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Investigating Factors Influencing Preservice Teachers' Intentions to Adopt Virtual Reality: A Mixed-Methods Study

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Abstract: As virtual reality (VR) becomes increasingly integrated into educational settings, understanding preservice teachers' (PSTs) perceptions and training needs is crucial for effective classroom implementation. Although existing research emphasizes VR's educational benefits, limited studies have explored how direct, hands-on VR experiences impact PSTs' intentions to adopt this technology. This mixed-methods study addresses this gap by examining factors influencing PSTs' willingness to adopt VR and identifying challenges hindering adoption following immersive VR activities using Oculus Quest. Structural equation modeling (SEM) analysis indicated that perceived usefulness and enjoyment directly influenced PSTs' intentions to adopt VR, whereas self-efficacy indirectly influenced intentions through perceived usefulness. Qualitative findings revealed that PSTs' initial reluctance to adopt VR, primarily due to low self-efficacy and limited VR knowledge, decreased after hands-on experiences, leading to increased willingness to integrate VR into their teaching practices. However, concerns regarding VR's appropriateness for young learners, potential health risks such as motion sickness, and classroom management challenges persisted. These results underscore the need for targeted VR training in teacher education programs, focusing on enhancing PSTs' perceived benefits, enjoyment, and self-efficacy while addressing pedagogical and health-related barriers.

Keywords: perceived usefulness; enjoyment; self-efficacy; presence; concerns; technology acceptance; technology integration barriers

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1. Introduction

Virtual Reality (VR) is a computer-generated simulation or interactive environment that replicates reality [1]. It offers users the feeling of immersion and real-time interactivity through a wearable head-mounted display that tracks the user's movement and position, modifying the virtual world instantaneously based on the actions of users [2,3]. The concept of VR originated in the 1960s with early innovations such as the Telesphere Mask by Morton Heilig and the "Ultimate Display" by Ivan Sutherland [2,4]. However, due to high costs, early applications of VR were primarily limited to government and academic research settings [5].

With significant technological advancements, VR is being utilized across various fields today, including medical surgeries, construction safety training, mental health, and education [6–9]. The unique ability of VR to create secure and controlled environments for learning—allowing users to visit places, interact with objects, or engage with scenarios that may be difficult, impractical, or unethical to replicate in real life—has captured the attention of scholars and educators [9,10]. Educational research also highlights several learning benefits of VR, including enhanced student information retention [11] improved communication skills [12], and increased student engagement and academic performance [13].

Despite these advantages, the large-scale implementation of VR in classrooms remains limited due to several barriers [14]. A review of 82 studies on VR applications identified challenges such as a lack of standardization, high costs, and health-related concerns [2]. While the cost of VR technology has decreased, setting up a fully equipped VR classroom can still require significant financial investment, with expenses reaching thousands of dollars, depending on the equipment chosen [1,15]. Additionally, prolonged use of VR headsets has been linked to cybersickness, including headaches, neck strain, and nausea [16].

As investment in VR technology is projected to grow to USD 441.84 billion by 2030 [17], ensuring its effective integration in education requires preparing pre-service teachers (PSTs) with proper training [18,19]. PSTs' perceptions and experiences with VR significantly impact their intentions to adopt and integrate it into their future teaching practices [20]. However, existing research (e.g., [19,21]) has primarily explored PSTs' general attitudes toward VR without providing direct experiences. This gap limits understanding of how practical VR interactions shape PSTs' perceptions regarding the technology's usefulness and their readiness to integrate it effectively into their instructional practices. Without firsthand exposure, PSTs may lack an understanding of VR's practical applications and feasibility, leading to its underutilization in classroom settings [18,20,22].

This study addresses these gaps by investigating PSTs' adoption intentions following direct, hands-on experiences with VR educational applications. Using a mixed-methods approach, data were collected from 163 PSTs who interacted with five different VR applications via Oculus Quest and completed an online survey assessing their adoption intentions. The study is guided by the following research questions: (a) What factors influence PSTs' decisions to adopt VR for teaching? and (b) What challenges hinder PSTs' adoption of VR for teaching? By addressing these questions, the study is expected to provide valuable insights into PSTs' perspectives on VR integration and offer practical recommendations for effectively incorporating VR into teacher education programs.

2. Theorical Backgrounds

2.1. Teacher Technology Integration: Perceived Usefulness and Self-Efficacy

Prior research has shown that teachers' adoption of technology is influenced by a complex interplay of various factors, making it challenging to address them in isolation due to their interconnected nature [23,24]. Ertmer [25] examined key factors influencing teachers' technology integration and identified two primary categories of barriers: first-order barriers and second-order barriers. First-order barriers are external to teachers' control and include access to technology, availability of teacher professional development, technology funding, and administrative support. Second-order barriers are internal to teachers and include teachers' beliefs about the usefulness of technology on student learning and teachers' self-efficacy in using technology in the classroom. Ertmer et al. [26] explained that when teachers begin implementing new instructional approaches, first-order barriers are likely to affect teachers' decisions on technology use as opposed to teachers' established beliefs. However, when this first-order barrier threshold is overcome, second-order barriers play a more important role in impacting the quality and quantity of technology integration in the classroom [26,27].

