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FACTORS INFLUENCING STUDENTS' INTERACTION AND ADOPTION OF DIGITAL VIRTUAL REALITY IN CHINESE HIGHER EDUCATION INSTITUTIONS: A TAM-BASED APPROACH

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ABSTRACT

This study investigates the factors influencing students' willingness to engage in digital virtual reality environments within Chinese higher education institutions. Utilizing the Technology Acceptance Model (TAM) as a theoretical framework and employing Structural Equation Modeling (SEM), the study provides valuable insights into the dynamics of virtual reality adoption among first-year college students at Gansu Hexi University. A total of 1456 students participated in the study, with data collected through validated and reliable structured questionnaires. The findings demonstrate the pivotal role of attitudes as a mediating factor, establishing a causal relationship between key variables—Perceived Ease of Use (PE), Perceived Usefulness (PU), and Willingness (W)—and interaction behavior. Specifically, Perceived Usefulness significantly influences attitudes (path coefficient = 0.721), which, in turn, impacts interaction (path coefficient = 0.363) and willingness (path coefficient = 0.387). Furthermore, Perceived Ease of Use directly influences attitudes (path coefficient = 0.205), underscoring the significance of user-friendly systems in fostering positive engagement. Additionally, the results highlight the critical interplay between willingness and interaction, demonstrating how students' intentions directly drive actual engagement in virtual environments. These findings align with established TAM literature, reinforcing the importance of perceived utility and usability in shaping technology adoption behaviors. This study provides actionable insights for educators, designers, and policymakers seeking to enhance the integration of virtual reality in educational settings. By addressing the factors that drive interaction and willingness, this research contributes to the optimization of immersive learning experiences, ensuring that technology serves as a transformative tool in contemporary education. The findings pave the way for future research to further refine virtual reality applications, promoting engagement and experiential learning in the digital era.

Keywords: Technology Acceptance Model (TAM), Digital Virtual Reality, Student Attitudes, Interaction Behavior, Chinese Higher Education.

1.0 INTRODUCTION

In recent years, virtual reality (VR) technology has experienced rapid advancements, transformed industries and redefined the landscape of digital interaction. According to the Ministry of Industry and Information Technology (2018), the global VR industry transitioned from its initial cultivation phase to a rapid development phase in 2019. By 2025, China's VR industry is projected to be among the world's leaders in terms of overall strength. Furthermore, the VR retail market was anticipated to grow to USD $41.5 billion by 2020 (Blum, 2017).

Advancements in computer equipment and related technologies have made human-computer interaction an integral part of daily life. Designing effective control modes for human-computer interaction is now considered a crucial aspect of hardware development. Traditional human-computer interaction relies on two-dimensional interfaces characterized by windows, icons, and menus, with devices like the mouse and keyboard serving as primary interaction tools (Karambakhsh et al., 2019). As VR technology progresses, it promises to revolutionize these interactions, creating immersive, engaging, and user-centered experiences.

2.0 BACKGROUND

Virtual reality (VR) technology has undergone significant advancements, transforming various fields, including education. The Ministry of Industry and Information Technology (2018) projected that China's VR industry would rank among the global leaders by 2025, with substantial investments driving innovation and adoption. Unlike augmented reality, which overlays virtual objects onto the real world, VR fully immerses users in synthetic environments, offering a seamless and interactive experience (Carbonell & Bermejo, 2017). This transformative technology is reshaping the education landscape, fostering active student participation and enhancing teaching and learning processes.

Digital displays have evolved from static, paper-based formats to dynamic and interactive platforms that integrate advanced technologies like VR. These advancements allow for richer media, hypertext interactivity, and immersive digital displays, enabling users to engage with content at unprecedented levels. Interactive communication, a hallmark of Web 2.0 and evolving Web 3.0 technologies, allows students to explore virtual environments autonomously, interact with educational content, and tailor their learning experiences (Cengzhi et al., 2019). This paradigm shift reflects the growing importance of user interaction and engagement in digital environments, supported by tools like gesture recognition and eye-tracking systems, which enhance the sense of immersion (Somrak et al., 2020).

VR technology's ability to create realistic, simulation-based environments is particularly relevant for education. Students can interact with virtual objects, navigate complex scenarios, and experience three-dimensional visualizations that deepen their understanding of subjects. For instance, VR applications in digital museums enable learners to explore historical artifacts in lifelike detail, creating an engaging and interactive learning environment (Honghe, 2019). These features demonstrate VR's potential to revolutionize education by bridging the gap between theoretical knowledge and experiential learning.

