

Research Article

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Metaverse-Driven Instructional Design: Enhancing Reflective Practice and Emotional Preparedness in Pre-Service Teachers

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Abstract

Background/purpose. This study addresses the growing gap in preparing pre-service teachers for immersive digital instruction, especially within metaverse environments. While many are familiar with digital platforms as learners, they often lack practical experience in managing and teaching in virtual settings. The purpose of this study is to design, develop, and implement a metaverse-based virtual learning environment that enhances pre-service teachers' virtual learning management competencies while addressing their emotional readiness and reflective practice development.

Materials/methods. This qualitative study employed the ADDIE model to design a virtual learning environment on the Metaverse Spatial platform using a four-phase learning model (Open Mind, Build Familiarity, Competency-Based Learning, Reflect and Evaluate) integrated with the SSPC framework. Seventy-eight pre-service teachers participated in over 70 hours of instruction. Data collection included semi-structured interviews, reflective journals, and peer feedback. Analysis employed thematic analysis and content analysis with triangulation.

Results. The findings revealed gaps between digital tool familiarity and practical application, requiring ongoing support and emotional readiness development. Implementation demonstrated improvements in instructional confidence, digital tool fluency, emotional adaptability, and collaborative design skills. Participants transitioned from technology users to digital learning designers through structured reflection and problem-solving.

Conclusion. The study demonstrates that metaverse-based virtual learning environments can effectively address both technical competencies and emotional readiness for virtual teaching. The four-phase model provides a comprehensive framework for preparing pre-service teachers for digital classrooms.

1. Introduction

The integration of metaverse technology in teacher education addresses the growing need to prepare pre-service teachers for immersive digital instruction and 21st-century classroom environments. UNESCO emphasizes the critical role of learning in advancing learning cities and promoting lifelong education, establishing the UNESCO Global Network of Learning Cities (GNLC), which aligns with the Sustainable Development Goals, particularly Goal 4, which advocates for quality education and lifelong learning opportunities for all individuals. UNESCO recognizes the integration of modern technology in education as a pivotal factor in advancing learning cities (UNESCO, 2020). Thailand's national policies, such as the 20-Year Higher Education Development Plan (2018–2037) and the National Education Policy, reflect a commitment to expanding access to digital technology and ensuring quality learning. Within this context, addressing 21st-century educational challenges requires metaverse-based approaches to motivate learners, close educational gaps, and prepare future educators to teach effectively in next-generation classrooms.

Previous research has demonstrated the transformative potential of virtual learning environments in educational settings. Research by Cao et al. (2023), Coban et al. (2022), and Damaševičius and Sidekerienė (2024) shows that meaningful virtual learning environments (VLEs) promote achievement of learning outcomes and foster essential 21st-century skills such as critical thinking and collaboration. The integration of the metaverse into teacher education enhances pre-service teachers' learning experiences, bolstering their confidence and pedagogical skills (Lee & Hwang, 2023). Sinlapaninman et al. (2023) report that students trained in metaverse-based virtual learning management express high satisfaction and effectively apply their knowledge in physical classrooms. Moreover, Farsi et al. (2023) found that students trained in the metaverse exhibited superior classroom management skills in virtual classrooms compared to those trained solely online. Hwang and Lee (2024) found that novice English teachers who participated in a fully developed metaverse language classroom demonstrated significantly higher technological self-efficacy. Additionally, Ji et al. (2022) found that immersive technologies reduce anxiety experienced during teaching practicums by providing a safer space for experimentation and learning, supporting emotional readiness among pre-service teachers.

Despite these promising findings, a significant gap remains in understanding how pre-service teachers comprehensively experience learning within metaverse environments and how these experiences translate into enhanced emotional readiness and pedagogical competencies. While existing studies have explored individual aspects of metaverse integration in education, there is limited research examining the holistic learning experiences of pre-service teachers in spatially focused, virtual, learner-centered environments. Moreover, systematic guidelines for developing effective metaverse-based learning environments tailored explicitly to teacher education remain underexplored, particularly regarding the integration of self-reflective practice and emotional competency development within metaverse-based teacher preparation programs.

The purpose of this study is to design, develop, and implement a metaverse-based virtual learning environment that enhances pre-service teachers' virtual learning management competencies while addressing their emotional readiness and reflective practice development. This research aims to bridge the gap between theoretical knowledge and practical application of virtual teaching skills through a systematic investigation of pre-service teachers' comprehensive learning experiences in immersive digital environments.

The research is significant as it contributes to the growing body of knowledge on immersive technology in teacher education and provides practical insights for developing effective virtual learning environments. The findings will inform educational institutions, teacher educators, and policymakers about the potential of metaverse technology in preparing future educators for 21st-

century classrooms, which is especially vital in teacher education and the lifelong learning agenda championed by UNESCO. Recognizing this potential, the present study aims to address the following research questions: 1) What are pre-service teachers' learning experiences, challenges, and emotional readiness in virtual teaching environments? 2) How can a metaverse-based, spatially focused, virtual, learner-centered learning environment be developed and implemented effectively for teacher education? 3) What are the implementation outcomes of the virtual learning environment as reflected through pre-service teachers' experiences as both learners and instructors?

2. Literature Review

2.1. The Concept of Metaverse and Its Role in Education

López-Belmonte et al. (2023) describe the metaverse as a fusion of virtual reality (VR) and augmented reality (AR) that serves as a revolutionary learning space supporting immersive and interactive learning. Kaewhanam et al. (2023) highlighted UNESCO's focus on virtual learning during the COVID-19 pandemic, emphasizing the expansion of online participation mechanisms and contemporary virtual learning frameworks. The metaverse can create virtual classrooms where educators engage students across physical distances, enhancing educational equity through dynamic virtual worlds. The metaverse is poised to become a crucial component in learning and training within complex digital educational ecosystems (Frydenberg & Ohri, 2023).

