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# BOARD # 465: Using Immersive Virtual Reality Environments to Improve Student Success for Online Students

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# Using Immersive VR Environments to Improve Student Success for Online Students: An NSF HBCU-UP Targeted Infusion Program Initiative

## Introduction

North Carolina A&T State University is pioneering the integration of virtual reality (VR) technology into online Information and Electronic Technology (IET) courses to enhance student success, retention, and engagement. This initiative specifically targets post-secondary students from groups traditionally underrepresented in STEM fields, including African American, Hispanic, Native American, and first-generation college students. It incorporates a newly developed digital twin campus, immersive course materials, and three successfully conducted VR classes, with students completing surveys to evaluate the impact. Metrics include enrollment demographics, qualitative feedback on equity and inclusion, and mixed-method evaluations using surveys, focus groups, and retention rate analysis. The primary objectives focus on enriching online technology courses with VR technology to increase attraction and persistence, redesigning course materials for immersive environments, and strengthening engagement and retention through gamified experiential learning. In addition, the project investigates the correlations between student perceptions of proficiency, engagement, and outcomes in VR courses. The survey results, discussed in this paper and illustrated in Figure 1, reveal positive trends in student engagement and perceptions of equity, highlighting VR's potential to scale online STEM education.

As Peter Drucker famously stated, "The best way to predict the future is to create it" [1]. Technological innovations, especially virtual reality, are actively shaping the future of education. VR provides immersive, realistic simulations that transform traditional learning into interactive experiences, making complex concepts more accessible and equitable [2], [3]. North Carolina A&T State University is exploring how VR can revolutionize STEM education for underrepresented groups, fostering inclusivity, engagement, and career readiness.

## Objectives of the Study

The specific objectives for this study are to:

i. Enrich online technology course offering with virtual reality technology to bolster attraction and persistence.
ii. Strengthen online student engagement across all demographic groups by taking advantage of identity-flexible aspects of virtual reality technology along with experiential learning techniques and opportunities for online community building to increase efficacy and persistence.
iii. Investigate the relationship between student perceptions of subject proficiency and levels of engagement and learning outcomes in the online VR courses.

## Theory and Impacts of Visual Reality

As a teaching and learning modality, VR is grounded in the theory of constructivism, where the learner actively constructs knowledge through their subjective representations and understanding of reality [4]. Constructivist learning strategies include situated and experiential learning, whereby the user engages in a process of learning by doing. This theory is undergirded by the notion that learning is a process that involves active construction by the learner and not a passive acquisition of information. This calls into question conceptions of learning as "the mind as a container waiting to be filled"; constructivist theory posits, on the other hand, that a learner's mind actively seeks out knowledge to satisfy its curiosity and makes connections between previous experiences and information to create knew knowledge and associations [5]. The underlying notion that learners produce knowledge and form meaning based upon their experiences provides a helpful framework for understanding the mechanisms for why VR modalities work to engage learners deeply. In short, VR works to promote student learning by creating and offering immersive learning environments that directly expose learners to the material being studied. This direct experiencing of the metaverse world allows, according to constructivist theory, for the learner to derive meaning [6].

Attempts to better understand the potential value of VR in enhancing student learning via visualization and interactions have yielded encouraging results. As a training modality and simulator, VR appears to be highly effective in preparing practitioners and improving performance across many different disciplines [7], [8], [9], [10], [11]. Whitmer [12] examined whether training in VR leads to performance improvements on the real-world task relative to a no-training condition and an active training control. Their results suggest that there are significant benefits to training in VR. Further, these researchers posit that the act of physically simulating the task during VR training may not be the sole driving force behind a user's learning. They cite related research [13], [14] that supports the notion that a process of "rich encoding" can complement VR learning to allow users to transfer their knowledge from the VR realm into the real world. This encoding can happen as users are afforded opportunities to make mistakes and errors – and thus learn from such faults – in the VR world that they would not be able to make in reality.