The integration of VR into educational settings aligns with the Technology Acceptance Model (TAM), which emphasizes the importance of perceived usefulness (PU) and perceived ease of use (PEU) in shaping users' attitudes and behavioral intentions (Davis, 1989). Perceived usefulness reflects students' belief in VR's ability to enhance their learning outcomes, while perceived ease of use highlights the importance of user-friendly interfaces and seamless interaction. Together, these factors influence students' attitudes, which mediate their willingness to adopt and interact with VR systems. Positive attitudes foster greater engagement

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and willingness, translating into active participation in immersive learning environments (Venkatesh & Davis, 2000).

Interactivity is a critical variable in VR adoption, as it allows users to control and manipulate their virtual environments. This feature not only enhances the learning experience but also provides students with a sense of agency and autonomy (Kang et al., 2020). High-quality interaction, involving multiple senses such as sight, sound, and touch, creates a convincing sense of immersion that is essential for effective learning (Freina & Ott, 2015). The inclusion of advanced technologies, such as gesture recognition and optical tracking, further enriches the VR experience, making it more intuitive and engaging (Habib & Chua, 2019).

In the context of Chinese higher education, the adoption of VR technology offers significant opportunities to enhance teaching methods and student learning outcomes. Digital interactive teaching approaches, supported by VR, enable dynamic presentations, animations, and simulations that facilitate comprehension and improve efficiency (Lei et al., 2020). As educational systems increasingly integrate digital tools, VR emerges as a key component of modern pedagogy, bridging the gap between theoretical instruction and hands-on application.

This study examines the factors influencing students' interaction and adoption of VR in Chinese higher education institutions, focusing on the mediating role of attitudes within the TAM framework. By analyzing the interplay between PU, PEU, and user attitudes, the research sheds light on the psychological mechanisms that drive VR adoption. The findings contribute to the development of tailored VR platforms that address students' needs, ensuring an engaging and immersive learning experience. Ultimately, this research provides a theoretical foundation for leveraging VR technology to transform education, fostering innovation and enhancing the overall learning process. The study seeks to address the following research questions:

1. How do Perceived Ease of Use (PE) and Perceived Usefulness (PU) influence students' attitudes toward using digital virtual reality in education?
2. How does students' attitude toward digital virtual reality mediate the relationship between Perceived Ease of Use, Perceived Usefulness, and their interaction behavior?
3. What is the relationship between students' attitudes and their willingness to adopt digital virtual reality in education?
4. How does willingness to use digital virtual reality influence students' interaction behavior in immersive learning environments?

3.0 CONCEPTUAL FRAMEWORK

The development of a conceptual model for factors influencing students' interaction behavior and willingness in virtual reality environments builds on the foundations of the Technology Acceptance Model (TAM) (Davis, 1989; Venkatesh & Davis, 2000). This model (Figure 1) explores the interconnections between Perceived Usefulness, Perceived Ease of Use, Attitudes, Willingness, and Interaction Behavior, emphasizing their mutual influence within virtual reality contexts.

Figure 1: The TAM conceptual Framework

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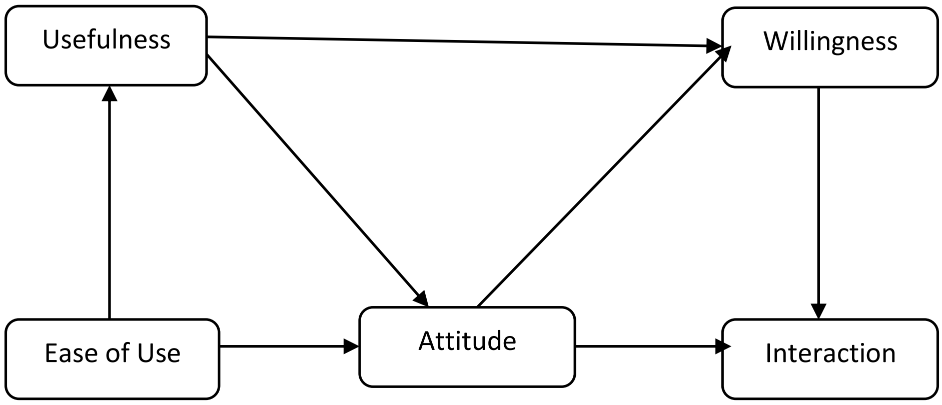

As illustrated in Figure 1, the conceptual framework highlights how Perceived Ease of Use directly impacts students' attitudes toward using virtual reality technology, which subsequently mediates their willingness to adopt and interact with the system. Similarly, Perceived Usefulness not only directly influences attitudes but also affects willingness to use the technology. Willingness acts as a driver, directly enhancing students' interaction behavior, showcasing the progression from initial perceptions to tangible actions within virtual environments.