2.2. Virtual Learning Environments (VLEs): Concepts and Principles

A virtual learning environment (VLE) is defined as a system that enables online teaching and learning by providing instructors with a platform to deliver digital content (Berge, 2002). VLEs extend beyond mere online tools; they are localized implementations of the metaverse, featuring gamified simulations and instructional designs that mirror real-life scenarios. This innovation enriches the learning experience, fosters a sense of community among users, transcends geographical barriers, and promotes educational inclusivity. In the era of digital transformation, Virtual Learning Environments (VLEs) have become fundamental to educational management at all levels. Particularly in the post-COVID-19 era, the significance of VLEs has grown considerably. VLEs are digital platforms designed to facilitate content delivery, communication, and assessment, aiming to enhance learning effectiveness and meet diverse learner needs across various contexts. Central to VLEs is a learner-centered approach that emphasizes synchronous interaction between instructors and students, which is vital not only for academic success but also for students' emotional well-being (Caprara & Caprara, 2022). According to Sinlapaninman et al. (2023), a VLE comprises teachers, learners, content, activities, assessments, and technology. Salmon (2013) proposes a five-stage model of learning interaction: access and motivation, online socialization, information exchange, knowledge construction, and development, while Dillenbourg et al. (2002) emphasize collaborative learning as a core principle of VLEs. Laurillard (2013) introduced the Conversational Framework, focusing on dynamic interactions among learners, instructors, and technology. Moreover, the integration of immersive virtual reality (IVR) technologies within VLEs has been shown to improve learning outcomes and content retention (Cao et al., 2023; Coban et al., 2022). VLEs embedded within virtual worlds—especially in Metaverse contexts—promote essential 21st-century skills such as critical thinking, creativity, communication, and collaboration (Damaševičius & Sidekerskienė, 2024). The metaverse enhances VLEs by making them more immersive, allowing learners to practice skills in realistic classroom settings (Huang et al., 2010). These advancements position VLEs not merely as digital platforms but as transformative tools that integrate technology, pedagogy, and social interaction into comprehensive educational experiences.

2.3. Virtual Learning Management in the Metaverse

Virtual learning management is a foundational component of the metaverse that facilitates interactive and practical learning experiences (Liu et al., 2022). Key principles include designing learning environments, developing digital content, and structuring activities to maximize engagement and outcomes (Herrington et al., 2007). Pre-service teachers require training in simulated environments that replicate authentic teaching contexts to improve their readiness before entering physical classrooms (Samuelsson et al., 2022). The metaverse provides an active learning platform that fosters essential teaching skills and transformative pedagogical practices (Dede, 2009).

2.4. Preparing Pre-service Teachers for 21st-Century Classrooms

Preparing pre-service teachers for modern classrooms requires mastery of pedagogical knowledge alongside the ability to integrate advanced technologies meaningfully. The metaverse, as an emerging virtual space, supports immersive, experiential, and interactive learning. Research indicates that metaverse environments enhance learner engagement by fostering a sense of presence and agency among pre-service teachers (Cukurbas Calisir et al., 2022). Lee et al. (2025) further highlight that such environments stimulate creativity in instructional design.

The TPACK framework (Mishra & Koehler, 2006) underpins these innovations by emphasizing the integration of content knowledge, pedagogy, and technology. Siemens' (2005) networked learning theory positions learners as co-constructors of knowledge within digital ecosystems, while Bandura's self-efficacy theory (1997) explains how beliefs in personal capabilities motivate and enhance teaching quality. The metaverse allows pre-service teachers to demonstrate competencies, receive feedback, and strengthen their professional identity, establishing a solid foundation for learning in distributed virtual spaces.

Research indicates that integrating the metaverse into teacher education enhances virtual learning management competencies and increases pre-service teachers' confidence (Sinlapaninman et al., 2023). Moreover, Farsi et al. (2023) found that students trained in the metaverse exhibited superior classroom management skills in virtual classrooms compared to those trained solely online. Additional studies highlight that metaverse-based virtual management training enables pre-service teachers to outperform traditional online learners, demonstrating the transformative potential of immersive technology in education (Heryatun & Septiana, 2020; Rafiq et al., 2022).

2.5. Pre-service Teachers' Learning Experience in the Metaverse

The integration of the metaverse into teacher education enhances pre-service teachers' learning experiences, bolstering their confidence and pedagogical skills (Lee & Hwang, 2023). It offers hands-on, immersive educational experiences that allow novice teachers to refine their skills in a safe, controlled environment (Merchant et al., 2014). The metaverse provides exposure to diverse teaching scenarios closely aligned with real-world classroom environments (Pantelidis, 2010). Such immersive practice improves preparedness and self-efficacy before entering actual classrooms. The metaverse's simulation of varied teaching contexts encourages pre-service teachers to develop flexible strategies tailored to real classroom demands (Ji et al., 2022). Importantly, emotional preparedness cultivated through immersive, context-rich experiences is increasingly recognized as essential in teacher education to enhance professional effectiveness (Açikgöl, 2019; Ji et al., 2022). Given the critical role of emotional awareness in teacher preparation, research suggests that simulated learning environments support emotional readiness and reduce anxiety related to classroom experiences (Ji et al., 2022; Öz & Kiris, 2018).

