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ORIGINAL PAPER

The Teaching Methods Classroom Meets Virtual Reality: Insights for Pre-Service Teaching Methods Instructors

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Abstract

As education preparation programs align their instruction to the contemporary technologies used in schools, they may begin to design and deliver virtual reality instruction in the teaching methods classroom. In this study, we examined the experiences of 24 pre-service teachers as they used virtual reality for the first time through the lens of the Technology Acceptance Model, and we explored their perspectives on virtual reality in the elementary classroom. Qualitative data were obtained through two surveys. The findings indicated that pre-service teachers experienced discomfort with virtual reality and perceived a variety of barriers toward integrating it into their elementary classrooms. Based on the study's findings, practical implications are shared for teaching methods instructors as they design and integrate virtual reality instruction into the teaching methods classroom.

Keywords Methods · Pre-service teachers · Teacher education · Technology integration · Virtual reality

Introduction

Virtual reality (VR) is a 3D simulation of either a real or computer-generated world within which users can navigate and even interact with the VR environment (Chandrasekera & Yoon, 2018), and it can be differentiated from other multimedia in three distinct ways: immersion, interaction, and involvement (Pinho et al., 2009). Therefore, VR can provide a medium for students to have experiences that would not normally be possible with traditional media by bridging conventional experiential learning barriers of space and time.

The annual Horizon Report that forecasts educational technologies that will drive revolution in education published by the nonprofit association EduCause, has repeatedly highlighted VR as (1) a key educational technology that is currently undergoing widespread adoption, and (2) an impactful educational technology for the next decade (Alexander et al., 2019; Brown et al., 2020). However, VR technologies are being developed at an exponential rate (HolonIQ, 2021), creating a technology-to-practice gap where best practices for integrating VR into education are unclear (Cherner & Fegely, 2023).

For pre-service teachers (PSTs) to be likely to use a new technology in their future classrooms, they must be comfortable with using it (Davis, 1989). Therefore, broad research investigations are needed to guide the integration of VR technology into the teaching methods classroom. In turn, this research will inform teaching methods instructors (TMIs) who will then be able to focus their teaching methods classroom pedagogy to prepare PSTs for this emerging technology and improve the probability that they will integrate VR into their own teaching.

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The Current Study

Given this context, a medium-sized university in the southeastern United States introduced VR to elementary PST participants in a teaching methods course to analyze their experiences using VR, as well as their perspectives on the use of VR in the elementary classroom. This qualitative study utilized the Technology Acceptance Model (TAM) and data from two open response surveys; one on participants' perceived usefulness of VR and one on their perceived ease of use of VR. This study had two research questions.

(RQ #1) What are PSTs' experiences using VR?
(RQ #2) What are PSTs' perspectives on VR in the elementary classroom?

This study is important in three distinct ways. First, this study contributes to the emerging literature on the use of VR in the teaching methods classroom. Second, the findings of this study inform researchers and TMIs of PSTs' perspectives on VR in elementary instruction. Third, the findings of this study provide significant practical implications for TMIs as they design and deliver VR instruction in the teaching methods classroom.

Review of Literature

Impact of VR

When VR experiences include replicas of real people and places, students can cultivate feelings of presence and immersion within the VR environment that mimic experiencing that context in the real world (Slater, 2018). Students' feelings of presence and immersion offer enhanced student engagement (McKenzie et al., 2019) and an active learning experience upgrade over other types of media, such as textbooks or videos (Allcoat & Von Mühlenen, 2018). The immersive aspect of VR can aid students in understanding abstract concepts (Curcio et al., 2016). Further, VR has been indicated to improve students' understanding of content, attitudes, and subject area achievement in science (Liu et al., 2020; Sarioglu & Girgin, 2020), English (Chen, 2016; Ou Yang et al., 2020), math (Demitriadou et al., 2020; Stranger-Johannessen, 2018) and social studies (Domingo & Bradley, 2018; Villena-Taranilla et al., 2019). These studies show that VR can positively impact learning.

Current literature has noted that primary and elementary students using VR have demonstrated learning gains. For instance, a meta-analysis of 21 journal articles published from 2010 to 2020 by Villena-Taranilla et al. (2022) noted a positive learning gain in K-6 education for immersive VR when compared to semi-immersive and non-immersive learning. Stull et al. (2013) found that VR helped build primary students' understanding of science concepts through engagement. In elementary social studies, VR can allow students to experience the culture or daily life of diverse populations, and such experiences can foster the development of empathy and perspective-taking in the primary grades (James, 2018).

