimposes digital information onto the physical world with technologies like smart glasses, giving workers real-time critical information and instructions, helping them to increase productivity without disrupting their workflow. MR merges the real and virtual worlds, enabling the user to interact with physical and digital objects. It allows users to visualise construction projects, plan site layouts, and even train in a blended environment that combines the advantages of VR and AR with devices like Microsoft HoloLens [10].

The user base for VR is expanding, as evidenced by the sales figures: millions are sold annually, while the practical applications of AR and MR in construction and other industries are driving its adoption [11]. XR technologies are able to provide detailed and realistic simulations for training workers and their developments across sectors. The construction industry is one of the sectors with a high risk of accidents, where we can deploy XR training to reduce the risks by having the workers train in a simulated environment and making them prepared for any possible hazards. However, the major challenge with the current state of the technology is that even though we have several simulated training platforms available, these are generic. Training is done in a general environment, which might be entirely different and may not align with the specific conditions of their site, which leads to the workers having to adapt to the real world even though they are trained in a simulated environment.

1.3. Generative AI

Generative Artificial Intelligence is capable of generating data such as realistic videos, 3D models, scripts, and voiceovers and is changing the way how we create and interact with digital content, which is particularly valuable in the easier generation of training environments and scenarios for XR platforms [12]. Models like Generative Adversarial Networks (GANs), which can generate highly realistic images and videos, are a major leap in the advances of generative AI, helping creators generate detailed training scenarios. GANs can generate realistic, lifelike animations and environments for VR training modules, making the learning process more effective [13].

Large Language Models (LLMs) are capable of generating concise, contextually relevant texts that are being used across industries [14]. These models can create scripts for training scenarios, instructional content, and interactive dialogues for the VR training models, providing a more personalised and engaging experience. The learning environments can also be made more interactive by providing real-time feedback and answering the trainee's questions by using LLMs like ChatGPT or by deploying synthetic voices and human-like avatars, which can be generated with a generative AI [15]. AI-generated voiceovers can be made to match specific accents, tones and languages to cater to a global audience giving a consistent, high-quality narration and guidance within the training modules. AI can also generate avatars which can closely resemble real people to interact with trainees, providing guidance, feedback and support for a better learning experience.

The evolution of AI is transforming the current approach in the development of XR content. The ability to easily generate high-quality and realistic training materials with AI helps ensure that the learners have an effective, engaging, and immersive training experience. Integrating AI into generating media, especially the creation of content for XR is driving innovation in the delivery of training and education with its capability to generate diverse and realistic content pave the way for more immersive, interactive, and effective learning experiences [16].

1.4. Learning in VR Environment

Learning in a VR environment gives a different approach compared to the conventional methods for education and training by offering an experience far more engaging and immersive than the traditional classroom settings or computer-based educational games. Learning in a simulated virtual environment enhances the engagement and skill development of the users as these platforms allow the users to engage with content in an immersive and practical manner providing a deeper understanding of the subject matter. VR-based learning presents several distinct advantages over traditional methods. Unlike conventional in-class training, VR provides a hands-on experience where learners can practice tasks within a safe, controlled setting [17]. This approach is particularly advantageous in construction training, where safety and risk management are critical concerns.

The adoption of VR-based learning is compelling and backed by solid statistics that show its effectiveness. Studies indicate that VR training in the construction sector can increase worker knowledge retention by up to 75% and reduce the risk of on-the-job accidents by up to 43%. VR learners were found to be completing their training 4 times faster and displayed 3.75 times more emotional connection to the content compared to learners in traditional classrooms [18.19]. The benefits of VR training are becoming more and more recognised and valued across several industries, as evidenced by the projection of the AR and VR training market to exhibit a 41.8% compound annual growth rate (CAGR) from 2023 to 2033, reaching an estimated value of US$298,682.1 billion [20].

2. Methodology

This paper takes an exploratory and evaluative approach to investigate the current state of how effective AI-enhanced VR training platforms are for health and safety training in the construction industry. The research is presented as a case study of the SafeSite platform, which is an AI-VR training tool. This case study looks into the platform's potential to improve safety training outcomes by examining the feedback and experiences of users during the User Acceptance Testing (UAT) phase.

