Lecture Notes in Educational Technology

Eric C. K. Cheng *Editor*

Innovating Education with AI

Selected Proceedings of 2024 4th Asia Education Technology Symposium

Springer

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Preface

This volume presents the proceedings of the 2024 4th Asia Education Technology Symposium (AEIS 2024), hosted in Hong Kong from November 8–10, 2024. The research spans breakthrough developments in virtual reality, artificial intelligence, and data-driven learning environments, with notable achievements in student engagement and learning outcomes. These proceedings reflect the symposium's role as a crucial platform where researchers, practitioners, and industry experts examine both the opportunities and challenges in contemporary educational technology across the Asia-Pacific region.

This compilation presents cutting-edge research examining the digital transformation of education, spanning virtual reality, artificial intelligence, augmented reality, and learning analytics. The peer-reviewed studies demonstrate significant advances across diverse educational contexts, from early childhood education to corporate training, with particular emphasis on theoretical frameworks combining established learning theories with emerging technological models. The findings illuminate critical developments in AI-assisted metacognition, emotion recognition systems, and personalized learning environments, while addressing implementation challenges and stakeholder perspectives. These proceedings not only document the current state of educational technology but also provide evidence-based insights into its practical applications, theoretical foundations, and future directions, particularly regarding accessibility, security, and pedagogical effectiveness in an increasingly digital learning landscape.***

The Digital Transformation of Education

The landscape of education is undergoing a profound transformation, driven by rapid technological advancement and changing societal needs. This evolution is characterized by the integration of immersive technologies, artificial intelligence, and data-driven approaches that are reshaping traditional teaching and learning paradigms. As evidenced in Chapter 1, virtual reality (VR) platforms are emerging as powerful tools for educational engagement, with studies showing that positive attitudes and immersive experiences significantly influence students' intent to use these technologies for learning. The research demonstrates that 59.8% of the variance in students' intent to use VR platforms can be attributed to factors such as enjoyment and perceived performance benefits.

The corporate sector's adoption of these technologies, as explored in Chapter 2, further underscores their growing importance. VR training applications have shown particular promise in improving performance, efficiency, and motivation across various industries, although challenges such as motion sickness and implementation costs remain significant considerations. This industrial application of educational technology provides valuable insights for broader educational contexts.

In the Asia-Pacific region, particularly in emerging economies, the integration of technology in education faces unique challenges and opportunities. Chapter 3's examination of augmented reality (AR) applications in mainland China's chemistry education demonstrates how technology can address resource constraints while enhancing student engagement and safety. The study reveals that AR technology not only improved learning outcomes but also provided a more accessible and safer alternative to traditional laboratory experiments.

Innovative Theoretical Frameworks and Methodological Approaches

The theoretical underpinning of educational technology integration combines established learning theories with emerging technological frameworks. Chapter 1 demonstrates this through its integration of Self-Determination Theory, Social Learning Theory, and Chiu's Engagement Model with the Technology Acceptance Model (TAM). This comprehensive theoretical approach provides a robust foundation for understanding how various factors influence student engagement and technology adoption.

The methodological sophistication in current educational technology research is exemplified in Chapter 4's investigation of AI-powered non-player characters (NPCs) in educational metaverse platforms. By incorporating cognitive theories such as Speech Act Theory and Prospect Theory, researchers have developed more effective ways to create meaningful educational interactions in virtual environments. The study achieved a performance ratio of 128% in maintaining relevance and speech act accuracy, demonstrating the potential of theory-driven design in educational technology.

Chapter 7's exploration of AI-assisted metacognitive strategies in academic reading further illustrates the importance of robust methodological frameworks. The study identified five distinct AI-assisted metacognitive strategies: planning, monitoring, evaluation, support, and AI prompting, each contributing to enhanced learning outcomes through structured interaction with AI tools.

Technology-Enhanced Learning Environments

The emergence of sophisticated learning environments is revolutionizing educational delivery and engagement. Chapter 10's investigation of speech-emotion recognition systems demonstrates how advanced machine learning methodologies can enhance online learning experiences. The system's 83.95% validation accuracy in detecting emotional expressions marks a significant advancement in creating more empathetic and responsive virtual learning environments.

