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Designing Metaverse-based language learning: How pre-service teachers applied the Triple-E framework

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Abstract: This study investigates how 36 pre-service teachers in Taiwan applied the Triple-E Framework (Engage, Enhance, Extend) during a four-week design-based course using a Metaverse-based platform. Data sources included 264 peer evaluations of the Metaverse design and final group projects. Results show that pre-service teachers excelled in creating visually engaging environments and instructional goals, but faced challenges in aligning their designs with real-world transfer. Thematic analysis of peer feedback revealed that "Engage" was the most frequently recognized dimension, while "Extend" was the least observed. Inferential analyses indicated strong interrelationships between the Triple-E dimensions and a significant association between dimensions. This study contributes to the field by offering a framework-guided, data-informed model for developing digital pedagogical skills in teacher education.

Keywords: Triple-E framework, design-based learning, metaverse, pre-service teachers.

1. Introduction

Technology-enhanced language learning has become an integral component of teacher education programs, equipping future educators with the digital competencies needed to support modern language instruction. Research shows that when pre-service teachers are trained in technology-enhanced language learning, they are more likely to raise technological awareness and increase knowledge (see Almumen, 2023). However, teacher education programs often face challenges in providing adequate pedagogical frameworks and hands-on experience with emerging technologies (Kessler, 2018). Design-based learning has emerged as a prominent pedagogical approach within teacher education, emphasizing creativity, critical thinking, and practical application of educational theories.

This study aims (1) to investigate how pre-service teachers integrated the Triple-E Framework into their preliminary hands-on Metaverse-based language learning design during their initial stages of teacher training, (2) to analyze their peer feedback for evidence of explicit or implicit recognition and reflection of the Triple-E dimensions, and (3) to identify and document specific Triple-E Framework design patterns within the final design of their Metaverse environments. As a result, three research questions are raised:

1. How did pre-service teachers apply the Triple-E Framework in their Metaverse-based language learning design tasks?
2. To what extent did peer feedback reflect the application of the Triple-E dimensions?
3. How were the Triple-E design patterns in their final Metaverse environment designs?

2. Related Work

The Triple-E framework, developed by Kolb (2017), is defined as a measurement scale for educators to evaluate how technology tools integrated into lessons help students engage in, enhance, and extend learning goals. According to Al-Khalidi (2021) the Triple-E framework is

a practical tool that combines instructional strategies, learning goals, and purposeful technology selection.

This framework has been validated through previous research, such as Schatzke (2019). She investigated the content and concurrent validity, as well as the reliability, of the Triple-E rubric as a tool for lesson design. Similarly, Al-Khalidi (2021) investigated how the Triple-E framework was employed as an evaluation tool by ESL (English as a Second Language) teachers to assess technology integration in their lesson planning. This study indicated that teachers held positive views towards using the Triple-E rubric for assessing their lesson plans.

Immersive learning environments, particularly within the Metaverse, offer innovative ways to engage learners by providing interactive and realistic experiences. As cited in Hwang and Lee (2024), the metaverse, an immersive 3D virtual world, contributes to revolutionizing many fields, including education. These virtual settings leverage experiential learning principles, supporting active participation, reflection, and knowledge application (Kolb, 2015). Although recent research highlights increased learner motivation and improved cognitive engagement in Metaverse environments due to authentic simulations and multisensory experiences (Adelana et al., 2023), Adelana et al. (2023) accentuate the need for effective teacher training and policy formulation to address challenges associated with adopting emerging educational technologies like virtual reality.

Hence, research focusing on how pre-service teachers design immersive learning environments to facilitate their teaching lessons needs more attention. The current research examines pre-service teachers' designs of the metaverse to enhance language teaching.

3. Methodology

3.1 Participants

The participants of this study were 36 undergraduate students majoring in foreign language education at a private university in central Taiwan. These students attended an elective course, namely "Fundamentals in Interactive Design".

3.2 Experimental Procedure

The experimental duration lasted four weeks. The students met in person in a classroom for three hours each week. In the first week, the instructor introduced the Triple-E framework and the metaverse platform ZEP (https://zep.us/en) to the students. Students were familiarized with how to integrate the components of the Triple-E framework into a metaverse design to facilitate language learning.

In the second week, students were trained in designing a simple metaverse using the Triple-E framework. In the third week, the students were divided into 10 groups of three to four students. Each group selected a topic to design a metaverse. In the last week, all the groups presented their metaverse design and received feedback from the teacher as well as other students. The feedback based on the criteria of the Triple-E framework was given in the form of a self-designed questionnaire, together with an open-ended question at the end to collect qualitative data for the study.

