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Using Photovoice to Assess Technology Student Perceptions of Virtual Reality Inside and Outside the Classroom

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Using Photovoice to Assess Technology Student Perceptions of Virtual Reality in Comparison to Traditional Lecture

1. Introduction

Despite its transformative potential, implementing Virtual Reality (VR) in higher education faces significant barriers, making widespread adoption challenging. Chief among these challenges is the high cost of VR hardware and software, which restricts access primarily to well-resourced institutions. Additionally, technical hurdles, such as the need for powerful computing resources, specialized setup and maintenance skills, and frequent software updates further complicate VR integration. Additionally, the steep learning curve for educators and students unfamiliar with the technology adds another layer of difficulty. Developing or sourcing high-quality, educationally relevant VR content demands significant time, expertise, and financial investment. Accessibility concerns also persist, as VR can be physically demanding or disorienting for some users, potentially excluding individuals with disabilities.

Nevertheless, the increasing demand from industry for students to be tech-savvy and well-versed in cutting-edge technologies makes VR implementation a valuable endeavor in higher education. This paper presents findings from a VR module implemented in a Technology course titled *Leadership Strategies for Quality and Productivity*. The instructional team secured 20 VR headsets for a learning module, encouraging students to critically explore and reflect on learning experiences with and through VR. Each week, students completed reflection activities responding to the comparison of learning experiences (VR vs. traditional in-person instruction).

The paper concludes by discussing lessons learned, offering practical recommendations for educators, and suggesting additional instructional resources for institutions with or without access to VR technology. The guiding research question for this qualitative study is as follows: *How do participant perceptions of virtual reality compare to in-person instruction, and how does this change over time?*

2. Background

The demand for effective remote learning solutions has surged in recent years, largely driven by the COVID-19 pandemic's acceleration of online and hybrid education models. While platforms such as Zoom and Microsoft Teams have facilitated communication, these tools often lack the immersive, interactive qualities necessary to deeply engage students, particularly in STEM disciplines where experiential learning is critical [1].

Immersive technologies, collectively called Extended Reality (XR), provide an alternative, offering environments where learners can move beyond passive observation and engage in highly interactive educational experiences. XR encompasses several tools, including Augmented Reality (AR), Mixed Reality (MR), and Virtual Reality (VR), which are transforming how educational content is delivered. Augmented Reality (AR) overlays digital content onto the physical world, blending virtual elements with real-world environments [2]. Mixed Reality (MR) takes this further by enabling real-time interaction between digital and physical components [3].

Virtual Reality (VR), or Immersive Virtual Reality (IVR), creates fully digital environments that isolate users from the physical world, immersing them completely in the learning experience [4].

Among these XR technologies, VR stands out for its ability to engage students by immersing them in virtual environments that eliminate distractions. VR creates opportunities for learners to explore complex systems, practice hands-on skills, and manipulate virtual objects within a safe, controlled environment [5].

3. Theoretical Foundation – Motivation to Learn

The theoretical foundation leverages Ambrose et al. 2010 Motivation to Learn framework. Motivation involves an individual's dedication to attaining a particular goal or outcome, taking on a central role in guiding individual choices and behaviors [6]. This is particularly important in the context of higher education, where students have the opportunity and expectation to be more self-directed in their learning journey. Goals act as the fundamental structure that shapes motivated actions [7-9]. The motivation to pursue a goal is significantly influenced by its subjective value or level of importance. Individuals are driven to participate in actions that lead to achieving goals of considerable significance. Individuals are similarly driven to pursue attainable goals. Conversely, when lacking confidence in achieving a specific aim, motivation for necessary actions wanes. This grasp of attainability is termed "expectancies" by motivation experts [10]. The interplay between value and expectancies is influenced by the context. Individuals assess their surroundings as either supportive or unsupportive in terms of this interaction. This perception shapes their motivational dynamics [11]. Recognizing the significance, individuals can perceive three essential factors —value, efficacy expectancies, and the supportive environment—to impact motivation. Furthermore, neglecting any of these elements could significantly hinder motivation.