Visual learning analytics (VLA), as examined in Chapter 9, provides another dimension to technology-enhanced learning. The study of synchronous online mathematics instruction revealed how VLA could help teachers analyze classroom interactions more effectively, with detailed statistics showing teacher-student interaction patterns and areas for improvement in the pedagogical approach.

The integration of AI in educational environments, as discussed in Chapter 8, presents both opportunities and challenges. The UAE case study highlights how AI can increase student engagement and provide personalized learning experiences while raising important considerations about ethics, privacy, and the balance between AI and conventional teaching methods.

Stakeholder Perspectives and Challenges

The successful implementation of educational technology requires careful consideration of various stakeholder perspectives. Chapter 6's examination of early childhood educators' attitudes toward generative AI reveals that while educators recognize the potential benefits, they face significant challenges, including inadequate training and resource constraints. Only half of the surveyed educators actively used emerging technologies, with their self-rated proficiency averaging 4.1 out of 10.

Teacher development and adaptation emerge as crucial factors, as shown in Chapter 5's study of AI-enhanced supervision for pre-service teachers in Japan. The research demonstrates how AI analysis of teaching performances can provide more precise feedback and improve professional development outcomes. Similarly, Chapter 13's integration of social media, computational evaluation, and digital surveys illustrates how teachers can effectively combine various technological tools to enhance learning outcomes.

Future Directions and Implications

Looking ahead, several key trends and implications emerge from the collective research. Chapter 14's focus on lifelong learning for the elderly highlights the importance of developing inclusive technological solutions that address the digital divide and accommodate diverse learning needs. The study emphasizes how technology can support both leisure and daily living needs while acknowledging the challenges of digital literacy and accessibility.

Security considerations in educational technology, as examined in Chapter 15, will become increasingly important. The study of undergraduate IT projects reveals the need for robust security practices in educational technology development, particularly given that 93% of breaches in the Asia-Pacific region are attributed to web application attacks.

The future of educational technology, as suggested by Chapter 12's development of interactive applications and Chapter 11's use of eye-tracking technology, will likely involve more sophisticated tools for personalized learning and assessment. These developments promise to create more engaging and effective learning experiences while raising important questions about data privacy, accessibility, and pedagogical effectiveness.

This comprehensive examination of educational technology transformation reveals a complex landscape of opportunities and challenges. The integration of various technologies—from VR and AR to AI and learning analytics—is reshaping educational practices across different contexts and stakeholder groups. Success in this transformation requires careful attention to theoretical frameworks, methodological rigor, stakeholder needs, and future implications. As education continues to evolve in the digital age, understanding these various dimensions becomes crucial for educators, administrators, and policymakers working to create effective and inclusive learning environments.

The diverse research presented here, from VR platforms and AI-enhanced learning to emotion recognition systems and metacognitive strategies, represents significant collaborative effort across international borders. These contributions have advanced our understanding of educational technology's potential while addressing crucial implementation challenges. We acknowledge the researchers whose methodologically rigorous work has established new benchmarks in technology-enhanced learning, contributing to more effective and inclusive educational environments.

Eric C. K. Cheng
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Contents

Virtual Reality and Augmented Reality Technologies in Education

Enhancing VR Education: A TAM-Based Study on Predicting Student Engagement and Intent to Use Virtual Reality

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Abstract. Virtual Reality (VR) platforms offer great potential to enhance student engagement through immersive and interactive learning experiences. These environments create dynamic spaces that can improve educational outcomes by fostering deeper learning engagement. However, existing research often fails to integrate critical motivational, cognitive, and social factors within VR environments that lead to fragmented and less effective learning experiences. This study examines how combining these engagement strategies can enhance student participation and improve learning outcomes in VR educational settings. Specifically, it explores how these strategies can be applied within the Technology Acceptance Model (TAM) to predict students' intent to use VR for learning. The findings show that integrating these factors into TAM effectively predicts students' intent to use VR platforms, with key predictors including positive attitudes, enjoyment of immersive technology, and perceived performance. This study provides a robust foundation to understand how motivational, cognitive, and social factors converge to influence learning outcomes in immersive environments, offering valuable insights for future educational technology research and practice.

