

Effects of a Cognitive-Motivational Immersive Virtual Reality Learning System on Undergraduate Students' Performance and Motivation in Project-Based Cultural and Creative Design Learning

Xianfan Luo^{1,2}, Kien Tsong Chau^{1*}, Siti Nazleen Abdul Rabu¹

¹ Centre for Instructional Technology and Multimedia, Universiti Sains Malaysia, 11800 Penang, Malaysia

² Guangzhou College of Technology and Business, Guangzhou, China

*Corresponding author: Kien Tsong Chau (kientsongchau@yahoo.com)

HOW TO CITE:

Xianfan Luo, Kien Tsong Chau, Siti Nazleen Abdul Rabu (2026). Effects of a Cognitive-Motivational Immersive Virtual Reality Learning System on Undergraduate Students' Performance and Motivation in Project-Based Cultural and Creative Design Learning. International Journal of Special Education, 41(12s), 1333-1352

COPYRIGHT STATEMENT:

Copyright: © 2026 Authors.
Open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).

ABSTRACT:

This study investigates the impact of the Cognitive Motivational Immersive Virtual Reality (CMI-VR) system on academic performance and motivation in project-based cultural and creative design (P-CCD) education. Traditional design pedagogy often struggles with the cognitive gap between 2D sketches and 3D realization. To address this, the CMI-VR system was developed by integrating Cognitive Load Theory and Gagne's Nine Events to manage cognitive processing, alongside Self-Determination Theory (SDT) to satisfy psychological needs for autonomy and competence. Using a quasi-experimental design with 84 undergraduate students, the study compared the CMI-VR system against Traditional Project-Based Instruction (TPI). Statistical results from ANOVA indicated that the CMI-VR group significantly outperformed the TPI group in both performances ($F = 36.949$, $p < .001$, $\eta^2 = .316$) and motivation ($F = 30.527$, $p < .001$). Crucially, gender was found to have no significant moderating effect, demonstrating the system's pedagogical inclusivity. These findings provide strong empirical evidence that theory-driven VR environments can effectively mitigate cognitive load while sustaining high intrinsic motivation. The study advocates a shift toward technology-empowered project-based models to facilitate the "creative inheritance" of cultural heritage in modern higher education.

Keywords: Virtual Reality, Project-Based Learning, Cognitive Load Theory, Self-Determination Theory, Cultural and Creative Design Education

INTRODUCTION

1.1 Research Background

The global virtual reality market is experiencing significant growth driven by the increasing demand for immersive technologies across

various industries. The immense potential of augmented reality and virtual reality promises to revolutionize sectors such as gaming, education, healthcare, and retail by enhancing user experiences and boosting productivity (Avilés-Castillo et al., 2025). Simultaneously, the

investment environment remains highly favorable with startups and educational initiatives focused on these technologies receiving increasing funding and institutional support to develop integrated applications (Mohamed & Sicklinger, 2022). According to Technavio (2025), the augmented reality and virtual reality market is projected to grow to \$641.25 billion between 2024 and 2029 representing a CAGR of 51.8 percent. In the specific context of China, the market size of VR content is projected to reach 83.27 billion yuan with corporate training identified as the fastest growing segment at a rate of 55 percent (Leadleo, 2022).

Recent advances in VR technology have opened new possibilities for design education by enabling immersive, interactive, and visually rich learning environments (Samala et al., 2025). VR allows learners to manipulate three dimensional design elements, observe the real time effects of design decisions, and engage in situated learning experiences that closely resemble authentic design practice. Prior research in educational technology indicates that VR environments can enhance learner engagement, spatial understanding, and experiential learning (Lin et al., 2024). Consequently, the market for VR education in China has garnered widespread attention. Currently, research on integrating VR technology within Chinese higher education primarily focuses on school enterprise cooperation and scientific research projects (Qiao, 2024; Luo, 2017). However, despite this growing interest, VR technology remains underutilized in standard higher education curricula (Pozzo et al., 2024). Although the application of VR in higher education attracts scholarly attention, systematic course implementation is scarce (He, 2024).

China has established itself as the world's largest design education provider with over 1,980 universities offering design art majors enrolling more than 500,000 students annually (Xu, 2021). With the rapid development of cultural and creative industries, higher education institutions are increasingly expected to cultivate design thinking, creative problem solving abilities, and practical design competencies. Cultural and

creative design education at the undergraduate level emphasizes project based learning where students integrate cultural knowledge, creative concepts, and technical skills to produce tangible design outcomes. Many Chinese universities have incorporated Project Based Cultural and Creative Design (P-CCD) courses into core modules (Wu, 2024; Lu, 2024).