In attempts to understand the mechanisms for why VR is effective in preparing users in training contexts and practical skill development could be, researchers have found that VR can engage learners and keep them engaged, in deeper more meaning ways, for longer than more traditional modalities. In their examination of Virtual Reality Learning Environments (VRLE) and the shift from Web-based and more conventional multimedia to more immersive and interactive VR learning environments, Huang [15] found that students who engaged with VR experienced increased time-on-task. This study corroborated earlier findings by [16], who examined an immersive learning environment for children ages 6-10 deemed the "NICE" project (Narrative Immersive Constructionist / Collaborative Environments). The NICE project provided an engaging setting where children could construct and cultivate simple virtual ecosystems, collaborate via networks with other remotely located children, and create stories from their interactions in the real and virtual world. Observations of fifty-two youth participants while they were interacting with each other and the virtual environment revealed that users had very little

difficulty learning how to use the interface technology and remained engaged throughout multiple sessions and even after hours of participation.

Researchers have also found that students who engage with VR for the purpose of learning content or developing skills enjoy their learning more [17], [18], [19], [7] and experience deeper learning engagement and longer-term retention of knowledge [15]. As it helps to improve motivation, VR has also been shown to increase user enthusiasm for learning in both higher education [20] and K-12 [21].

Previous studies have shown that VR technology and platforms can increase accessibility in many postsecondary fields and offer the potential for greater inclusion [22]. A recent case study from Morehouse College, an HBCU, demonstrated that the use of virtual reality in online settings can significantly increase undergraduate success and engagement [23].

**Literature Review**

The application of immersive virtual reality (VR) in education has garnered significant attention as a tool to enhance student learning outcomes, engagement, and equity. Immersive VR facilitates active learning by simulating realistic environments where students can interact with abstract concepts in meaningful ways. Freina and Ott [4] emphasize that VR's potential lies in its capacity to support experiential learning and increase motivation through dynamic, engaging experiences. Makransky and Lilleholt [2] further explore the emotional and cognitive benefits of VR in learning environments, demonstrating that students experience increased presence and interest, which positively influence their learning outcomes.

Research also underscores VR’s role in promoting inclusivity in educational contexts. Slater [24] illustrates that VR environments can help reduce social anxiety and foster public speaking skills by allowing students to practice in realistic yet low-risk settings. Similarly, avatar customization has been shown to support identity representation and increase a sense of belonging, particularly for students from marginalized backgrounds [16]. These findings suggest that personalized and immersive environments can play a crucial role in supporting diverse learners.

In the context of STEM education, VR has proven particularly beneficial. Wu [11] argues that immersive environments allow for better comprehension of complex scientific phenomena, especially when traditional hands-on experiences are limited. VR simulations in chemistry, biology, and engineering provide students with opportunities to conduct experiments and explore scenarios that would otherwise be inaccessible due to safety or resource constraints [15].

The integration of gamification elements into VR-based learning further enhances its effectiveness. Cheong [25] notes that game-based mechanics, such as rewards and challenges, can increase student motivation and foster critical thinking. Makransky [26] also observed that while VR increases presence, the addition of gamified elements ensures cognitive engagement and knowledge retention.

Despite these advantages, challenges remain in the implementation of VR technologies in online education. Dhawan [27] points out that while online learning became more prevalent during the

COVID-19 pandemic, the digital divide and lack of training in emerging technologies can exacerbate existing educational inequalities. As such, there is a growing emphasis on developing accessible and inclusive VR solutions that support all learners, regardless of their socio-economic background.

Taken together, the literature affirms the transformative potential of immersive VR in education, particularly in STEM disciplines and among underrepresented student populations. This review supports the current project's premise that integrating VR into online STEM education can enhance learning outcomes, engagement, and equity, thereby contributing to broader goals of educational inclusion and workforce development.