Researchers have found that if teachers do not value technology use, technology integration efforts are likely not to succeed [28]. For example, Chand et al. [29] reported that the evaluation of the "smart-class" initiative implemented in over 1600 public schools in India did not demonstrate any significant impact on students' subject knowledge, attitude toward subjects, and subject self-efficacy beliefs. A follow-up study revealed that public school teachers in India value knowing content more than the learning process, and some teachers

felt the e-content provided challenged teacher authority and autonomy, which caused teachers' resistance to technology integration. A study by Donnelly et al. [30] also demonstrated that if a teacher does not believe the open nature of technology use is beneficial for student learning, they likely consider integrating technology pedagogically unsuitable.

The availability of VR in recent years has allowed researchers to examine PSTs' adoption of VR in their future classrooms, revealing that teachers' beliefs about VR significantly influence their intention to use it. For instance, Adelana et al. [31] surveyed 231 PSTs and found that perceived usefulness strongly predicts PSTs' readiness and behavioral intention to use VR. Similarly, Eutsler and Long [32] reported that PSTs who held positive perceptions of VR's potential to enhance student engagement indicated their intention to adopt VR in their future classrooms. Based on the previous studies, the current study predicts that PSTs' perceived usefulness of VR use for student learning would positively affect their intention to integrate VR in their future classrooms. Thus, the following hypothesis is proposed:

H1. *PSTs' perceived usefulness of VR use positively affects their intention to use VR.*

Heath [33] argued that although teachers' beliefs in the usefulness of technology are crucial, these beliefs alone do not ensure successful technology integration. Teachers are likely not to use technology if they do not feel confident in integrating technology even though they believe in the importance of technology. Self-efficacy in technology integration refers to a teacher's perceptions of and capabilities to integrate technology into the classroom [34]. Siddiq et al. [35] reported that teachers with a higher level of technology self-efficacy are likely to integrate technology more in the classroom. Kwon et al. [36] found that teachers' self-efficacy toward using technology predicts technology integration and suggested that teachers are more likely to believe using technology is useful when they feel confident in using technology. Similarly, Al Breiki et al. [37] investigated science teachers' adoption of VR and highlighted the importance of perceived skills. These previous studies revealed that perceived readiness in skills significantly influences attitudes towards utilizing VR, thereby impacting the adoption of VR in their teaching practice. Based on the prior studies' findings, the current study introduces the following hypotheses:

H2. *PSTs' perceived self-efficacy in VR use positively affects their intention to use VR.*

H3. *PSTs' perceived self-efficacy in VR use positively affects their perceived usefulness of VR use.*

2.2. Virtual Reality Enjoyment

Perceived enjoyment has emerged as a crucial factor in technology adoption, complementing the role of perceived usefulness [38]. Perceived enjoyment is defined as "the extent to which the activity of using a specific system is perceived to be enjoyable in its own right, aside from any performance consequences that may be anticipated" ([39] (p. 1113)). Koenig-Lewis et al. [40] claimed that users adopt a new technology not just as a tool to enhance performance but also as a source of enjoyment. Davis et al. [39] found that individuals' intentions to use technology in the workplace are primarily influenced by their perceptions of its usefulness in enhancing job performance, while the enjoyment of using the technology plays a secondary role.

Studies have examined the relationship between perceived enjoyment and intention to use, perceived usefulness, and perceived self-efficacy and found a significant positive relationship [41,42]. For instance, Dickinger et al. [43] found that perceived enjoyment of using a mobile service is a strong factor affecting users' attitudes and intentions to use a mobile service. Liu et al. [44] tested university students' intention to use library mobile applications and confirmed a significant positive relationship between enjoyment and

perceived usefulness. Yi and Hwang [45] found that a sense of enjoyment in using a new system helps users feel confident in their ability to use the system.

Several recent studies also reported a positive relationship between enjoyment of VR and users' intention to use it. For example, Lee et al. [5] studied user acceptance of VR and found that perceived enjoyment of VR both directly and indirectly influences users' intention to use VR. A study by Jang and Park [46] also confirmed that perceived enjoyment is a significant determinant of users' intention to use VR games. From these findings, the study includes the following hypotheses for the present study:

H4. *PSTs' enjoyment of VR use positively affects their perceived usefulness of VR use.*

H5. *PSTs' enjoyment of VR use positively affects their intention to use VR.*

H6. *PSTs' enjoyment of VR use positively affects their perceived self-efficacy in VR use.*

2.3. Virtual Reality Presence

What distinguishes VR from other technologies is its ability to make users feel like they are in a simulated environment [47]. The concept of 'presence" is an illusion of "being there," and it is widely defined as users' sense of psychologically leaving their physical location and feeling as if they are transported to a virtual world [48]. Users who perceive a level of presence feel like they are there, and thus they are more likely to feel immersed in VR environments when they interact with objects and characters [46].