2.6. Competency-Based Learning (CBL)

Competency-based learning offers a structured approach to equipping educators with the skills, knowledge, and attitudes essential for today's educational demands. CBL emphasizes digital fluency, technological competence, effective use of online tools, and reflective practice. Competency-Based Learning (CBL), which stresses skill acquisition through hands-on practice and problem-solving in simulated scenarios, is highly compatible with metaverse learning (Tsai, 2020). Thus, the metaverse empowers learners to take control of their education and develop deep conceptual understanding in a flexible and interactive environment (Mughal et al., 2022). Recent studies highlight the need for authentic, technology-enhanced competencies within CBL frameworks. Tammets et al. (2022) argue that digital learning ecosystems should focus on skill development, learner-centered approaches, and reflective teaching strategies to support lifelong learning. Sinlapaninman et al. (2023) found that metaverse training reduces technology-related stress among pre-service teachers while enhancing instructional design abilities. Lee et al. (2025) demonstrated that integrating metaverse elements into connected practice guides improves technological skills and encourages deeper reflection. Together, these findings underscore the importance of implementing competency-based learning to prepare teachers effectively for 21st-century classrooms.

2.7. The Integration of the Metaverse Within Teacher Education

The metaverse presents a promising avenue for engaging teacher education, fostering self-reflective practice, and enhancing emotional readiness among novice teachers. Recent literature affirms that highly immersive virtual environments promote technology acceptance and support engaging, self-efficacy-enhancing learning experiences through active participation (Hwang & Lee, 2024; Ji et al., 2022). Hwang and Lee (2024) found that novice English teachers who participated in a fully developed metaverse language classroom demonstrated significantly higher technological self-efficacy. Self-reflective practice is fundamental to teacher education. Cadiz (2022) demonstrated that novice teachers who regularly engaged in reflective practices developed deeper beliefs regarding effective teaching and classroom management, reinforcing the notion that teacher education must be reflective and foster continuous professional growth. Mengyuan (2023) confirmed that supervised reflective activities help novice teachers develop an epistemological identity, fostering a disposition toward lifelong reflective inquiry. Emotional readiness is a critical component of metaverse-driven instructional design. Ji et al. (2022) found that immersive technologies reduce anxiety experienced during teaching practicums by providing a safer space for experimentation and learning. Narrative reflection, as discussed by Abruzzo and Jacobs (2022), offers emotional processing that deepens understanding and internalization of teaching experiences. Collectively, these studies emphasize the necessity of incorporating emotional competency development within metaverse-based teacher preparation programs rather than treating it as an afterthought.

2.8. Processes of Reflection

Reflection is widely recognized as a crucial process for deep learning and professional growth in education. Established models such as Kolb's Experiential Learning Cycle (1984)—comprising concrete experience, reflective observation, abstract conceptualization, and active experimentation—and Gibbs's Reflective Cycle (1988) offer systematic approaches to analyzing experiences and identifying improvement areas. Schön (1983) promotes reflective practices within virtual learning environments, emphasizing expression, peer interaction, and critical discussion.

Integrating metaverse platforms into reflection enables learners to engage in complex interactive activities such as Collaborative Online International Learning (COIL), fostering creative thinking and self-assessment (Esguerra et al., 2024). Through metaverse simulations, pre-service teachers can practice instructional methods and deepen their professional identity development. López-Belmonte et al. (2023) assert that teaching in the metaverse offers authentic opportunities for

future educators to design lessons, interact with virtual students, and engage in self-assessment, facilitating experiential learning seldom attainable in traditional simulation labs. Mengyuan (2023) further highlights that structured reflective practices enhance pre-service teachers' clarity about their personal growth and professional roles.

2.9. Guidelines for Developing Metaverse-Based Learning

Creating effective metaverse-based learning environments requires thoughtful design and the integration of suitable technologies (Freina & Ott, 2015). Successful metaverse education follows key principles: realistic environments, interactive learning experiences, and appropriate assessment methods (Kye et al., 2021). Competency-based development leverages immersive environments and technology to support skill acquisition through practice and application (Sinlapaninman et al., 2023). Teacher training programs must be enhanced to address digital skill gaps among instructors, ensuring equitable access to high-quality learning opportunities. This development hinges on bridging technological divides in teacher preparation, enabling pre-service teachers to function effectively in virtual classrooms (Gürkan & Bayer, 2023; Khunaivi et al., 2023). Collectively, these studies confirm that immersive, competency-based virtual environments like the metaverse enhance instructional skills and foster a reflective, confident teacher identity. Multiple studies provide compelling evidence that integrating metaverse-supported instructional design into teacher education can significantly enhance reflective practice and emotional preparedness among pre-service teachers. These immersive digital environments not only improve technology adoption and self-efficacy but also foster reflective practices that encourage prosocial development. Furthermore, narrative techniques that engage emotional experiences enable pre-service teachers to confront modern classroom challenges with increased resilience and reduced hesitation. This comprehensive framework reflects the complex transformation necessary for teacher education to meet 21st-century learning demands.

3. Methodology

3.1. Research Design

This study employed a qualitative approach to explore pre-service teachers' instructional and emotional readiness in a virtual learning environment (VLE) embedded in Metaverse Spatial. The ADDIE model (Danks, 2011) guided the instructional design through five phases conducted in two research cycles, aligning with UNESCO's (2015) learner-centered and context-sensitive innovation framework.

3.2. Participants

Participant Selection and Sampling

The sample comprised 78 purposively selected students from the Computer Education Program at Kalasin University, Thailand, enrolled in two courses. The rationale for selecting 78 participants was based on the principle of theoretical saturation in qualitative research, where this number was deemed sufficient to capture diverse perspectives and experiences within the specific context of pre-service teacher education. The sample size also aligns with the course enrollment and ensures manageable group sizes for immersive metaverse activities.