3. Case Study: SafeSite

The fast-paced nature of the construction industry puts forward an urgent need to train both existing and new staff as quickly as possible. The shortage of skilled workers is a major challenge faced by many countries, and it often pushes them to rely on labour from other countries. It is critical to train the workers quickly and effectively to adjust to the rapidly changing requirements of the industry and to maintain flow to ensure high-quality output. Effective training is necessary for workers to avoid injuries and accidents on site [21]. A new AI-VR training program for offshore construction was developed jointly by V-LAB and TriCore Technical Services to address these issues, providing an innovative training solution using advanced AI to create detailed and dynamic VR simulations that are replicas of real-world conditions, enabling workers to gain valuable experience and improve their skills safely and efficiently. This tool not only helps in accelerating the training process but also makes sure that workers are equipped and trained on how to handle any challenges that come with their role, which in turn increases the safety and productivity on construction sites.

VR technology was used to simulate one of the complex rooms of a substation, offering a safe and controlled space for immersive training exercises. A 3D model of the room was converted into the FBX file format and imported into Unreal Engine. Such process ensured realism by providing material textures. Firefighting scenarios and equipment operations were simulated using Unreal Engine. A Text-to-voice converter was used to store safety guidelines in audio format, which were then integrated into the model.

The exercise closely aligned with the Global Wind Organisation (GWO) Fire Awareness module, specifically Lesson 7 on Fire Extinguisher Training [22]. The module introduced participants to fundamental fire safety concepts, including fire theory, the fire triangle, and different types of fires, along with the combustion process. Trainees identified potential fire hazards in offshore settings and effectively used various fire extinguishers to control fires. This hands-on module replicated real-life scenarios, ensuring that participants responded confidently and accurately to fire emergencies, reinforcing their preparedness for real-world situations.

The workflow involved scanning offshore sites using LiDAR sensors, such as Matterport, to capture highly accurate point cloud data. This data was then processed using the Open3D library to generate a 3D model from the point cloud. For initial testing of the platform, Navisworks model of an offshore site was converted to VR-compatible format, and the 3D environment was imported into the virtual reality platform to create an immersive and realistic training scenario.

This training module focused on the Safety Protocol and Fire Extinguisher Training on an offshore platform. The workers were introduced to the theoretical part first, where they were familiarised with the basics of fire safety, including an overview of the Fire Triangle, which are the three essential components necessary for a fire to ignite: heat, fuel and oxygen. Then they were trained on different fire classes to help them identify the types of fires they might come across while working (Class A for ordinary combustibles, Class B for flammable liquids, and Class C for electrical fires). This was followed by lessons on different types of fire extinguishing agents like water, CO_2, foam and powder and the situations where each one is used.

Once the theoretical section is completed, the training moves to practical simulations. A fire is initiated in the virtual environment, starting from a random point on the offshore platform. The system determines the class of fire (e.g., electrical, oil-based, or general combustible) and simulates its behaviour accordingly. AI algorithms control the fire's spread, intensity, and duration based on environmental factors, mimicking real-life fire behaviour. The trainees then have to identify the type of fire based on visual cues (e.g., colour of the flames, source of the fire). Depending on the fire type, the trainee should move through the environment using VR controllers to locate and select the appropriate fire extinguisher. Extinguisher types (e.g., water, CO_2, foam) are placed in realistic locations, helping the trainees to familiarise with the actual site. If the trainees select the correct fire extinguisher, the system will let them extinguish the fire. If the wrong extinguisher is used (e.g. water on an electrical fire), the system responds with visual feedback, showing the fire worsening or spreading further.