VR in the Teaching Methods Classroom

VR is beginning to be integrated into teaching methods courses. Hite et al. (2017) introduced VR to PSTs through science lessons. Results showed that PSTs ranked VR as their second-most preferred method out of eight total methods of instruction (VR, reading on the internet, videos, reading textbooks, simulation, model, hands-on activities, and teacher instruction) behind hands-on activities. PSTs also experienced significant gains on four different assessments on the topics of hearts and circuits. A study by Haghanikar and Hooper (2021) presented VR alongside children's literature to allow PSTs to experience homelessness and develop cultural competence. Attwood et al. (2020) specifically examined secondary PSTs' perspectives on the application of VR in the classroom. Attwood et al. (2020) found that gender had no correlation with participants' perspectives on VR's importance as a tool in schools and there was no association between participants who reported to have used VR in the past five years and their perceptions about VR's benefits for learning classroom management. Research has noted that PSTs may be curious and display interest in using VR in their future classrooms (Casey et al., 2022; Eutsler & Long, 2021), especially for engagement, motivation, and immersive learning (Cooper et al., 2019). Another feature that intrigues PSTs about VR is the factor of enjoyment (Bower et al., 2020). Given the relative novelty of VR in education, research on the utilization of VR for teaching and modeling instruction for PSTs in the teaching methods classroom is still emerging (Nussli & Oh, 2016; Peterson & Stone, 2019). These studies represent the limited literature on VR in PST teaching methods courses.

Challenges While engagement and motivation are often noted as the favorable attributions of learning with VR, there are negative impacts that have been reported in the literature. A decrease in comprehension and an overload of information was experienced by college students in a training simulation (Makransky et al., 2019). Research has indicated that PSTs are concerned about VR's pedological use in the classroom, self-efficacy with using VR, the possibility of distractions, and the lack of access to VR technologies (Bower et al., 2020; Cooper et al., 2019). Lastly, research indicates that there is a correlation between VR presence and VR sickness (Kim et al., 2021). For example, users can experience cybersickness which can present as fatigue, nausea, and dizziness (Dużmańska et al., 2018; Saredakis et al., 2020; Veličković & Milovanović, 2021). When compared to TV in two dimensions, VR causes significantly more cybersickness symptoms (Geršak et al., 2018).

Theoretical Framework

Davis's (1989) seminal TAM is a theoretical framework that explains how a new technology gains users' acceptance and gets adopted (Fig. 1). In the TAM, Davis (1989) theorized that a new technology's perceived usefulness and perceived ease of use determine users' attitudes about a technology and their resulting intentions to adopt it into use. Perceived usefulness focuses on users' perceptions of a new technology's utility and its ability to enhance their work performance while perceived ease of use is users' perceptions of a new technology's weaknesses with practical and technical issues. While limited by contextual variables like socioeconomic and cultural factors (Chuttur, 2009), the TAM remains an effective theoretical framework predicting the likelihood of new technology's adoption among users (Granić & Marangunić, 2019).

Method

As outlined above, previous research has indicated that VR can positively impact learning in the elementary classroom, however, literature is still developing on the use of VR in the PST teaching methods classroom. Therefore, qualitative methods were chosen for this exploratory case study research to investigate the experiences of PSTs purposefully and thoroughly as they used VR and explore their perspectives on VR in the elementary classroom.

Participants

The current study was conducted at a medium-sized liberal arts university in the southeastern United States. The participants consisted of a convenience sample of 24 PSTs from two elementary social studies teaching methods courses. Thirteen of the students were elementary majors and 11 were special education majors. Thirteen of the participants were seniors in college and 11 were juniors. The sample included 22 females and two males. The participants' ages ranged from 21 to 27 years old ($M = 22.58$, $SD = 1.67$). Only three participants had any previous VR experience, and none had previous VR experience in an educational context. Participation was voluntary, and all students who attended the classes participated in this study.