However, traditional instructional approaches frequently struggle to support the complexity and experiential nature of design learning. To address these challenges, this study proposed a Cognitive Motivational Immersive Virtual Reality (CMI-VR) Learning System grounded in established learning and motivation theories. The system structurally integrated Cognitive Load Theory with Gagné's Nine Events of Instruction to manage cognitive complexity, while combining Self Determination Theory with the ARCS motivational model to foster and sustain student engagement in project based cultural and creative design learning.

1.2 Problem Statement

In project based cultural and creative design learning within universities, several persistent practical issues hinder effective instruction. Recent surveys of art and design programs at universities in China reveal systemic challenges in the teaching systems of some institutions (Wang & Qu, 2024).

The first problem is the immense cognitive complexity of the curriculum which easily overwhelms students. The course covers multiple modules including cultural history, design semiotics, digital modeling, and cultural IP operation. This results in fragmented knowledge points lacking a central theme making it difficult for students to form a systematic understanding (Wang & Qu, 2024). Furthermore, most classes remain teacher led and lack contextualized task driven learning. Consequently, students often listen more but retain and practice less resulting in a lack of intrinsic motivation and limited teacher student interaction (Wu, 2024).

The second problem involves the inability to fully realize virtual project propositions as most students avoid material and technological

challenges. Cultural and creative product design is a highly practical discipline, but current teaching often lacks sufficient practical components and industry connections. Traditional learning models prioritize rendering and software operation training over product manufacturing processes, material selection, and cost analysis. This leads students to focus on low-risk visual aspects such as simple graphical stickers while avoiding complex material and technological implementation due to low confidence and competence (Du & Fan, 2025).

The third problem pertains to the high implementation barriers of 3D printing and digital modeling technologies. Most universities cannot provide sufficient equipment resources and supporting technical expertise for all students (Wang et al., 2025; Hou & Hu, 2021). Analysis of student works reveals weaknesses in volume perception and rigid dynamic expression reflecting insufficient spatial ability and digital modeling skills. In response to these persistent challenges including high cognitive complexity, low student engagement, superficial realization of design concepts, and limited access to digital fabrication technologies, this study proposed the CMI-VR Learning System as an instructional intervention.

1.3 Research Objectives

This study aimed to compare the effectiveness of the CMI-VR learning system with traditional project-based instruction in undergraduate cultural and creative design courses. Specifically, the study focused on examining student learning performance and learning motivation while considering gender differences as a moderating factor. The specific research objectives were as follows.

1. To examine the effect of the learning model (CMI-VR learning system versus traditional project-based instruction) on undergraduate student learning performance in project based cultural and creative design courses.
2. To investigate the effect of the learning model on undergraduate student learning motivation as measured by the ARCS

motivational dimensions (Attention, Relevance, Confidence, and Satisfaction).

3. To determine whether gender moderates the effects of the CMI-VR learning system on student learning performance.
4. To determine whether gender moderates the effects of the CMI-VR learning system on student learning motivation.

1.4 Research Questions

Based on the above objectives, the study seeks to answer the following research questions:

1. Is there a significant difference in learning performance between students who learn through the CMI-VR learning system and those who learn through traditional project-based instruction?
2. Is there a significant difference in learning motivation (Attention, Relevance, Confidence, and Satisfaction) between students using the CMI-VR learning system and those receiving traditional project-based instruction?
3. Does gender moderate the effect of the learning model on student learning performance?
4. Does gender moderate the effect of the learning model on student learning motivation in project based cultural and creative design learning?

1.5 Research Hypothesis

Based on Cognitive Load Theory, Gagne's Nine Events of Instruction, ARCS motivational theory, and Self Determination Theory, this study proposed the following null hypotheses to examine the effects of the learning model and gender on undergraduate student learning outcomes.

Main Effects of Learning model

- H₀₁** There is no significant difference in student academic performance between those using the CMI-VR learning system and those using Traditional Project Based Instruction (TPI).

Main Effects of Gender

- H₀₂** Gender does not significantly moderate the relationship between the instructional mode and student academic performance. relationship between instructional mode and students' academic performance.

Effect of Instructional Mode on Learning Motivation

- H₀₃** There is no significant difference in learning motivation between students using the CMI-VR learning system and those using Traditional Project Based Instruction (TPI).

Effect of Gender on Learning Motivation

- H₀₄** Gender does not significantly moderate the relationship between the instructional mode and student learning motivation.

1.6 Significance of Research

This study offered theoretical, practical, and educational contributions to immersive learning, design education, and cultural and creative industry training.

Regarding theoretical significance, the study extended Cognitive Load Theory, Gagné's Nine Events of Instruction, ARCS motivational theory, and Self Determination Theory by examining how a CMI-VR learning system supported complex project based design tasks. Unlike traditional instruction, the CMI-VR system structurally integrated cognitive sequencing and motivational mechanisms within an immersive environment. This provided empirical evidence of its impact on both learning performance and learning motivation. Furthermore, incorporating gender as a moderating variable contributed to a nuanced understanding of individual differences in VR enhanced learning.

