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Exploring the Impact of Virtual Reality on Students' Perceptions and Competency in Multimodal Communication

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Abstract. The diverse modalities of virtual reality (VR) environments make them highly appealing for learning experiences. This short paper explored the impact of immersive VR on students' perceptions and competencies in multimodal communication. Guided by Kolb's Experiential Learning Theory, the research involved first-year students in a multimodal communication course, where they engaged with the Oculus First Contact VR app. Pre- and post-session surveys assessed students' expectations and perceptions of VR in education. The findings suggested that while students generally viewed VR as an effective tool for enhancing engagement and collaboration, concerns remained regarding its ability to significantly improve independent learning or real-world application of content. However, students recognized the potential of VR to facilitate hands-on skill development, particularly in simulating complex scenarios that traditional methods struggle to replicate. Additionally, this short paper identified five key themes relating to students' perceptions of VR's rhetorical success in multimodal communication, including its ability to evoke wonder and enhance competency in multimodal communication.

Keywords: Multimodal Communication, Virtual Reality, Students' Perception, Immersive Learning.

1 Introduction

1.1 Multimodal Communication in Immersive Virtual Reality

As digital, information-rich, and distributed learning communities continue to grow, virtual reality (VR) technologies emerge as a relatively underexplored yet highly promising component of multimedia learning and multimodal communication. While other digital tools have found their place in educational contexts, VR stands out by engaging users through multiple sensory modalities, offering unique opportunities for more immersive and interactive learning experiences. These opportunities diverge significantly from earlier forms of virtual technologies, largely due to the increasing prevalence of head-mounted displays (HMDs) since 2013 [1].

In addition, VR environments offer unparalleled flexibility, with applications featuring various participation structures, interactivity levels, and engagement norms [2]. These adaptable frameworks make VR particularly well-suited for a variety of educational settings, allowing learners to engage dynamically based on specific instructional objectives. Whether applied to immersive storytelling or abstract conceptual exploitation, VR technologies enrich traditional delivery methods by integrating multimodal elements such as written text, 2D and 3D images, color schemes, and audio-visual components.

The rich modalities make VR environments appealing for learning experiences. A growing body of research recognizes the distinct affordances of immersive VR in enhancing learning, particularly by fostering a sense of presence and authenticity [2-4]. VR offers the potential to make multimodal communication a central practice in classrooms by incorporating non-verbal resources into the meaning-making process. In particular, immersive VR, facilitated by HMDs, engages users across multiple sensory channels—visual, auditory, tactile, and kinesthetic—

allowing for a richer, more embodied learning experience. This contrasts sharply with desktop-based VR, which restricts learners to interacting with a screen, focusing their attention primarily on verbal and visual cues [5].

Through the orchestration of broader communication modes, immersive VR integrates various modalities, fostering active participation and opening new avenues for learning and communication [6]. These multisensory experiences not only increase engagement but also deepen learners' understanding of content by engaging them in more complex, multimodal interactions [1, 4, 7].

Despite the growing popularity of VR, particularly in education—where it has become one of the fastest-growing markets [8]—the pedagogical potential of immersive VR for enhancing multimodal communication remains largely underexplored. Furthermore, student perspectives are critical in shaping effective instructional design and ensuring that these technologies are integrated meaningfully into learning environments. To fully harness VR's transformative potential, students' views must inform how these immersive technologies are used to support both individual and collaborative learning.

As VR continues to evolve, its influence on both media and education will likely expand, offering new and transformative ways to engage with and produce knowledge in virtual environments [2, 9]. However, it is essential to actively consider and integrate students' experiences and perspectives into this evolving landscape, as their insights can provide valuable guidance for optimizing VR's use in educational settings. With this in mind, we aimed to explore how the use of immersive VR in a multimodal communication course impacts students' perceptions and competencies in multimodal communication. Guided by Kolb's Experiential Learning Theory [10, 11], we sought to study 1) how students perceive the use of VR in education and 2) their perceptions of VR and its impact on their competencies in multimodal communication.

1.2 Experiential Learning Theory

The inherently experiential nature of learning is particularly compelling, as learning cannot occur without some form of experience. For instance, consider trying to learn how to swim without ever getting into the water. The theoretical knowledge of swimming strokes or breathing techniques is insufficient without the physical experience of navigating through water. Similarly, think about how difficult it would be to "unlearn" how to type on a keyboard—once acquired, the skill becomes automatic through repeated practice. As John Dewey [12] famously argued, although not all experiences are equally educative, "all genuine education comes about through experience" (p. 25). Dewey's perspective underscores the idea that meaningful learning is inseparable from direct engagement and experience.

