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Enhancing Undergraduate Performance and Engagement in Costume History Course through a Personalized Experiential Virtual Reality System

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Abstract

This study investigated the effectiveness of a Personalized Experiential Virtual Reality (*PE-VR*) system compared to a Normal Virtual Reality (*NVR*) system in enhancing undergraduates' learning performance and engagement. A total of 30 undergraduate students participated in the experiment. Learning performance was assessed using a pre-test and post-test design and analyzed through ANCOVA, while learning engagement was measured with a standardized questionnaire and analyzed using ANOVA. The results revealed that, after controlling for pre-test scores, the *PE-VR* system significantly outperformed the *NVR* system in improving post-test performance (M=64.33 vs. M=46.33). Similarly, students who used the *PE-VR* system demonstrated significantly higher levels of learning engagement (M=63.09) than those using the *NVR* system (M=46.33). These findings highlight that the personalized and experiential features embedded in the *PE-VR* system can effectively support students' learning outcomes and sustain their engagement. The study provides empirical evidence supporting the integration of VR-based personalized learning tools in higher education contexts.

Keywords: Personalized Experiential Learning, Virtual Reality, Undergraduate, Engagement, Costume History

Introduction

In the 21st century, the rapid advancement of information and communication technology has led to the emergence of various new technologies that are continuously integrated into the education sector, driving innovation and transforming teaching models. However, traditional teaching methods are increasingly inadequate to meet the diverse learning needs of a new generation of students who have grown up in an information-rich environment. In response, innovative tools such as augmented reality (AR) and virtual reality (VR) have been widely adopted in educational practice and have received positive feedback from students (Ibrahim et al., 2021; Lim & Lim, 2020).

History education has primarily depended on traditional lecture-based methods, with minimal integration of technological tools, resulting in classrooms that often lack interactivity and meaningful contextual engagement with learning materials (Wa Ima et al., 2023). This has often led students to experience poor learning performance, low levels of engagement, and increased cognitive load during the learning process (Perrotta & Bohan, 2013; Warrick, 2021; Baghaei & Riasati, 2013). In contrast, virtual reality (VR) technology can create highly immersive and interactive learning environments that make students feel as if they are physically present, which deepens their understanding of the content, elicits positive emotional responses, and effectively enhances their engagement (Zhang et al., 2023; Sun et al., 2022; Parong & Mayer, 2021; Al-Ansi et al., 2023).

The value and impact of VR technology in education are becoming increasingly evident, with the global educational VR market reaching USD 17.18 billion in 2024 (Fortune Business Insights, 2025). According to data released by Statista (Germany, 2023), the value of China's virtual reality education market is projected to reach USD 300 million by 2024 and is expected to grow steadily at a compound annual growth rate (CAGR) of 48.81% from 2024 to 2030, expanding to an estimated USD 3 billion by 2030.

Problem Statement

A primary issue confronting history education is the persistently low degree of student engagement. Owing to the abstract and theoretical character of historical studies, teaching practices continue to depend predominantly on conventional teacher-centered strategies, with limited technological integration and outdated assessment methods, which collectively hinder active student participation (Ibrahim et al., 2021; Wa Ima et al., 2023). Such conventional approaches typically require students to read or recite textbook content with little to no contextual adaptation or meaningful interaction (Inda et al., 2020). Within this traditional framework, instructors function as the central transmitters of information, while learners assume a largely passive role, confined to listening and taking notes with scarce opportunities to cultivate creative thinking or engage in deeper inquiry (Ahmad et al., 2014; Wa et al., 2023). When pedagogical strategies fail to relate historical knowledge to students' everyday experiences, instruction often results in rote memorization rather than fostering critical reflection on the broader significance of historical events. As a result, student motivation and active engagement in history lessons remain markedly low (Perrotta & Bohan, 2013).

A further obstacle confronting students in history classrooms is the lack of interaction with learning materials. Research indicates that when history instruction lacks creative approaches, students' interest in the subject often diminishes significantly (Baghaei & Riasati, 2013). Requiring students to commit to memory lists of notable individuals, dates, and occurrences without appreciating their broader relevance can be demotivating and counterproductive. Historical knowledge should not be reduced to mere memorization but rather should be interpreted and contextualized for deeper comprehension. Unfortunately, conventional pedagogical methods frequently remain outdated and inadequate, failing to create interactive learning environments that nurture students' analytical abilities (Ahmad et al., 2014). As such, there is an urgent need to promote historical thinking competencies, which are vital for enhancing academic outcomes and encouraging inquiry-based learning. Scholars in history education consistently emphasize that overcoming these barriers requires the implementation of appropriate, innovative teaching strategies tailored to stimulate active participation and critical engagement (Ahmad et al., 2014).