Instruction

Three of the researchers served as the instructors for two 75-minute class sessions and worked as a team, switching roles between instructing, guiding, and supporting participants. Participants were instructed to bring a VR-enabled smartphone with them to class (12 brought iPhones and 12 brought smartphones of other brands). Bring your own device (BYOD) strategies have been used by schools for over a decade to cut down on expenses (Kobus et al., 2013). Aside from limiting the spread of germs between students, the strategy is prevalent in schools as a lasting impact of the COVID-19 pandemic and Nuhoğlu Kibar et al. (2020) found that college students who used their own device were more familiar with the technology and were more engaged. For the lesson and study, the instructors asked participants to pre-download the required VR app to their smartphone before class began.

These class periods served as the PSTs' introduction to VR in an educational context, so the instructors began by demonstrating VR devices and overviewing the literature on the use of VR in the classroom. Participants were supplied with Google Cardboard and Merge VR headsets (Fig. 2) for their use. The lesson demonstration was built upon the National Council for the Social Studies College, Career, and Civic Life Framework to engage students in an inquiry lesson exploring how ancient Egyptian culture was reflected in its art and utilized the Google Expeditions (2021) Ancient Egypt VR experience. Participants explored ancient Egyptian locations and culture, analyzed its art, and compared different types of sources within the VR experience. The instructors guided participants and provided

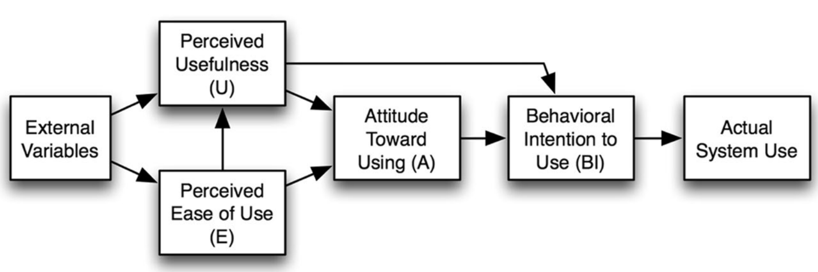

Fig. 1 The Technology Acceptance Model courtesy of Wikipedia Commons (2011), unedited

Fig. 2 Participants utilizing Google Cardboard and Merge VR headsets

breaks/opportunities for collaborating on a schema map, working on a graphic organizer, reflecting, and contributing to a group debrief. After completing the lesson, students were introduced to several other VR apps and given time to experiment with the apps that interested them, as well as the different headsets. At the end of the class sessions, students were instructed to complete the surveys.

Data Collection & Analysis

Qualitative data were collected via two open response surveys online. Both surveys were aligned to the TAM's core factors of perceived ease of use and perceived usefulness and utilized open response questions to gather a deeper understanding of participants' experiences and perspectives. The surveys were completed by students at the conclusion of the classes. Data on participants' experiences with VR were gathered through a survey where they described their TAM-based perceived ease of use – such as the practical and technical issues they encountered with the VR hardware and software during the instruction (e.g., Describe any issues you came across during the VR experience separated by semicolons.). In addition, participants completed a second open response survey on their TAM perceived usefulness – their perspectives related to VR in the elementary classroom (e.g., What potential benefits do you see with using VR in the classroom?; Describe an activity idea you have which integrates VR into your instruction.). Open coding and inductive analysis (Creswell & Poth, 2018) were used to synthesize the participants' experiences and perspectives. Codes that summarized the experiences and perspectives of participants were refined through two rounds of open coding. These two rounds were used to distinguish the qualitative data into separate parts based on similarities and differences among the responses (Saldaña, 2016). Then, the codes were sorted into categories, and from these categories, themes were developed (Saldaña, 2016).

Validating Themes

Researchers must communicate the actions they have taken to ensure the validity of their findings (Creswell & Poth, 2018). Strategies used in this study were peer debriefing, audit trail, and member checking. Peer debriefing (Lincoln & Guba, 1985) was performed among three of the researchers and was used to align codes to themes. Notes within the Excel coding documents were used to maintain an audit trail that documented qualitative coding and analysis decisions (Lincoln & Guba, 1985). The themes and categories were shared with the participants after the data were coded and analyzed to verify the accuracy of the findings, and the participants were asked to critique or offer feedback on the themes and categories. The member checking (Creswell & Poth, 2018) occurred via email due to the graduation of numerous participants. The accuracy of the themes and categories was affirmed in the one response received by the researchers from the participants; however, no additional insights were offered. The themes and categories were then finalized.