Self-efficacy pertains to an individual's personalized convictions governing their adeptness in executing plans in anticipated circumstances [12]. In more straightforward terms, it signifies a person's assurance in accomplishing a specific task. Albert Bandura's framework underscores that self-efficacy beliefs evolve through the interpretation of information from four key sources, shaping one's perception of their capabilities [12]. These beliefs significantly impact motivation and behavior.

Seeing value pertains to the perceived significance an individual gives to a specific goal, result, or action. It signifies the personal importance or desirability linked to achieving a particular outcome. The notion of value is pivotal in driving individuals to pursue objectives and participate in behaviors, as people are inclined to dedicate effort and resources to endeavors they view as meaningful and valuable. This valuation can differ based on personal interests, beliefs, and experiences [13].

A supportive environment pertains to a setup that promotes effective learning, development, and student well-being. This includes factors like physical safety, emotional stability, positive social interactions, fairness, and chances for active participation. Within this context, students are motivated to voice their thoughts, embrace challenges, collaborate with peers, and explore personal interests. Teachers and administrators hold a vital responsibility in establishing and

sustaining such an atmosphere by nurturing respectful connections, presenting suitable challenges, ensuring essential resources, and catering to individual requirements [14].

4. Methods

4.1 Participants

The participants included 40 students enrolled in a senior-level technology class titled, Leadership Strategies for Quality and Productivity, at a large research-intensive university in the Midwest. The participant pool was diverse in terms of age and academic standing. Ages ranged from 19 to 25. Participants were randomly assigned to either Group A or Group B, each consisting of 20 students. This study has IRB approval as Exempt Category 1.

4.2 Intervention

This study focused on comparing immersive Virtual Reality (VR) lessons with traditional PowerPoint (PPT) lessons, offering students a unique learning experience across three key topics. Each lesson included both an informative section and a hands-on experiential activity designed to be as consistent as possible between the two modalities. This approach enabled a direct comparison of student engagement, presence, and learning outcomes in each mode. The primary difference between the two formats was the level of immersion: VR utilized 3D environments and interactive elements, while PPT relied on conventional text, images, and in-person group activities. Table 1 provides an overview of the module intervention.

Table 1. VR Module Overview

Activity	**Topic**	**Descriptors**
Onboarding	1) Introduction to Immersive Technology and Metaverse & (2) Equipment/HMD Walkthrough	(1) Guest lectures on immersive technology, its applications in education and industry, and the Metaverse's implications for immersive learning & (2) Hands-on walkthrough of IVR equipment and HMDs to familiarize students with immersive technology tools.
Week 1: Individual Lesson Comparisons	Leadership vs. Management	Students categorized leadership and management terms using both physical whiteboards (PPT) and virtual rooms (IVR).
Week 2: Individual Lesson Comparisons	The Iceberg Model – Understanding Root Causes	Students analyzed root causes using the Iceberg Model and built space-themed spaghetti towers. For PPT students built with noodles and marshmallows and in IVR with 3D objects and drawings
Week 3: Individual Lesson Comparisons	Gamification for Increased Quality and Productivity	Students explored gamification concepts through online games in PPT and interacted with virtual game mechanics in IVR.

During Weeks 1-3, a cross-over design was used to balance for order effects such as fatigue or learning progression, the students were divided into two groups:

- Group A started with IVR lessons on Tuesdays and switched to PPT on Thursdays.
- Group B started with PPT on Tuesdays and switched to IVR on Thursdays.

This AB/BA counterbalancing minimized order effects while maintaining the integrity of the within-subject comparison. The analysis focused on individual-level data rather than group comparisons, isolating the impact of the instructional modality itself. Attendance was recorded for each lesson to ensure that only participating students were included in the analysis, particularly since student absenteeism could have been a factor (but was determined to not influence the study).