Regarding practical significance, the CMI-VR system addressed challenges commonly observed in design education such as fragmented knowledge, low engagement, and difficulties in implementing 3D modeling. By simulating design processes in a virtual environment, the system reduced reliance on costly equipment while

enabling students to test and visualize design concepts safely.

Regarding educational significance, the study enhanced undergraduate design education by fostering cognitive integration, creative problem solving, and experiential learning among students. Improvements in learning motivation across the ARCS dimensions promoted sustained engagement. The empirical validation of the CMI-VR approach offered a model for transitioning from teacher centered to learner centered pedagogy.

Finally, regarding social and industry significance, the study supported the cultivation of professionals equipped to respond to real world cultural IP development and market demands. The findings provided evidence for policymakers and educational administrators to strategically adopt the integration of VR into higher education.

2 Literature Review

This chapter reviews the theoretical framework, empirical research, and technological background related to the application of the Cognitive Motivational Immersive Virtual Reality (CMI-VR) system in project based cultural and creative design education. The review is organized around five core themes including the development and application of virtual reality in design education, the current practices and challenges of project based cultural and creative design courses, the pedagogical foundations of Cognitive Load Theory and Gagné's Nine Events of Instruction, the application of Self Determination Theory and the ARCS motivation model, and the identification of existing research gaps. Through synthesizing these perspectives, this chapter establishes the theoretical and empirical foundation for the proposed CMI-VR learning system.

2.1 Virtual Reality and Its Application in Design Education

Virtual reality is an immersive technology that enables users to interact with computer-generated three-dimensional environments. This offers experiential learning opportunities that are fundamentally difficult to

achieve through traditional instructional media. According to Milgram and Kishino (1994), VR systems can be classified into non immersive, semi-immersive, and fully immersive forms based on differing levels of sensory engagement and interaction. Desktop VR operates as a semi-immersive approach relying on conventional displays and input devices. It is increasingly adopted in higher education due to its cost effectiveness and ease of implementation (Maroukgas, 2024).

Empirical studies demonstrate that VR can enhance learner engagement, spatial understanding, and experiential learning by allowing students to manipulate virtual objects and observe real time feedback. Within design education, VR supports the visualization of abstract concepts, the simulation of real-world contexts, and the iterative exploration of design solutions. Meta analyses and experimental studies indicate that VR based learning can improve procedural knowledge, creative performance, and motivation when appropriately designed (Radianti et al., 2020; Makransky & Petersen, 2021). However, researchers consistently caution that immersive features alone do not guarantee learning gains and must be strategically aligned with instructional goals and learner cognitive capacities.

2.2 Project Based Cultural and Creative Design Courses

Cultural and creative products integrate cultural elements with creative concepts to produce tangible goods with high added value. Project based learning acts as a constructivist pedagogical strategy that immerses students in authentic and real-world design tasks to foster inquiry based learning and interdisciplinary skills (Wu & Tu, 2023). Within design education, Project Based Cultural and Creative Design (P-CCD) courses aim to bridge the gap between traditional cultural heritage and modern consumer markets by engaging students in the complete design lifecycle.

Despite the significance of these courses, current instructional practices face several critical bottlenecks. Many courses rely heavily on teacher-looking instructional models and

outdated theoretical content that fail to integrate cutting edge technologies such as artificial intelligence and virtual reality (Wu, 2024). Consequently, student works frequently exhibit a superficial understanding of cultural symbols. This leads to the mechanical replication of traditional patterns without deep cultural translation (Wang & Qu, 2024). Furthermore, there is a distinct disconnect between two-dimensional conceptualization and three-dimensional realization. Students often struggle to translate hand drawn sketches into physically viable products due to a lack of material and spatial comprehension (Wang & Qu, 2024).

To address these practical limitations, recent educational reforms advocate for integrating project-based pedagogy with digital empowerment. Within heritage education in universities, sustainable cultural innovation practices engage students in real world design tasks to facilitate the creative inheritance of intangible cultural heritage crafts and enhance their practical abilities (Yan & Li, 2023). By organizing comprehensive projects such as regional intangible cultural heritage tasks, students engage in market research, design ideation, prototype fabrication, and product evaluation (Du & Fan, 2025; Xu, 2024).

The integration of immersive and generative technologies significantly enhances this project-based approach. Implementing virtual reality in design courses allows for the digital reconstruction of traditional crafts enabling students to interact with three-dimensional models efficiently (Hou & Hu, 2021). Artificial intelligence assists in brainstorming and pattern generation which provides diverse creative solutions and inspires student creativity (Du & Fan, 2025). Furthermore, digital modeling and virtual reality technologies significantly compress the prototype iteration cycle and reduce material waste compared to traditional manual fabrication (Wang & Qu, 2024). This technology empowered project-based learning model not only enhances student creative output and spatial cognition but also ensures higher market viability for their cultural products (Wu, 2024).