3.3 Measuring Tools

Figure 2 illustrates a sample student-designed metaverse environment used to facilitate immersive language learning experiences. In the top panel, learners navigate the environment using customizable avatars, promoting a sense of presence. Non-player characters (NPCs), represented by AI-guided agents, provide interactional prompts and simulate real-world interlocutors. Other visual elements, such as signage, pathways, and terminals, serve as contextual backdrops that replicate authentic settings, here, a simulated airport.

In the lower panel, the environment further integrates task-based language learning strategies through embedded quizzes and decision-making challenges. Real-time video and audio features enable synchronous communication among peers and instructors, supporting oral language practice and collaborative interaction. Users' emotional reactions, expressed through avatar animations, while the real-time chat function allows for text-based negotiation of meaning. Together, these multimodal elements support learner engagement (via immersive interaction).

This study's measurement tools comprise 264 peer feedback forms in the second week and nine group-designed Metaverse artifacts. Examples of the final Metaverse design by students are presented in Figure . Thematic analysis was conducted on the feedback data to identify students' learning design experiences. The first and second authors coded 20 percent of the data separately. The inter-rater reliability using Cohen's Kappa was 0.9, indicating high agreement. The rest of the data coding was done by the first author. Table 1. Peer-Feedback Questionnaire presents the self-design questionnaire, based on the components of the Triple-E framework, to collect peer feedback, with 5 indicating "Very Good," 4 indicating "Good," 3 indicating "Average," 2 indicating "Okay," and 1 indicating "No improvement."

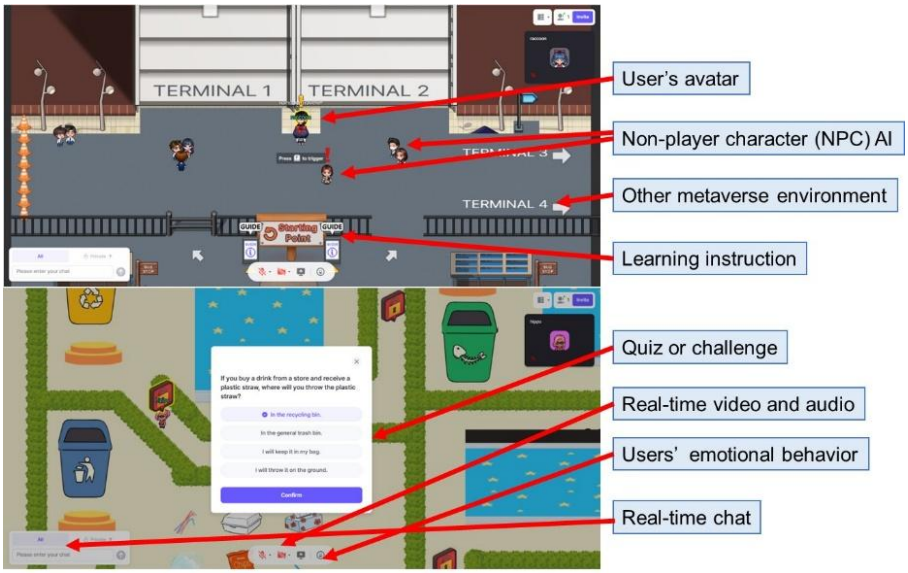

Figure 2. The sample of students' design of Metaverse-based language learning

Table 1. *Peer-Feedback Questionnaire*

Item	Score				
1. Interaction with the Environment How well can learners explore and interact with the virtual space? Are there tasks, objects, or NPCs to engage with?	1	2	3	4	5
2. Engagement Elements (Avatars, Challenges, Rewards, Storytelling) Does the design include fun elements like avatars, rewards, challenges, or a story to make learning interesting?	1	2	3	4	5
3. Triple E-Framework: Engage (Capturing Attention) Does the design grab learners' attention and keep them interested in learning?	1	2	3	4	5
4. Language Learning Support (Enhance Learning) Does the design help learners practice language through clear tasks, feedback, and activities?	1	2	3	4	5
5. Real-World Connection (Extend Learning) Can learners use what they learn in real-life situations (e.g., ordering food, traveling, job interviews)?	1	2	3	4	5

What other feedback based on the Triple-E framework do you want to give to your friends?