The final challenge is the relatively low learning performance of undergraduates in Chinese costume history courses. The traditional teaching approach, which primarily relies on the one-way transmission of knowledge, creates significant obstacles for students to actively and deeply engage with the material. This passive learning model often leads to disengagement and boredom, which, in turn, negatively affects students' motivation and overall learning performance. As a result, many students are unable to achieve satisfactory outcomes in their studies of Chinese costume history (Liu, 2024; Niu, 2016; Chen, 2019; Li, 2024).

These challenges highlight the urgent need to develop an experiential VR learning system to enhance university students' performance and engagement. Such a system can help students adopt appropriate learning strategies tailored to their individual learning characteristics, thereby increasing learning performance and engagement. By doing so, it can effectively overcome the limitations of traditional teaching methods and conventional multimedia learning, providing students with an optimized learning experience and improved learning outcomes.

Research Objectives

The principal purpose of this study is to examine the extent to which a personalized experiential virtual reality (*PE-VR*) learning system can enhance university students' academic performance and engagement within the context of a costume history course. Furthermore, this study aims to generate empirical insights into how the newly developed *PE-VR* system can address persistent instructional limitations by offering a more holistic and interactive approach to costume history education. To achieve these aims, the effectiveness of the PE-VR system is systematically compared with that of a Normal virtual reality (*NVR*) learning system. Accordingly, the study pursues the following specific objectives:

1) To investigate the influence of the *PE-VR* system on undergraduates' learning performance scores in Chinese costume history.
2) To evaluate the impact of the *PE-VR* system on undergraduates' learning engagement in Chinese costume history.

Research Questions

Specifically, the study will address the following Research Questions (RQs):
1) RQ1: Is there a significant difference in learning performance scores (PS) between undergraduates applying the *PE-VR* system and those using the *NVR* system?
2) RQ2: Is there a significant difference in learning engagement (LE) between undergraduates applying the *PE-VR* system and those using the *NVR* system?

Research Hypotheses

This study aims to develop a personalized experiential learning system. Since there is currently no similar study available for reference, the null hypothesis assumes that the system has no effect on learners. The significance level adopted for this study is 0.05 ($\alpha=0.05$).

1) H_{O1}: There is no significant difference in learning performance scores (PS) between undergraduates applying the *PE-VR* system and those applying the *NVR* system. (RQ1)
2) H_{O2}: There is no significant difference in learning engagement (LE) between undergraduates applying the *PE-VR* system and those applying the *NVR* system. (RQ2)

Conceptual Framework

This quantitative study employed a 2 by 2 quasi-experimental factorial design with a non-equivalent control group, using a pre-test and post-test to evaluated the effectiveness of the *PE-VR* system, as shown in Figure 1, the Conceptual Framework. The study included two groups: the *PE-VR* system as the experimental group and the *NVR* system as the control group. Both groups will undergo the treatment as well as pre-test and post-test assessments.

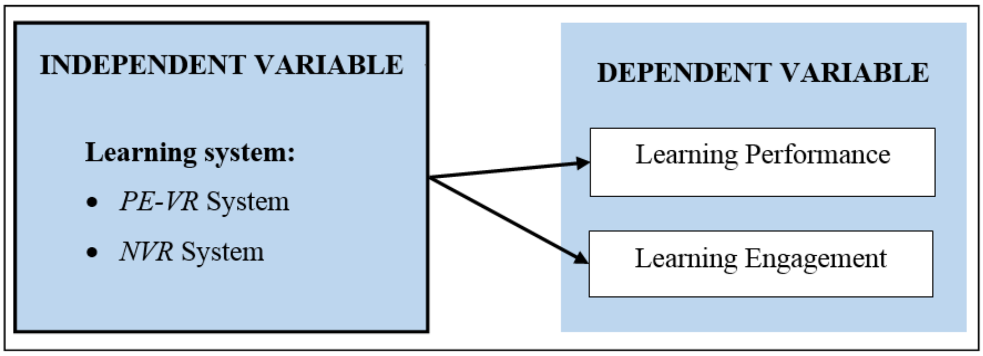

Figure 1. The Conceptual Framework

Theoretical Framework

Figure 2 shows a theoretical framework that outlines the distribution of the relevant theories and clearly illustrates their interrelationships.