2.2 Cognitive Load Theory and Gagné's Nine Events of Instruction

Cognitive Load Theory proposed by Sweller (1988) explains learning through the limited capacity of working memory and distinguishes among intrinsic, extraneous, and germane cognitive load (Sweller et al., 2011). In cultural and creative design learning, intrinsic cognitive load is naturally high due to the complex integration of cultural knowledge, spatial reasoning, and creative problem solving. Although VR possesses the potential to reduce cognitive barriers by visualizing abstract concepts and supporting spatial cognition, poorly designed VR environments may increase extraneous cognitive load through excessive sensory stimulation, complex navigation, or irrelevant information (Makransky et al., 2019; Parong & Mayer, 2018). Empirical research indicates that immersive VR does not automatically improve learning outcomes and may actively hinder performance if cognitive load is not carefully managed (Makransky & Petersen, 2019). Conversely, VR environments that apply robust instructional design principles such as segmentation, signaling, and scaffolding can enhance germane cognitive load and support schema construction to facilitate deeper learning (Radianti et al., 2020).

To operationalize these principles in instructional design, this study adopts Gagné's Nine Events of Instruction which align external teaching activities with internal cognitive processes (Gagné, 1985; Gagné et al., 1992). The nine events ranging from gaining attention to enhancing retention and transfer provide a flexible yet highly structured framework for organizing learning activities in complex courses. Prior studies demonstrate the effectiveness of applying Gagné's model in visual communication design education within China to support meaningful learning and knowledge transfer (Zhang, 2019; Qin, 2024). Integrating Cognitive Load Theory with Gagné's instructional events offers a systematic approach to designing VR based learning experiences that perfectly balance immersion with cognitive efficiency.

2.3 Self-Determination Theory and ARCS Motivation Theory

Self Determination Theory conceptualizes motivation as driven by the satisfaction of three basic psychological needs including autonomy, competence, and relatedness (Deci & Ryan, 1985; Ryan & Deci, 2017, 2020). When these fundamental needs are met, learners exhibit higher intrinsic motivation, active engagement, and superior academic performance. VR environments are particularly well suited to supporting these principles because they allow learners to explore virtual spaces autonomously, practice specialized skills in a safe environment, and engage in social interaction through shared virtual experiences (Riva et al., 2016; Freeman et al., 2017). Empirical studies, such as those by Gim et al. (2022) and Wang & Qu (2024), demonstrate that VR-based education within the metaverse and immersive environments can significantly enhance learners' perceived autonomy, competence, and relatedness. These studies suggest that satisfying these basic psychological needs is critical for increasing overall motivation and task persistence in technology-enhanced learning contexts.

Complementing this perspective, Keller's ARCS model provides a highly practical framework for designing and measuring learning motivation across four specific dimensions including Attention, Relevance, Confidence, and Satisfaction (Keller, 1987). The ARCS model is widely validated within higher education and proves particularly effective for assessing college student motivation in enhanced technology learning environments (Song & Keller, 2001; Huang & Hew, 2016). Its multidimensional structure allows researchers to rigorously examine both initial engagement and sustained motivation. This makes it an ideal instrument for evaluating motivational outcomes in VR supported project-based learning.

2.4 Research Gaps

Although existing studies have independently explored VR applications in higher education, project-based learning in design education, and various motivation theories, a comprehensive

review of the literature reveals several critical research gaps.

First, there is a lack of theory driven instructional frameworks designed to manage high cognitive complexity in immersive environments. Existing literature indicates that while VR environments offer high immersion, they frequently fail to yield positive learning outcomes if the cognitive load is not carefully managed (Makransky & Petersen, 2021). Limited research systematically integrates cognitive theories with structured instructional frameworks such as Gagne's Nine Events of Instruction to mitigate extraneous cognitive load and optimize intrinsic cognitive load within VR based design education.

Second, there is a distinct disconnect between cognitive scaffolding and comprehensive motivational support in the current literature. Although individual studies have explored motivation in VR, very few have systematically combined Self Determination Theory with the ARCS model to address autonomy, competence, and multifaceted motivation in a unified immersive learning system (Wang & Qu, 2024). Empirical evidence regarding how VR supported instruction simultaneously affects both learning performance and multidimensional learning motivation under conditions of high cognitive complexity remains insufficient.

Third, very few studies examine the crucial interaction between the learning model and learner characteristics such as gender within VR based design learning contexts (Wu et al., 2020). Although emerging evidence suggests that individual differences in spatial ability and gender can significantly influence cognitive load and spatial presence in immersive environments, these factors are rarely integrated into comprehensive pedagogical models for design education (Makransky & Petersen, 2021). Understanding how different demographic groups respond to cognitive and motivational interventions in virtual environments is essential for designing inclusive educational technologies.