4.3 Data Collection

At the end of Weeks 1, 2, and 3, participants submitted a minimum of 200-word reflection responding to this prompt:

- *Compare and contrast virtual reality to a traditional lecture learning experience. What did you like and dislike?*

4.4 Data Analysis

The qualitative open-ended reflection responses were analyzed using thematic analysis, which is defined as a foundational qualitative method for discovering patterns within the data [15]. Using the 6-step process of conducting thematic analysis, first, the researchers familiarized themselves with the data by reading and rereading participants' responses. Second, the NVivo Pro 12 qualitative analysis software was used to code the reflections according to motivation to learn (e.g., self-efficacy, seeing value, and a supportive environment [10]). Third, after coding, the researchers searched for patterns within the data. Fourth, the researchers examined the data to generate initial themes and exchanged findings. Fifth, after the themes were identified, a visual was created highlighting each theme and its corresponding sub-themes. Due to the qualitative nature of the research, the main purpose of the analysis was to explore potential themes within the data. Quotes were drawn from the data to allow readers to make their own judgments on credibility, accuracy, and fairness [16].

5. Results and Discussion

Due to space limitations, only a subset of themes and quotes are included.

5.1 Week 1 – Leadership vs. Management

In the first week, students' reflections centered on learning the technology and navigating instructional support. Here, the primary focus was on a **supportive environment**.

5.1.1 Lack of Peer Interaction

This theme refers to a limited or insufficient level of engagement, collaboration, or communication among peers, which can hinder learning, social development, and the exchange of ideas.

- *There is a disconnect in virtual reality that can overall **negatively impact the effects of learning** for an individual. While VR can simulate social interactions to some extent, it may **lack the richness and complexity of face-to-face interactions.***
- *I like hearing other perspectives and while I know you can talk in virtual reality when everyone is in the same room **that tool is not super useful rather it is just confusing.***
- *I felt that during the VR lesson, I was **missing** the ability to **connect directly** with my peers and my professor. I felt that just looking at the avatars was not even close to the same feeling as it would be actually sitting in a lecture.*

5.1.2 Technology Distractions

This theme refers to interruptions or loss of focus caused by digital devices, applications, or online content that divert attention from the primary task or learning activity.

- *While in the VR environment, students were able to place **random** objects in the lobby and then when those things get placed into the environment, **it is hard to not focus on that because they are generally quite random and can become distracting.***
- *Something bad about VR is that it can be distracting. **People were all over the place doing crazy things.***
- *I think it provides too many distractions. A virtual classroom is almost like a **playground** that **kids would take advantage of.***

5.1.3 Technical Challenges

This theme refers to difficulties or malfunctions related to virtual reality hardware, software, or usability that can disrupt the user experience and hinder learning or productivity.

- *What I disliked was mostly **seeing** through the virtual reality headset. I'm not sure if it's because I have to take off my glasses but it's usually a little **blurry** for me.*
- *Sometimes it's **hard** to get the hand remotes to **point** and **click** on the things that you **want**. During our session last Tuesday something had happened in the space causing us **not to be able to click** on anything or move anything.*
- *VR learning can also be challenging to figure out at the start. **The technology itself may present barriers**, such as **learning how to operate** the VR headset or navigate virtual environments.*

5.2 Week 2 – Iceberg Model to Understand Root Causes

By the second week, responses indicated clear learning gains related to VR's capabilities. Here, the primary focus was on **self-efficacy**.

5.2.1 Tech Enhanced User's Ability to Accomplish Tasks

This theme refers to the improvement in efficiency, accuracy, or effectiveness of completing tasks through the use of technology-driven tools and solutions.

- *I could run, jump, and turn all with the press of a button or moving a joystick. It **makes things easier** in the learning environment.*
- *The technology **allowed me to manipulate** virtual objects in a visually stimulating manner and non-traditional manner.*
- *The VR experience has **opened a whole new world** of productivity and efficiency for me. I never was able to really pay attention in class very well.*

5.2.2 Desire to Use Tech Well

This theme refers to an individual's motivation and commitment to effectively learn, adapt, and utilize technology to enhance productivity, problem-solving, or overall performance.