Findings

In this section, findings are presented as themes supported by example verbatim quotes from the surveys. These quotes are attributed to participants via randomly generated gender-neutral pseudonyms to protect the participants' confidentiality. Two overarching themes were revealed from the qualitative analysis and are expounded upon below.

(RQ #1) What are PSTs' Experiences Using VR?

Theme 1: PSTs Experienced Discomfort with VR

For this study, the PSTs utilized either Google Cardboard or Merge VR headset hardware. This theme describes PSTs' agreement that they experienced discomfort with their VR experiences. In their inventory surveys, pre-service teachers noted multiple types of discomfort.

> Skyler: [I had a] hard time focusing the lenses, so it was a little blurry. [I] had to keep adjusting.
> Quinn: Headache, blurry vision, doesn't fit over glasses.

This theme is subsumed by the categories of discomfort expressed by pre-service teachers: (1) blurriness, (2) sickness, and (3) cumbersome headsets.

Blurriness Over half of the PSTs explained that the VR experiences were blurry for them in multiple ways. In addition, students who wore glasses could not utilize them within the VR headsets, causing additional blurry experiences.

> Harley: [I] felt like the scene was blurry – whole pic[ture] never in focus.
> Nicky: [It was difficult] making it clear without having my eyes hurt was the only issue I faced.
> Peyton: My eye sight [sic.] doesn't allow me to use the [VR] goggles.

From struggling to focus on the VR's visuals to the hardware required for immersive VR not being built for those who wear prescription glasses to aid their eyesight, these data confirmed that blurriness contributed to PSTs' discomfort with VR.

Sickness Another uncomfortable aspect of the VR experiences that was expressed by over a third of the PSTs in their inventory survey responses was that the VR experiences produced sickness.

> Robbie: The goggles were hard to focus, they made my head hurt after a while.
> Sidney: Very pixelated and gave me a headache.

Furthermore, One of the PSTs noted that they felt claustrophobic during their VR experience.

> Carter: [Merge headset] felt claustrophobic; felt almost out of control… [I] liked [Google Cardboard] better; most issues resolved.

In summary, these data indicated that uncomfortable experiences caused by sickness were common among PSTs. These data validate this category and overall theme that PSTs experienced discomfort with VR.

Cumbersome Headsets Over a third of the PSTs described the physical VR Google Cardboard and Merge VR headsets as cumbersome for various reasons, causing discomfort. These included their phones not fitting into the headsets' viewer slots, trouble with the interaction buttons, and more. For example:

> Clarke: I had trouble pushing the button to switch to the next screens.
> Carter: [The headsets were] heavy.
> Adrian: Had to remove my glasses to use the headset.

As outlined above, PSTs characterized VR as cumbersome due to the nature of the physical headsets, which caused discomfort. These responses among PSTs support this category's theme.

(RQ #2) What are PSTs' Perspectives on VR in the Elementary Classroom?

Theme 2: PSTs Perceive a Variety of Barriers to Integrating VR into Their Classrooms

This theme describes the wide variety of barriers PSTs anticipated to integrating VR into their elementary classrooms. Barriers in education are circumstances that are perceived as being obstacles to educational achievement (Carielli, 2004). These barriers included aspects related the PSTs' future hypothetical students as well as their teaching.

> Skyler: Wi-Fi problems, tour guides not working like they did today, not having enough headsets or phones available for all students.
> Harley: Motor skills…visual/spatial issues, sensory problems.
> Adrian: Development[al] appropriateness.

The following sections will outline the categories of barriers characterized by the PSTs in their open response surveys: (1) inclusivity; (2) equity of access, (3) comfort of students, and (4) classroom management.

Inclusivity Over a third of the PSTs noted that there were inclusivity barriers to using VR in the classroom. Inclusivity in education is a focus on meeting the needs of all students, recognizing that those with disabilities are often excluded from learning experiences (Stubbs, 2008).

> Sidney: Students with visual and language issues.
> Carter: Sensory/auditory issues.
> Mickey: Problems for those who struggle with vision.

Within this category, five different PSTs mentioned sensory issues as a barrier they foresaw, which represented the largest sub-group. These data indicated that PSTs anticipated inclusivity as a large barrier to integrating VR into their classrooms.