3.4 Inferential Analysis

To complement the rubric-based evaluations of the student-designed metaverse environments, a series of inferential statistical analyses was conducted to further examine patterns in the data. First, Spearman's rank-order correlation was employed to analyze the relationships among the five items included in the Likert-scale peer evaluation form (n = 264). Second, a chi-square test of independence was conducted to investigate the association between the frequency of Triple-E dimensions identified in peer comments. Third, the Friedman test was applied to assess statistically significant differences in the perceived quality of Engage, Enhance, and Extend elements within the nine final group projects. Following a significant Friedman test result, Wilcoxon signed-rank tests were used for pairwise comparisons between dimensions. A Bonferroni adjustment was applied to control for Type I error in the multiple comparisons.

4. Findings

4.1 How did pre-service teachers apply the Triple-E Framework in their Metaverse-based language learning design tasks?

Quantitative peer evaluation data from 264 responses during Week 2 reveal that students evaluate their peers' metaverse designs as creating engaging and visually appealing environments, as well as integrating the real-world application of language learning tasks in the initial stages. The average peer ratings (on a 5-point scale) are presented in Table .

Table 2. *Descriptive Statistics of Peer Evaluation*

Item	N	Minimum	Maximum	Mean	Std. Deviation
Item1	264	3	5	4.27	.692
Item2	264	2	5	4.19	.733
Item3	264	2	5	4.21	.728
Item4	264	2	5	4.18	.773
Item5	264	2	5	4.18	.758

A Spearman's rank-order correlation was conducted to examine the relationships among the five Likert-scale items. All items were strongly and positively correlated, with Spearman's rho values ranging from .77 to .85, all statistically significant at $p < .001$. The strongest correlation was observed between Item 4 and Item 5 ($\rho = .85$, $p < .001$), suggesting substantial overlap in the constructs they measured. Internal consistency reliability for the five items was excellent, with a Cronbach's alpha of $\alpha = .95$.

4.2 To what extent does peer feedback reflect the application of the Triple-E dimensions?

To explore how peer comments reflected the Triple-E Framework, 264 open-ended responses were coded based on the presence of elements related to Engage, Enhance, and Extend. The largest segment represents students who addressed only one dimension of Engage (39%). A significant portion (34.1%) addressed two elements of Engage and Enhance. A smaller proportion of 18% reflects feedback covering only the Enhance dimension. Notably, 20% of the comments did not relate to the Triple-E dimensions. Only 1% emphasized the Extend dimension. No comments focused on all the Triple-E dimensions.

Regarding peer comments that were thematically coded according to the Triple-E Framework, comments coded under the Engage dimension often emphasized aesthetic appeal and interactivity. Comments categorized under Enhance demonstrated awareness of how designs supported conceptual understanding and language practice. The Extend

dimension, although least frequently mentioned, was reflected in feedback recognizing real-world application.

A chi-square goodness-of-fit test was performed to examine whether the observed frequencies of eight coding categories, including Engage (1), Enhance (2), Extend (3), Engage and Enhance (4), Engage and Extend (5), Enhance and Extend (6), Engage and Enhance and Extend (7), and None (8), were significantly different. The test revealed a statistically significant difference, χ^2 (5, N = 264) = 165.50, $p < .001$, indicating a preference of Engage (N=102), Enhance (N=48), Engage and Enhance (N=59), and None (N=52) over Extend (N=2), and Engage and Extend (N=1).

4.3 How were the Triple-E design patterns in their final Metaverse environment designs?

The final Metaverse learning environments, developed by nine student groups, were evaluated using a rubric based on the Triple-E Framework. Each group project was scored on a scale of 0–2 in three categories: Engage (attention-capturing design), Enhance (language learning support), and Extend (real-world application).

The Engage dimension yielded the highest overall performance, with five groups achieving the maximum score of 2. This finding suggests that most students were successful in designing environments that visually captured learners' attention and integrated interactive elements such as avatars, quests, or gamified tasks. The relatively strong performance in this dimension reflects a focus on surface-level engagement and the motivational aspects of digital design.

In contrast, fewer groups reached the top score in the Enhance dimension. Only four out of nine groups achieved a score of 2, indicating that while some students embedded meaningful instructional support, many designs demonstrated only partial or limited enhancement. The Extend dimension was the most underdeveloped, with just one group attaining a top score of 2 and three groups receiving a score of 0. This trend highlights a recurring challenge in creating virtual learning activities that explicitly promote real-world application or knowledge transfer beyond the digital environment.