In summary, this chapter reviewed relevant theories, empirical findings, and technological developments related to VR, project based

cultural and creative design learning, cognitive load, instructional design, and motivation. These discussions highlight the absolute necessity for a Cognitive Motivational Immersive Virtual Reality learning system that strictly integrates Cognitive Load Theory, Gagne's instructional events, Self Determination Theory, and the ARCS model to address the identified academic gaps. This robust theoretical foundation directly informs the design and methodology of the present study which is introduced in the subsequent chapter.

3 Research Methodology

This chapter describes the research methodology adopted to examine the effects of a Cognitive Motivational Immersive Virtual Reality (CMI-VR) learning system on student academic performance and learning motivation in project based cultural and creative design education. Grounded in Cognitive Load Theory, Self Determination Theory, Gagne's Nine Events of Instruction, and the ARCS motivation model, this study employed a quasi-experimental design to compare the effectiveness of CMI-VR with traditional project-based instruction (TPI). The chapter detailed the research design, variables, population and sampling procedures, research instruments, experimental procedures, and data analysis methods. Through a systematic and controlled methodological approach, this study aimed to provide empirical evidence on the pedagogical value of cognitively and motivationally informed immersive VR in higher education design learning.

3.1 Research Variables

This study employed a quasi-experimental design involving three categories of research variables including independent variables, dependent variables, and moderator variables. The independent variable was the learning system which consisted of two instructional modes. The Cognitive Motivational Immersive Virtual Reality (CMI-VR) learning system served as the experimental condition and Traditional Project Based Instruction (TPI) served as the control condition. The dependent variables included student academic performance and learning motivation. Gender (male and female) was

treated as a moderator variable to examine its potential interaction effects with the instructional mode on learning outcomes. All experimental activities were conducted in a computer laboratory under controlled instructional conditions. To clarify the scope of the

experiment, the research variables are categorized as shown in Table 3.1 below. the learning system as the independent variable, gender as the moderator, and performance and motivation as the dependent variables.

Table 3.1. Independent, moderator, and dependent variables

Independent variable (IVs)	Moderator variables (MVs)	Dependent variable (DVs)
Learning System (CMI-VR and TPI)	Gender (Male, Female)	Performance Motivation

3.2 Research Population and Sampling

3.2.1 Population

The research population consisted of undergraduate students enrolled in the Art Department of Guangzhou College of Technology and Business located in Huadu District, Guangzhou, Guangdong Province, China. All participants were aged between 19 and 22 years and had not previously taken any project based cultural and creative design courses, thus ensuring they were unfamiliar with the specific course structure and learning requirements prior to the study.

3.2.2 Sampling Techniques

A systematic sampling technique was adopted to select participants from the population. Each eligible student was assigned a unique identification number, and participants were selected at fixed intervals of three students. Systematic sampling was chosen to ensure that each student had an equal probability of selection thereby minimizing sampling bias and enhancing the representativeness of the sample. In addition, this method was time efficient, cost effective, and highly suitable for the size and structure of the target population.

3.2.3 Sample

Sample size determination followed the guidelines proposed by Krejcie and Morgan (1970) which provided a widely accepted formula for estimating sample size based on population

size, confidence level, and precision. Given the population size of 220 students, a confidence level of 95 percent, a population proportion of 0.50, and a precision level of 0.05, the recommended sample size was 84 participants. To account for potential attrition during the experiment, the final sample size was maintained at 88 students.

The sample consisted of 40 students in the experimental group (CMI-VR) and 44 students in the control group (TPI). All participants had completed prerequisite graphic design courses and passed the national art examination prior to admission indicating a relatively homogeneous academic background. According to Sullivan (2007), a sample size of 84 is sufficient for detecting meaningful effects using analysis of variance. The study was conducted between March and June 2024 and March and June 2025, corresponding to the periods when the project-based cultural and creative design courses were offered at the universities.

3.3 Research Instruments

Two research instruments were employed to collect data on learning outcomes and learning motivation. These were the Project Based Cultural and Creative Design Learning Outcome Test and the Instructional Materials Motivation Scale.

3.3.1 Project-Based Cultural and Creative Design Learning Outcome Test

The learning outcome test was developed by the researchers to assess student knowledge and understanding of project based cultural and creative design concepts. Initially, a pretest was administered to establish baseline equivalence among the participants. Because the pretest results confirmed that the baseline scores between the two groups of students were highly similar, demonstrating initial equivalence, the subsequent data reporting and analysis in this study focused exclusively on the post test results to evaluate the learning outcomes following the intervention.

The test contained 31 items and was administered within a 20-minute time limit. The item order was randomized to prevent testing effects. The total possible score was 100 points with scores above 60 indicating a basic mastery of the required knowledge. Content validity was established through expert review by two professors in visual communication design from different universities, and revisions were made based on their feedback. Reliability analysis indicated high internal consistency with a Cronbach's alpha value of 0.928 for the post test (Cronbach, 1951) demonstrating satisfactory reliability for empirical research.