Building on this, Experiential Learning Theory (ELT) offers a distinct approach to understanding the learning process, contrasting sharply with behavioral learning theories that emphasize external stimuli and responses. Emerging from a constructivist approach, ELT posits that life experiences are not merely supplementary but central to the learning process, where "knowledge is created through the transformation of experience" ([11], p. 49). Kolb [10, 11] emphasizes that learning is an active, cyclical process in which experiences are reflected upon, conceptualized, and then tested in new contexts. This dynamic interaction between action and reflection forms the foundation of experiential learning.

Kolb [10, 11] proposed a four-stage cyclical model of knowledge development, emphasizing the conscious recognition and transformation of experience. This model consists of four adaptive learning modes: concrete experience, reflective observation, abstract conceptualization, and active experimentation. These stages form a continuous cycle, often depicted as a spiral, where each phase builds on the previous one.

In this model, knowledge is developed through both grasping and transforming experience. Grasping occurs through two distinct processes: concrete experience (direct involvement in events) and abstract conceptualization (thinking and analyzing concepts). Once an experience is grasped, it is transformed through two additional processes: reflective observation (reflection on the experience) and active experimentation (applying what has been learned in practice) [10, 13].

Although widely used by researchers and practitioners, ETL has faced several critiques, particularly regarding its empirical foundation and theoretical coherence. Some scholars argue that the model lacks sufficient empirical support to justify its widespread application [14, 15]. Other major criticisms focus on the ambiguity in defining "concrete experience" [16] and its failure to adequately address the social and cultural context of learning [17].

A recent review by Morris [13] clarified the concept of "concrete experience" by emphasizing that learners are active participants engaged in hands-on, real-world experiences. These experiences are not passive; they require learners to be involved in authentic, uncontrived situations that reflect real-world scenarios. The review highlights that the knowledge gained through experiential learning is not universal or static but context-specific. Learners must recognize that factors such as time, place, and cultural context shape the knowledge produced during the learning process. The findings suggest that experiential learning is a complex process involving active

engagement, contextually rich experiences, critical reflection, and the application of knowledge in new settings. Kolb's model also underscores the importance of learner responsibility and autonomy.

2 Methodology

2.1 Participants

The study included 34 first-year students enrolled in a themed course on Multimodal Rhetoric and Communication designed to develop their skills in written, oral, visual, electronic, and nonverbal communication. Of the students who completed the assessments and participated in the VR session, 14 were female, 15 were male, and two identified as other. The participants had an average age of 18.52 years (SD = 0.626).

The participants came from a variety of academic backgrounds, with 25% from the College of Engineering and another 25% from the College of Computing. Other disciplines included the College of Science (13.6%), College of Business (4.5%), and College of Liberal Arts (2.3%).

A small proportion of students (11%) reported owning a VR headset, and the majority (59%) had never used VR in an educational context. Most participants also indicated they had limited or no familiarity with VR in general.

2.2 Study Context

The Multimodal Communication course focuses on enhancing students' skills across written, oral, visual, electronic, and nonverbal modes (WOVEN). Students engage with a mix of fictional and non-fictional texts related to the theme of space exploration, including science fiction and real-world research, to master effective communication across multiple media and forms of expression. In this context, VR can assist students to learn about strategies for effective translation, transformation, and transference of communication across modes and media. Students also engage in critical thinking while applying it to digital technologies like VR. Using VR also contributes to the students' abilities to use a variety of technologies to address different types of audiences.

Throughout the course, students hone their ability to navigate and apply the nuances of different communication modes. Whether analyzing a scene from Interstellar or crafting an argument in a podcast, they explore how combining different modes—written, oral, visual, electronic, and nonverbal—can convey ideas more effectively. By engaging with texts from television shows, films, comics, and more, students learn to adapt their communication style to suit the message, context, and audience.

In addition, students delve into the intricacies of crafting persuasive arguments that resonate with specific audiences while engaging with the question: What is effective rhetoric and how does successful multimodal persuasion work? They practice analyzing the rhetoric of space-themed visuals and constructing researched arguments through various media, such as podcasts. The course emphasizes not only the content of arguments but also how multi-modal elements—imagery, sound, and text—shape audience perception and engagement through the use of rhetorical analysis strategies. Students were able to critically engage with the VR application while identifying whether the rhetoric of the VR app was successful or not. As one student states, "… the visual and oral rhetoric was very successful and immersed me in the world."

2.3 Data Collection

After receiving IRB approval, the research team planned the VR session and collected data using online surveys and forms in three phases. Approximately ten days before the VR session, participants were invited to complete a screening survey on the online survey platform Qualtrics. This survey included sections on

1) Confidence in using VR, encompassing items asking about students' confidence in using various VR features, such as controlling avatars and interacting with 3D models of objects, rated on a 5-point Likert scale from 1 (very unconfident) to 5 (very confident).