**Digital Twin Campus and Course Development**

North Carolina A&T has created a digital twin campus, which is a virtual reproduction of the actual setting that allows students to travel and communicate in a familiar yet adaptable digital space. In order to provide a smooth transition between technology and pedagogy, faculty have created immersive course materials specifically for VR platforms. Three VR classes have been successfully held thus far, providing students with exceptional chances to interact with immersive learning settings. Through thorough questionnaires, participants in these courses gave insightful comments on learning outcomes, inclusion, and involvement.

Building upon this framework, students have contributed their technological know-how, creativity, and problem-solving abilities to help shape the digital twin campus. To improve the realism and usefulness of the virtual environment, for example, students in advanced design and engineering courses have worked together to produce 3D models of campus landmarks. In addition to enhancing the digital twin, their work gives them practical expertise with cutting-edge technologies including user interface design, CAD modeling, and spatial computing.

This strategy highlights the mutually beneficial relationship between the university's technology endeavors and its students' academic development. In addition to helping to develop the digital twin campus, students can put their theoretical knowledge into practice by participating in real-world applications. Additionally, interdisciplinary groups of students from disciplines including education, computer science, and architecture have collaborated to create interactive learning modules that may be included into a variety of courses. Through gamified tasks and simulations, these modules provide peers the opportunity to investigate difficult ideas in biology, engineering, and physics, promoting greater comprehension and memory.

Students made significant contributions to the advancement of the idea of a Digital Twin Campus through practical projects and teamwork. Their capacity to combine theoretical understanding with real-world applications is demonstrated by the examples that follow.

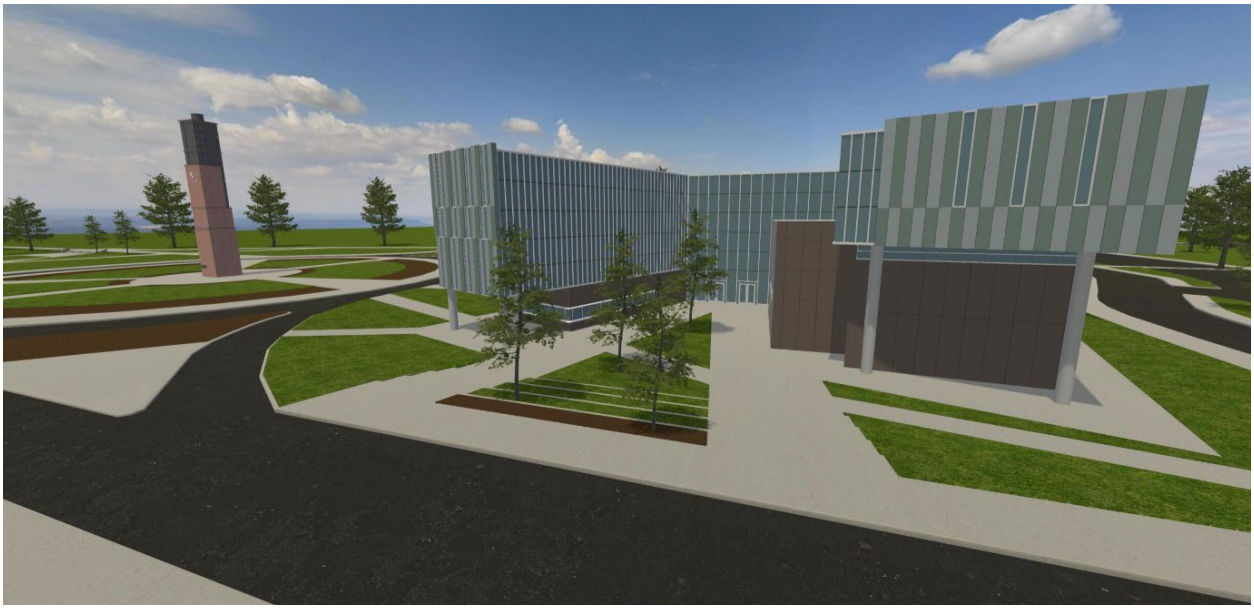

Figure 1: 3D-rendered towers representing the potential of digital twin campus technology

Figure 2: A digitally modeled classroom showcasing how virtual design can enhance learning environments.