The fire extinguishing process also has key actions to ensure that the trainee is operating the extinguisher properly in the simulation. Just like in the real world, the trainee has to pull the safety pin on the extinguisher and then aim at the base of the fire itself, as aiming directly at the flames will not suppress the fire effectively. Then, the trainee extinguishes the fire using the VR controller by moving them as it is done in real life. The AI then evaluates how the trainee performs to ensure that the proper technique is used for accurate and complete fire suppression. Trainees are also given training on additional emergency procedures like raising alarms and executing evacuation plans after extinguishing the fire, which is critical for ensuring and enforcing broader safety protocols.

The module concludes with participants inspecting firefighting equipment, ensuring that it is properly maintained for future use. This step involves identifying faults or damages, which are simulated to replicate real-world maintenance checks. Throughout the session, the system tracks user actions, such as response time, accuracy selecting the fire extinguishers, and operational effectiveness. AI algorithms provide real-time feedback on user performance and issue corrective guidance when necessary. At the end of the training session, the participants receive detailed performance scores and recommendations for improvement, helping them understand areas for further training.

4. Results and Discussion

Figure 1 shows the scanned site in the VR environment.

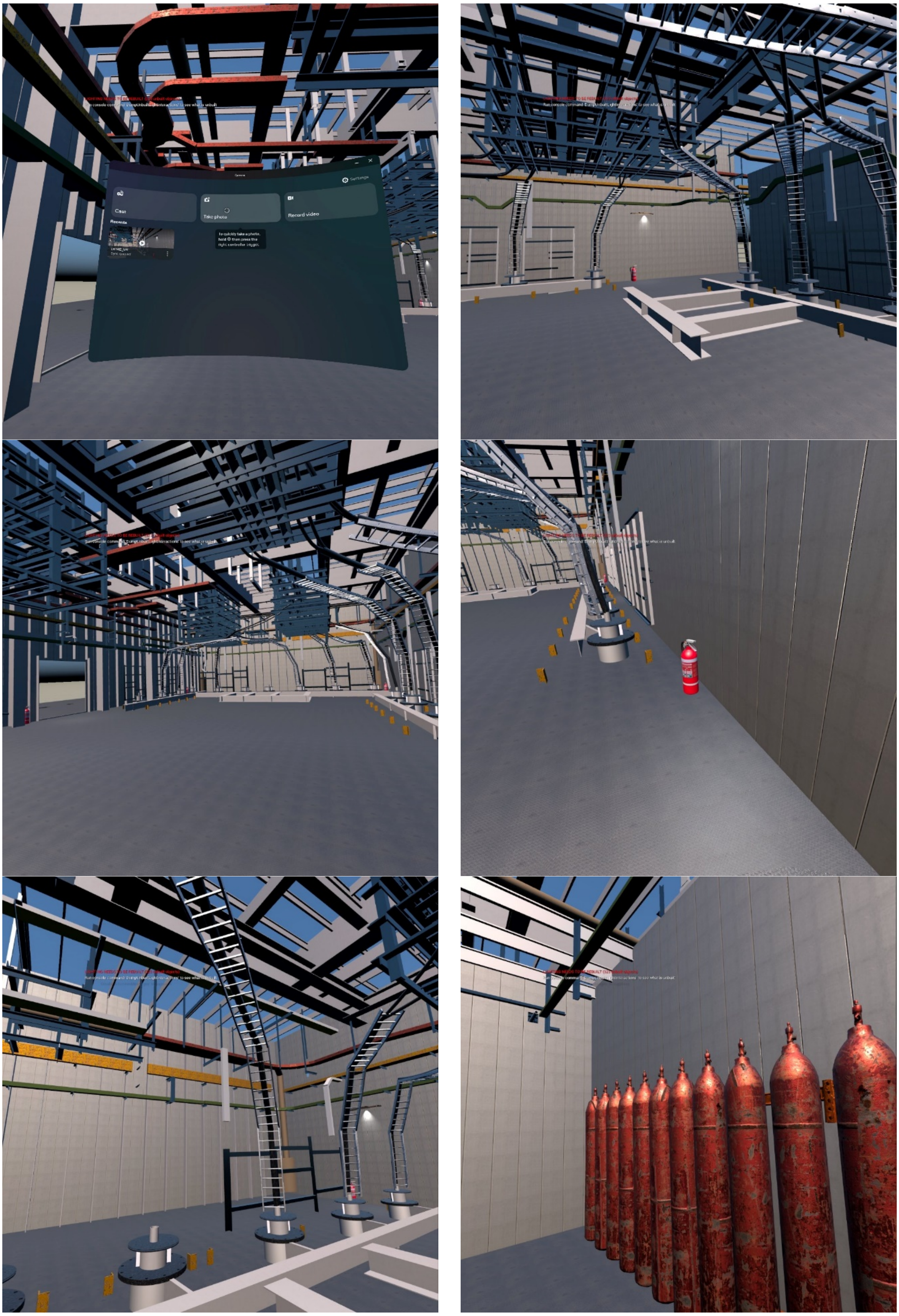

Figure 1: SafeSite VR environment

Figure 2 shows the user selecting appropriate fire extinguishers in a practical simulation.

Figure 2: Safety Protocol and Fire Extinguisher Training Module

The case study demonstrates the effectiveness of AI-VR training tool SafeSite in providing an immersive learning platform for offshore workers. The VR fire extinguisher training module presented an interactive, immersive and realistic virtual environment where the workers could become familiar with fire safety procedures. The training begins with a high-fidelity 3D replica of the actual site, which was scanned to create the virtual training environment mirroring the worker's actual workplace. Inside the environment, each trainee is represented by a customisable avatar controlled by the user. The VR controllers are mapped to hand movements, allowing the user to interact freely with the digital world and carry out the learning tasks.

The use of VR enabled the participants to experience and interact with high-risk scenarios without real-world risks. The project initially faced a significant challenge with running Open3D, a freely available library to process point cloud data. The substantial processing power and memory strained the resources, leading to a performance bottleneck. To address this, the existing trained algorithm, Multi View Stereo, was used to develop 3D objects from 2D images. This stage involved feeding the model with relevant data to generate 3D models to use inside the developed VR environment. By selecting a combination of approaches discussed above and engaging in joint development efforts, seamless AI-VR integration model was achieved.