2) Expectations for using VR in an educational setting, exploring what students anticipated gaining from using VR in their learning environment.

3) VR experience and background, gathering information about students' prior experience with and knowledge of VR. The survey remained open until the VR session.

In the VR session, to provide an engaging introduction to VR, students interacted with the "Oculus First Contact" (OFC) Meta app through Oculus Meta Quest 2 and Meta Quest Pro VR headsets. OFC app was purposefully chosen to help students develop the skills needed for effective multimodal communication, blending

visual, auditory, and kinesthetic learning experiences. For instance, by allowing students to lift objects, insert disks, and wave, the app helps them understand how nonverbal actions and gestures communicate intent or trigger responses in a virtual environment. These interactions develop nonverbal communication skills, which are crucial in multimodal settings where physical actions contribute to meaning-making. This highlights that communication in VR goes beyond words—it includes physical and non-verbal cues that are essential for interpreting and constructing meaning in the virtual environment.

Additionally, the experience of interacting with a robot and a butterfly introduces students to digital narratives where verbal and nonverbal communication comes together. This helps enhance their visual and auditory literacy, as they must interpret cues from these characters through their movements, sounds, and responses. As students manipulate objects in a 3D space, they develop a sense of spatial reasoning and visual literacy. The ability to understand and respond to the spatial arrangement of objects, interpret visual stimuli, and recognize the relationship between different elements is critical in multimodal communication, where visual representation plays a key role. The app also provides tactile feedback through the VR controllers when students interact with objects, making them more attuned to multisensory communication. This helps them grasp how different sensory modalities (touch, sight, and sound) work together to deliver a cohesive message, enhancing their understanding of multimodal literacies. By following the sequence of actions—lifting objects, engaging with characters, inserting disks—students engage in a multimodal process where their actions, the app's visual and auditory cues, and the narrative structure work together. This sequence helps develop their ability to interpret and integrate multiple communication modes, similar to how they might analyze text, images, and video in educational materials.

During the VR session, each student spent approximately 5-7 minutes in the OFC app (concrete experience). Afterward, they participated in an activity that included questions about their experiences (abstract conceptualization). Specifically, they were asked what the app prompted them to do, which parts of the experience stood out, how successful they found the OFC app in terms of its rhetoric, how apps like this could improve education, and how VR could be used in the context of space exploration.

At the end of the class session, students completed a reflection form that included sections on their confidence in using VR, their emotions, and their overall experiences with VR. Additionally, the form asked about challenges they faced, suggestions for future improvements, whether the VR experience changed their perspective or understanding of the subject matter, how the VR experience influenced their understanding of multimodal literacies, and whether their competencies in multimodal communication improved after using the OFC (reflective observation).

2.4 Data Analysis

We conducted descriptive analyses on survey data to explore students' perceptions of VR in education, both generally and within their specific field of study. Additionally, we applied thematic analysis [18-20] to examine students' perceptions and multimodal competencies following their VR experience. Two researchers (GRA and co-author) began by reading the students' responses to familiarize themselves with the data. These responses focused on students' perceptions of whether the VR app was successful in terms of rhetoric and how the VR experience impacted their competency and perspectives on multimodal communication. The researchers independently created initial codes by identifying segments of the data relevant to the research questions. They then compared their codes, resolved any discrepancies, and collaboratively developed and refined the final themes.

3 Findings

3.1 How Do Students Perceive VR in Education?

Before the VR session, we posed a series of questions to assess students' overall perceptions of the role of VR in education. The survey results revealed that students generally responded positively to the use of VR, with average ratings for each item hovering around four on a 5-point Likert scale indicating agreement with the statements, with 1 = Strongly Disagree and 5 = Strongly Agree (Table 1). This suggests that, overall, students perceive VR as having a positive impact in educational settings.

Specifically, students expressed strong agreement with statements related to the benefits of learning with VR. For example, they highly agreed that "Learning with VR will be beneficial," reflecting a general belief in the value of VR as a tool for enhancing education. Additionally, students rated "Group work will be more interesting when using VR" highly, suggesting that they see the potential for VR to make collaborative learning more engaging and dynamic. These findings underscore the perceived potential of VR to enrich both individual learning experiences and group interactions in educational contexts.

Table 1. Descriptive statistics of students' perceptions of VR in education (N = 31).