Inclusion and Exclusion Criteria

Inclusion Criteria:

1. Currently enrolled students in the Computer Education Program at Kalasin University
2. Registered in the two target courses during the study period
3. Willingness to participate in metaverse-based learning activities

4. Basic computer literacy and internet access
5. Consent to participate in interviews and reflective activities

Exclusion Criteria:

1. Students with severe technical limitations preventing access to the metaverse platform access
2. Participants who withdrew from the courses during the study period
3. Those who did not complete the required learning activities
4. Students who declined to participate in data collection procedures

3.3 Data Collection Instruments

Semi-Structured Interview Protocol Development

The semi-structured interview protocol was developed through a systematic process involving: 1) Literature review to identify key themes related to pre-service teacher experiences in virtual environments, 2) Consultation with experts in teacher education and educational technology, 3) Pilot testing with a small group of similar participants to refine question clarity and flow, and 4) Alignment with theoretical frameworks including TPACK, connectivism, and self-efficacy theory.

The interview protocol focused on three main dimensions, as shown in Table 1:

Table 1. Interview Questions

Dimension	Interview Question	Theoretical Framework Alignment
1.1 Thematic Analysis of Learners' Prior Experience	1. Can you describe your past experiences using digital platforms or technologies in your learning or teaching?	TPACK – Technology Knowledge (TK): Understanding the use of digital tools in teaching and learning. Connectivism – Learning through linking digital tools and knowledge.
1.2 Digital Competency Challenges and Expectations	2. What digital skills do you think are essential for teaching in virtual or immersive environments, and what concerns or expectations do you have about them?	TPACK – Integrating TK, PK, and CK in immersive environments. Bandura's Self-Efficacy Theory – Learners' perceived ability to teach using technology.
1.3 Emotional Readiness for Virtual Instruction	3. How do you feel about the idea of teaching or learning in a fully virtual classroom?	Bandura's Self-Efficacy Theory – Confidence and emotional regulation in virtual teaching. Connectivism – Emotional support and readiness through networked collaboration.

Reliability and Validity Measures

Reliability:

1. Inter-rater reliability was established through multiple researchers independently coding a subset of interview transcripts
2. Test-retest reliability was assessed by conducting follow-up interviews with selected participants

3. Internal consistency was maintained through standardized interview procedures and training for all data collectors

Validity:

1. Content validity was ensured through expert review of interview questions and theoretical Alignment

2. Construct validity was established by grounding questions in established theoretical frameworks

3. Face validity was confirmed through pilot testing and participant feedback

4. Triangulation of data sources (interviews, reflective journals, peer feedback) enhanced overall validity

Additional Data Collection Methods

Beyond semi-structured interviews, data collection included:

1. Reflective Journals: Participants maintained structured reflective journals throughout the learning process

2. Peer Feedback: Systematic peer evaluation sessions using standardized feedback forms

3. Gibbs' Reflective Cycle: Structured reflection activities following Gibbs' six-stage model

4. Competency Checklists: Monitoring tools to track participant progress across 70 hours of implementation

5. Expert Evaluations: Likert scale assessments of VLE content, structure, engagement, and suitability

Instructional Design and Implementation

Phase 1: Analysis and Design:

Phase 1 involved qualitative analysis of pre-service teachers' experiences, digital competency challenges, and emotional readiness in virtual learning. Data from semi-structured interviews were thematically analyzed using Braun and Clarke's model, supported by relevant theories and empirical studies, highlighting gaps between familiarity and confidence in virtual teaching competencies.

The design phase integrated competency-based learning with SSPC activities (Sinlapaninman et al., 2023), guided by TPACK (Mishra & Koehler, 2006) and connectivist theory (Siemens, 2005). Bandura's self-efficacy theory (1997) supported authentic task practice and reflection, fostering teaching proficiency development, as summarized in Table 2.

Table 2. Competency-Based Learning Activities Blueprint

Learning Phase	Activities	Virtual Learning Management Competencies	Theoretical Integration
1. Open Mind (<i>Exploration & Emotional Preparedness</i>)	Learners reflect on their prior experiences, interests, and beliefs about teaching. They begin to explore	- Emotional readiness - Goal setting and self-awareness in	Self-Efficacy: Encourages belief in one's ability to grow and succeed.

Learning Phase	Activities	Virtual Learning Management Competencies	Theoretical Integration
	educational challenges and emotional readiness for virtual instruction.	virtual teaching contexts	Connectivism: Initiates internal connection to learning motivations.
2. Build of Familiarity <i>(Metaverse Tools & Avatar Interaction)</i>	Learners explore tools in the Metaverse, interact with avatars, join group chats, and navigate virtual spaces.	• Metaverse tool literacy • Digital communication • Navigating immersive learning environments	TPACK: Builds technological familiarity as part of instructional planning. Connectivism: Builds connection through digital and social interaction. Self-Efficacy: Develops confidence using virtual tools.
3. Competency-Based Learning (SSPC) <i>(Project Work and Simulation)</i>	Select: Choose a topic and teaching methods aligned with interests. Search: Explore digital content and learning resources. Produce: Design instructional activities and create virtual classrooms. Communicate: Facilitate trial teaching sessions using designed Metaverse environments.	• Lesson planning and teaching method selection • Using Metaverse tools and resources • Designing immersive instruction • Managing and facilitating virtual classrooms	TPACK: Integrates pedagogy, content, and technology in action. Connectivism: Knowledge creation through active, social learning. Self-Efficacy: Strengthened through authentic practice and production.
4. Reflect and Evaluate <i>(Self-Assessment & Peer Feedback)</i>	Learners evaluate their teaching simulations, reflect on performance, and give/receive peer feedback to refine skills and build professional identity.	• Self and peer assessment • Reflective thinking • Improving instructional design	Self-Efficacy: Reinforced by feedback and evidence of progress. TPACK: Enables reflection on integration success. Connectivism: Promotes reciprocal learning and shared growth.