Users demonstrated ability to learn and apply fire safety skills more efficiently. The seamless integration of theory and practice within the VR environment allowed participants to immediately implement what they learned. Compared to traditional classroom and physical drills, the VR platform significantly reduced the time required to master critical skills like identifying fire types, selecting the correct extinguisher, and performing evacuation procedures. This efficiency was especially visible in repeated training sessions, where participants improved their response times and accuracy with each attempt. The VR platform fostered rapid user familiarisation with fire safety equipment and emergency procedures. Trainees who had no prior experience with fire extinguishers or offshore emergency protocols were able to quickly adapt to the tasks, demonstrating competency with both fire extinguishing techniques and evacuation procedures. This was beneficial in reinforcing real-time decision-making under pressure, an area where traditional methods often fell short.

The ability to virtually work with fire in a controlled environment provided a high level of realism, enabling users to gain hands-on experience without the risks associated with real-world training. The interactive nature of the VR scenarios, including dynamic fire behaviour and real-time feedback, further contributed to higher levels of engagement and retention compared to passive learning methods.

The main challenge experienced during this process was to re-construct low-density areas in the point cloud, which results in uneven surface generation. This challenge was overcome by using several techniques. A surface reconstruction algorithm was used to estimate and fill in the gaps between sparse points. Additionally structures were scanned from different viewpoints and corresponding point cloud data integrated before converting them into a 3D model. Such strategies lead to generating more accurate and smooth 3D models to use for training.

Another major challenge faced during the project was the development of AI algorithms capable of generating and processing complex training scenarios. The computing power demand to handle extensive data volumes in real-time to simulate the offshore construction scenarios was a performance bottleneck. To overcome such challenges the team consulted AI experts, and the computational infrastructure was updated to improve performance.

Overcoming the mentioned challenges, the project demonstrated adaptability and ensured that the training was applicable to diverse operational roles within the industry, thereby maximising the educational impact. When compared to older, more passive methods such as classroom lectures or physical drills, the VR module significantly enhanced user engagement and confidence. Participants reported that the immersive, interactive scenarios helped them feel more prepared for real-life emergencies. Additionally, the ability to repeatedly engage with fire scenarios allowed users to build muscle memory and response confidence, which is typically harder to achieve in traditional setups due to time and resource constraints.