Items	M	SD
Learning with VR will be beneficial.	3.94	.727
Learning with VR will improve the interactivity between my peers and instructors.	3.77	.920
Groupwork will be more interesting when using VR.	3.97	.983
I will be more excited to learn using VR.	3.87	.885
I will be more engaged in class activities using VR.	3.71	.902
The use of VR will improve my overall learning experience.	3.61	.882
Learning using VR will help me visualize course content and improve my learning performance.	3.81	.833
Using VR will help me to learn more independently.	3.45	.961
Using VR will help me to interact in a collaborative setting.	3.71	.973
Using VR will raise my confidence in applying the lecture content to real-world tasks and problems.	3.61	.882

In examining the effects of the VR experience on students' perspectives, three themes emerged (Table 2), providing insight into how students with varying levels of prior VR experience processed and responded to the immersive experience.

Table 2. Themes from students' perception of VR after VR experience.

Theme	Definition	Coding	Quotes
Reinforcement of Prior Knowledge	For students with prior VR experience, the session strengthened their views on its potential.	Reinforced, prior knowledge, educational tool	"It reinforced my opinion that as VR technology advances, it will be able to find a place as an educational tool." "I still find the subject fascinating."
Immersive and Eye-Opening Experiences	First-time VR users were impressed by the immersive and educational aspects, exceeding their initial expectations.	First-time, immersive, educational	"It was my first time, so I thought it was more immersive than I expected."
Expansion of VR Applications	Both new and experienced users expanded their understanding of VR, considering new applications beyond entertainment.	Expansion, opened eyes, useful	"I failed to think about the wide range of possibilities such as through military uses, exercising simulations, and such." "It really opened my eyes to VR."

The first theme**,** *reinforcement of prior knowledge,* highlighted how students with prior experience using VR saw the session as a validation of their existing views rather than a transformative experience. These students expressed that their understanding of VR's potential, particularly as an educational tool, was reinforced. They did not feel their perspective changed significantly, but rather that the experience strengthened their belief in VR's relevance and future applications. As one student noted, "It reinforced my opinion that as VR technology advances, it will be able to find a place as an educational tool." This suggested that for those already familiar with the technology, the recent VR experience served to confirm the value and possibilities they had previously considered.

In contrast, the theme of *immersive and eye-opening experiences* emerged primarily from first-time users who were new to VR. These students were struck by how immersive and educational the experience was, often exceeding their initial expectations. The hands-on nature of the session provided them with a more profound sense of VR's capabilities. For these participants, the experience offered more than just exposure to new technology; it demonstrated how VR could be used effectively in multimodal contexts. One student remarked, "It was my first time, so I thought it was more immersive than I expected," highlighting the novelty and impact of VR on those unfamiliar with its potential.

The theme of *expansion of VR applications* was evident among both experienced and new users, as students reported a broadened understanding of how VR could be applied beyond traditional entertainment or educational uses. Before the recent VR experience, many students associated VR mainly with gaming or recreational activities. However, the experience opened their eyes to new possibilities, such as military training, and other practical

applications. One participant shared, "I failed to think about the wide range of possibilities such as through military uses, exercising simulations, and such." This suggested that the VR session successfully expanded students' perspectives on VR, enabling them to see its value in various fields beyond their initial assumptions.

3.2 What Are Students' Perceptions of VR and Its Impact on Their Competencies in Multimodal Communication?

Our thematic analyses resulted in five themes on the OFC's rhetorical success, highlighting students' perception of VR in multimodal communication as well as the perceived impact of VR in their multimodal competencies. (Table 3).

One of the most prominent themes was *the sense of wonder and curiosity*. The majority of students expressed that the OFC successfully instilled excitement about the possibilities of VR. For instance, one participant remarked on the awe they felt when interacting with the 3D printer feature, saying, "Seeing all the incredible things created with the 3D printer had me stopping in awe." These responses suggest that the app effectively demonstrated the potential of VR to create immersive, transformative experiences. The introduction to VR controls and the various features of the app played a pivotal role in cultivating these feelings of wonder, suggesting that VR technology can be a powerful tool for capturing attention and sparking imagination in educational settings.

The second theme revolved around the *immersive and interactive* nature of the app. Participants highlighted the successful use of visual, auditory, and interactive elements in making the VR environment feel engaging and connected. One student commented that "the visual and oral rhetoric was very successful and immersed me in the world," while another appreciated how the OFC "created an inviting atmosphere that encouraged the player to want to interact." The combination of these sensory elements made the experience both immersive and straightforward, allowing students to feel deeply engaged with the content. The strong connection between the user and the virtual world indicated that the app's design was effective in drawing students into the experience, which is critical for enhancing learning in VR environments.