Figure 1. Storyboards to Visualize Learning Processes

In this phase, the VLE was developed based on instructional blueprints, creating immersive spaces on the Metaverse Spatial platform. Expert evaluations using Likert scales assessed content, structure, engagement, and suitability. Quantitative and qualitative feedback guided iterative refinements, aligning with established frameworks and global digital learning standards.

Phase 2: Implementation and Evaluation:

Phase 2 involved implementing the VLE with 78 pre-service teachers over 70 hours, monitored via competency checklists. Evaluation emphasized reflective practice using Gibbs' cycle and peer feedback, fostering metacognitive growth and professional development.

3.4. Data Analysis

Analytical Approach

Mixed-methods analysis integrated qualitative reflections and feedback to assess instructional competence and collaborative learning. The study employed two primary analytical methods:

Thematic Analysis

Thematic analysis following Braun and Clarke's (2006) six-phase approach was used to analyze interview data:

1. Familiarization with data through repeated reading of transcripts
2. Generation of initial codes systematically across the dataset
3. Searching for themes by collating codes into potential themes
4. Reviewing themes to ensure they work in relation to coded extracts and the entire dataset
5. Defining and naming themes to capture the essence of each theme
6. Producing the final report with vivid examples and analytic narrative

Content Analysis

Content analysis was integrated to systematically categorize and quantify patterns in reflective journals and peer feedback. This approach enabled the identification of recurring themes and the frequency of specific competency-related concepts across different data sources.

Data Integration and Triangulation

Data from multiple sources (interviews, reflective journals, peer feedback, competency checklists) were triangulated to enhance the credibility and trustworthiness of findings. This integration produced rich insights into pre-service teachers' reflective experiences and competency development in the metaverse environment.

4. Results

This study explored the design and implementation of a metaverse-based virtual learning environment (VLE) to enhance pre-service teachers' virtual learning management competencies. The findings are presented in alignment with the three research questions: (1) pre-service teachers' learning experiences, challenges, and emotional readiness in virtual teaching environments, (2) the development and implementation of a metaverse-based learning environment, and (3) the implementation outcomes reflected through pre-service teachers' experiences. Using qualitative content analysis of observations, reflections, and coaching data, the study highlights knowledge creation, VLE development, and reflective processes supporting professional growth.

Research Question 1: Pre-service Teachers' Learning Experiences, Challenges, and Emotional Readiness

1. Needs and Challenges in Virtual Teaching Environments:

To understand pre-service teachers' readiness for virtual instruction, this study examined 78 participants' prior experiences, digital competency gaps, and emotional preparedness. The analysis revealed three core areas of need and challenge that directly impact their learning experiences in virtual environments.

Table 3. Pre-service Teachers' Perspectives.

Empathy Analysis	Findings	Interpretation	Sample Interview Answers
Thematic Analysis of Learners' Prior Experience	Participants were familiar with digital tools (e.g., Google Classroom, Zoom, etc.) but lacked experience using them.	There is a gap of experience using digital tools.	"I've learn in Zoom a lot, but I wouldn't know how to lead a class myself."
Digital Competency Challenges and Expectations	Participants felt uncertain using digital tools. They need guidance and ongoing support.	Despite recognizing the value of immersive tools, limited experience creates hesitation; all training activities both inside and outside the classroom are needed.	"The Metaverse is exciting, but I don't know how to use it. I want a step-by-step guide or training."

Empathy Analysis	Findings	Interpretation	Sample Interview Answers
Emotional Readiness for Virtual Instruction	Participants felt low confidence, anxiety, and isolated. They want to improve with peer/mentor support and structure environments.	Emotional readiness for virtual instruction is supported by collaboration and structured environments.	"When I have a problem learning or teaching online, I want someone to help me. Feedback and group discussion make me feel good."

The analysis identified gaps between familiarity and practical application of digital tools. While participants recognized the value of virtual learning technologies, their limited hands-on experience created uncertainty and hesitation. This finding highlights the critical need for structured training programs that bridge the gap between theoretical knowledge and practical implementation.

2. Emotional Challenges and Growth Opportunities:

In-depth interviews revealed significant emotional dimensions in pre-service teachers' virtual learning experiences. Participants anticipated several challenges, including limited virtual teaching practice, lack of confidence, and fear of failure in managing virtual classrooms, and feelings of isolation due to insufficient peer or instructor support.

Despite these challenges, pre-service teachers expressed optimism and demonstrated openness to growth. They valued guided simulations, hands-on practice, and reflective activities, showing motivation and willingness to develop their virtual teaching competencies. This balance between acknowledged difficulties and growth mindset provided important insights for designing supportive learning environments.



Figure 2. New Knowledge Creation for Developing a Virtual Learning Environment

3. Summary of Learning Experience Patterns:

The comprehensive analysis of learners' experiences revealed key patterns that shaped the development of the learning framework. Participants demonstrated openness to new experiences and interest in interactive tools, alongside motivation to enhance their digital teaching skills.

However, they also faced limited practical experience, low confidence in using digital tools for instruction, and emotional hesitancy in virtual environments.