- *In the next couple of class periods, **I plan on trying to improve** on this skill so that I can get the full experience without having to feel the stress.*
- *With the virtual experience I thought it was a little confusing at first **but once you get the hang of it**, it was easy to operate and understand.*
- *I thought this experience was interesting **because I didn't know how to** draw in VR prior to this so learning how to do this was quite an enjoyable experience.*

5.3 Week 3 – Gamification for Increased Quality and Productivity

By the third week, students highlighted VR's value and potential opportunities in real-world applications. Here, the primary focus was on **seeing value**.

5.3.1 Appreciation of Both Experiences

This theme refers to the recognition of the unique benefits of both virtual reality and traditional lecture-based learning, valuing their complementary roles in enhancing understanding and engagement.

- *I think there is a time and place for **both activities** tho.*
- ***Both are very efficient** in my opinion.*
- *I think **both methods had their strengths and weaknesses** in facilitating creativity in learning in immersive environments.*

5.3.2 Enhanced Collaboration

This theme refers to the improved ability of individuals or groups to work together effectively through better communication, teamwork, and shared problem-solving, often facilitated by technology or structured interaction.

- *The ability to interact with 3D models and simulations brought concepts to life in a way that **traditional methods simply couldn't match**.*
- *The ability to interact, converse, and collaborate as if we were in the same room was truly remarkable. I could see their avatars, hear their voices, and even engage in activities together, **fostering a sense of camaraderie** that transcended physical distance.*
- *Additionally, VR facilitates collaborative learning experiences, **enabling students to work together** in virtual classrooms or labs regardless of physical location.*

5.4 Summary

The guiding research question was as follows: *How do participant perceptions of virtual reality compare to in-person instruction, and how does this change over time?*

A preliminary thematic analysis conducted using NVivo revealed distinct patterns in student responses across the three-week module. In the first week, students' reflections centered on learning the technology and navigating instructional support. By the second week, responses indicated clear learning gains related to VR's capabilities. By the third week, students highlighted VR's value and potential opportunities in real-world applications. This is summarized in Figure 1. This is very much in alignment with Maslow's Hierarchy of Needs in that a supportive environment (e.g., psychological needs, safety and security, and love and belonging) must be established before self-efficacy and seeing value (e.g., self-esteem and self-actualization). This highlights the importance of orientation and onboarding before throwing participants into the lion's den of VR.