The project garnered substantial interest from various stakeholders, including safety trainers, offshore construction companies, and regulatory bodies. The feedback was overwhelmingly positive, highlighting the effectiveness and innovative aspects of combining AI with VR in training modules. Industry experts acknowledged the potential of such technologies to set new standards in safety training, particularly in high-risk industries. End-users / trainees, reported that they were satisfied with the realistic and interactive nature of the training, noting significant boost in confidence and competence in handling real-world challenges. This positive reception opened up opportunities for broader applications and potential for wider adoption.

5. Conclusion

The SafeSite project has successfully integrated AI algorithms for the generation of 3D objects tailored for use in VR environments. As well as the used algorithms also enabled the creation of dynamic and contextually relevant training scenarios. This innovative approach allowed automatic generation of scenarios that mimic real-life conditions encountered in offshore construction, providing trainees with immersive and challenging virtual environments.

This paper illustrates the effectiveness of incorporating novel technologies like AI and VR in offshore construction safety training. The gap between theoretical knowledge and practical application is bridged using realistic simulations provided by the AI-VR training programme. The controlled low-risk virtual environment helps the trainees to engage in hands-on practice, giving the trainees better safety awareness and decision-making abilities. The capability to replicate complex, high-risk scenarios in a virtual setting not only improves learning outcomes but also equips workers with the confidence and competence needed to navigate the challenges they will face on-site.

The success of the SafeSite programme underscores its potential to establish new benchmarks for safety training in the construction sector. By using AI to generate and adapt training scenarios in real-time, the programme delivers highly personalised and relevant learning experiences. This means that such trainees are familiarised with many possible situations and dangers, thereby improving their capabilities of how well they can prepare for and respond to such situations.

With the continuous development and evolution of AI and VR technologies in providing simulations and adaptive learning opportunities, workforce development is expected to expand the adoption of immersive training for better learning opportunities. These advancements not only address current challenges in training but also pave the way for a safer, more resilient construction industry. The ongoing development and integration of AI and VR into safety training programmes will be crucial in setting new standards for safety, efficiency, and effectiveness, ultimately leading to a more capable and prepared workforce.

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Declaration on Generative AI

During the preparation of this work, the author(s) used Chat-GPT and Grammarly in order to: correct grammar and spelling, improve clarity and composition, minor restructuring of sentences for readability. After using these tool(s)/service(s), the author(s) reviewed and edited the content as needed and take(s) full responsibility for the publication's content.

References

[1] Health and Safety Executive, Fatal Injuries in Great Britain, 2023. Available: https://www.hse.gov.uk/statistics/fatals.htm [Accessed: Aug. 19, 2024].

[2] R. Hakimian, "Great Britain construction-related fatalities increase again," *New Civil Engineer*, 2024. Available: https://www.newcivilengineer.com/latest/uk-construction-related-fatalities-increase-again-04-07-2024/ [Accessed: Aug. 20, 2024].

[3] A. Tezel, E. Dobrucali, S. Demirkesen, and I. A. Kiral, "Critical success factors for safety training in the construction industry," *Buildings*, vol. 11, no. 4, p. 139, 2021. https://doi.org/10.3390/buildings11040139.

[4] A. Alzarrad, M. Miller, L. Durham, and S. Chowdhury, "Revolutionizing construction safety: Introducing a cutting-edge virtual reality interactive system for training US construction workers to mitigate fall hazards," *Front. Built Environ.*, vol. 10, p. 1320175, 2024. https://doi.org/10.3389/fbuil.2024.1320175.

[5] M. Zhang, L. Shu, X. Luo, M. Yuan, and X. Zheng, "Virtual reality technology in construction safety training: Extended technology acceptance model," *Automation in Construction*, vol. 135, Article 104113, Jan. 2022. https://doi.org/10.1016/j.autcon.2021.104113.