Tussyadiah et al. [49] claimed, "Findings from previous research on presence in VR demonstrate that the enhanced sense of reality during a VR experience increases enjoyment and values of the VR experience, generates positive consequences on attitude, belief, and intention, and increases performance". (p. 143). Several studies presented the relationships between presence and enjoyment and perceived usefulness. Jensen and Konradsen [50] reviewed 10 VR studies that examined learner attitudes toward VR use and reported that study participants perceived using immersive VR as useful for learning, and the VR experience is enjoyable and fun. Mikropoulo and Natsis [51] reviewed 53 VR related research studies published from 1999 to 2009 and found three studies demonstrating positive learning outcomes through VR presence. In these studies, students performed their learning tasks successfully when they experienced a high sense of presence and showed focused learning during the exposure to the VR learning environment. Based on previous findings, the study adds the following hypotheses:

H7. *PSTs' VR presence experience positively affects their enjoyment of VR use.*

H8. *PSTs' VR presence experience positively affects their perceived usefulness of VR use.*

3. Methods

3.1. Overview of Methods

Based on the eight hypotheses derived from previous research, an online survey was designed to collect both quantitative and qualitative data. This study utilized a convergent parallel mixed-methods design, where data were collected simultaneously but analyzed separately [52] to examine both the factors influencing PSTs' decisions to adopt VR and the barriers hindering its adoption. Structural Equation Modeling (SEM) was used for quantitative analysis while open codes were applied to qualitative responses to gain deeper insights into participants' perspectives. The following sections detail the data collection and analysis procedures.

3.2. Participants

A total of 163 PSTs from a southeastern U.S. research university participated in the study. These participants were enrolled in a required teacher certification course taught by the researcher. One of the course objectives was to explore emerging technologies in content teaching. To meet this objective, VR was introduced, and participants had the opportunity to explore educational VR applications (apps) and reflect on ways to integrate them into their future classrooms. The majority of participants were female (89.4%), with most majoring in Elementary Education (51.5%) and Early Childhood Education (22.8%). Sophomores (45.4%) and juniors (38.7%) comprised the largest groups. The sample was predominantly White (93.3%), with limited representation from other racial groups. Regarding VR experience, 63.8% of participants were unfamiliar with Oculus Quest, while only 3% reported being very or extremely familiar with the device (See Table 1 for details).

Table 1. Participants' Demographic Information.

Variable	Category	Frequency (*n*)	Percentage (%)
Gender	Female	146	89.4
	Male	15	9.2
	Prefer Not to Say	2	1.4
Major	Elementary	84	51.5
	Early Childhood	37	22.8
	Social Studies	19	11.7
	Special Education	17	10.4
	Spanish Education	3	1.8
	Others	3	1.8
Year	Freshman	9	5.5
	Sophomore	74	45.4
	Junior	63	38.7
	Senior	17	10.4
Ethnicity	White	152	93.25
	Black	3	1.84
	Latinx	3	1.84
	Asian	2	1.23
	Others	3	1.84
Familiarity of Oculus Quest	Not familiar at all	104	63.8
	Slightly familiar	38	23.3
	Moderately familiar	15	9.2
	Very familiar	4	2.45
	Extremely familiar	1	0.61

3.3. VR App Selection

The researcher selected five educational VR apps for participants to explore. To identify appropriate apps, the researcher reviewed various educational VR recommendation websites and examined user experiences shared on online platforms such as Reddit and the Meta Store (previously known as the Oculus App Store). Apps were chosen based on four key criteria: (1) relevance to participants' academic majors, such as social studies and elementary education; (2) high interactivity levels, prioritizing apps that promote active participation and hands-on object manipulation rather than passive observation; (3) ease of use, excluding apps considered overly complex or difficult for VR beginners; and (4) affordability, choosing free or low-cost options to encourage PSTs to explore educational VR without financial constraints. Due to limited class time, participants were only able to

explore approximately five apps, spending about 10 min on each. Therefore, once five apps were selected out of the 12 initial app list, no additional exploration was conducted. Table 2 summarizes the selected apps along with the rationale for their selection.

Table 2. Apps Used for VR Exploration.

App Name	Educational Purpose	Price
Anne Frank House	The app was introduced as a VR lesson example in social studies class. The app provides users with an opportunity to visit the Secret Annex virtually.	Free
Wander	The app was integrated to help PSTs explore the possibility of providing virtual field trips.	USD 9.99
Ocean Rift	The app was demonstrated as an example of using VR for science content learning. The app allows students to learn and interact with underwater animals such as dolphins, sharks, and turtles.	USD 9.99
Mondly	The app was introduced to show how VR can be used to improve foreign language skills. It puts users into a virtual environment (e.g., flight, taxi) where they talk with a virtual avatar using a chosen language.	USD 14.99
Notes on Blindness	The app was introduced to show that VR can be used to promote empathy. The app describes the life experience of John Hull who became completely blind after years of failing sight.	Free

3.4. Data Collection

This study utilized a pre-survey and post-survey instrument to assess PST's perceptions and experiences with VR. The pre-survey included items on demographics (e.g., major, gender, ethnicity), familiarity with VR technology, and their initial intention to adopt VR in future classrooms. To assess adoption intention, participants responded to a multiple-choice question with three options: Yes, Maybe, or No, followed by an open-ended question asking them to explain their reasoning. This survey was conducted before participants engaged with VR apps. Participants were asked to explore each of the five apps for about 10 min with a short break in between. During breaks, students discussed what they liked or disliked about the use of VR for teaching. After completing the VR exploration, participants completed a post-survey that measured five factors identified during the literature review process: perceived usefulness, self-efficacy, intention to use, enjoyment, and presence, along with open-ended questions.