Equity of Access Over one third of the PSTs also foresaw equity of access being an issue to integrating VR into the classroom. PSTs noted that all students may not have equitable access to VR hardware and software depending on their socio-economic status or school's funding.

> Robbie: Not all kids may have phones to use [VR] especially in younger grades.

Skyler: Not having enough headsets or phones available for all students.
Carter: Not sufficient access to technology.

These survey responses highlight how PSTs perceived that equity of access was a major hurdle to integrating VR into their instruction.

Comfort of Students Over one third of the PSTs identified maintaining the comfort of students as a barrier to integrating VR into their classrooms.

Ashley: Making sure the students are comfortable with using the equipment.
Nicky: People getting dizzy.
Frankie: Kids with glasses may struggle.

The responses from PSTs about their concerns for the comfort of their future students are similar to their personal experiences outlined in Theme 1.

Classroom Management Half of the PSTs expressed classroom management fears for issues that could arise during teaching with VR. Classroom management consists of comprehensive skills for leading a class. Working through technical issues, keeping students on appropriate content, and maintaining student participation were all classroom management issues raised by the PSTs.

Parker: Getting all students to participate.
Peyton: Children exploring the app and finding something inappropriate.
Nicky: No Wi-Fi, confusing.

As outlined above, PSTs identified numerous classroom management fears related to teaching with VR. Classroom management fears contributed toward Theme 2 – PSTs perceive a variety of barriers to integrating VR into their classrooms.

Discussion

The purpose of this study was to investigate PSTs' experiences using VR, as well as their perspectives on VR in the elementary classroom. Using the TAM framework as a lens, the findings of this study reveal that PSTs conveyed low perceived ease of use with VR. Participants reported general discomfort with smartphone headset VR. Furthermore, the PSTs described low perceived usefulness with VR. The participants explained that they perceived a variety of barriers to integrating VR into their classrooms, and they had a wide range of further questions about VR before feeling comfortable with integrating it into their instruction.

(RQ #1) What are PSTs' Experiences Using VR?

The PSTs described experiences with blurriness and sickness while exploring the VR worlds across their hour and fifteen-minute VR exposure time. These findings are consistent with previous research (Moro & McLean, 2017; von Mammen et al., 2016) in different contexts that described discomfort among participants who used head-mounted VR devices like the headsets used in this study. Settgast et al. (2016) reported that VR cybersickness can include vision problems and symptoms of headaches and nausea. If the participants' exposure time to VR were shortened, perhaps the reports of cybersickness would subside. However, MacQuarrie and Steed (2017) explained that cybersickness may be in part attributed to a lack of peripheral vision in VR headsets. A lack of peripheral vision may explain one noteworthy participant experience. One PST described their specific discomfort as feelings of claustrophobia while using VR. Claustrophobia is exemplified by a fear of bodily restriction (Rachman & Taylor, 1993). Interestingly, while the PST felt claustrophobic with the restrictive strap-on head-mounted Merge headset, they noted they did not feel nearly the same effects with the Google Cardboard headset which is designed to be held up to the eyes like binoculars. The Google Cardboard headset provided them with the ability to quickly disengage the VR experience when they felt claustrophobic. This finding may warrant further, generalizable research to determine if binocular-like headsets that users hold up to their eyes are preferable to mitigate cybersickness. These data illuminate insights into how PSTs experience discomfort with VR.

In addition, the PSTs characterized the VR headsets as cumbersome. The PSTs explained that the headsets were heavy, their glasses did not fit the headsets, and pressing the buttons on the headsets to navigate the menus and VR options were difficult. The PSTs' experiences with their eyeglasses not fitting into the VR headsets is a distinctive finding of this study and is important to PST education and VR design in general. According to data from The Vision Council (2013), over half of all Americans use some type of vision correction. Therefore, VR headsets not fitting users' eyeglasses may be a potential barrier to more widespread consumer adoption. Participants also reported cumbersome interactions with the VR hardware. Merchant (2012) noted that virtual environments can be interacted with through either hardware (e.g., physical buttons, screen touching) or software (e.g., gaze tracking, hand tracking) controls. The quality of interactive components is essential for human-machine interaction (Mayer & Fiorella, 2014). Parong and Mayer (2018) noted that well-designed VR includes intuitively placed multimedia elements and controls with which users may interact. Indeed, inefficient, or ineffective selection and navigation in VR apps can be frustrating to users (Alghofaili et al., 2019) and such VR design issues can lead to students finding themselves out of place, confirming the experiences of participants in this study. Thus, participants' experiences with blurriness, headaches, and cumbersome VR hardware indicate that PSTs experience discomfort using VR.