This framework underscores the importance of Attitudes as a mediating factor, bridging the relationships between perceived ease of use, perceived usefulness, willingness, and interaction. It reveals that fostering positive attitudes among students can amplify their willingness to engage and interact in virtual reality settings. Moreover, the framework accounts for the dynamic relationships between these constructs, illustrating how perceptions and attitudes are intricately tied to actual behaviors in a virtual environment (Venkatesh & Davis, 2000).

One key contribution of this study is the development of a practical, TAM-based model that elucidates the underlying psychological and behavioral mechanisms driving students' interaction and adoption of virtual reality technology. By leveraging these insights, educators, curriculum designers, and policymakers can develop targeted strategies to enhance student engagement in immersive learning environments. This includes designing user-friendly interfaces, ensuring the utility of VR applications, and fostering positive attitudes through engaging and interactive educational experiences. Ultimately, this research offers a comprehensive approach to optimizing VR technology's integration into educational settings, paving the way for more effective and immersive learning opportunities.

4.0 METHODOLOGY

This study employed a quantitative research design grounded in the principles of the Structural Equation Model (SEM). A cross-sectional approach was utilized to collect data at a specific point in time, facilitating the analysis of relationships between key constructs and participants' behaviors (Creswell & Creswell, 2018). The research focused on identifying factors influencing students' interaction behavior and willingness to adopt digital virtual reality in educational contexts. Data were collected from a sample of 1,458 first-year college students at Gansu Hexi University using a multi-stage cluster sampling method. The sample was composed of 289 male students (19.8%) and 1,169 female students (80.2%), ensuring demographic diversity.

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The survey instrument was structured around five constructs—Perceived Usefulness, Perceived Ease of Use, Attitude, Willingness, and Interaction Behavior—along with demographic data, including gender. The questionnaire comprised 33 items, measured using a 5-point Likert scale, with responses ranging from "1 = Strongly Disagree" to "5 = Strongly Agree." The reliability of the instrument was evaluated using Cronbach's alpha, which yielded a value of 0.972 for the 33 items, indicating excellent internal consistency. Each construct was measured using 6–8 items, adapted from validated scales and prior studies. These scales were informed by key sources, including Davis (1989), Venkatesh & Davis (2000), Chang et al. (2017), and Kang et al. (2020).

This methodology provided a structured framework for analyzing the factors influencing students' attitudes, willingness, and interaction behaviors in virtual reality environments. The findings contribute to understanding the psychological and behavioral dynamics underpinning VR adoption, offering practical recommendations for optimizing VR technology in educational settings.

4.1 Findings

The data screening process revealed no missing data points, ensuring the dataset's completeness. Although a few outliers were detected, they were deemed acceptable considering the sample size and the study's objectives. However, it's crucial to note that the data deviated from a normal distribution, as evidenced by the significant Kolmogorov-Smirnov test results. Given this deviation, the researcher has chosen Partial Least Squares Structural Equation Modeling (PLS-SEM) as the analytical approach for this study. PLS-SEM is particularly well-suited to handle non-normally distributed data, making it an appropriate choice in such circumstances. The results of the Partial Least Squares Structural Equation Modeling (PLS-SEM) conducted to address the two research questions presented in Figures 2 and 3 are presented below.