To develop the perceived usefulness items, the researcher adapted items from Hur, Shen, Kale, and Cullen [53], which examined PSTs' intention to use mobile devices using structural equation modeling. The term "mobile devices" was replaced with "VR". Self-efficacy items were adapted from Wang, Ertmer, and Newby [54], originally containing 16 items measuring PSTs' self-efficacy in computer technology. Three items with high factor loadings directly related to classroom teaching were selected and modified from "computer capabilities" to "VR". Intention to use items were adopted from Venkatesh and Davis [55], where "system" was replaced with "VR" and specified for teaching use. Participants responded to each item using a 5-point Likert scale (1: strongly disagree to 5: strongly agree). These three constructs demonstrated high internal consistency, with

Cronbach's alpha values exceeding the satisfactory level of 0.7 [56]: perceived usefulness (0.91), self-efficacy (0.88), and intention to use (0.92).

Given that participants had just completed the VR session, the levels of enjoyment and presence were assessed using single items. Previous research has shown that single-item measures can exhibit reliability and validity, especially when the construct is straightforward, easily comprehensible, and focused [57,58]. For the "enjoyment" factor, participants were asked to answer how enjoyable the VR exploration was (1: not enjoyable to 5: very enjoyable). For the "presence" factor, respondents were asked to express to what degree they feel they were immersed in VR learning (1: not at all to 5: to a very great degree). The identified factors and associated measurement items used in this study are provided in Table 3.

Table 3. Constructs and Measurement Items.

Constructs	Items	Measurement Items	Item Level		Overall	
			Mean	SD	Mean	SD
Perceived Usefulness [53]	PB1	Integrating VR will enhance my teaching effectiveness.	4.15	0.79	4.18	0.73
	PB2	Integrating VR will help me teach a lesson in a more effective way.	4.26	0.81		
	PB3	Integrating VR will enhance my student learning.	4.32	0.76		
Self-Efficacy [54]	SE1	I feel confident that I have the skills necessary to use VR for teaching.	3.96	0.91	4.01	0.86
	SE2	I feel confident that I can successfully teach relevant subject content with the appropriate use of VR.	4.20	0.91		
	SE3	I feel confident that I understand the capabilities of VR well enough to utilize them in my classroom.	4.02	0.98		
Intention to Use [55]	IU1	Given that I have access to VR devices, I predict that I would use it for my teaching.	4.18	0.97	3.97	0.96
	IU2	I intend to adopt VR for my teaching.	3.85	1.03		
Enjoyment	EJ	How enjoyable is exploring VR apps using Oculus quest?	4.45	0.76	4.45	0.76
Presence	PR	To what extent do you feel that you are immersed in the virtual learning environment?	3.98	0.84	3.98	0.84

The rest of the survey included three multiple-choice questions and follow-up open-ended questions. As in the pre-survey, participants indicated their willingness to adopt VR in their future classrooms by selecting Yes, Maybe, or No, followed by an explanation of their reasoning. Additional multiple-choice questions assessed participants' experiences with motion sickness and the perceived difficulty of using VR. The post-survey also included two open-ended questions: one asked participants to describe their overall VR exploration experience, and the other inquired whether they would recommend continued VR integration in the course, along with their justification. The study was approved by the researcher's Institutional Review Board (IRB) and was determined to involve no more than minimal risk to participants. As a result, informed consent was waived in accordance with the Common Rule (45 CFR 46.116).

3.5. Data Analysis

3.5.1. Quantitative Data Analysis

To explore how identified factors affect participants' decision to adopt VR, this study employed structural equation modeling (SEM). SEM was chosen for its ability to evaluate the fit of theoretical models to empirical data and assess potential causal relationships among multiple independent and dependent variables [59]. This advanced statistical technique offers several advantages over traditional multivariate data analysis techniques, such as explicitly accounting for measurement errors, leading to more precise estimates of the relationships between constructs, and incorporating unobserved (latent) variables when studying abstract psychological or social constructs [59,60].

SEM encompasses the evaluation of two models: the measurement model and the path model. The measurement model relates latent (unobserved) variables to their observable indicators, and confirmatory factor analysis is used to evaluate the measurement model [60]. The path model, also known as the structural model, depicts the hypothesized causal relationships between variables, illustrating direct and indirect effects. The first step of SEM is model specification [59]. Based on the eight hypotheses developed, a research model was created (See Figure 1). In this proposed model, enjoyment and presence are exogenous variables (independent variables), while perceived usefulness, self-efficacy, and intention to use are endogenous variables (dependent variables). Perceived usefulness and self-efficacy also serve as exogenous variables for intention to use, demonstrating interrelationships among the five factors. The confirmatory factor analysis and measurement model were analyzed using SPSS Amos.

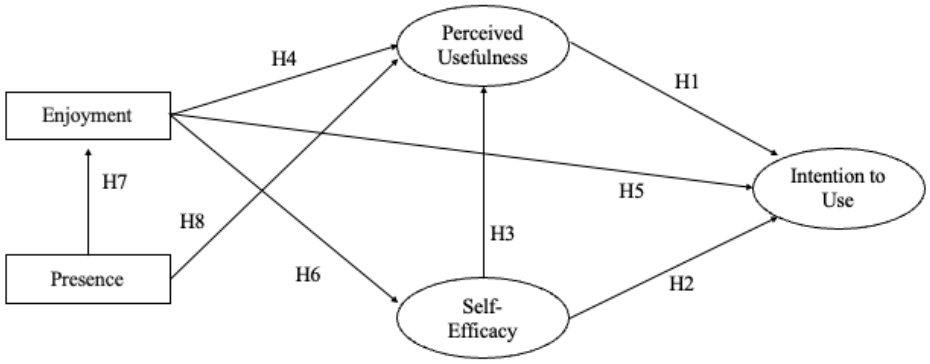

Figure 1. Proposed Research Model.