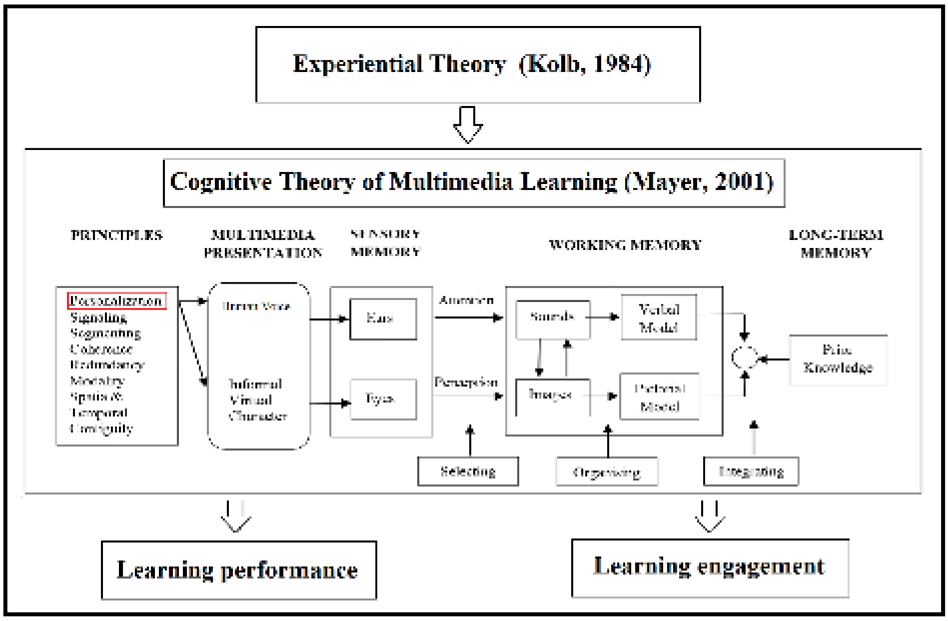

Figure 2. The Theoretical Framework

The integrated concept of personalized experiential learning constitutes the central focus of this study and provides essential theoretical guidance for developing the personalized experiential VR learning system. The pedagogical theories supporting this study, namely Kolb's Experiential Learning Theory (1984), Mayer's Cognitive Theory of Multimedia Learning (2001), and Mayer's Personalization Principle (2009), jointly establish a robust foundation for the conceptualization of personalized experiential learning. These theories not only underpin the design rationale of the personalized experiential VR learning system but also enrich and expand its theoretical implications.

Methodology

Research Design

This study employed a quasi-experimental research design with a non-equivalent control group and a pre-test, post-test structure to investigate the effectiveness of the interactive *PE-VR* system, as showed in Figure 5. It explores whether there are significant differences between the *PE-VR* system and the *NVR* system for university students, with a primary focus on their effects on learning performance and learning engagement.