These insights informed the development of a four-phase learning model designed to address identified barriers while promoting active engagement: (1) Open Mind - fostering openness and emotional readiness, (2) Build of Familiarity - providing hands-on experience with digital tools, (3) Competency-Based Learning - developing relevant competencies through authentic tasks, and (4) Reflect and Evaluate - supporting growth through self-reflection and feedback.

Research Question 2: Development and Implementation of Metaverse-Based Learning Environment

1. Virtual Learning Environment Design and Structure:

Based on the analysis of pre-service teachers' experiences and challenges, a comprehensive virtual learning environment was developed to enhance both technical competencies and emotional readiness. The environment was implemented on the Metaverse Spatial platform and organized into thematic zones designed to support different aspects of the learning process.

The VLE featured a gallery-style main classroom, conference room, and breakout rooms for small-group collaboration. Learners engaged in teaching simulations, peer discussions, and assessments using virtual whiteboards, shared notes, media-sharing interfaces, portals connecting learning spaces, and digital assessment tools. The design was piloted with 78 pre-service teachers over 70 hours, with experts rating the design highly in validity, usability, and pedagogical alignment.

Table 4. Virtual Learning Environment

Zone	Learning Phase	Key Functions	Figure
Main Conference Room	Open Mind	Supports awareness and understanding through multimedia (e.g., presentations, infographics, videos). Lays the foundation for readiness and engagement.	
Small Meeting Room / Social Interaction Zone	Build of Familiarity	Provides informal space for communication and collaboration to reduce anxiety and build digital confidence.	
Gallery Room & Virtual Teaching Lab	Competency-Based Learning, Scaffolded Onboarding, Reflect and Evaluate	This stage motivates the learner to take action through real projects based on the SSPC — Select, Search, Produce, and Communicate. Activities are real teaching situations, such as lesson planning and online instruction from the learners.	

Zone	Learning Phase	Key Functions	Figure
		Such simulations promote digital literacy, collaboration, and self-efficacy that connect theory to practice within a safe learning environment for pre-service teacher strengthening. Reflection on the learning experiences as well.	
Recreational Park & Café	Emotionally Responsive Learning Design	Supports relaxation, social interaction, and emotional balance. Encourages motivation and a sense of belonging.	

2. Pedagogical Features and Integration:

The virtual learning environment integrated simulation-based instruction, learner-centered design, and emotional scaffolding within the structured virtual platform. Following the SSPC framework (Select, Search, Produce, Communicate), learners engaged in authentic, project-based tasks to develop digital literacy, civic awareness, and instructional creativity. The environment featured immersive hubs aligned with instructional phases to support sequential and communicative learning. Emotional growth was fostered through peer collaboration and formative feedback, while reflective assessments, including self-evaluations and guided reflections, supported professional development and enhanced pedagogical competence among pre-service teachers.

Research Question 3: Implementation Outcomes and Reflective Experiences

1. Reflective Learning Processes and Outcomes:

To enhance engagement in the metaverse-based classroom, reflective activities were designed using Gibbs' (1988) Reflective Cycle. Drawing on coaching strategies and positive reinforcement, learners reflected on both their own teaching practices and those of their peers. Structured reflection emphasized self-awareness and growth-oriented feedback, fostering critical thinking and professional insight. These reflective processes supported metacognitive development and deeper understanding of teaching practices, contributing to more effective learning and instructional decision-making in virtual environments. The dual coaching strategy—supportive ("pull") and directive ("push")—guided pre-service teachers' reflections through prompts such as "What went well?" and "What could be improved?"

2. Key Themes in Reflective Experiences:

Using Braun and Clarke's (2006) thematic analysis and Elo and Kyngäs's (2008) content analysis, reflections revealed four prominent themes that characterized pre-service teachers' learning experiences:

Instructional Confidence and Clarity: Learners reported satisfaction regarding lesson structure and flow while expressing uncertainty about overall teaching effectiveness. Instructor feedback emphasized student engagement and affirmed effective practices, reinforcing learner insights and fostering growing confidence in instructional contexts.

Digital Tool Fluency: Many learners encountered challenges using immersive digital tools such as whiteboards and shared media platforms. Their reflections revealed limited prior experience in this domain, leading to targeted coaching and recommendations for iterative practice essential for developing fluency within virtual teaching environments.

Emotional Readiness and Adaptability: Early reflections revealed feelings of nervousness and apprehension, which gradually evolved into greater confidence due to peer support and instructor validation. This theme highlights the role of emotional resilience in professional growth and the necessity of addressing emotional challenges as a critical component of teacher development.

Collaborative Virtual Classroom Design: Learners expressed appreciation for peer-designed virtual learning spaces, noting how spatial organization enhanced clarity and engagement. Instructor feedback acknowledged these design strengths and encouraged continued innovation in virtual instructional space planning.

3. Innovation and Problem-Solving Outcomes:

During the implementation, a practical challenge emerged that became an opportunity for collaborative innovation. Learners noted that avatars spawned in random locations upon entry to the virtual classroom, creating confusion about lesson orientation. This obstacle led to collaborative problem-solving as pre-service teachers co-designed a navigational framework to enhance classroom usability. The solution involved integrating number markers, directional arrows, and an updated classroom map into the virtual design. These visual navigation aids guided users to the lesson's entry point and suggested logical progression through the space. This innovation reduced spatial disorientation, increased overall usability, and empowered pre-service teachers to translate reflective insights into actionable improvements.