Another theme was the creation of an *inviting and friendly atmosphere*. Students frequently used words like "friendly" and "inviting" to describe the experience, emphasizing how the OFC's design encouraged interaction and exploration. For example, one participant noted that "the cute robot made me want to continue carrying out the tasks," illustrating how the app's playful elements contributed to a welcoming environment. The use of colorful visuals, joyful music, and friendly avatars made the virtual space approachable and engaging, easing students into what might otherwise have been an unfamiliar or intimidating environment. This theme indicated the importance of creating a positive atmosphere in educational VR experiences to facilitate user engagement.

While the app was largely successful in creating an immersive experience and considered successful in terms of rhetoric, some students identified shortcomings related to *the lack of clear instructions* from the VR application. This theme emerged from feedback about moments when participants felt lost or confused, such as when one student mentioned, "The robot's instructions were unclear, and it was difficult to actually remove disks from the 3D printer." Another participant noted that there were "a few moments that broke my immersion, like my hand passing right through objects." These instances of unclear instructions or technical glitches detracted from the overall immersive experience, breaking the flow of engagement and causing frustration. While the free-exploration aspect of the experience allowed for some autonomy, these challenges in navigating the environment highlighted areas where more explicit guidance could improve the overall effectiveness of the rhetoric.

The final theme, *enhanced competency and adaptability in multimodal communication*, reflected how the VR experience increased students' understanding and flexibility in identifying and using multiple modes of communication. The immersive nature of VR enabled students to interact with electronic, visual, and nonverbal forms of communication, aligning with the WOVEN framework. Students quickly adapted to these new forms of communication in the VR environment, learning how to interpret nonverbal cues, such as controller vibrations and visual interactions with virtual objects. As one student explained, "I now have a greater understanding of the electronic and visual modes of communication." This adaptability indicated that VR can effectively enhance multimodal communication skills, providing students with a richer and more integrated learning experience. The session also allowed students to explore how different modes interact seamlessly in immersive environments, deepening their overall multimodal communication competency.

Table 3. Themes from students' perceptions of VR in multimodal communication and its impact on their competencies and learning abilities.

Theme	Definition	Coding	Quotes
Sense of Wonder and Curiosity	The VR experience successfully evoked excitement and curiosity about VR's potential.	Wonder, possibilities, awe	"It was successful in instilling a sense of wonder and the possibilities of VR." "Seeing all the incredible things created with the 3D printer had me stopping in awe."
Immersive and Interactive Rhetoric	The combination of visuals, sound, and interactivity effectively immersed participants.	Immerse, interactive, straightforward	"The visual and oral rhetoric was very successful and immersed me in the world." "The game created an inviting atmosphere that encouraged the player to want to interact."
Inviting and Friendly Atmosphere	The experience created a welcoming, friendly environment that encouraged participation.	Friendly, inviting, playful	"The game created an inviting atmosphere that encouraged the player to want to interact." "The cute robot made me want to continue carrying out the tasks." "Students utilized words such as 'friendly' and 'inviting' to describe the successfulness of the VR experience."
Lack of Clear Instructions	Moments where unclear instructions disrupted immersion and caused confusion.	Unclear, difficult, lack of instructions, free-exploring, pros and cons	"The robot's instructions were unclear, and it was difficult to actually remove disks from the 3D printer." "There were a few moments that broke my immersion, like my hand passing right through objects." "There were very few occasions where the users complained about lack of clear instructions…" "The lack of clear instructions, which have pros and cons in creating a free-exploring environment."
Enhanced Competency and Adaptability in Multimodal Communication	VR use increased students' understanding and adaptability in electronic, visual, and nonverbal communication. Students quickly adapted to using multiple modes of communication in the VR environment, gaining insights into how these modes interact in an immersive setting.	Electronic, visual, WOVEN, nonverbal, tactile, adaptability, multimodal	"I now have a greater understanding of the electronic and visual modes of communication." "I was not expecting the vibrations of the controller when I 'touched' an object in the virtual environment." "I was able to apply nonverbal communication when interacting with the robot." "This also goes hand in hand with visual communication as you are visually seeing things."

4 Discussion

The findings reveal that students generally perceived VR as a positive and impactful tool in education, strongly agreeing on its benefits for enhancing both individual and collaborative learning experiences [21-23]. Notably, consistent with previous studies (e.g.,[21]), students believed that group work could become more engaging with VR, suggesting that the technology fosters more dynamic and interactive collaboration among peers. This supports the notion that VR environments offer immersive, hands-on learning experiences that are difficult to replicate through traditional methods [24, 25].