In summation, the PSTs' responses document their challenges with using VR. These findings indicate that the PSTs perceived the VR to have a low ease of use rating. Based on the TAM, PSTs are unlikely to accept and adopt VR due to perceived ease of use issues with the technology's cumbersome hardware and software, as well as the potential for cybersickness.

(RQ #2) What are PSTs' Perspectives on VR in the Elementary Classroom?

This study also investigated PSTs' perceptions of VR in the elementary classroom. PSTs perceived a variety of barriers to integrating VR into their classrooms. Participants perceived accessibility to be a barrier to integrating VR into the elementary classroom. While this finding may be attributed in part to the number of special education major PSTs in the sample, considerations related to access and inclusivity are realities within teaching and are applicable to most teaching contexts. As the participants noted, VR accessibility is, indeed, limited for those with a disability (Hamilton, 2018; Thiel & Steed, 2021). The PSTs' concerns about students with eyeglasses being able to participate in VR activities represent a legitimate concern for VR design in general because according to the National Center for Health Statistics (2021), around 25% of children ages 2–17 in the United States wear glasses. Furthermore, Thiel and Steed (2021) note that VR users are primarily controlling the device through their own body movements, which is problematic for those with limited mobility. Simulation sickness, motor impairment, hearing loss, and photosensitive epilepsy present other barriers for VR users (Hamilton, 2018). Some VR platforms, apps, and advancements have increased accessibility (e.g., Half-Life: Alyx and Job Simulator; eye tracking) in order to create more inclusive options. However, most VR platforms have yet to address these barriers (Hamilton, 2018).

PSTs perceived equity of access to VR technologies as an additional barrier to integrating VR into the elementary classroom. The digital divide – the gulf between those who have access to technologies and those who do not – is a long-standing, prevalent issue in education (Scheerder et al., 2017; van Dijk, 2020). For example, high speed internet and computer access is strongly correlated with students' socioeconomic status and race/ethnicity (Singh et al., 2020). Galanek et al. (2018) have explained that smartphones are significantly more likely to be important to non-white students, those of lower socio-economic status, and those with disabilities. In her seminal piece on the digital divide, Damarin (2000) explained that equity of access to technology in education "requires that instructors recognize and adapt their technologically-enhanced instruction to a wide variety of students" and their levels of access to technologies (p. 18). This research reinforces findings by Bower et al. (2020) which noted access as an external barrier that concerned PSTs about integrating VR. Furthermore, this study's findings reinforce those from a study by Figueroa-Flores and Huffman (2020) that explained that the majority of codes associated with PSTs' perceptions of the limitations of VR in the classroom were either about access to VR technology (44%), or the cost of integrating VR into the classroom (31%). It is important to note that some schools may have VR equipment checkout systems available to students, helping reduce this barrier (Colegrove, 2019; Hayes, 2023). In summation, these data indicate that equity of access to VR technologies represents a significant barrier for teachers as they integrate VR instruction.

The comfort of students was also a perceived barrier to PSTs. The researchers believe this finding is likely connected to the discomfort PSTs experiences while using VR. However, this critique of VR is not without scientific precedent. Shibata et al. (2011) and Howarth (2011) found that the disassociation of convergence and accommodative eye demands within a VR headset may contribute to visual discomfort. Cybersickness, or feelings of unease beyond visual discomfort, may be caused by a disconnect between the eyes and inner ear balance mechanisms from a lack of peripheral vision in VR headsets (MacQuarrie & Steed, 2017). Turnbill and Phillips (2017) noted that visual comfort concerns are prevalent in relation to VR headsets. However, Turnbill and Phillips (2017) found no adverse ocular-specific effects, such as myopia, in relation to young adults wearing VR headsets for 40-minute timeframes. However, concerns about children wearing VR headsets may persist until more research can be performed because children have a shorter pupillary distance than adults, the demographic for which VR headsets are often calibrated (MacLachlan & Howland, 2002). To address the comfort issues, Fegely at al. (2020) and Hagan et al. (2020) suggest that teachers remind elementary students to remove their VR headsets if they begin to feel discomfort or anxiety. Altogether, these data suggest that any adverse effects experienced by students in VR are temporary, and such discomfort can be addressed by teachers advising students on what to expect and protocols for if students begin to feel uncomfortable.