3.3.2 Instructional Materials Motivation Scale (IMMS)

Learning motivation was measured using the Instructional Materials Motivation Scale (IMMS) adapted from Keller (2010). The IMMS is grounded in the ARCS motivation model and has been widely validated in multimedia and technology-enhanced learning contexts (Cardoso-Júnior & Faria, 2021). The scale assesses four motivational dimensions: Attention, Relevance, Confidence, and Satisfaction.

The adapted IMMS consisted of 34 Likert-type items rated on a five-point scale ranging from 1 (strongly disagree) to 5 (strongly agree). Two items from the original instrument were removed following validation by two instructional design experts with over five years of professional experience, as these items were deemed

unsuitable for the participants' academic level. The revised instrument demonstrated excellent reliability, with a Cronbach's α coefficient of 0.980, indicating high internal consistency (Salkind, 2015).

Alternative motivation scales, including the Motivated Strategies for Learning Questionnaire (Pintrich & De Groot, 1990), the Intrinsic Motivation Inventory (Ryan et al., 1989), and the Academic Motivation Scale (Vallerand et al., 1989), were reviewed but not adopted due to their limited focus on instructional materials and course design. The IMMS was administered online via the "Wen Juan Xing" (WJX) platform during the eighth week of the course.

3.4 Data Analysis Methods

Both descriptive and inferential statistical analyses were conducted using IBM SPSS Statistics 27. The significance level was set at $p < .05$. Descriptive statistics were used to summarize demographic information and baseline performance. Reliability analysis was conducted to assess the internal consistency of the research instruments.

To examine the effects of the instructional mode and gender on academic performance and learning motivation, one way and two-way analysis of variance were employed. Two-way analysis of variance was specifically used to investigate interaction effects between the independent variable and the moderator variable on the dependent variables. This analytical approach allowed for a comprehensive examination of both main effects and interaction effects in the CMI-VR learning context.

4 Developments Of The Cmi-Vr System

The Cognitive-Motivational Immersive Virtual Reality (CMI-VR) learning system was designed by integrating Self-Determination Theory (SDT), Gagné's Nine Events of Instruction, and Cognitive Load Theory (CLT) to support project-based cultural and creative design learning. The system aims to enhance learners' autonomy, competence, and relatedness while structuring instructional events to manage

cognitive load and promote knowledge retention and transfer. This section explains how these theoretical principles were operationalized in the CMI-VR system.

4.1 Application of Self-Determination Theory (SDT) in the CMI-VR System

Self-determination theory emphasizes that learning motivation is enhanced when learners' needs for autonomy, competence, and belonging are met (Deci & Ryan, 1985; Ryan & Deci, 2000). The CMI-VR system aims to support these three psychological needs through interactive, learner-controlled, and culturally meaningful design features.

4.1.1 Application of the Autonomy Principle

The implementation of the autonomy principle is reflected in allowing learners to exercise meaningful choices and control throughout the learning process. In the CMI-VR system, participants can personalize the appearance, clothing, style, and behavioral responses of their non-player characters (NPCs), thereby fostering a sense of ownership and self-identity. This personalization helps increase learners' autonomous participation and aligns with the emphasis on learner autonomy in SDT.

Furthermore, learners can control the pace and sequence of exploration within learning modules.

The system requires learners to engage in autonomous exploration before moving on to subsequent learning levels. For example, in the initial module, participants must navigate a vast virtual environment, autonomously exploring paths to the next learning stage. When learners encounter difficulties, the system provides subtle, non-controllable cues, such as color-changing symbols. These cues guide exploration without imposing external pressure, thus maintaining autonomy and preventing learners from losing interest.

4.1.2 Application of the Competency Principle

The competency principle is implemented through a progressive modular structure and an automatic absorption mechanism that reinforces learners' sense of mastery. Figure 4.1 shows once learners have mastered specific cultural and creative knowledge (e.g., the Artworks and Cultural Symbols), the system automatically integrates this knowledge into subsequent modules, reusing and expanding upon it in increasingly complex tasks. This continuity allows learners to experience skill growth and knowledge accumulation across modules, thereby reinforcing their sense of mastery.