However, despite VR's promise, students expressed reservations in certain areas. Specifically, perceptions of VR's ability to significantly enhance independent learning or boost confidence in applying lecture content to real-world problems received slightly lower ratings. These concerns, also noted by both instructors and students in previous studies (e.g., [21, 25]), may reflect doubts about VR's effectiveness in supporting self-directed learning or real-world application, where traditional or hybrid approaches could still hold more value. Furthermore, some

students may experience anxiety when using the technology independently, potentially leading them to engage with VR for leisure activities like gaming rather than focusing on educational tasks [26-28].

After experiencing VR firsthand, students' perceptions evolved from theoretical optimism to a concrete understanding of its practical applications. They saw VR not just as an engagement tool but also as a platform for hands-on skill development across various disciplines. As noted in earlier studies (e.g., [29]), students increasingly recognized VR's potential for simulating real-world scenarios, allowing practical learning experiences that are difficult to achieve through traditional methods. For example, VR was seen as useful for practicing medical procedures or complex design tasks in a controlled, immersive environment. Beyond skill-building, students appreciated VR's capacity to enhance traditional learning experiences—such as virtual museum visits or historical reenactments—by offering deeper and more immersive engagement with educational content. Supported by existing research (e.g., [30]), this shift in students' perspectives from abstract possibilities to tangible, practical benefits underscores VR's potential not only to enhance engagement but also to transform learning through immersive, experiential methods that bridge the gap between theory and real-world application.

Students' perceptions of the VR app (OFC) were largely positive, particularly regarding its immersive nature, sense of wonder, and friendly atmosphere. The app successfully captured their attention by combining visual, auditory, and interactive elements to create a captivating and welcoming environment. This design fostered curiosity and engagement, encouraging students to explore the virtual space and interact with its features. These themes once more highlighted VR's inherent ability to create a strong sense of presence and immersion when applied properly [31].

A key factor in the app's rhetorical success was its ability to create an inviting and approachable atmosphere, which students described as "friendly" and "playful." The inclusion of an interactive robot character and its non-verbal communication style, colorful visuals, and joyful music helped make the experience less intimidating, particularly for those new to VR technology. The full immersion provided by the head-mounted VR device likely contributed to students' positive perceptions of VR in multimodal communication, emphasizing how immersive VR enhances the sense of presence [28, 32]. This emphasized the importance of designing an environment that eases users into the VR experience, especially in educational settings where the technology may be unfamiliar.

However, consistent with previous findings [33-35], technical issues or a lack of experience disrupted some students' sense of presence and immersion, negatively affecting their satisfaction and perception of the VR experience in multimodal communication. Some students reported moments where unclear instructions or technical glitches, such as difficulty removing disks from a 3D printer or hands passing through objects, interrupted their immersion. These disruptions detracted from the overall flow of the experience. This suggests that while VR can create highly immersive and engaging communication environments, careful attention to instructional design, VR simulator development techniques (which include sensory immersion into an interactive 3D design), and technical reliability are crucial to maintaining that immersion [36, 37].

A key takeaway from the study was the enhancement of students' competencies in multimodal communication, particularly within the WOVEN framework. The VR environment required students to quickly adapt to multiple modes of communication, learning to interpret nonverbal cues, tactile feedback, and visual interactions with virtual objects. This adaptability suggested that VR is a powerful tool for developing multimodal communication skills, offering a more integrated and immersive learning experience than traditional classroom settings.

5 Conclusion

These findings demonstrate that incorporating VR into education can boost student engagement, enhance collaboration, and expand learners' perspectives on real-world applications and technologies. VR offers a valuable tool for creating more interactive and immersive learning environments, particularly in courses focused on visualization and hands-on activities. As students broaden their understanding of VR, educators can integrate it into curricula to strengthen both traditional and collaborative learning, fostering greater engagement, improving comprehension of complex concepts, and building confidence in applying knowledge to real-world challenges.

Through the lens of experiential learning theory, actively engaging with and reflecting on the VR experience also enhanced students' technological and multimodal communication skills, especially in adapting to electronic, visual, and nonverbal modes. This adaptability highlights VR's potential for developing communication skills across various modes, aligning with the WOVEN framework. By integrating VR, educators can improve students' fluency in multiple communication modes, making learning more interactive and applicable. Addressing navigation challenges and improving instructional clarity will further optimize VR's potential for teaching complex communication skills, leading to more effective and engaging learning experiences.