PSTs described classroom management fears associated with VR-centric activities. While this finding may be attributed to the large number of special education PSTs in the sample, behavior concerns are commonly at the forefront of PSTs' concerns across specializations (Stoughton, 2007). Research by Figueroa-Flores and Huffman (2020) noted that 15% of all codes from their qualitative data about their PST participants' perceptions of the limitations of VR in the classroom were about the time associated with integrating VR in the classroom. This study also supports research by Cooper et al. (2019) that notes Australian PSTs had concerns about classroom monitoring and the cost of implementing VR in the classroom. Indeed, such fears are legitimate because VR is a relatively new technology and VR lesson pedagogy and classroom management strategies are in their infancy (Fegely et al. 2020; Hagan et al. 2020). Further, Attwood et al. (2020) found no association between secondary PSTs who used VR within the past five years and their perceptions of VR's benefits for learning classroom management, indicating that PSTs' experiences with VR and their perceptions about VR classroom management are not influenced by each other. These data indicate that PSTs are likely to foresee classroom management barriers related to VR implementation.

These hesitancies related to inclusivity, equity, and classroom management can be explained by the short treatment of this study. The researchers posit that as PSTs gain more experience and comfort with VR, a number of these perceived barriers may be placated. Supporting this perspective, Attwood et al. (2020) have advocated for greater integration of VR experiences in teaching methods courses to assist PSTs with becoming comfortable with VR and classroom management skills. Some of the PSTs' perceived barriers are not easily remedied, however. For example, PSTs' questions about equity of access to VR technologies are context-based within PSTs' future schools and teaching positions. As Figueroa-Flores and Huffman (2020) highlight, equity of access continues to be the biggest hurdle of VR integration. "If students don't have access or school districts can't afford them," explain Figueroa-Flores and Huffman (2020), then VR technologies cannot be used, therefore "More research needs to be done in this area" (p. 8). As the VR market is expected to grow significantly in the coming years (Johnson, 2019), access issues may shrink as an area of concern. In summary, PSTs' perceived barriers to VR integration outlined in the literature aligned with the barriers to VR integration perceived by the PSTs.

As detailed above, these findings indicate that PSTs perceive numerous barriers that impact VR's perceived usefulness for them in the elementary classroom. The PSTs did not perceive VR as a new technology that could increase their performance as teachers. Based on the TAM, it is unlikely that the PSTs will integrate VR into their future instruction. Next steps are outlined in the "Practical Implications" section.

Practical Implications

This study contributes to the limited literature specifically on VR in the teaching methods classroom. The findings provide a portrait of PSTs' perspectives on VR technology and contribute toward an array of best practices for TMIs as they introduce PSTs to VR. Based on the TAM, these combined findings suggest that PSTs are unlikely to accept VR and adopt it in their teaching. However, these findings can be used to inform practical techniques TMIs can use to preempt low perceived ease of use and perceived usefulness among PSTs as they facilitate VR instruction in the teaching methods classroom, outlined below.

Consider Not Using VR Headsets

While using VR headsets may facilitate a more immersive experience for PSTs, not using VR headsets - at least at first - can eliminate the perceived ease of use practical issues experienced by the PSTs in this study such as blurriness, headaches, and claustrophobia. Similarly, not using headsets may eliminate the cumbersomeness of interfacing smartphones with VR headsets, issues changing screens, and navigation issues. Alternatively, TMIs could use both handheld and headset-based deliveries for their VR lessons. Handheld deliveries could be used for the informational aspect and the exploration of different VR apps/experiences, while the headset-based deliveries could be included as an optional immersion experience. While using VR headsets, TMIs could instruct PSTs to take VR headsets off if they experience discomfort or nausea and explore the VR through the handheld interface instead. Pivoting instruction to encourage PSTs to explore VR experiences through a handheld format also eliminates the cost of acquiring a full class set of VR headsets, which eliminates an additional barrier to implementing VR lessons in the teaching methods classroom.