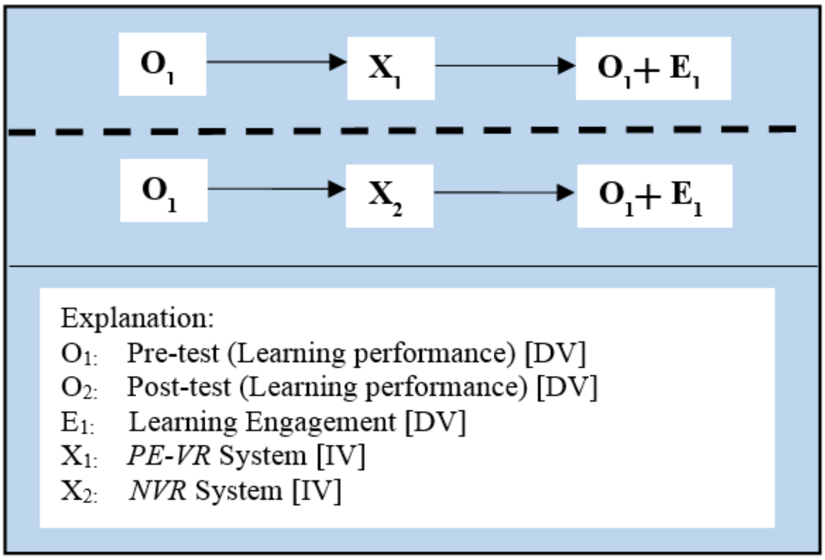

Figure 5. The Research Design

Participants

The participants were 30 first-year undergraduate students majoring in design and art from a university in Jiangxi Province, China. They were selected through stratified sampling and randomly assigned to either the experimental group (*PE-VR* system) or the control group (*NVR* system). Two different presentation modes were used as treatments in this study, with identical learning content and scope for both groups. Each group consisted of 15 participants aged between 18 and 20 years. Both groups completed a pre-test, received the treatment, and then took a post-test to assess the effectiveness of the *PE-VR* system on students' learning performance and engagement in costume history.

Research Procedure

Before conducting the study, we adhered to ethical guidelines for study involving human participants. All participants provided informed consent, ensuring they understood the purpose and procedures of the study and their right to withdraw at any time.

Confidentiality was maintained by anonymizing all collected data and using it solely for study purposes. This experimental study consisted of four main stages: introduction, pre-experiment, treatment during the experiment, and post-experiment. The study lasted seven days.

On Day 1, the researchers introduced the entire study process and explained how to use the learning system. Participants were informed that they would complete the pre-test on learning performance, the post-test on learning performance, and the learning engagement scale according to the designated schedule. They then received training on using the learning system, including keyboard skills, navigation buttons, links, and the system user manual. Afterwards, the pre-test was administered to assess the students' initial learning performance.

From Day 2 to Day 6, the experimental group used the *PE-VR* system, while the control group used the *NVR* system to study Chinese costume history. Students were not allowed to switch modules freely and were required to complete the five modules in sequence. During this period, students could consult the instructors at any time for technical or learning issues; the instructors acted as guides and facilitators throughout the learning process. On the final day, after completing all learning activities, all participants took the post-test on learning performance and completed the learning engagement scale, marking the end of the experiment.

Instruments

This study employed the learning engagement questionnaire developed by Reeve and Tseng (2011), which assesses students' engagement with the *PE-VR* system across four dimensions: agentic, behavioral, cognitive, and emotional engagement. The questionnaire consists of 22 items and has a reported Cronbach's alpha of 0.82, indicating high reliability. To measure participants' prior knowledge of Chinese costume history, the study used the Basic Knowledge of Chinese Costume History Questionnaire, developed by the Department of Costume History at a technical university in China, as both the pre-test and post-test instrument. This questionnaire consists of 25 items covering fundamental topics in Chinese costume history and has a Cronbach's alpha of 0.75, indicating good reliability.

Data Analysis

This study used SPSS version 27 to analyze the data collected from the measurement instruments. Analysis of covariance (ANCOVA) and one-way analysis of variance (ANOVA) were conducted to test the hypothesis that different learning systems affect undergraduates' learning performance and engagement. The significance level for all analyses was set at 0.05 ($p< 0.05$). The pre-test performance scores (Pre-PS) were controlled as a covariate.

This study involved a simple sample of 30 undergraduates. The descriptive statistical analysis of the collected data is presented in Table 1.

Table 1
Descriptive Statistics for Variables

Variable		Frequency (N=30)	Percentage (%)
Learning System	*PE-VR* System	15	50
	NVR System	15	50

Results

Testing of Hypothesis H_{O1}

H_{O1}: There is no significant difference in learning performance scores (PS) between undergraduates applying the PE-VR system and those applying the NVR system. (RQ1)

An ANCOVA was conducted in SPSS to examine the effect of different learning systems (*PE-VR* and *NVR*) on learning engagement. The results of Levene's Test of Equality of Error Variances are shown in Table 2.

Table 2
Levene's Test of Equality of Error Variances[a]

F	df1	df2	Sig.
3.167	1	28	0.086

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.
a. Design: Intercept + Pretest +Group

As shown in Table 2, Levene's test revealed no significant difference in error variances between groups, F (1, 28) =3.167, p=0.086, confirming that the assumption of homogeneity of variances was satisfied. Accordingly, the ANCOVA could be validly conducted.

