Augmented Reality (AR) and Virtual Reality (VR) in the Context of Education: Mapping the Impact of AR and VR in AEC Education

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ABSTRACT

The architecture, engineering, and construction (AEC) industry has witnessed transformative advancements in technology; but a critical gap still exists in students' understanding of the applications and positive impacts of AR and VR. Bridging this gap requires a comprehensive classification and quantification of the effectiveness of existing AR and VR applications in AEC education. One solution involves the development of a web-based platform that classifies applications based on functionalities, target audience, and educational objectives. This platform offers search, detailed profiles, user reviews, and an assessment tool for student learning outcomes. The major outcomes will be a taxonomy of AR and VR applications, a catalog with detailed descriptions, and performance metrics assessing skills improvement and practical knowledge application. Future work involves leveraging the platform's insights to guide educators, researchers, and institutions in selecting and implementing these technologies, thereby enhancing education quality in the AEC domain.

1. INTRODUCTION

The educational framework is undergoing a significant transformation, with the advent of technology catalyzing changes across teaching methodologies and learning environments. Central to this transformation is the introduction of AR and VR technologies that offer unparalleled opportunities for immersive and interactive learning experiences. These technologies are not new; their evolution has been observed since the early days of heavy computers to the present-day Head-Mounted Displays (HMDs), promising to bring the classroom to life in ways previously unimaginable.

As digital innovations continue to break through the traditional boundaries of educational delivery, it is imperative to understand the various applications and their effectiveness in enhancing learning outcomes. While AR brings digital information into the real world, enhancing the tangible environment with additional layers of interactivity, VR fully immerses the user into a digital experience, revolutionizing how educational content is consumed. These technologies have shown promise in various sectors; however, their application in AEC education remains inadequately explored. Limited attention has been given to systematically analyzing the affordances and limitations of immersive AR/VR simulations.

2. RELATED WORKS

The growing interest in AR and VR within educational settings has sparked a considerable amount of research into their

applications and implications. A meta-analysis by Merchant, et. al (2014) assesses the impact of VR-Based Instruction on learning outcomes, finding significant improvements when employing games, simulations, and virtual worlds. In line with the objectives of my research, these insights are particularly relevant to the AEC industry, where such immersive experiences can be integral to student learning and engagement.

VictoryXR stands out as a pioneering force, using the potential of VR to transcend the limitations of traditional online and in-person classes. This VR learning solutions offer K-12 students and instructors personalized live tutoring and customizable 3D models. Educational institutions can tailor their virtual classrooms with these resources and access an extensive library of 3D content (VictoryXR, 2016). In synthesizing these related works, I seek to build upon the existing body of knowledge, evaluating the practical applications of AR and VR technologies in AEC education and identifying ways they may serve as a cornerstone for innovative learning strategies.

3. PROPOSAL DESIGN

The project proposal aims to gap between the potential and actual use of AR/VR in AEC education through a web-based platform. This platform will systematically classify and evaluate the integration of these technologies into the curriculum, featuring search functionalities, detailed application profiles, user reviews, and an online assessment tool to evaluate student learning outcomes.

3.1 Developing a Taxonomy

A taxonomy serves as the foundation for organizing AR/VR applications by their functional characteristics, educational objectives, and user needs to help select the most appropriate tools for specific learning outcomes. The initial structure of the taxonomy is built from a review of current applications. Franz, et al. (2024) present the lack of a framework to help designers choose appropriate scene-viewing techniques for VR applications. They propose a scene taxonomy that categorizes scenes based on visual properties like openness, scale, area, the presence of social actors, and types of tasks users perform within these environments, enhancing accessibility for those with impairments. Insights from AEC professionals and educational technologists will refine the taxonomy for practicality, reflecting real-world requirements or standards. An iterative process involving prototype testing with target users and feedback from students and educators will refine the taxonomy for accuracy and usability.