4. Peer Teaching and Feedback Experiences:

Pre-service teachers demonstrated ability to provide constructive feedback grounded in pedagogical theory. Participants assessed peers' use of digital tools, lesson structure, and emotional regulation during instruction. While content knowledge was generally strong, some encountered technical difficulties due to unfamiliarity with the platform. To address challenges in providing direct feedback due to time limitations and social discomfort, anonymous peer feedback was implemented. This strategy supported more honest and constructive evaluations, promoting a psychologically safe environment conducive to learning and helping develop critical assessment skills among participants.

Overall, the implementation outcomes demonstrate that structured reflection, when paired with timely feedback and collaborative problem-solving opportunities, can transform surface-level observations into deeper pedagogical understanding. This interplay between self-awareness and guided coaching lays the foundation for cultivating adaptive, reflective, and confident virtual educators.

5. Discussion

This study focused on the development of a Virtual Learning Environment (VLE) on a metaverse platform to enhance pre-service teachers' competencies in managing virtual instruction. The findings

provide important insights into how immersive virtual environments can support teacher education through competency-based learning and reflective practice, while addressing the emotional and technical challenges that pre-service teachers face in digital learning contexts.

Development of Virtual Learning Environment on the Metaverse to Enhance Virtual Learning Management

The findings demonstrate that pre-service teachers' instructional management competencies can be effectively developed through the Metaverse Spatial platform when grounded in systematic understanding of learners' needs. This finding aligns with previous research by Sinlapaninman et al. (2023), who found that metaverse-based virtual learning management training leads to high satisfaction and effective knowledge application. However, the current study extends this understanding by revealing the critical importance of pre-implementation needs analysis in designing effective virtual learning environments. Similar to findings by Farsi et al. (2023), who demonstrated that metaverse-trained students exhibited superior classroom management skills compared to those trained solely online, this study confirms the effectiveness of immersive virtual training. However, the current research provides additional insights into the specific design elements that contribute to this effectiveness, particularly the four-stage learning model integrated with the SSPC framework (Select, Search, Produce, and Communicate).

Most learners reported a lack of exposure to immersive digital learning environments and were lacking in using digital tools and creating instructional activities in virtual spaces due to passive learning experiences. To address these concerns, the learning model consisted of four stages: Open Mind (awareness building), Build of Familiarity (confidence building), Competency-Based Learning (skills development), and Reflect and Evaluate (self-assessment and consolidation). Each phase was integrated with the SSPC framework, providing learners with systematic opportunities to engage in hands-on instructional design in a simulated classroom environment. This design approach differs from previous studies by providing a more comprehensive framework that addresses both technical and emotional aspects of virtual teaching. While Wang et al. (2022) emphasized the need to address digital skill gaps among instructors, the current study goes further by demonstrating how structured, phase-based learning can systematically build these competencies while simultaneously addressing emotional readiness. The VLE design aligns with the OECD's (2030) emphasis on developing transformative competencies for 21st-century educators, particularly in equipping them to design and facilitate learning in rapidly evolving digital contexts (Miettinen, 2022). Furthermore, it reflects UNESCO's (2020) vision of inclusive, equitable, and lifelong digital learning. Unlike previous implementations that focused primarily on technology adoption, this study demonstrates how learners can transition from being technology users to becoming digital learning designers, representing a fundamental shift in agency and ownership.

Reflective Practice and Professional Development: Comparison with Existing Literature

The study's findings on reflective practice both confirm and extend previous research in significant ways. Consistent with Cadiz (2022), who demonstrated that novice teachers engaging in reflective practices developed deeper beliefs about effective teaching, this study found that structured reflection led to improved instructional design thinking and greater confidence in questioning teaching methods. However, the current research provides unique insights into how the Pull-Push Coaching model can be implemented in virtual environments. The implementation of the Pull-Push Coaching model emerged as a key mechanism to foster deep learning, involving "pulling" learners to reflect through guided questions and "pushing" them with targeted feedback from facilitators. This approach builds upon Schön's (1983) theory of the reflective practitioner while demonstrating practical application in metaverse contexts. Unlike previous studies that applied reflective frameworks in traditional settings, this research shows how virtual environments can

enhance reflective practice through immersive experiences and collaborative problem-solving. The findings align with Mengyuan (2023), who found that supervised reflective activities help develop epistemological identity. However, the current study extends this understanding by demonstrating how virtual environments can provide authentic contexts for reflection that were previously difficult to achieve in traditional teacher education programs. The tangible improvements in virtual classroom design—such as navigation systems and spatial zoning—represent concrete evidence of how reflection translates into practical teaching competencies. This approach reflects the principles of Cognitive Apprenticeship (Collins et al., 1989), which emphasizes learning through observation, practice, and flexible mentoring. The virtual environment provided unique affordances for this apprenticeship model that differ significantly from traditional classroom-based teacher education, offering repeated practice opportunities and immediate feedback in risk-free environments.

Emotional Readiness and Self-Efficacy: Novel Contributions to the Field

The study's findings on emotional readiness provide important new insights that extend beyond previous research. While Ji et al. (2022) found that immersive technologies reduce anxiety during teaching practicums, the current study provides a detailed understanding of how specific design features contribute to emotional support and confidence-building in virtual environments. Emotional readiness emerged as a prominent theme both before and during implementation. The identification of anxiety related to simultaneous management of content, tools, timing, and learner engagement represents a more nuanced understanding of the emotional challenges in virtual teaching than previously documented. This finding contrasts with studies that focused primarily on technical competencies, highlighting the critical importance of addressing emotional dimensions in teacher preparation programs.