Table 3
Tests of Between-Subjects Effects
Dependent Variable: Post-PS

Source	Type III Sum of Squares	df	Mean Square	F	Sig.[a]
Learning System	1786.360	1	1786.360	6.871	0.014
Pretest	3996.993	1	3996.993	15.374	0.000
Corrected Total	13446.667	29			

As reported in the Tests of Between-Subjects Effects (Table 3), after controlling for Pre-PS, the covariate had a significant effect on Post-PS, F (1, 29) =15.374, p<0.001, indicating that prior learning performance was a significant predictor of Post-PS. In addition, there was a significant difference in Post-PS between the two learning systems (*PE-VR* System and *NVR* System), F (1, 29) =6.871, p=0.014, suggesting that the type of learning systems had a significant impact on Post-PS.

Table 4
Estimates and Pairwise Comparisons

Estimates
Dependent Variable: Post-PS

Learning System	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
PE-VR System	63.094[a]	4.175	54.527	71.661
NVR System	47.572[a]	4.175	39.006	56.139

a. Covariates appearing in the model are evaluated at the following values: Pre-PS=22.17.

Pairwise Comparisons
Dependent Variable: Post-PS

(I)Learning System	(J) Learning System	Mean Difference (I-J)	Std. Error	Sig.[b]
PE-VR	*NVR*	15.522*	5.922	0.014
NVR	*PE-VR*	-15.522*	5.922	0.014

Based on estimated marginal means
*. The mean difference is significant at the0.05 level.
b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

As shown in the Estimates and Pairwise Comparisons results (Table 4), after controlling for a Pre-PS of 22.17, the adjusted mean Post-PS for the *PE-VR* System was 63.094, whereas the adjusted mean for the *NVR* System was 47.572. This indicates that the mean Post-PS in the *PE-VR* System was significantly higher than that in the *NVR* System, with a mean difference of 15.522, which was statistically significant ($p<0.05$).

In conclusion, Pre-PS had a significant effect on Post-PS. After controlling for Pre-PS, there was a significant difference in Post-PS between the learning systems (*PE-VR* and *NVR*), with the *PE-VR* group performing significantly better than the *NVR* group. Therefore, hypothesis $Ho_1$was rejected.

Testing of Hypothesis H_{O2}

H_{O2}: There is no significant difference in learning engagement (LE) between undergraduates applying the PE-VR system and those applying the NVR system. (RQ2)

An ANOVA was conducted in SPSS to examine the effect of different learning systems (*PE-VR* and *NVR*) on learning engagement. The results of Levene's Test of Equality of Error Variances are shown in Table 5.

Table 5
Levene's Test of Equality of Error Variances[a,b]

F	df1	df2	Sig.
0.096	1	28	0.759

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.
a. Dependent variable: Engagement
b. Design: Intercept + VR system

Levene's test for equality of variances indicated a non-significant result (p=0.759, p>0.05), indicating that the variances in the different learning systems (*PE-VR* and *NVR*) were approximately equal. Thus, the assumption of homogeneity of variances was satisfied, and the ANOVA could be appropriately conducted.

Table 6
Tests of Between-Subjects Effects
Dependent Variable: LE

Source	Type III Sum of Squares	df	Mean Square	F	Sig.[a]
Corrected Model	2305.633[a]	1	2305.633	12.671	0.001
Intercept	201228.300	1	201228.300	1105.853	0.000
Learning system	2305.633	1	2305.633	12.671	0.001
Error	5095.067	28	181.967		
Total	208629.000	30			
Corrected Total	7400.700	29			

a. R Squared=0.312 (Adjusted R Squared=0.287)

The results of the ANOVA (Table 6) revealed that the difference in learning engagement between the two groups was significant, F (1, 28) =12.671, p=0.001 (p<0.05). Hence, hypothesis Ho2 was rejected. This indicates that undergraduates who used the PE-VR system demonstrated significantly higher learning engagement than those in the NVR system.