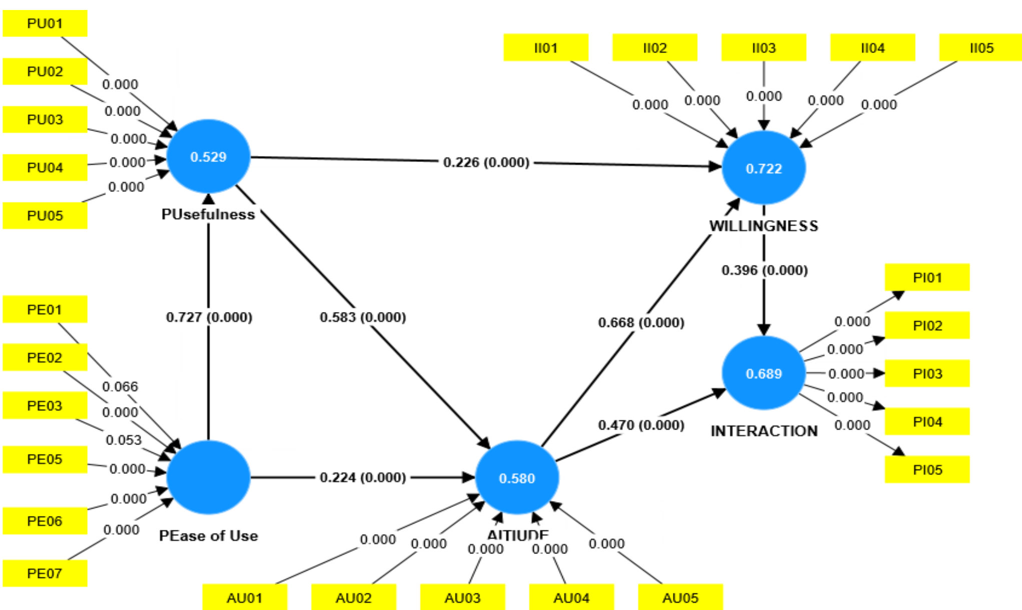

Figure 2: The assessment model using (PLS-SEM)

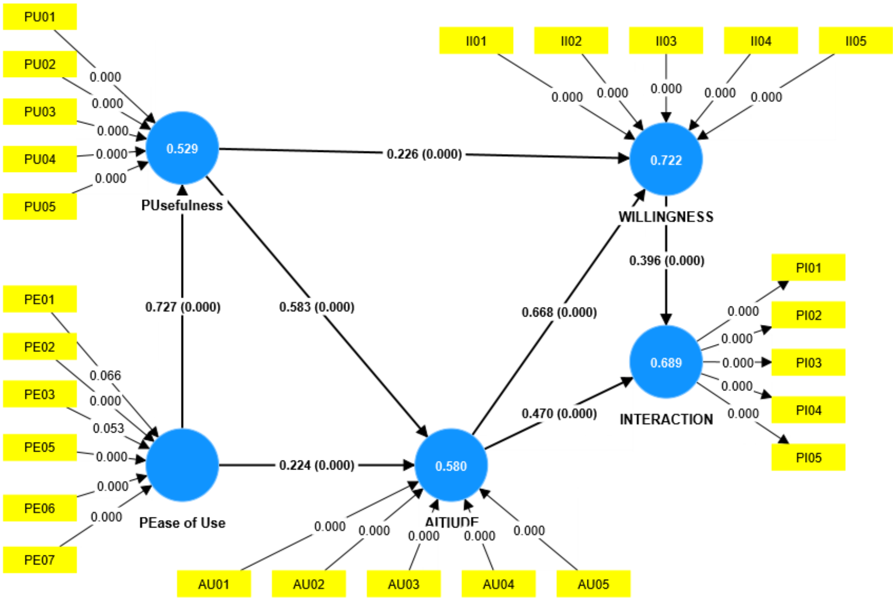

Figure 3: The structural model using (PLS-SEM)

The findings from this study are based on the analysis of the structural equation model (SEM) and reliability measures, highlighting the relationships between constructs within the conceptual framework. The results are presented below:

1. Measurement Model Assessment

- Reliability and Validity:

The internal consistency reliability for all constructs was confirmed with Cronbach's alpha values above 0.7. For the Interaction construct, Cronbach's alpha was 0.901, with composite reliability (CR) at 0.926 and an average variance extracted (AVE) of 0.716, indicating high reliability and convergent validity.

- Outer Loadings:

All items for constructs such as Attitude, Willingness, Perceived Ease of Use, Perceived Usefulness, and Interaction demonstrated acceptable loadings (>0.7), with values ranging from 0.721 to 0.886, confirming the constructs' validity.

2. Structural Model Assessment

- R-Square Values:

The variance explained (R^2) for the constructs indicates a good predictive capability of the model:

- Attitude: $R^2 = 0.58$, suggesting that 58% of the variance in Attitude is explained by Perceived Ease of Use and Perceived Usefulness.

- Interaction: $R^2 = 0.689$, indicating that 68.9% of the variance is explained by Attitude and Willingness.
- Perceived Usefulness: $R^2 = 0.529$, with Perceived Ease of Use as the primary predictor.
- Willingness: $R^2 = 0.722$, reflecting that Attitude strongly contributes to Willingness.