Cover the Cost and How to Obtain VR Equipment

TMIs can present their students with current information on the expected costs of implementing class-wide VR based on different contemporary devices. TMIs may cover possible local, state, and national grants, as well as crowdsource funding (e.g., DonorsChoose) opportunities to obtain money for class VR integration. In addition, TMIs can share lesson frameworks that utilize a smaller number of VR devices in a station rotational model, such as a three-group blended learning rotational model (McKenzie & Fegely, 2023). By informing PSTs of both the expected cost of obtaining a full class set of VR materials as well as a lower-cost alternative teaching strategy for VR instruction with fewer VR materials, PSTs will be prepared for different possible real-world teaching scenarios. In turn, this may preempt perceived access barriers among PSTs.

Model Classroom Management Strategies

To address concerns about VR classroom management, TMIs can model VR pedagogical and classroom management strategies in their teaching methods instruction. For example, TMIs can model best practices by performing a class-wide VR test-run to ensure PST comfort and understanding (Fegely et al. 2020; Hagan et al. 2020). TMIs can also model guidance from Fegely et al. (2020) and Hagan et al. (2020) that encourages teachers to review classroom management expectations with students before beginning a VR lesson, such as remaining stationary in chairs with proper spacing between each student, note-taking protocols, as well as using headphones to avoid echoing audio. By TMIs modeling these pedagogical and classroom management practices, PSTs will be able to learn VR classroom management strategies and develop their VR classroom management self-efficacy.

Discuss Inclusivity and Accessibility Solutions

PSTs were concerned about the inclusivity and accessibility of VR. This concern is justified because there are numerous barriers to VR for individuals with disabilities and there is a great need for research and development in this area (Hamilton, 2018; Thiel & Steed, 2021). At the same time, several adaptations or accommodations are possible. For example, if a student has limited range of motion or is more prone to falling, using a hand controller can allow them to move without walking or moving their arms (Hamilton, 2018). Hamilton (2018) also notes that there are simple things that can help with simulation sickness such as talking about the comfort of the experience or avoiding fast head movements in order to minimize the possibility of the headset moving. Unfortunately, several perceived ease of use and perceived usefulness barriers have yet to be addressed in VR. Students with hearing loss, visual impairment, or photosensitive epilepsy will have fewer options that are accessible to them (Hamilton, 2018).

Limitations & Future Research

Based on these exploratory findings, future research can generate deeper lines of inquiry and resultingly deeper understandings of PSTs' experiences and perspectives related to VR. While the BYOD approach to this study reflects contemporary post-pandemic trends, it is a limiting factor. For future studies, the researchers suggest focusing on specific VR hardware, expanding the variety of VR apps the participants use, integrating individual interviews as a data collection strategy, and triangulating qualitative data with additional quantitative measures. This study is limited by the open response surveys and sample which included a significant number of special education PSTs. Deeper insights and connections between research questions may be ascertained through in-depth individual interviews.

Conclusion

Teachers' perceptions of students' learning needs have been suggested to be indicators of their future instruction and technology usage (Sullivan & Moriarty, 2009). Furthermore, guidance from the TAM framework explains that only technologies with strong perceived ease of use and perceived usefulness are likely to be adopted by users (Granić & Marangunić, 2019). Therefore, PSTs' discomfort using VR and their perceptions that there are numerous barriers to implementing VR in the elementary classroom may indicate apprehension to integrate VR into their future lessons.

As TMIs design teaching methods VR instruction, this study's practical implications can aid TMIs as they create instruction that addresses potential perceived ease of use and perceived usefulness VR issues and reduces the perceived barriers that may discourage PSTs. Through this preemptive strategy, TMIs can better develop PSTs' confidence to integrate VR into instruction, increasing the probability that they will integrate this transformative technology into their future instruction.

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Declarations

Research Involving Human and Animal Rights Human participants only.

Informed Consent Protocol #2020.121 was approved as exempt by the Coastal Carolina University Institutional Review Board (IRB) under the Federal Policy for the Protection of Human Research Subjects categories #1& 2. Informed consent was provided by participants.

Conflicts of Interest The authors declare that they have no conflict of interest.

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