3.5.2. Qualitative Data Analysis

Qualitative data analysis was conducted using Taguette, a free and open-source qualitative research tool. The researcher first examined participants' adoption intentions and their reasoning by comparing pre-survey and post-survey responses, identifying similarities and differences in their choices and justifications. To analyze these responses, qualitative coding techniques were applied [61], including in-vivo coding (e.g., "fun", "interactive"), descriptive coding (e.g., "lack of experience", "age concerns"), and value coding (e.g., "promoting engagement", "providing different perspectives"). Additionally, participants' responses regarding their general VR experience and recommendations for future course adoption were coded. The researcher then created a comparative table to analyze coding patterns across pre- and post-survey responses, specifically focusing on the Yes and Maybe responses. During this process, codes related to the four exogenous variables (i.e., enjoyment, presence, perceived usefulness, and self-efficacy) from the quantitative analysis were refined. For example, the code "lack of experience" was renamed "lack of self-efficacy" and the code "promoting engagement" was reclassified as "perceived useful-

ness". Other codes related to barriers to adoption were also reviewed and re-categorized where necessary. For instance, the codes "lack of device", "students' misuse of device" and "breaking device" were consolidated into a new category, "classroom management issue". While the reasons for adoption remained largely consistent between the two surveys, notable shifts were observed in the reasoning behind Maybe responses. To identify emerging patterns, the frequency of maybe responses in both surveys was quantified, and variations in reasoning were compared to uncover meaningful trends.

To establish the trustworthiness of the qualitative research, this study adhered to Lincoln and Guba's [62] four criteria: credibility, transferability, dependability, and confirmability. Credibility, ensuring the findings align with reality, was enhanced through methodological triangulation by integrating both quantitative and qualitative analyses. Transferability, which concerns the generalizability of the findings, was addressed by providing a thick description of the data collection and analysis processes. To ensure dependability, referring to the consistency of the findings, the researcher engaged in peer debriefing, presenting codes and analysis outcomes to a peer with extensive educational research background for feedback. Confirmability, ensuring the degree of neutrality, was achieved by incorporating direct quotations into the findings to allow readers to verify the accuracy of the data analysis, thereby strengthening the rigor of the study [63].

4. Findings

4.1. Confirmatory Factor Analysis: Measurement Model

To check how well the measured variables represent each latent variable, this study first checked the measurement model by conducting a confirmatory factor analysis [60]. Internal consistency reliability was evaluated by reviewing the Cronbach alpha coefficient and the composite reliability (CR). All Cronbach's alpha values were above 0.85, and all CR values were above 0.85, meeting the minimum requirements of both criteria, 0.70 [64]. The convergent validity was reviewed based on each item's factor loading and each construct's average variance extracted (AVE). All factor loading was higher than 0.8, and AVE was over 0.5, demonstrating acceptable convergent validity [60]. For detailed results, please refer to Table 4.

Table 4. Internal Consistency Reliability and Convergent Validity Tests.

Constructs	Items	Factor Loading (>0.70)	AVE (>0.50)	CR (>0.70)	Cronbach's Alpha(>0.70)
Perceived Usefulness	PB1	0.88	0.77	0.91	0.91
	PB2	0.86			
	PB3	0.89			
Self-Efficacy	SE1	0.80	0.72	0.89	0.88
	SE2	0.83			
	SE3	0.90			
Intention to Use	IU1	0.92	0.82	0.90	0.92

Discriminant validity was examined based on the criterion suggested by Fornell and Larcker [65]. The criterion highlights that the square root of AVE should be greater than the correlation between the construct and other constructs. As demonstrated in Table 5, all constructs showed discriminant validity. Finally, the findings presented that the data fitted the model adequately according to the relevant indices: $\chi^2/df = 1.46$, $p = 0.099$, CFI = 0.99, GFI = 0.953, TLI = 0.98, NFL = 0.97, RMSEA = 0.60 [60].

Table 5. Discriminant Validity Test.

	Perceived Usefulness	Self-Efficacy	Intention to Use
Perceived Usefulness	**0.877**		
Self-efficacy	0.614	**0.85**	
Intention to Use	0.870	0.589	**0.91**

4.2. Structural Model and Hypothesis Testing

Figure 2 presents the outcomes of SEM analysis, which shows standardized path coefficients and the statistical significance of each path. The model showed a good fit. The χ^2/d.f. was 1.458 and $p = 0.053$, satisfying the fit threshold of 5.0 or less [66]. Other indices were higher than the recommended minimum value of 0.90: CFI = 0.988; AGFI = 0.909; GFI = 0.952; TLI = 0.982; NFL = 0.964. The RMSEA (0.053) was lower than the recommended maximum value of 0.06 [60]. As shown in Figure 2, perceived usefulness and enjoyment in this structural model accounted for 77.3% of the variance in intention to use VR. Additionally, perceived self-efficacy and enjoyment accounted for 46.3% of the variance in perceived usefulness.