- Predictive Relevance (Q^2):

  Using Stone-Geisser's Q^2, all constructs demonstrated predictive relevance with Q^2 values above 0:

  - Willingness: $Q^2 = 0.522$
  - Interaction: $Q^2 = 0.489$
  - Attitude: $Q^2 = 0.422$
  - Perceived Usefulness: $Q^2 = 0.386$

3. Hypothesis Testing

The path coefficients and significance levels highlight the relationships between constructs:

- Perceived Ease of Use → Perceived Usefulness ($\beta = 0.727$, $p < 0.001$): A strong and significant relationship indicates that ease of use directly impacts students' perceptions of usefulness.
- Perceived Ease of Use → Attitude ($\beta = 0.224$, $p < 0.001$): Perceived ease of use also influences students' attitudes positively.
- Perceived Usefulness → Attitude ($\beta = 0.583$, $p < 0.001$): Perceived usefulness significantly shapes students' attitudes.
- Attitude → Willingness ($\beta = 0.668$, $p < 0.001$): Attitude is a key driver of students' willingness to adopt virtual reality.
- Willingness → Interaction ($\beta = 0.396$, $p < 0.001$): Willingness strongly predicts students' interaction behaviors in virtual reality.

4. Model Fit

The model fit indices demonstrated acceptable fit:

- SRMR: Saturated model = 0.153, Estimated model = 0.157
- NFI: 0.928, indicating good model fit.

5. Multicollinearity

Variance inflation factors (VIF) for all items were below the threshold of 5, indicating no significant multicollinearity issues among the predictors.

The Answer of the research questions:

Research Question 1: How do Perceived Ease of Use (PE) and Perceived Usefulness (PU) influence students' attitudes toward using digital virtual reality in education?

The analysis reveals that both Perceived Ease of Use (PE) and Perceived Usefulness (PU) significantly influence students' attitudes toward digital virtual reality.

- Perceived Ease of Use → Attitude ($\beta = 0.224$, $p < 0.001$):

  A statistically significant positive relationship indicates that ease of use fosters favorable attitudes toward virtual reality. When students find the technology easy to navigate, they are more likely to develop positive perceptions.

- Perceived Usefulness → Attitude ($\beta = 0.583$, $p < 0.001$):

  Perceived usefulness has a strong direct effect on attitude, suggesting that students' perception of virtual reality as beneficial for learning significantly enhances their attitude.

- Indirect Influence via Perceived Ease of Use → Perceived Usefulness ($\beta = 0.727$, $p < 0.001$):

  Perceived ease of use indirectly contributes to attitude through its strong effect on perceived usefulness, highlighting its role in shaping students' perceptions of the technology's value.

Research Question 2: How does students' attitude toward digital virtual reality mediate the relationship between Perceived Ease of Use, Perceived Usefulness, and their interaction behavior?

Students' attitude serves as a central mediator between Perceived Ease of Use, Perceived Usefulness, and interaction behavior.

- Perceived Ease of Use → Interaction (Indirect Effect = 0.105):

  The effect of perceived ease of use on interaction behavior is mediated by attitude, showing that user-friendly systems contribute to higher engagement through their impact on attitudes.

- Perceived Usefulness → Interaction (Indirect Effect = 0.273):

  The relationship between perceived usefulness and interaction behavior is also mediated by attitude, emphasizing that the perceived benefits of virtual reality drive interaction when students develop positive attitudes.

- Attitude → Interaction ($\beta = 0.470$, $p < 0.001$):

  Attitude significantly influences interaction behavior, highlighting that students with positive attitudes are more likely to engage actively in virtual reality environments.

Research Question 3: What is the relationship between students' attitudes and their willingness to adopt digital virtual reality in education?

Students' attitudes have a strong positive influence on their willingness to adopt digital virtual reality.

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- Attitude → Willingness ($\beta = 0.668$, $p < 0.001$):

  The results indicate that students with positive attitudes are significantly more willing to adopt virtual reality technology in their education. Attitude emerges as a key driver of willingness.

- Indirect Effects:

  Perceived ease of use and perceived usefulness indirectly influence willingness through attitudes, demonstrating the importance of attitudes in translating cognitive evaluations into behavioral intentions.

Research Question 4: How does willingness to use digital virtual reality influence students' interaction behavior in immersive learning environments?

Willingness directly impacts students' interaction behavior, emphasizing its role as a critical determinant of engagement.