However, the study's small sample size (N=34) and focus on first-year students limit the generalizability of the findings. The short duration of the VR sessions may have also restricted deeper engagement and long-term

retention of skills. Future research should expand the sample size, include diverse student backgrounds from different levels (freshman, sophomore, junior, senior, graduate or high school), different majors and backgrounds, such as English language learners, and explore the long-term effects of VR on multimodal competencies through more immersive and extended sessions. Future studies could include longer session durations and extended follow-up assessments to evaluate how VR influences the development and retention of multimodal competencies, providing deeper insights into the extent and durability of VR's educational impact. Additionally, other extended reality technologies, such as mixed reality and augmented reality, as well as the growing integration of generative AI with VR, could be incorporated into future studies to compare their performance and further enhance understanding of multimodal communication. Objective assessments, such as pre- and post-tests, would also help measure actual competency gains. The amount and availability of VR headsets could also be expanded to include more students in the activities. Furthermore, in future iterations of the VR experience, instructional clarity could be improved by providing more explicit, user-friendly and accessible guidance within the application ahead of the experience. Allocating time for students to practice their VR control skills beforehand can help create a seamless VR experience during the class session.

Exploring the potential of VR technologies in undergraduate rhetoric and composition classrooms encourages broader reflection on the role of digital technologies in higher education. It inspires us to view technology as a tool that students can critically engage with while also learning its functionalities. In this regard, VR helps their critical thinking skills. Implementing VR and related technologies requires significant collaboration, fostering interdisciplinary engagement across schools, departments, and institutes, as well as partnerships between instructors and researchers. By embracing these innovations, the educational landscape is enriched, challenging traditional pedagogies and fostering the creation of more immersive, engaging, and inclusive learning environments that meet the needs of lifetime learners.

References

1. Jensen, L., and Konradsen, F.: ‘A review of the use of virtual reality head-mounted displays in education and training’, Education and Information Technologies, 2018, 23, pp. 1515-1529.
2. Mills, K.A., and Brown, A.: ‘Immersive virtual reality (VR) for digital media making: transmediation is key’, Learning, Media and Technology, 2022, 47, (2), pp. 179-200.
3. Elme, L., Jørgensen, M.L., Dandanell, G., Mottelson, A., and Makransky, G.: ‘Immersive virtual reality in STEM: is IVR an effective learning medium and does adding self-explanation after a lesson improve learning outcomes?’, Educational technology research and development, 2022, 70, (5), pp. 1601-1626.
4. Mills, K.A., Scholes, L., and Brown, A.: ‘Virtual reality and embodiment in multimodal meaning making’, Written Communication, 2022, 39, (3), pp. 335-369.
5. Glaser, M., Aberle, S., and Schwan, S.: ‘Learning versus researching in a desktop virtual reality: How reception goals influence the processing of uncertain information marked by verbal and visual cues’, Computers & Education, 2023, 201, pp. 104826.
6. Mills, K.A., and Exley, B.: ‘Sensory literacies: The full sensorium in literacy learning’, International Encyclopedia of Education: Volume 10-Literacies and Languages. Vol. 10.[4th ed.], 2023, pp. 480-486.
7. Tang, K.-S., Won, M., Mocerino, M., Treagust, D.F., and Tasker, R.: ‘Multimodal affordances of immersive virtual reality for visualising and learning molecular interactions’, Learning from animations in science education: Innovating in semiotic and educational research, 2020, pp. 75-100.
8. Fernandez, M.: ‘Augmented virtual reality: How to improve education systems’, Higher Learning Research Communications, 2017, 7, (1), pp. 1-15.
9. Minogue, J., and Jones, M.G.: ‘Haptics in education: Exploring an untapped sensory modality’, Review of educational research, 2006, 76, (3), pp. 317-348.
10. Kolb, D.A.: ‘Experience as the source of learning and development’, Upper Sadle River: Prentice Hall, 1984.
11. Kolb, D.A.: ‘Experiential learning: Experience as the source of learning and development’ (FT press, 2014. 2014).
12. Dewey, J.: ‘Experience and education’ (Simon and Schuster., 1938. 1938).
13. Morris, T.H.: ‘Experiential learning–a systematic review and revision of Kolb’s model’, Interactive learning environments, 2020, 28, (8), pp. 1064-1077.
14. Miettinen, R.: ‘The concept of experiential learning and John Dewey's theory of reflective thought and action’, International journal of lifelong education, 2000, 19, (1), pp. 54-72.
15. Coffield, F., Moseley, D., Hall, E., Ecclestone, K., Coffield, F., Moseley, D., Hall, E., and Ecclestone, K.: ‘Learning styles and pedagogy in post-16 learning: A systematic and critical review’, 2004.
16. Bergsteiner, H., Avery, G.C., and Neumann, R.: ‘Kolb's experiential learning model: critique from a modelling perspective’, Studies in continuing education, 2010, 32, (1), pp. 29-46.
17. Jarvis, P.: ‘Adult learning in the social context’ (Routledge, 2012. 2012).
18. Braun, V., and Clarke, V.: ‘Using thematic analysis in psychology’, Qualitative research in psychology, 2006, 3, (2), pp. 77-101.