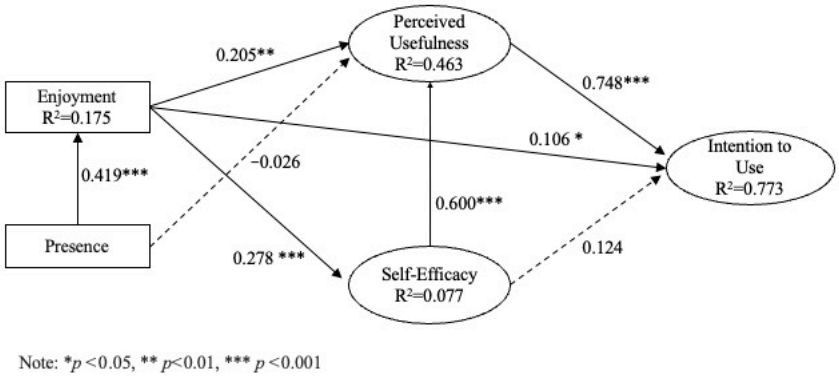

Figure 2. Outcomes of SEM Analysis.

The results of the hypothesis tests are shown in Table 6. All the proposed casual relationships are statistically significant except for H2 and H8. Specifically, two factors, perceived usefulness (H1, β = 0.748, Critical Ratio (C.R.) = 9.080, $p < 0.001$) and enjoyment (H5, β = 0.106, CR = 2.021, $p < 0.05$), have a notable impact on intention to use VR ($R^2 = 0.773$). The impact of perceived self-efficacy (H2, β = 0.124, CR =1.705, $p = 0.08$) on intention to use is found to be not significant. Perceived usefulness ($R^2 = 0.463$) is significantly impacted by two determinants: perceived self-efficacy (H3, β = 0.600, CR = 7.786, $p < 0.001$) and enjoyment (H4, β = 0.205, CR = 2.783, $p < 0.01$). However, the impact of presence (H8, β = −0.026, CR = 1.705, $p = 0.08$) on perceived usefulness is found to be not significant. Finally, presence (H7, β = 0.419, CR = 5.871, $p < 0.001$) significantly impacts enjoyment (R2 = 0.175), and enjoyment (H6, β = 0.278, CR = 3.452, $p < 0.001$) significantly impacts perceived self-efficacy ($R^2 = 0.077$).

Finally, to examine the influential impact of the four factors on the intention to use VR, the total effects of the constructs on the intention were computed. The results present: perceived usefulness (β = 0.748), self-efficacy (β = 0.573), enjoyment (β = 0.419), and presence (β = 0.156) are statistically significant at the 0.01 level. Findings also show the indirect effects of self-efficacy (β = 0.449), enjoyment (β = 0.312), and presence (β = 0.156) are statistically significant at the 0.05 level. This means while perceived self-efficacy and presence do not directly influence intention to use, these factors indirectly influence intention to use via perceived usefulness and enjoyment.

Table 6. Summary of the structural results.

Hypothesis	Standardized Coefficient	CR	*p*-Value	Results
H1: Perceived Usefulness → Intention to Use	0.748	9.080	***	Supported
H2: Perceived Self-efficacy → Intention to Use	0.124	1.705	0.08	Not Supported
H3: Perceived Self-efficacy → Perceived Usefulness	0.600	7.786	***	Supported
H4: Enjoyment → Perceived Usefulness	0.205	2.783	0.005	Supported
H5: Enjoyment → Intention to Use	0.106	2.021	0.043	Supported
H6: Enjoyment → Perceived Self-efficacy	0.278	3.452	***	Supported
H7: Presence→ Enjoyment	0.419	5.871	***	Supported
H8: Presence→ Perceived Usefulness	−0.026	−0.373	0.709	Not Supported

*** $p < 0.001$.

4.3. Qualitative Analysis Findings

A qualitative analysis of open-ended responses provided further insights into factors influencing PSTs' decisions to adopt VR and challenges hindering VR adoption. Initially, about 68% of PSTs indicated interest in adopting VR in their future classrooms. This initial willingness was primarily influenced by perceived usefulness, such as enhancing student engagement and understanding, as well as anticipated enjoyment. For example, P1 (Special Education, Junior) explained, "I would be interested in using virtual reality because I could see students really enjoying and appreciating the use of it. I also could see how it would allow for students to understand what is being taught in a new way and be able to visually experience things that they would not have beforehand".

Following the hands-on experiences with VR, the percentage of PSTs willing to adopt VR increased to approximately 82%. Participants continued to emphasize enjoyment and perceived usefulness as significant motivating factors. P2 (Elementary Education, Sophomore) remarked, "I really enjoyed using the VR headset because it gave me a glimpse into places and events I would not otherwise access. I think students will also enjoy the VR experience and stay engaged with materials as I was". Similarly, P3 (Elementary Education, Sophomore) described how the immersive nature of VR contributed to her increased enjoyment and better understanding of its educational benefits: "I really enjoyed having the opportunity to immerse myself in an experience. Virtual Reality is something that could truly help students with their learning in numerous subjects, and that's something I would never have thought of prior to completing the virtual reality experience myself".

PSTs initially indicated several challenges that hindered their adoption of VR. Before direct VR experiences, approximately 34% of participants were reluctant ("maybe"), primarily due to limited self-efficacy and insufficient understanding of VR technology. For example, P4 (Social Studies, Junior) stated, "I am not exactly sure what virtual reality entails. I think I could figure it out, but as of right now, I would not be comfortable with it". Similarly, P5 (Elementary Education, Sophomore) emphasized the importance of confidence for adoption: "I said maybe just because I would want to be fully confident in what I am teaching, so I would need to learn more before deciding".