Keywords: Virtual Reality in Education · VR-enhanced Learning · VR Engagement Strategies · Immersive Learning

1 Introduction

1.1 Background

The use of Virtual Reality (VR) platforms in educational settings presents a unique opportunity to enhance student engagement through immersive, interactive learning experiences. These environments offer possibilities for making rich, engaging, and dynamic spaces that can significantly improve educational outcomes. For instance, Pringle et al.

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[1] demonstrate the effectiveness of immersive environments that deeply engage students. Similarly, Maddox and Fitzpatrick [2] discuss how VR can facilitate both cognitive and behavioural engagement, highlighting its potential to transform traditional educational methods.

However, the full potential of these environments requires us to understand how different motivational, cognitive, and social factors converge to influence learning outcomes. Social interactions is one crucial element in boosting the effectiveness of VR-based learning. As Mystakidis et al. [3] emphasise, social engagement within VR environments is essential for deep learning, as it encourages students to actively engage with and learn from one another. Glassman et al. [4] also discuss how collective efficacy, such as that fostered through social interactions in immersive environments, can lead to a sense of collective achievement to motivate students to engage deeply with content. In a virtual environment, these social interactions can be conducted through dialogues with peers or virtual avatars.

This study seeks to investigate these dynamics and lay the groundwork for an integrated approach to designing effective immersive learning environments that harness the full power of VR technologies.

1.2 Research Gap and Rationale

Key attributes of motivation, cognitive engagement, and social interaction in VR are frequently studied in isolation. Checa and Bustillo [5] note that many VR studies lack a pedagogical foundation, resulting in isolated learning experiences that are not linked to broader learning processes. Won et al. [6] highlight the absence of active learning features in many VR educational tools, such as peer-to-peer interactions or intelligent agent engagements. Solving these gaps of isolated learning experiences and lack of intelligent agent engagements are crucial to foster deeper student engagement.

Furthermore, educational VR platforms must cater to diverse learning styles and needs. This requires a teaching method that adapts to various contexts and learner profiles that supports different types of learners—those who thrive on autonomy, those who need structured engagement, and those who benefit from social interactions. Won et al. also emphasise the importance of personalised intelligent feedback, where students can receive tailored responses more closely linked to situational content. The current study aims to fill these gaps by developing a comprehensive framework that integrates these critical elements, leading to more effective and engaging VR learning environments.

1.3 Literature Review

Lombard and Ditton [7] highlight the importance of presence in virtual environments, explaining how the sense of 'being there' is shaped by both psychological and technological factors. Interactions with others, known as virtual agents, can also enhance social presence, as socially interactive agents increase engagement through emotional and social cues [8].

Liu et al. [9] discuss how VR not only enhances motivation but also significantly boosts participation, which is closely tied to both psychological and social engagement. Mystakidis et al. [3] further highlight that individual differences, including cognitive abilities and motivation, greatly influence learner engagement in SVREs. They also stress the importance of a strong social presence to enhance collaboration and communication.

Piccione et al. [10] explore how presence and agency within VR environments significantly influence learners' attitudes and enjoyment, where learners must feel that they are in control of a natural environment that is not 'manufactured'. Ferguson et al. [11] further support this by examining how both active and passive learning modes in VR play a part in learning in both scaffolding and cognitive interest. Plotzky et al. [12] highlight VR's effectiveness in skill training to bring out soft skills and empathy while also highlighting gaps in encouraging social interactions.

1.4 Conceptual Models

Self-Determination Theory (Deci & Ryan) [13]: Self-Determination Theory (SDT) emphasises the importance of students' needs for autonomy, competence, and relatedness to foster intrinsic motivation. In the context of VR, this theory can be used to support environments that drive these psychological needs to cultivate positive attitudes toward VR.

Chiu's Engagement Model [14], building on SDT, integrates behavioural, cognitive, and agentic engagement to enhance perceived usefulness and influence students' attitudes toward adopting technology like VR platforms. By combining this with Fussell and Truong's TAM [15], the model shows how perceived usefulness, ease of use, and enjoyment directly shape users' attitudes and intentions to use the technology. Key variables include technology-related perceptions, perceived usefulness, performance, and enjoyment, all of which contribute to a positive attitude and the intent to use the VR platform in educational settings.

Agentic engagement involves students taking an active role in shaping their learning experiences, which not only enhances their sense of autonomy but also contributes to a deeper emotional connection with the learning material. Active involvement in decision-making processes within the VR environment also fosters a sense of ownership and responsibility, which can translate into positive attitudes towards the method.