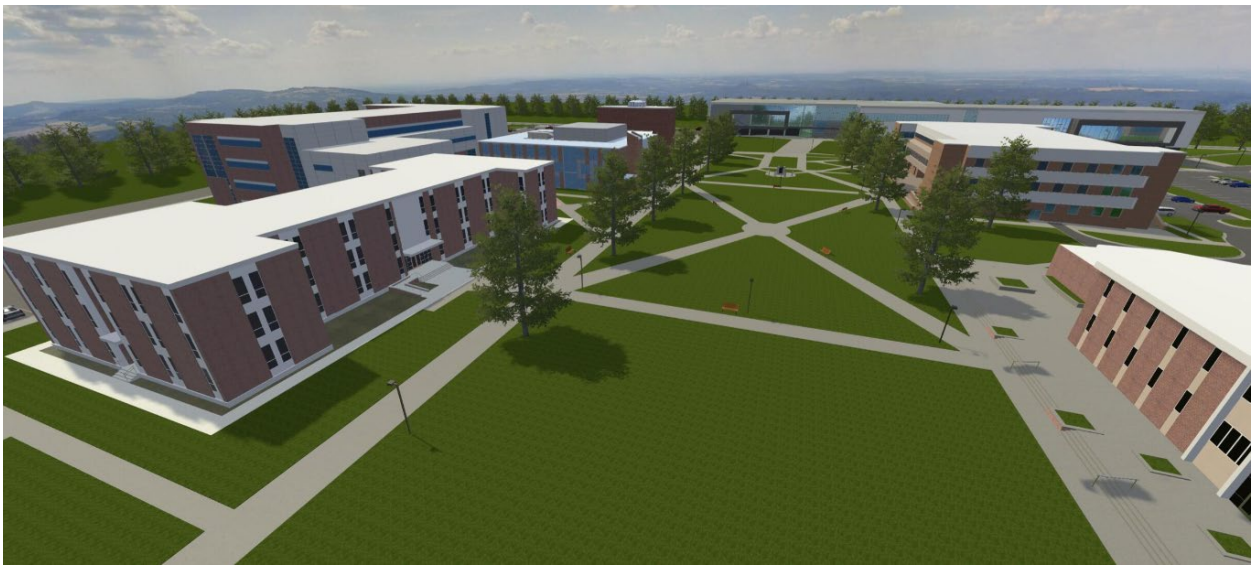

Figure 3: An external view of a campus landscape

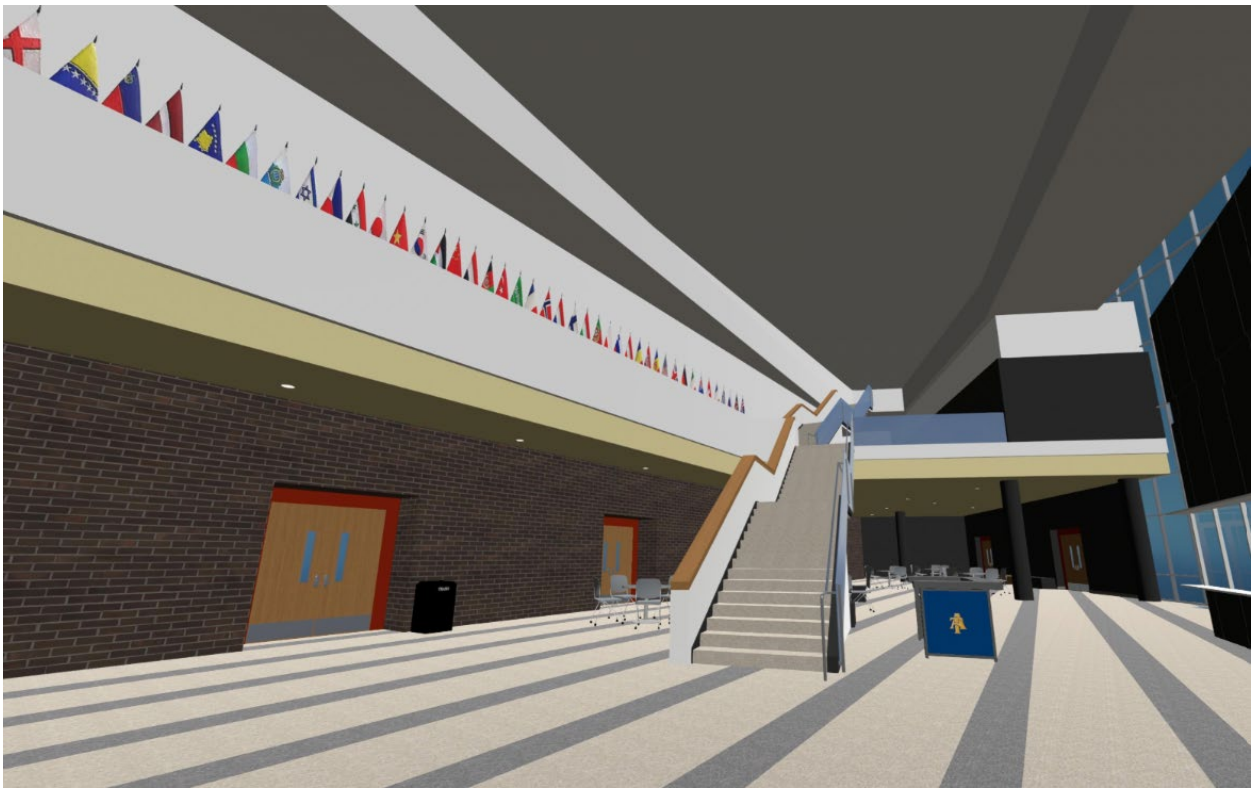

Figure 4: Detailed internal structure of a building, highlighting precise planning.

## Enriching Online Technology Courses

VR integration bridges theoretical knowledge with practical applications across diverse disciplines. In a chemistry course, for instance, students simulate hazardous chemical spills and practice safety protocols in a safe virtual environment. Geography students explore environmental disasters and propose engineering solutions, while nursing students perform virtual dissections and diagnose simulated patients. By offering realistic scenarios, these courses connect abstract concepts to practical applications, fostering a deeper understanding of the subject matter. Gamified lessons further enhance experiential learning by transforming complex concepts into engaging, interactive experiences that promote critical thinking and problem-solving [25], [26]. Such features are especially beneficial for underrepresented students, offering equal access to high-quality, interactive learning experiences that may otherwise be unavailable due to resource limitations.

## Strengthening Engagement and Retention

Maintaining engagement and retention in online education has long been a challenge, with dropout rates often higher than in traditional classes [28]. VR addresses these issues by offering collaborative simulations, such as global summits or historical explorations, which foster a sense of community and active participation. Supportive environments allow students to practice essential skills, such as public speaking, in realistic yet nonthreatening settings. Personalized avatars, which students can design to reflect their identities, further promote inclusivity and reduce social anxiety [24]. Survey results confirm the effectiveness of these strategies, with the majority of participants reporting higher levels of engagement and a strong sense of connection in the VR-based classes (Figure 5).