Additional reasons for PSTs' initial reluctance included concerns related to age appropriateness, classroom management, and health considerations. Approximately 25% of PSTs were particularly concerned about age suitability and potential classroom distractions. For instance, P6 (Elementary Education, Sophomore) shared, "I said maybe because I will most likely be teaching a younger age group, and VR might be too distracting for them". Health-related concerns (about 8%) were also present. P7 (Elementary Education, Sophomore) shared, "I used it once before, and it personally made me a little motion sick. It might make younger children motion sick as well".

Following hands-on VR experiences, the percentage of PSTs indicating reluctance ("maybe") significantly decreased to around 17%. Although initial concerns related to self-efficacy diminished substantially to less than 2%, pedagogical challenges persisted. Over 70% of the remaining reluctant participants recognized VR's educational usefulness but continued to question its suitability for younger learners or students with special needs. For example, P8 (Elementary Education, Sophomore) explained, "The reason I say maybe is just because of the potential age groups I may have to teach. Younger children may get too distracted". Similarly, P9 (Special Education, Senior) elaborated, "As a special education major, I think it will depend on the student. If a student has sensory issues, I do not think it would be in their best interest to place them in a virtual reality environment".

Concerns regarding classroom management also remained persistent after experiencing VR firsthand, particularly related to logistics such as headset availability, student monitoring, and maintaining classroom discipline. For instance, P10 (Elementary Education, Junior) articulated:

> My main concern in using VR for my classroom is not having enough headsets for all students. The Oculus may have to be a station in the classroom, and I wonder if that is a good use of my time. I also wonder how I can monitor what students are viewing, since they may not want to view the educational games that I want them to. I would need a way to monitor their use and still effectively work with other students who do not have the headset at the time.

Finally, while health-related concerns were minimally mentioned in open-ended responses (less than 4%), post-survey quantitative data revealed that approximately 57% of PSTs reported experiencing mild dizziness, including about 9% who indicated substantial discomfort.

5. Discussion

5.1. Discussion of the Findings

This study aimed to identify factors influencing PSTs' adoption of VR for teaching and explore challenges hindering such adoption. The quantitative and qualitative findings provided complementary insights, particularly highlighting perceived usefulness, enjoyment, self-efficacy, and presence as influential factors while also revealing persistent pedagogical challenges such as age-appropriateness, classroom management, and health concerns.

In alignment with previous studies [31,32], perceived usefulness emerged as the strongest direct determinant of PSTs' intention to adopt VR ($\beta = 0.748$, $p < 0.001$). This finding supports prior research [24,26], which emphasized that teachers' beliefs about the positive impact of technology on student learning are critical for technology integration. Qualitative data reinforced this conclusion, with participants frequently emphasizing VR's educational benefits, such as enhanced student engagement and deeper learning through immersive experiences, as a major factor driving adoption. This confirms H1, suggesting that when PSTs perceive VR as an effective tool for student learning, they are more likely to integrate it into their future classrooms.

Enjoyment was another key factor influencing PSTs' adoption of VR, both directly ($\beta = 0.106$, $p < 0.05$) and indirectly through perceived usefulness and self-efficacy ($\beta = 0.312$, $p < 0.05$), supporting H4, H5, and H6. These findings indicate that the more PSTs enjoy the VR experience, the more likely they are to perceive VR as useful for student learning, feel confident using it for teaching, and intend to incorporate it into their classrooms. Participants' qualitative responses highlighted how personal enjoyment during VR activities positively shifted their attitudes toward adoption. This aligns with previous research emphasizing the role of enjoyment in technology acceptance [5,39] reinforcing the notion

that enjoyment can enhance engagement and willingness to adopt new technologies in educational contexts.

This study diverged from some previous research regarding perceived self-efficacy. Unlike prior findings [36], which identified self-efficacy as a direct predictor of technology adoption, this study did not find a significant direct effect of self-efficacy on PSTs' intention to use VR, rejecting H2. However, self-efficacy had a significant indirect effect on intention via perceived benefits ($\beta = 0.449$, $p < 0.05$), highlighting its essential mediating role. Qualitative data provided context for this discrepancy, revealing that initial low self-efficacy stemmed from limited understanding and confidence with VR technology. After hands-on experiences, PSTs' confidence and adoption improved, suggesting that building self-efficacy through experiential learning is crucial for the adoption of VR in classrooms. These findings also support previous studies [20,37], which suggested that skill readiness is a key factor in VR adoption. Regarding presence, the quantitative analysis found that a higher sense of presence significantly enhanced enjoyment, supporting H4 ($\beta = 0.419$, $p < 0.001$). This suggests that when users feel immersed in the VR environment, they are more likely to enjoy the experience, consistent with prior findings [46,49]. However, presence did not significantly impact perceived usefulness, rejecting H5 ($\beta = -0.026$, $p = 0.709$). This finding suggests that while immersion enhances enjoyment, it does not necessarily translate into perceived educational value. Simply feeling "being there" is not sufficient; the VR content itself must support meaningful learning experiences. This aligns with concerns raised in qualitative responses, where some participants noted that overly immersive experiences could be distracting rather than educational. These findings highlight the need for further research on designing VR environments that balance immersion with educational effectiveness.