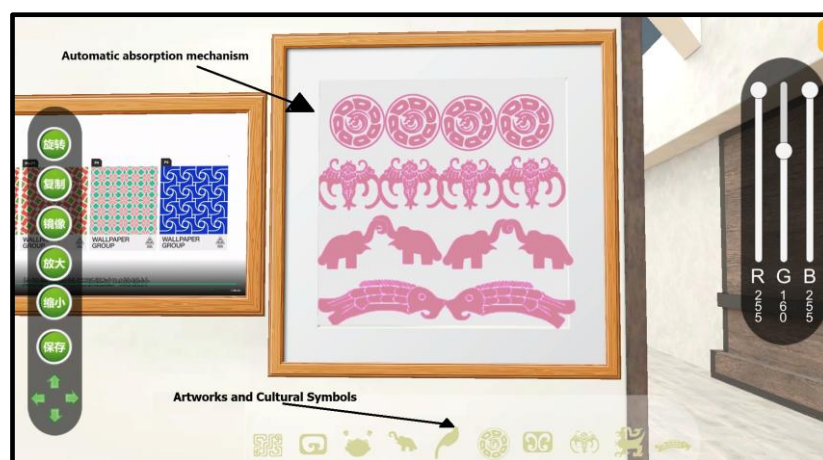


Figure 4.1 the competency principle is implemented automatic absorption mechanism

Feedback mechanisms further support competency development. After completing a

learning task, learners immediately receive task-related feedback, including virtual rewards (e.g.,

coins, badges, flags), celebratory animations, and sound effects. The system employs an increasing difficulty level across modules to ensure that the challenge is optimally matched to the learner's evolving abilities. Color-coded task lists and time prompts, among other visual indicators, display progress and performances, enhancing learners' sense of efficacy and control.

4.1.3 Application of the Relevance Principle

The relevance principle is embodied by embedding learning content within culturally

familiar and meaningful contexts. Instead of abstract or futuristic environments. Figure 4.2 shows the CMI-VR system incorporates traditional Chinese artifacts, museum scenes, and historical relics that resonate with learners' cultural backgrounds. These familiar elements help establish emotional and cognitive connections between learners and the learning content.

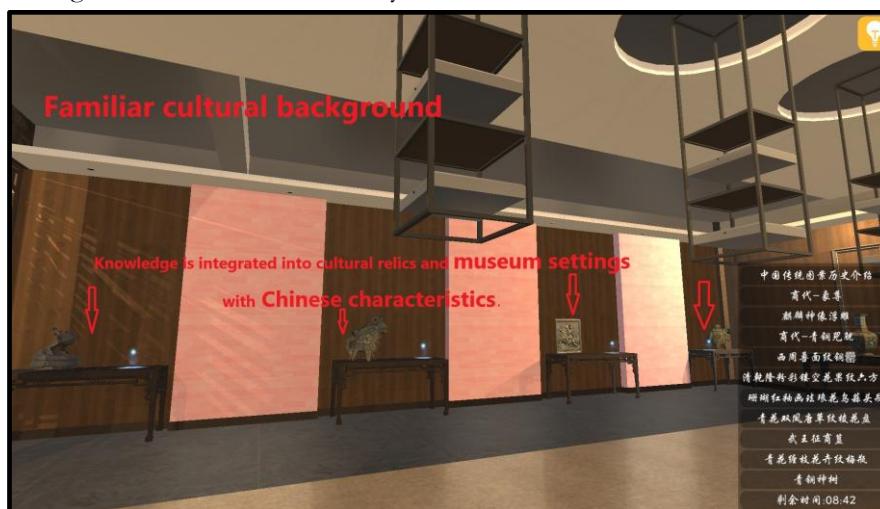


Figure 4.2 The relevance principle is embodied by embedding learning content within culturally familiar and meaningful contexts

The continuity between modules further enhances relevance. Objects and visual elements encountered in previous modules reappear in subsequent assessments, enabling learners to connect previous experiences with new tasks. Furthermore, the system allows learners to choose learning paths that align with their interests and personal goals, thereby enhancing the relevance and personal meaning of the learning experience.

4.2 Application of Gagne's Nine Events of Instruction in CMI-VR system

Gagne's Nine Events of Instruction provide a structured framework for aligning external instructional activities with internal cognitive processes (Gagne, 1985; Gagne et al., 1992). The CMI-VR system integrates all nine events across its modular design.

First, attention is gained through immersive game-based scenes, sound effects, and visually engaging environments. Second, learning goals are communicated using interactive prompts, such as a lightbulb icon that provides task objectives and operational guidance. Third, recall of prior learning is stimulated through repeated exposure to previously learned objects, scenes, and quiz items.

Fourth, new content is presented using multimodal representations, including text, images, voice narration, and video, often highlighted with luminescent visual effects to guide attention. Fifth, Figure 4.3 shows learning guidance is provided via task lists that outline learning objectives and progress indicators. Sixth, performance is elicited through guided practice videos and free-canvas design activities that allow learners to apply newly acquired skills.



Figure 4.3 Learning guidance is provided through a task list.

Seventh, feedback is provided immediately through visual, auditory, and reward-based cues. Eighth, performance is assessed using summative tests in the final module, requiring learners to demonstrate mastery without external assistance.

Finally, retention and transfer are enhanced through virtual commercial objects that simulate real-world applications, allowing learners to apply pattern knowledge in authentic design contexts.

Table 4.1 summarizes the relationship between Gagne's nine teaching events and self-determination theory (SDT).