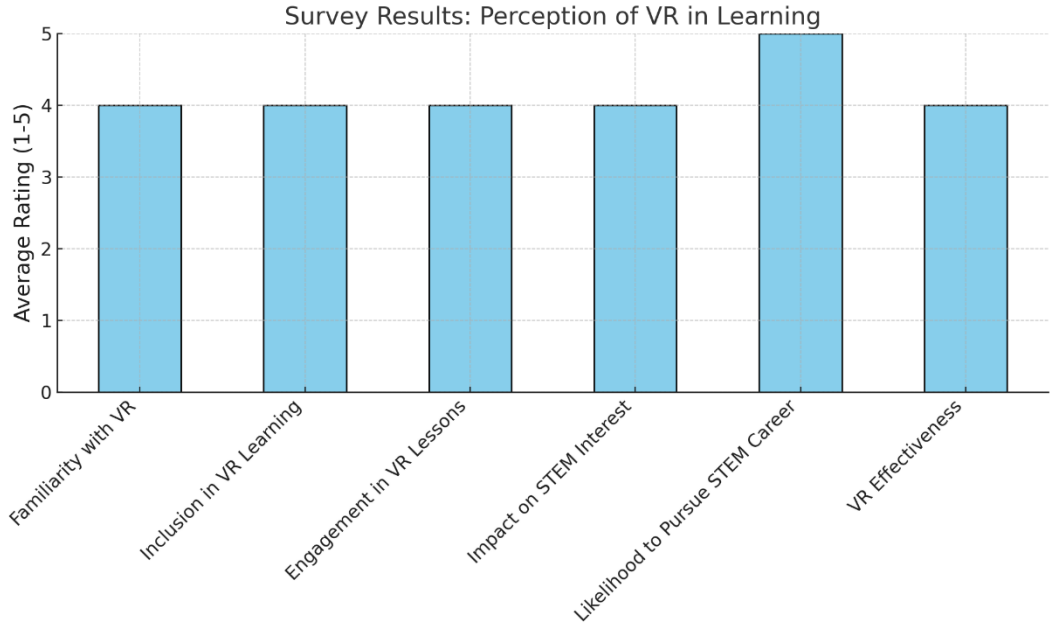


Figure 5: Survey Results

## VR Avatar Design Evaluation

Participants in VR courses highlighted the importance of avatar customization in promoting diversity and inclusivity. The survey feedback emphasized the importance of culturally representative features such as skin tones and hairstyles, which allowed students to see themselves reflected in the virtual space. The ability to design and personalize avatars fostered a sense of belonging and empowerment, particularly among students from traditionally underrepresented groups. Although avatars moderately reduced social anxiety and increased comfort in group activities, some participants suggested further refinements, such as additional customization options and interactive features that facilitate collaboration. Despite these limitations, avatars were generally successful in creating a supportive and engaging environment that encouraged active participation.

## VR Perception of Equity and Inclusion Evaluation

Surveys revealed that students generally felt included in the VR learning environment, with high ratings for inclusion and equitable collaboration. The virtual reality classroom was widely perceived as a respectful and welcoming space for diverse identities. Participants noted that the immersive nature of VR leveled the playing field by providing equal opportunities for interaction and engagement, regardless of students' backgrounds. The lessons were described as engaging and impactful, particularly in helping students understand complex STEM subjects. Participants also highlighted VR's ability to simulate real-world scenarios, which they found instrumental in building both technical skills and confidence. Strong career readiness scores underscored the alignment of VR courses with workforce readiness goals. However, some students suggested that additional resources and guidance could further enhance inclusivity and equitable participation, indicating the need for ongoing refinement of VR content and delivery methods.

## Conclusion

This initiative affirms that immersive virtual reality (VR) environments hold transformative potential for advancing online STEM education, particularly for underrepresented student populations. By embedding a digital twin campus, customizable avatars, and gamified experiential content into course design, the project fostered an engaging, inclusive, and skills-oriented learning environment. Students reported higher levels of confidence, participation, and a deeper connection to both the course content and their peers—factors known to bolster persistence in STEM pathways.

Crucially, the identity-flexible nature of VR allowed students to navigate learning spaces with reduced social anxiety, contributing to a stronger sense of belonging and agency. These findings align with constructivist theories of learning, demonstrating that active, immersive engagement not only improves knowledge retention but also enhances self-efficacy and academic motivation.

Looking ahead, future efforts will focus on scaling VR integration across additional IET and STEM courses, incorporating student feedback to refine inclusivity features, and implementing robust longitudinal tracking to measure impact on course completion rates and long-term STEM retention. Through continued innovation and evidence-based refinement, North Carolina A&T is

establishing a scalable model for inclusive, effective online education—one that not only addresses digital equity but also redefines how students experience and succeed in virtual learning environments.

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