Table 7
Pairwise Comparisons
Pairwise Comparisons
Dependent Variable: LE

(I)Learning System	(J) Learning System	Mean Difference (I-J)	Std. Error	Sig.[b]
PE-VR	*NVR*	17.533*	4.926	0.001
NVR	*PE-VR*	-17.533*	4.926	0.001

Based on estimated marginal means
*. The mean difference is significant at the0.05 level.
b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

The results of the pairwise comparisons using the Bonferroni correction are showed in Table 7. It shows that there was a significant difference in learning engagement between the *PE-VR* and NVR systems (Mean Difference=17.533, p=0.001, p<0.05). This indicates that undergraduates who used the *PE-VR* system demonstrated significantly higher learning engagement compared to those in the NVR system.

Table 8
Univariate Tests

	Sum of Squares	df	Mean Square	F	Sig.
Contrast	2305.633	1	2305.633	12.671	0.001
Error	5095.067	28	181.967		

The Univariate Test Table (Table 8) confirms that the results in the Pairwise Comparisons Table are significant (p=0.001, p<0.05).

In summary, there was a significant difference in learning engagement between the two learning systems (*PE-VR* and *NVR*), with the *PE-VR* group demonstrating significantly higher engagement than the *NVR* group. Therefore, Hypothesis HO2 was rejected.

Research Findings

The results of the ANCOVA indicated that, after controlling for the effect of Pre-PS, the *PE-VR* system significantly outperformed the *NVR* system in enhancing learning performance. Specifically, the mean Post-PS for the *PE-VR* group was 64.33, which was substantially higher than that of the *NVR* group (M=46.33). This difference can be attributed to the personalized and experiential learning features integrated into the *PE-VR* system, which effectively support learners in improving their performance. In contrast, the *NVR* system employs a conventional, uniform teaching model that offers limited immersive experience, resulting in comparatively lower learning outcomes.

Consistent with the findings on learning performance, the ANOVA results further demonstrated that the *PE-VR* system also led to significantly higher levels of learning engagement than the *NVR* system. The mean engagement score for the *PE-VR* group was 90.67, compared to 73.13 for the *NVR* group. This difference can be explained by the immersive and interactive elements embedded in the *PE-VR* environment, which actively stimulate undergraduates’ participation, motivation, and sustained attention. Meanwhile, the *NVR* system’s standardized delivery fails to adapt to individual needs or foster active involvement, contributing to lower engagement levels. Together, these results highlight that the personalized and experiential features of the *PE-VR* system not only enhance students’ performance but also promote greater engagement throughout the learning process.

Conclusion

This study demonstrates the significant advantage of implementing a personalized experiential virtual reality (*PE-VR*) system over a normal virtual reality (*NVR*) system in enhancing students’ learning performance. Through the integration of personalization and immersive learning experiences, the *PE-VR* system enables learning materials to be engaged with in a more meaningful and adaptable manner. Personalized features allow content and learning pace to be adjusted in real time according to learners’ needs and progress, thereby fostering deeper understanding and supporting active knowledge construction. In contrast, the traditional *NVR* system, which is based on a uniform delivery model, lacks the flexibility and interactivity required to address diverse learner needs fully and may restrict students' opportunities to gain richer learning experiences.

The significance of these findings lies in their contribution to the advancement of educational technology and instructional design within higher education. Practical evidence has been provided that supports the integration of personalized and immersive VR technologies to improve teaching effectiveness and student outcomes. Furthermore, valuable insights are offered for educators and institutions seeking to modernize curriculum delivery through the adoption of emerging technologies. By implementing learning systems that emphasize personalization and experiential engagement, learners may be more effectively motivated, cognitive barriers can be reduced, and sustained learning engagement can be promoted, ultimately facilitating improved academic performance.

Contribution

This study makes both theoretical and contextual contributions to the field of technology, particularly in the application of personalized experiential virtual reality (*PE-VR*) systems in higher education. Theoretically, it extends existing learning theories, such as experiential learning theory and personalization principles, by demonstrating how their integration within an immersive VR environment can substantially enhance learner engagement and performance. The findings provide empirical evidence that the combination of personalization and immersive interaction fosters deeper cognitive processing, thus enriching the body of knowledge on how advanced technologies can be systematically aligned with pedagogical frameworks. Contextually, this study addresses a specific gap in fashion design education, where personalized and experiential learning are critical yet often under-supported by traditional systems. By situating the *PE-VR* system in a real-world classroom environment and comparing it with *NVR* learning system, the study not only validates its practical effectiveness but also offers actionable insights for curriculum designers and educators seeking to integrate VR into disciplines that demand high levels of visual, spatial, and creative engagement.

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