[6] S. Mystakidis and V. Lympouridis, "Immersive learning," *Encyclopedia*, vol. 3, pp. 396-405, 2023. https://doi.org/10.3390/encyclopedia3020026.

[7] F. Q. Chen, Y. F. Leng, J. F. Ge, et al., "Effectiveness of virtual reality in nursing education: Meta-analysis," *J Med Internet Res.*, vol. 22, no. 9, p. e18290, Sep. 2020. https://doi.org/10.2196/18290.

[8] K. M. Kapp and T. O'Driscoll, *Learning in 3D: Adding a New Dimension to Enterprise Learning and Collaboration*, 2nd ed., New York, NY: Pfeiffer & Co., 2010.

[9] V. Dudhee, V. Vukovic, and F. Rahimian, "Building sensory information in augmented reality: A conceptual framework," in: A. Roxin, Ed., *Nouvelles Perspectives du BIM: Le Jumeau Numérique de la Construction Intelligente (Smart Building)*, 1st ed., Paris: Eyrolles, 2022, pp. 109-122. https://izibook.eyrolles.com/produit/9610979/9782212356199.

[10] V. Dudhee and V. Vukovic, "Building information model visualisation in augmented reality," *Smart and Sustainable Built Environment*, vol. 12, no. 4, pp. 919-934, 2023. https://doi.org/10.1108/SASBE-02-2021-0021.

[11] Fortune Business Insights, Virtual Reality Market Report, 2023. Available: https://www.fortunebusinessinsights.com/industry-reports/virtual-reality-market-101378 [Accessed: Aug. 10, 2024].

[12] K.-B. Ooi, G. W.-H. Tan, M. Al-Emran, M. A. Al-Sharafi, and A. Capatina, "The potential of generative artificial intelligence across disciplines: Perspectives and future directions," *J. Comput. Inf. Syst.*, pp. 1–32, 2023.

[13] L. Banh and G. Strobel, "Generative artificial intelligence," *Electron. Mark.*, vol. 33, no. 1, 2023.

[14] V. Dudhee and V. Vukovic, "How large language models and artificial intelligence are transforming civil engineering," *Proc. Inst. Civ. Eng.: Civ. Eng.*, vol. 176, no. 4, p. 150, 2023. https://doi.org/10.1680/jcien.2023.176.4.150.

[15] M. Taylor, Z. Muwaffak, M. Penny, B. Szulc, S. Brown, A. Merritt, and S. Hilton, "The rise of the AI scientist: Unleashing the potential of Chat-GPT powered avatars in virtual reality digital-twin laboratories," 2023.

[16] S. Doolani, C. Wessels, V. Kanal, C. Sevastopoulos, A. Jaiswal, H. Nambiappan, and F. Makedon, "A review of extended reality (XR) technologies for manufacturing training," *Technologies*, vol. 8, no. 4, p. 77, 2020. https://doi.org/10.3390/technologies8040077.

[17] M. Webb, M. Tracey, W. Harwin, O. Tokatli, F. Hwang, R. Johnson, N. Barrett, and C. Jones, "Haptic-enabled collaborative learning in virtual reality for schools," 2021.

[18] PwC, PwC's study into the effectiveness of VR for soft skills training, PwC UK, 2023. Available: https://www.pwc.co.uk/issues/technology/immersive-technologies/study-into-vr-training-effectiveness.html [Accessed: Aug. 17, 2024].

[19] SBA, 10 Benefits of VR in Construction Safety Training, 2023. Available: https://sbanimation.com/10-benefits-of-vr-in-construction-safety-training/ [Accessed: Aug. 11, 2024].

[20] Future Market Insights, AR and VR in Training Market Share, Size & Forecast by 2033, 2023. Available: https://www.futuremarketinsights.com/reports/ar-and-vr-in-training-market [Accessed: Aug. 19, 2024].

[21] CITB, *CSN Industry Outlook - 2024-2028*, 2024.

[22] Global Wind Organisation, *Basic Safety Training Standard* (V18), 2023.