3.2 Using an Assessment Tool

An assessment tool within the platform will provide quantitative and qualitative measures of the educational impact of AR/VR applications, gauging the effectiveness of these technologies in real-time. User experience tests and student surveys can help spot any usability problems and gather opinions on the application's interface; by "measuring student performance on tests or assessments before and after using the application or conducting surveys…to gauge student perceptions of the technology's impact on learning or even a student's increased motivation around a topic," the effectiveness of AR/VR applications in achieving the desired learning outcomes can be validated (McGrath, et.al, 2023). Data visualization tools can also be employed to present these insights in an accessible manner to educators, helping them make informed

decisions about integrating these technologies into their teaching strategies.

One notable resource that uses a similar approach to assess educational technology's impact is the "Learning Analytics Tools" provided by platforms such as Canvas. These Learning Management Systems (LMS) offer analytics features that track student engagement, grade distributions, and assignment completion rates, providing educators with a data-driven basis for evaluating the effectiveness of their teaching methods and materials. This system aligns with my proposed assessment tool's objective to translate user data into actionable insights in AEC education.

3.3 Implementation

The implementation plan details a phased, agile approach for the platform's development, testing, and launch, emphasizing continuous improvement, stakeholder feedback, and modular design for easy updates and scalable growth. Rigorous testing protocols will ensure platform stability and user satisfaction, informed by usability testing frameworks. Testing protocols, including unit tests and integration tests, will be implemented to ensure the platform's reliability and performance. Tools like Adobe XD and other user testing platforms such as UsabilityHub can be used to prototype and test the interface design before full-scale development.

The launch includes targeted dissemination to AEC educational communities, supported by partnerships with academic institutions. Prior to launch, the platform will be introduced to the AEC community through webinars, workshops, and presentations at educational and industry conferences to build anticipation and gather initial feedback. The International Journal of Construction Education and Research publishes studies and research on educational practices, materials and methods, sustainability and technology in the construction industry, serving as a potential outlet for publicizing information about the platform, which is crucial for credibility and adoption of the platform.

4. ANTICIPATED OUTCOMES

Given the nature of the project focused on integrating AR/VR technologies into AEC education through a web platform, anticipated outcomes can be projected based on theoretical expectations and similar initiatives. Anticipated results include better performance on tasks requiring 3D conceptualization, as reported in the study by Kaufmann, et al. (2005). The authors present an evaluation design for this AR system, aiming to examine its impact on spatial abilities. They introduce Construct3D, a prototype tool developed for geometry education, emphasizing its potential in offering a natural, face-to-face, teaching environment through see-through head-mounted displays (HMDs). This AR setup allows students to view and interact with 3D objects directly, improving their understanding of geometric concepts.

The interactive and immersive nature of AR/VR is expected to increase student engagement. The platform could provide metrics on cooperative learning, paralleling findings in studies like van der Meer, et al. (2023). Their review analyzed 139 scientific research articles on VR for Collaborative Learning (CL), and they created a taxonomy to classify these articles, focusing on skills and competencies trained and systems used. The literature reflects optimism about VR's use to support CL, suggesting VR is an efficient tool that engages learners, supports distance learning, and cultivates remote collaboration.

5. CONCLUSION

Creating a web-based platform that classifies AR and VR applications within AEC education will serve as a comprehensive resource for educators, researchers, and students, detailing the functionalities, target audience, and educational objectives of these applications. The data collected through the platform are anticipated to offer valuable insights into the technologies' applications, guiding future development and research in educational technology. The platform is expected to yield insights for future tech developments, offer students an enhanced learning experience, and help educators choose tech tools aligned with educational goals, ultimately advancing professional training in the AEC industry.

6. FUTURE WORK

While the results presented are projected based on the understanding of current trends and research in the field, actual outcomes would require rigorous testing and validation with actual users in controlled educational settings following the platform's implementation. An expansive/broad data testing phase with a larger user base will provide additional data to fine-tune the platform. The success of this platform in AEC education could pave the way for similar innovations across various disciplines, where AR/VR technologies have yet to be fully utilized for educational enhancement.

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