The VLE design as a psychologically safe space with opportunities for non-evaluative rehearsal, personalized coaching, continuous technical support, and peer collaboration in low-stakes environments represents a novel approach to addressing emotional readiness. While Bandura's (1997) self-efficacy theory has been applied in various educational contexts, this study demonstrates specific applications in metaverse-based teacher education that were not previously explored in the literature. The finding that learners could gradually build confidence and take ownership of their teaching performance in digital contexts through structured support systems provides practical guidance for teacher educators that was not available in previous research. This represents a significant advancement in understanding how to design virtual learning environments that support both technical and emotional development.

Theoretical Integration and Framework Development

This study contributes to the field by demonstrating how multiple theoretical frameworks—TPACK, connectivism, self-efficacy theory, and reflective practice models—can be integrated effectively in virtual learning environments. While previous studies have applied these frameworks individually, the current research shows how their combined application can create comprehensive learning experiences that address the complex demands of 21st-century teacher preparation. The four-phase learning model developed in this study represents a unique contribution that bridges theory and practice in ways not previously demonstrated in the literature. The integration of emotional support, technical skill development, and reflective practice within a single coherent framework provides a template for future virtual learning environment design in teacher education.

Unique Contributions to the Existing Body of Literature

This study makes several distinct contributions to the field of teacher education and virtual learning environments:

First, it provides the first comprehensive framework that systematically addresses the gap between theoretical knowledge and practical application of virtual teaching competencies through phase-based learning integrated with authentic practice opportunities.

Second, the study demonstrates how collaborative problem-solving in virtual environments can lead to innovative solutions that improve usability and learning outcomes, as evidenced by the navigation system co-designed by participants.

Third, it offers practical guidance for implementing reflective practice in virtual environments through the Pull-Push Coaching model, providing concrete strategies for teacher educators working in digital contexts.

Fourth, the research provides detailed understanding of the emotional dimensions of virtual teaching preparation, offering specific design principles for creating psychologically safe learning environments that build confidence and self-efficacy.

Finally, the study contributes to the theoretical understanding of how multiple frameworks can be integrated effectively in virtual learning environments, providing a foundation for future research and practice in metaverse-based teacher education.

These contributions collectively advance the field's understanding of how immersive virtual environments can be designed and implemented to prepare pre-service teachers for the demands of 21st-century digital classrooms, addressing both the technical and emotional aspects of virtual teaching competencies in ways that were not previously available in literature.

6. Conclusion

This study addressed three research questions regarding pre-service teachers' experiences in virtual learning environments, the development of metaverse-based learning systems, and implementation outcomes. Regarding pre-service teachers' learning experiences and emotional readiness, the study revealed a significant gap between digital tool familiarity and confidence in practical application. Participants demonstrated openness to learning despite challenges including limited hands-on experience, anxiety about managing multiple teaching elements simultaneously, and feelings of isolation. Emotional readiness emerged as critical, requiring systematic support through collaboration and structured environments. For the development and implementation of the metaverse-based learning environment, the study successfully created a comprehensive VLE on the Metaverse Spatial platform using a four-phase model: Open Mind, Build Familiarity, Competency-Based Learning, and Reflect and Evaluate. The integration of the SSPC framework with thematic zones created authentic learning opportunities that bridged theory and practice, with expert evaluations confirming high validity and pedagogical alignment. Implementation outcomes demonstrated significant positive impacts through structured reflective practice using Gibbs' Reflective Cycle and the Pull-Push Coaching model. Participants developed four key competencies: instructional confidence, digital tool fluency, emotional readiness, and collaborative design skills. The reflective processes enabled transformation of observations into deeper pedagogical understanding, evidenced by collaborative problem-solving and innovative solutions. This study demonstrates that a thoughtfully designed virtual learning environment, grounded in a deep understanding of learners' needs and experiences, can effectively address gaps in instructional exposure, digital competence, and emotional readiness. Through a structured learning sequence, reflective scaffolding, and targeted support, pre-service teachers not only improved their teaching skills but also developed a confident and adaptive professional identity capable of designing meaningful learning experiences in immersive digital worlds. The research contributes a comprehensive framework integrating multiple theoretical perspectives with practical implementation strategies for metaverse-based teacher

education. Future research should explore long-term impacts on classroom practice and scalability across different educational contexts.

7. Suggestion

1. Recommendations for This Study, to enhance the learning outcomes of preservice teachers in immersive environments, it is recommended that instructors integrate structured reflective activities throughout the course using well-established frameworks such as Gibbs's Reflective Cycle. We should embed the positive coaching strategy, which includes supportive prompts and directive feedback, into virtual learning cycles to enhance emotional readiness and pedagogical competencies. The design of virtual classrooms in Metaverse Spatial should also include clear orientation features such as instructional signage and guided navigation to reduce cognitive overload. Additionally, the instructional process should encourage learners to co-create virtual learning environments, fostering creativity and ownership in instructional design.

2. Recommendations for Future, Research Future studies should explore the long-term impact of immersive virtual teaching experiences on professional identity development and teaching self-efficacy among preservice teachers. Expanding the sample to include cross-institutional or international cohorts would allow researchers to examine cultural and contextual variables in virtual instruction. Moreover, integrating learning analytics into Metaverse platforms could provide real-time feedback loops, enhancing personalized learning and adaptive teaching strategies. Finally, future research should look at comparing traditional online learning with immersive virtual environments to see how they differently affect teaching skills and the ability to reflect on learning.

Declarations

Author Contributions. U.S.: Literature review, conceptualization, methodology, data analysis. W.Y.: review-editing and writing, original manuscript preparation. All authors have read and approved the published on the final version of the article)

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Data Availability Statement. (Please provide a statement about where data supporting the results reported in this study)

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