Social Learning Theory (Bandura) [16]: Social Learning Theory complements these frameworks by encouraging social interactions in learning. Social Learning Theory suggests that individuals learn by observing and modelling the behaviours of others, which is important in environments like VR, where students interact with avatars or peers. Within the VR platform, students learn by observing, imitating, and modelling the behaviour of others, which reinforces their social engagement and further shapes their attitudes toward the platform, enhancing its perceived usefulness and enjoyment.

Additionally, social interactions within VR—whether through collaboration with peers or interaction with virtual agents—can create a sense of community and belonging. These social dynamics are crucial as they satisfy the need for relatedness, a core component of Self-Determination Theory, thereby reinforcing both engagement and intent to use the platform.

Our model (Fig. 1) builds on Chiu's Engagement Model, Social Learning Theory, and the Technology Acceptance Model (TAM) to provide a comprehensive understanding of how user engagement drives the adoption of VR technology for learning. First, we consider learning processes that drive behavioural, cognitive, and agentic engagement, linking them to TAM constructs, such as perceived ease of use, usefulness, and enjoyment. We then connect Social Learning Theory through social avatars and interactions to enrich agentic engagement.

H1: Behavioral engagement positively influences perceived ease of use, enjoyment, and technology-related perceptions in the VR platform. When students are actively involved in learning tasks, they are more likely to find the VR platform user-friendly enjoyable, and positively perceive the technology.

H2: Cognitive engagement positively influences the perceived usefulness and perceived performance of the VR platform. Engaging deeply with the content and employing critical thinking makes students more likely to view the VR platform as an effective and valuable learning tool.

H3: Agentic engagement positively influences students' attitudes toward using the VR platform. When students take an active role in shaping their learning experiences, they are likely to develop more favourable attitudes toward the use of VR.

H4: Social interactions with avatars in the VR platform positively influence students' attitudes toward the platform. Interacting with social avatars or peers within the VR environment enhances students' positive attitudes, making the platform more engaging.

H5: Perceived ease of use, perceived usefulness, and positive attitudes significantly predict students' intent to use the VR platform for learning. If students find the VR platform easy to use and valuable and have a positive attitude toward it, they are more likely to intend to use it for learning purposes.

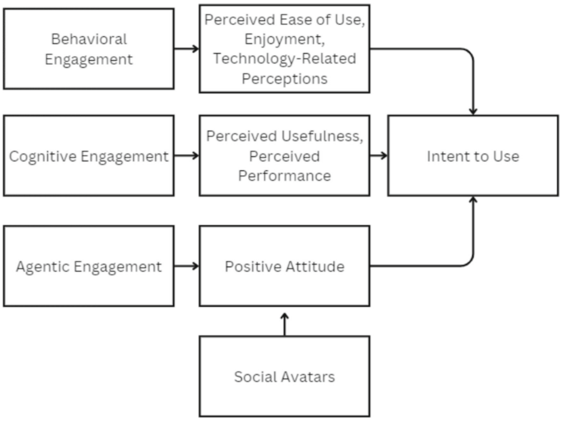

Fig. 1. Research Model.

2 Method

This study employed a **comparative research design** to examine the influence of VR-enhanced learning on student engagement and intent to use VR. Two distinct interventions were designed for students in History and Economics courses, each with unique activities and learning objectives. The purpose of this comparison was to explore how different learning environments and tasks within VR affected students' perceptions of the technology and their engagement with the content.

2.1 Participants

The study involved a total of 56 students enrolled in courses in history (30 participants) and economics (26 participants). The sample sizes were determined by existing and available classes at the time of the study. As a pilot study, these numbers were considered sufficient to gather initial insights and evaluate the use of the VR platform and AI tools in an educational setting. The findings from this study will inform future research. Participants integrated research and collaborative activities into their learning using AI tools and the VR platform. The intervention spanned several VR sessions, during which students engaged in both individual and group-based tasks, culminating in reflective essays.

2.2 Virtual Reality Platform

Classlet, the VR platform used in this study, provides essential educational tools such as interactive dialogues, multiple-choice questions (MCQs) for assessing student understanding, and authoring tools that allow educators to create and customise content. These features help structure learning, enabling students to engage with material in a way that reflects classroom activities. The platform is designed to support the creation and delivery of educational content, ensuring that learning objectives are met through practical and interactive methods.