19. Braun, V., and Clarke, V.: ‘One size fits all? What counts as quality practice in (reflexive) thematic analysis?’, Qualitative research in psychology, 2021, 18, (3), pp. 328-352.
20. Terry, G., Hayfield, N., Clarke, V., and Braun, V.: ‘Thematic analysis’, The SAGE handbook of qualitative research in psychology, 2017, 2, (17-37), pp. 25.
21. Baxter, G., and Hainey, T.: ‘Student perceptions of virtual reality use in higher education’, Journal of Applied Research in Higher Education, 2019, 12, (3), pp. 413-424.
22. Yilmaz Soylu, M., and Lee, J.: ‘Examining College Students' Readiness of Virtual Reality in Education’. Proc. 2024 AERA Annual Meeting, Philadelphia, Pennsylvania, April 11–14 2024 pp. Pages.
23. Matome, T.J., and Jantjies, M.: ‘Student perceptions of virtual reality in higher education’, Balancing the tension between digital technologies and learning sciences, 2021, pp. 167-181.
24. Yilmaz Soylu, M., Kim, L., and Lee, J.: ‘Insights into College Students’ Experiences and Expectations for VR Integration in Education’, in Editor (Ed.)^(Eds.): ‘Book Insights into College Students’ Experiences and Expectations for VR Integration in Education’ (2024, edn.), pp. 13-15.
25. Idrees, A., Morton, M., and Dabrowski, G.: ‘Advancing extended reality teaching and learning opportunities across the disciplines in higher education’, in Editor (Ed.)^(Eds.): ‘Book Advancing extended reality teaching and learning opportunities across the disciplines in higher education’ (IEEE, 2022, edn.), pp. 1-8.
26. Cheng, M.-T., Chen, J.-H., Chu, S.-J., and Chen, S.-Y.: ‘The use of serious games in science education: a review of selected empirical research from 2002 to 2013’, Journal of computers in education, 2015, 2, pp. 353-375.
27. Greenwald, S.W., Corning, W., Funk, M., and Maes, P.: ‘Comparing Learning in Virtual Reality with Learning on a 2D Screen Using Electrostatics Activities’, J. Univers. Comput. Sci., 2018, 24, (2), pp. 220-245.
28. Makransky, G., Borre-Gude, S., and Mayer, R.E.: ‘Motivational and cognitive benefits of training in immersive virtual reality based on multiple assessments’, Journal of Computer Assisted Learning, 2019, 35, (6), pp. 691-707.
29. Portuguez-Castro, M., and Santos Garduño, H.: ‘Beyond Traditional Classrooms: Comparing Virtual Reality Applications and Their Influence on Students’ Motivation’, Education Sciences, 2024, 14, (9), pp. 963.
30. Marougkas, A., Troussas, C., Krouska, A., and Sgouropoulou, C.: ‘How personalized and effective is immersive virtual reality in education? A systematic literature review for the last decade’, Multimedia Tools and Applications, 2024, 83, (6), pp. 18185-18233.
31. Häfner, P., Häfner, V., and Ovtcharova, J.: ‘Teaching methodology for virtual reality practical course in engineering education’, Procedia Computer Science, 2013, 25, pp. 251-260.
32. Rupp, M.A., Odette, K.L., Kozachuk, J., Michaelis, J.R., Smither, J.A., and McConnell, D.S.: ‘Investigating learning outcomes and subjective experiences in 360-degree videos’, Computers & Education, 2019, 128, pp. 256-268.
33. Xiangming, L., Wang, K., Wang, Y., He, J., and Zhang, J.: ‘Assessing User Experiences in Virtual Reality Learning Environments’, The Asia-Pacific Education Researcher, 2024, pp. 1-12.
34. Behm-Morawitz, E.: ‘Mirrored selves: The influence of self-presence in a virtual world on health, appearance, and well-being’, Computers in human Behavior, 2013, 29, (1), pp. 119-128.
35. Hooi, R., and Cho, H.: ‘Virtual world continuance intention’, Telematics and Informatics, 2017, 34, (8), pp. 1454-1464.
36. Hartstein, A.J., Verkuyl, M., Zimney, K., Yockey, J., and Berg-Poppe, P.: ‘Virtual reality instructional design in orthopedic physical therapy education: a mixed-methods usability test’, Simulation & Gaming, 2022, 53, (2), pp. 111-134.
37. Radianti, J., Majchrzak, T.A., Fromm, J., and Wohlgenannt, I.: ‘A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda’, Computers & Education, 2020, 147, pp. 103778.