A Friedman test was conducted to assess differences between Engage, Enhance, and Extend ratings across nine final student designs. The test revealed a statistically significant difference among the three dimensions, $\chi^2(2, N = 9) = 9.91$, $p = .007$. Mean scores indicated that Engage (M = 1.56) and Enhance (M = 1.44) were rated higher than Extend (M = 0.67).

Post-hoc Wilcoxon signed-rank tests revealed that both Engage (W = 0.00, p = .023) and Enhance (W = 0.00, p = .020) scored significantly higher than Extend. At the same time, there was no significant difference between Engage and Enhance (p = .564). The results revealed that students' designs were significantly more effective at engaging and enhancing learning than at extending learning opportunities. No significant difference was found between engagement and enhancement performance, but extending learning was clearly the weakest dimension.

5. Discussion and Conclusion

This study examined how pre-service teachers implemented the Triple-E Framework in designing Metaverse-based learning environments, offering valuable insights into the evolving digital pedagogy of teacher candidates. Peer evaluation data from Week 2, alongside the rubric-based analysis of final group projects, consistently pointed to the Engage dimension as the most effectively realized aspect of students' work. Across both data sources, pre-service teachers demonstrated strong capabilities in creating visually stimulating, interactive spaces that successfully captured learner attention through elements such as avatars, narrative-driven tasks, and gamified activities.

However, a statistically significant disparity was observed across the three dimensions, Engage, Enhance, and Extend, with the Extend dimension receiving the lowest evaluations. While many student designers showed competence in developing tasks that supported language learning and cognitive engagement (Enhance), they faced notable challenges in designing experiences that promoted knowledge transfer to real-world contexts (Extend).

These results highlight the importance of more targeted scaffolding within teacher preparation programs, particularly in supporting pre-service teachers to conceptualize and implement designs that extend learning beyond the virtual environment. The findings echo earlier qualitative and quantitative analyses, reinforcing a recurring pattern: while students excel at crafting engaging and instructional virtual experiences, they often struggle with designing for real-world applicability. This highlights a critical gap in the pedagogical reasoning that underpins immersive learning design and signals the need for additional training, guided examples, and reflective activities focused on the Extend component of the framework.

Despite some limitations, including a relatively short intervention period, reliance on self- and peer-assessment, and a simplified coding rubric, the study contributes to the growing body of research on immersive learning and digital pedagogy. It affirms the utility of the Triple-E Framework as a scaffold for instructional design in Metaverse environments and demonstrates how peer feedback can serve as a formative tool in the design-based learning process. Future research should explore how extended exposure to iterative design tasks and longer-term collaborations might enhance pre-service teachers' ability to integrate the Extend dimension effectively. Longitudinal studies could also investigate how these design skills translate into actual classroom practice, particularly in language education settings where immersive and experiential learning hold increasing relevance.

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References

Adelana, O. P., Ayanwale, M. A., Ishola, A. M., Oladejo, A. I., & Adewuyi, H. O. (2023). Exploring pre-service teachers' intention to use virtual reality: A mixed-method approach. *Computers & Education: X Reality*, *3*, 100045. https://doi.org/10.1016/j.cexr.2023.100045

Al-Khalidi, I. (2021). Using the Triple E framework as an instructional design tool for the assessment of technology integration in a variety of TESOL contexts. *The Asian ESP Journal*, *17*(2), 48–73.

Almumen, H. (2023). Technology and multimodality in teaching pre-service teachers: Fulfilling diverse learners' needs. *Technology, Knowledge and Learning*, *28*(2), 745–767. https://doi.org/10.1007/s10758-021-09550-1

Hwang, Y., & Lee, J.-Y. (2024). Exploring pre-service English teachers' perceptions and technological acceptance of metaverse language classroom design. *SAGE Open, 14*(4). https://doi.org/10.1177/21582440241300543

Kessler, G. (2018). Technology and the future of language teaching. *Foreign Language Annals*, *51*(1), 205–218. https://doi.org/10.1111/flan.12318

Kolb, D. A. (2015). *Experiential learning: Experience as the source of learning and development* (Second). Pearson Education.

Kolb, L. (2017). *Learning first, technology second: An educator's guide to designing Authentic lessons*. International Society for Technology in Education.

Schatzke, S. E. (2019). *A validation study of the Triple E Rubric for lesson design: A measurement tool for technology use in the classroom* [Doctoral dissertation, University of North Texas]. UNT Digital Library. https://digital.library.unt.edu/ark:/67531/metadc1505198/