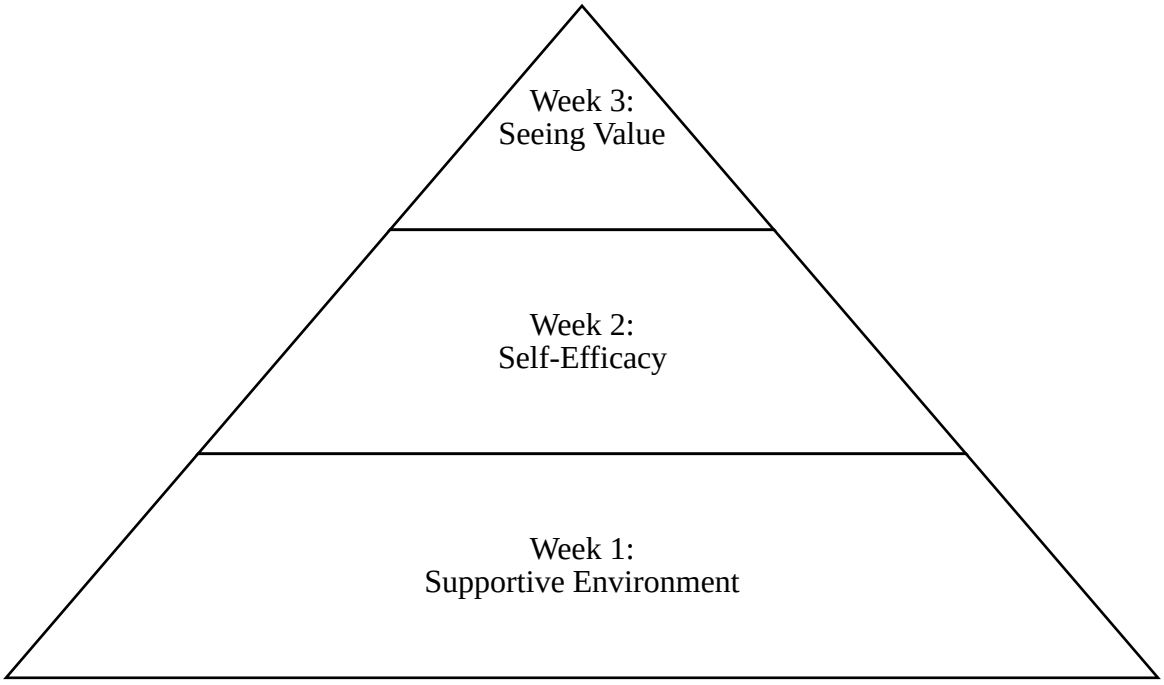

Figure 1. Motivation to Learn VR – Over Time

5.5 Recommendations for Practitioners

The findings from this study hold significant implications for how educators, institutions, and policymakers can better integrate VR into educational settings. However, several considerations must be made to effectively adopt and integrate VR into classrooms.

First, educators should recognize that the effectiveness of VR-based learning depends not only on the technology's immersive qualities but also on how well it aligns with course content and learning objectives. While VR enhances engagement, its true impact lies in how it is integrated into instruction. Educators should be trained to design interactive experiences that leverage VR's potential, allowing students to explore concepts more deeply and benefit from the increased sense of agency these environments provide. Additionally, professional development programs should equip educators with strategies for handling technical challenges, such as headset malfunctions or student fatigue, ensuring that VR enhances learning rather than becoming a distraction.

Second, from an institutional standpoint, maintaining up-to-date and reliable VR equipment is crucial. This study highlighted challenges associated with using older Meta Quest 1 headsets, including lag and app incompatibility, which can hinder the learning experience. To effectively integrate immersive technologies, institutions should prioritize upgrading and maintaining modern VR hardware. Additionally, establishing dedicated technical support for classrooms utilizing VR can help educators and students resolve issues efficiently, ensuring a smoother and more effective learning experience.

Third, for policymakers, this study highlights the need for equitable access to VR technology in education. While VR has shown great potential for improving learning experiences, its advantages may be restricted to institutions with the financial means to support the required infrastructure. To address this disparity, policymakers should push for funding and resources that make VR accessible across diverse educational settings, not just in well-funded schools. This could involve offering grants or subsidies to underserved communities, enabling them to integrate and maintain VR technologies within their curricula.

Ultimately, integrating VR into classrooms can drive more engaging and effective educational experiences. However, this requires careful planning, adequate training for educators, and a commitment to ensuring that all students have access to the tools and support they need to benefit from immersive learning environments.

6. Conclusion

The COVID-19 pandemic revealed an urgent need for experiential remote education, especially as traditional in-person learning environments became inaccessible. This shift underscored the demand for innovative, immersive learning solutions that could offer students hands-on experiences remotely. However, despite the demand, such immersive learning opportunities remain limited due to several barriers, including technological constraints, lack of access to necessary hardware, and insufficient instructional resources. Currently, many students and

educators lack the tools and support required to transition from traditional teaching models to experiential, technology-enhanced learning platforms.

This study contributes to the growing body of research on VR in education. By comparing VR with traditional instruction, this research will provide insights into how immersive technologies can enhance the educational experience for STEM undergraduates. Additionally, it aims to inform future curriculum design by offering recommendations on how to integrate VR effectively into STEM education to optimize student motivation to learn.

Future research in engineering education using virtual reality (VR) should focus on areas that enhance learning, improve accessibility, and align with pedagogical best practices. Specifically, future research should consider pedagogical effectiveness, curriculum integration, enhancing technical skills, collaborative learning, cognitive and psychological impacts of VR, accessibility and inclusion, long-term impacts and sustainability, and ethical and social responsibility.

While traditional face-to-face instruction remains the foundation of education, industry demands that students be more proficient with technology. VR emerges as a powerful supplementary tool, as it enables immersive, interactive, and highly customizable learning experiences, offering new ways to engage with content.

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