Finally, qualitative findings provided deeper insights into persistent barriers affecting VR adoption. Pedagogical concerns, including age appropriateness, classroom management, and health risks, remained persistent even after PSTs' direct VR experiences. Participants expressed concerns about younger students becoming distracted and the difficulty of managing both VR equipment and non-VR students in the same lesson. These pedagogical issues continue to pose challenges for technology adoption. Additionally, health-related concerns, particularly dizziness and motion sickness, reaffirm previous research highlighting VR's potential negative side effects [2].

5.2. Implication of the Findings

This study offers both theoretical and practical contributions to VR use in the field of education. Theoretically, it extends existing models of teacher technology barriers by incorporating enjoyment and presence as key factors influencing PSTs' VR use in classrooms. The findings highlight the role of VR enjoyment, which has been underexplored in education despite its recognized importance in other fields [5,46]. Future research can expand on these findings to further explore PSTs' intentions to integrate VR into their classrooms.

Practically, this study provides valuable guidance on integrating VR into teacher education. One of the primary reasons for hesitancy in adopting VR before actual exploration in this study was a lack of understanding and confidence in using the technology, highlighting the need for structured VR training sessions. To successfully introduce VR in teacher education, the findings suggest highlighting the role of perceived usefulness and enjoyment. Providing hands-on experiences should include discussions on the educational benefits of VR and the selection of applications that are both engaging and pedagogically valuable. Additionally, helping PSTs develop confidence in navigating VR applications is

crucial, as it fosters a deeper appreciation for VR's instructional potential and supports its seamless integration into teaching practices.

The findings also highlight the importance of addressing PSTs' concerns when introducing VR. These concerns include the suitability of VR for young learners, potential motion sickness, and classroom management challenges. Manufacturers often provide age guidelines for VR usage; for example, the Oculus Quest 2 used in this study is recommended for ages 10 and up. Educators should guide teachers to follow the specific age and health guidelines associated with the VR devices being used. Providing strategies to minimize motion sickness—such as adjusting headsets, maintaining stable wireless connections, and limiting VR usage duration—is also crucial. Furthermore, integrating classroom management strategies tailored to VR can equip PSTs to seamlessly incorporate VR into their teaching. By addressing these factors, education programs can better prepare PSTs to effectively integrate VR technology into their future classrooms, maximizing its educational benefits while minimizing potential challenges.

Finally, the impact of enjoyment on perceived benefits has a suggestion for VR developers. When designing educational VR apps, developers should consider ways to make apps educationally enjoyable. Researchers have found strategies to make VR experiences more enjoyable, including adding social interactions, providing a customized experience, and increasing vividness to enhance user enjoyment [5,67]. By focusing on enhancing user enjoyment, VR developers can greatly enhance educators' perceived usefulness of VR learning experiences. This approach not only creates a more engaging learning environment but also encourages the adoption of VR in classroom settings.

5.3. Study Limitations and Future Research Directions

Although this study provides valuable insights into PSTs' perceptions about VR adoption, several limitations should be acknowledged. First, most participants were traditional-aged college students who had a lack of previous experience in using immersive VR tools. PSTs who are older or who have a wide range of previous VR experiences may perceive the VR exploration experience differently. Future studies should explore a more diverse group to gain a broader understanding of VR adoption in teacher education.

While other studies have indicated that ease of use is one of the important determinants of VR technology adoption (e.g., [68,69]), this study did not include the ease of use factor due to the following two reasons. To avoid technical issues hindering students' VR learning experience, the researcher assisted participants individually or as a small group while providing step-by-step explanations. Additionally, participants used five different apps, making it difficult to determine whether measuring the VR device's ease of use or each app's ease of use. While most participants did not encounter any technical issues, there were a few participants who expressed difficulties in navigating VR apps. This indicates that depending on PSTs' previous VR experiences, they may find VR use either easy or difficult, which can affect their confidence and perceived usefulness. Future studies should explore how the perceived ease of VR use affects participants' self-efficacy, perceived usefulness, and intention to use. Understanding this relationship can better help PSTs utilize VR more effectively in a teacher education classroom and future K-12 classrooms.

This study limited participants to approximately 10 min of exploration for each of the five VR apps, which helped minimize motion sickness. However, motion sickness remains a significant concern in VR research [70]. Future studies should examine how motion sickness affects PSTs' intention to use VR in their future classrooms by adding this as a possible factor to a research model. Finally, although previous research supports the use of single-item measures [58], future studies should incorporate multi-item scales for

measuring presence and perceived enjoyment to improve the reliability and validity of these constructs.

6. Conclusions

The findings of this study highlight the importance of integrating structured VR training into teacher education programs to equip PSTs with the necessary skills and pedagogical knowledge for effective classroom integration. Providing hands-on experiences that highlight both the educational usefulness and practical applications of VR is essential for fostering adoption. Engaging and immersive VR education apps can further strengthen PSTs' understanding of their instructional benefits, promoting greater integration. Additionally, addressing concerns related to classroom management, age appropriateness, and health-related issues can enhance PSTs' confidence in using VR while minimizing potential barriers. By providing targeted VR training, teacher education programs can better prepare future educators to leverage VR as a powerful instructional tool that enriches student learning experiences.

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