Participants in this study accessed Classlet through either the desktop or mobile versions, depending on their preferences and available technology. The desktop version, particularly when used with VR headsets, offered a more immersive experience, while the mobile version provided flexibility and convenience, allowing students to engage in learning activities from any location. Both versions included the same core educational tools, ensuring all participants had access to the platform's interactive features; see Fig. 2 for screenshots of the two modules.

2.3 Procedure

History Course Intervention. Participants in the history course were tasked with researching historical content for over 6 weeks. The primary tool used by participants for research was ChatGPT, which provided students with resources, insights, and suggestions to help them develop character stories rooted in historical contexts. Participants were also given a workshop on best practices to use the tool.

- Week 1–5: Students independently researched 15th to 17th-century European spice history, focusing on topics such as the economic impact of the spice trade, cultural exchanges with the East, political manoeuvres around trade routes, and social transformations. They developed historically accurate character stories reflecting the socio-cultural, political, and economic aspects of the period. This was carried out at

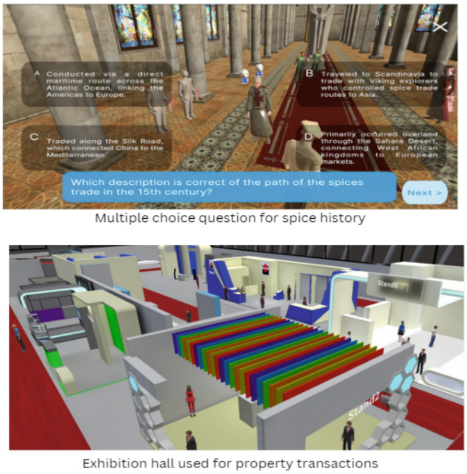

Fig. 2. Screenshots of the virtual reality platform.

locations of the students' choosing, such as their homes or school. Time was dedicated each week (30 min) in class for brainstorming sessions to support their progress.

- Week 6: Students uploaded their character stories to a Google Form, which was then shared on the VR platform for peer interaction. This collaborative experience aimed to deepen their understanding through exposure to diverse historical narratives.

Economics Course Intervention. The Economics course involved a shorter but more intensive 3-week intervention that combined research with interactive simulations. The focus was on understanding housing markets through a game-based learning approach.

Week 1–3: Each week, students participated in simulated buying and selling transactions in a game environment. As sellers, they researched housing data and tailored strategies to buyer profiles. As buyers, they selected apartments based on their profiles. After each round, with fewer buyers, students had to adapt their strategies. The lecturer introduced pricing events, challenging them to navigate fluctuating market conditions and reinforcing their understanding of economic theories through this dynamic process. This entire activity was conducted at locations of the students' choosing, such as their homes or school.

Behavioural Engagement: The immersive VR environment, coupled with structured tasks like weekly research in the History course and simulated transactions in the Economics course, required consistent student participation. The interactive nature of the VR platform, including tasks such as completing quizzes, interacting with comments boards or interacting with avatars, promotes active involvement.

Cognitive Engagement: The VR platform's immersive learning experience, where students researched historical content and developed character stories, as well as analysed and responded to dynamic market conditions, encouraged deep cognitive processing. The use of avatars and virtual simulations helped students think critically as they immersed themselves in realistic and context-rich scenarios.

Agentic Engagement: The VR platform allowed participants to take control of their learning through the creation of their own narratives, which were adopted in the simulations. Participants also collaborated with peers and had social interactions with avatars. This autonomy in decision-making allowed students to shape their own learning experiences.

2.4 Data Collection and Analysis

The primary data collection method was a Technology Acceptance Model (TAM) survey administered post-intervention to assess participants' attitudes toward the VR platform, their enjoyment, perceived performance, and intent to use the platform for learning. The survey included 1–5 Likert-scale items that corresponded to the following constructs:

- TECH1, TECH2, TECH3: Measures of technology-related perceptions.
- ATT2: Positive Attitude Toward the VR.
- EASE1: Perceived Ease of Use.
- ENJOY1: Enjoyment of Immersive Simulation Technology.
- PERF2: Perceived Performance of the VR.
- USEFUL: Perceived Usefulness.
- INT1: Intent to Use VR.