- Willingness → Interaction ($\beta = 0.396$, $p < 0.001$):

  A significant positive relationship indicates that students who are willing to adopt digital virtual reality are more likely to interact actively within immersive learning environments.

- Indirect Effects via Attitude:

  The influence of perceived usefulness and ease of use on interaction behavior is mediated by willingness, which in turn is influenced by attitudes. This underscores the cascading effects of perceptions and attitudes on engagement.

5.0 CONCLUSION

The findings highlight the pivotal roles of Perceived Ease of Use and Perceived Usefulness in shaping students' attitudes, which mediate the relationship between these constructs and interaction behavior. Attitude is a critical mediator that bridges cognitive evaluations (ease of use, usefulness) and behavioral outcomes (interaction and willingness). Furthermore, willingness directly influences interaction, underscoring its importance in engaging students in immersive virtual reality environments.

These results provide practical insights for educators and technology designers, suggesting that simplifying the user experience and enhancing the perceived value of virtual reality can foster positive attitudes, willingness, and engagement, ultimately optimizing learning outcomes in immersive environments.

6.0 DISCUSSION

This study examines the factors influencing students' interaction behavior and their willingness to adopt digital virtual reality (VR) in educational settings. Aligned with the Technology Acceptance Model (TAM) (Davis, 1989), the study reveals that both Perceived Ease of Use (PE) and Perceived Usefulness (PU) play pivotal roles in shaping students' attitudes toward

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VR. The direct impact of PE on attitudes ($\beta = 0.224$, $p < 0.001$) underscores the significance of user-friendly interfaces in fostering positive perceptions of VR. When students perceive the technology intuitive and easy to navigate, their likelihood of developing favorable attitudes toward VR increases. Furthermore, PE exerts a strong direct influence on PU ($\beta = 0.727$, $p < 0.001$), emphasizing that usability enhances students' appreciation of VR's value. Concurrently, PU significantly impacts attitudes ($\beta = 0.583$, $p < 0.001$), indicating that students who perceive VR as an effective learning tool are more inclined to develop positive attitudes. This finding aligns with prior research conducted by Venkatesh and Davis (2000).

Attitude emerges as a central mediator in the model, bridging the gap between PE and PU and influencing behavioral outcomes such as interaction and willingness. The indirect effects of PE and PU on interaction behavior through attitude highlight the importance of cultivating positive perceptions to drive engagement. For instance, PU indirectly influences interaction behavior (Indirect Effect = 0.273), underscoring the role of perceived value in shaping student engagement. This aligns with Ajzen's (1991) Theory of Planned Behavior, which posits that attitudes are pivotal determinants of behavioral intention. These findings suggest that designing VR applications with clear educational benefits can significantly enhance student interaction by positively shaping their attitudes.

The study reveals a robust correlation between attitudes and willingness ($\beta = 0.668$, $p < 0.001$), underscoring that students with favorable attitudes are more inclined to adopt virtual reality (VR). This finding aligns with prior research by Venkatesh et al. (2003), which emphasizes attitudes as a pivotal factor influencing behavioral intention. Furthermore, willingness directly impacts interaction behavior ($\beta = 0.396$, $p < 0.001$), highlighting its role as a motivator that translates positive attitudes into active engagement. These findings align with the Unified Theory of Acceptance and Use of Technology (UTAUT), which emphasizes the significance of behavioral intention in predicting technology usage.

The implications of these findings extend beyond theoretical frameworks and practical applications. Theoretically, the study extends the Technology Acceptance Model (TAM) framework by emphasizing the mediating role of attitudes and the critical influence of willingness in bridging the gap between attitudes and interaction behavior. It also contributes to our understanding of how positive experiences (PE) and perceived usefulness (PU) interact to shape behavioral outcomes in virtual reality (VR) contexts. Practically, the results suggest that educators and VR developers should prioritize user-friendly designs and effectively communicate the clear educational benefits of VR to foster positive attitudes and willingness. Simplifying interfaces and providing training can reduce barriers, while showcasing the practical applications of VR in achieving learning objectives can enhance adoption.

In conclusion, this study emphasizes the pivotal roles of positive experiences (PE), perceived usefulness (PU), attitudes, and willingness in shaping students' interaction behavior in immersive VR environments. By addressing these factors, educators and developers can create more engaging and effective learning experiences. Future research could explore additional constructs, such as social influence and system reliability, to further enhance the adoption and integration of VR technology in educational settings. These findings contribute to a deeper understanding of technology acceptance in immersive learning and provide actionable insights for optimizing VR's potential in education.

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