The survey also included open-ended questions for qualitative feedback (what you like or dislike about the method), allowing participants to express their thoughts on the learning experience. We conducted the following statistical analysis:

- Cronbach's Alpha: Assessed the internal consistency of survey items to ensure reliability.
- Descriptive Statistics: Calculated mean, standard deviation, minimum, and maximum values for each survey item.
- Shapiro-Wilk Test: Tested the normality of data distributions.
- Spearman's Rank-Order Correlation: Examined relationships between survey constructs due to deviations from normality.
- Multiple Regression Analysis: Explored the relationships between key predictors (e.g., Positive Attitude, Enjoyment, Perceived Performance) and the outcome variable (Intent to Use the VR)

All participants were fully informed about the study's purpose, potential risks, benefits, and their rights before agreeing to participate. The informed consent process was conducted via an online survey where participants had to acknowledge their understanding of the study and provide explicit consent by entering their names and confirming their willingness to participate. This ensured that participation was voluntary and that participants were aware of their right to withdraw from the study at any time without any consequences.

3 Results

The Cronbach's α of 0.866 indicates a high level of internal consistency among the items, suggesting that they reliably measure the same construct within the Technology Acceptance Model (TAM).

The descriptive statistics show that participants generally hold positive attitudes towards using the VR platform for learning, with mean scores for intent (INT1: $M = 4.018$, $SD = 0.820$) and attitude (ATT2: $M = 4.179$, $SD = 0.765$) indicating a favourable disposition toward adopting the technology (a score of 5 being the highest). Enjoyment (ENJOY1: $M = 4.036$, $SD = 0.785$) and perceived performance (PERF2: $M = 4.018$, $SD = 0.774$) also scored highly, reflecting positive perceptions of the VR's usability and effectiveness for learning. The Shapiro-Wilk tests indicated non-normal distribution across variables ($p < .001$), justifying the use of non-parametric methods for further analysis.

The Spearman's correlation analysis revealed strong positive correlations between participants' intent to use the VR for learning and three key factors: a positive attitude toward the VR platform ($\rho = 0.678$, $p < .001$), enjoyment of immersive simulation technology ($\rho = 0.639$, $p < .001$), and perceived performance of the VR as an effective learning tool ($\rho = 0.660$, $p < .001$).

Additionally, the correlation between USEFUL (perceived usefulness for gaining real-world knowledge) and PERF2 ($\rho = 0.686$, $p < .001$) suggests that participants who found the VR useful also perceived it as an effective method for improving knowledge and skills. This supports the idea that usefulness and performance are closely linked in influencing participants' intent to use the technology.

The multiple regression analysis provides further insight into how the key predictors influence participants' intent to use VR for learning. The overall model was significant, explaining 59.8% of the variance in intent ($R2 = 0.598$, $F(3, 52) = 25.834$, $p < .001$). This indicates a strong explanatory power of the model in predicting intent.

- ATT2 (Positive attitude toward the VR) emerged as a significant predictor ($\beta = 0.345$, $t = 3.227$, $p = 0.002$). This suggests that participants with a more favourable attitude toward VR are more likely to intend to use it.
- ENJOY1 (Enjoyment of immersive simulation technology) also showed a significant positive effect on intent ($\beta = 0.342$, $t = 3.297$, $p = 0.002$). This highlights that participants who enjoy using immersive technology like the VR platform are more inclined to adopt it for learning purposes.
- PERF2 (Perceived performance of the VR platform) was another significant predictor, though slightly weaker than the others ($\beta = 0.267$, $t = 2.368$, $p = 0.022$). This indicates that the perceived effectiveness of VR as a learning tool contributes positively to the intent to use it, but its influence is slightly less pronounced compared to attitude and enjoyment.

Table 1 summarises the results, demonstrating that positive attitude (ATT2), enjoyment (ENJOY1), and perceived performance (PERF2) were significant predictors of students' intent to use the VR platform.

3.1 Issues Reported by Students

Technical and Device-Related Issues. These included challenges related to technical difficulties, device compatibility, platform stability, and system bugs that disrupted the learning experience. History students noted that [sic]: "[I had] Technical issues: can't play by browser"; "Only desktop is available to use metaverse smoothly, when using