Table 4.1. The relationship between Gagne's Nine Events of Instruction and SDT

Gagne's 9 learning events	SDT
1. Gaining attention	Autonomy principle
2. Inform learners of goals	
3. Stimulate recall of prerequisite learning	Competence principle
4. Presenting new content	
5. Provide learning guidance	Relatedness principle
6. Elicit performance (practice)	
7. Provide feedback	
8. Assess performance	
9. Enhancing memory and transfer	

4.3 Application of Cognitive Load Theory in the CMI-VR System

Cognitive Load Theory (CLT) emphasizes the limited capacity of working memory and

distinguishes among intrinsic, extraneous, and germane cognitive load (Sweller, 1988; Sweller et al., 2011). Given the complexity of cultural and creative design learning, the CMI-VR system was designed to manage cognitive load strategically.

Intrinsic cognitive load was addressed by segmenting learning content into progressive modules, allowing learners to focus on manageable units of information. Extraneous cognitive load was minimized by avoiding unnecessary visual clutter, providing intuitive navigation, and using signaling techniques (e.g., luminescent cues and color prompts) to direct attention to essential information. Germane cognitive load was enhanced by encouraging schema construction through repeated application of learned patterns across modules and by embedding learning tasks in meaningful, culturally relevant contexts.

The integration of CLT with SDT and Gagne's instructional events ensures that immersion does not overwhelm learners cognitively but instead supports efficient processing, deep learning, and sustained motivation.

In summary this chapter describes the planning, design, and development phases of the CMI-VR system. This chapter also describes the design process of the CMI-VR system, the software used, and all the theories applied. The differences between the two systems are summarized in a comparative study. Finally, a pilot study was

conducted to determine the effectiveness and reliability of the system.

5 Results

This chapter presents the statistical analysis of the data collected to evaluate the effects of the CMI-VR learning system on student performance and motivation.

5.1 Preliminary Analysis and Assumption Testing

5.1.1 Reliability of Research Instruments

The internal consistency of the research instruments was evaluated using Cronbach's alpha coefficient to ensure the stability and reliability of the data collected from the 84 participants.

Firstly, the Project-Based Cultural and Creative Design (P-CCD) performance test demonstrated high reliability. As shown in Table 5.1, Cronbach's α coefficient was 0.79, while the standardized Cronbach's α reached 0.928. Both values exceed the commonly accepted threshold of 0.70, suggesting that the test items consistently measure students' academic performance without significant random errors.

Table 5.1 The Cronbach's α of P-CCD Performance Test

Variable	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
P-CCD Performance Test	0.790	0.928	84

Secondly, the Instructional Materials Motivation Scale (IMMS) was utilized to assess learning motivation. The IMMS yielded an alpha coefficient of 0.980, indicating excellent internal consistency. This exceptionally high value confirms that the adapted scale is a highly reliable instrument for measuring motivational constructions within the context of this study.

5.1.2 Pre-test Homogeneity and Baseline Balance

To ensure the validity of the experimental design, a One-Way ANOVA was conducted to

assess the initial equivalence of the two groups based on their pre-test scores. As shown in the "One-way Pretest" output (show in Table 5.2), the CMI-VR group ($M = 29.23$, $SD = 10.70$) and the TPI group ($M = 30.23$, $SD = 11.63$) started with nearly identical baseline knowledge.

The ANOVA results confirmed that this 1.00-point difference was not statistically significant, $F(1, 82) = 0.168$, $p = .683$. Additionally, Levene's test of homogeneity of variances was non-significant ($F = 0.805$, $p = .372$), satisfying the assumption of equal variances. This confirms a high level of "baseline

balance,” ensuring that any subsequent gains in student performance can be attributed to the

instructional intervention rather than prior knowledge disparities.

Table 5.2 Descriptive Statistics and One-Way ANOVA for Pre-test Scores

Group	N	Mean (M)	Std. Deviation (SD)	F	p
CMI-VR	40	29.23	10.700	0.168	.683
TPI	44	30.23	11.626		
Total	84	29.75	11.139		

5.2 HYPOTHESIS TESTING

5.2.1 Impact of Learning System and Gender on Academic Performance

A Two-Way ANOVA (2×2) was performed to examine the main effects of the instructional system (CMI-VR and TPI) and gender (Male and Female), as well as their interaction effect on post-test performance (show in Table 5.3).

H₀₁ There is no significant difference in student academic performance between those using the CMI-VR learning system and those using Traditional Project Based Instruction (TPI).

A significant main effect was observed for the learning system, $F(1, 80) = 36.949, p < .001, \eta_p^2 = .316$. The CMI-VR group ($M = 67.10$) significantly outperformed the TPI group ($M = 43.14$). Based on this evidence, the study rejects the null hypothesis (H_{01}), confirming that the CMI-VR system has a significant positive effect on academic performance.

H₀₂ Gender does not significantly moderate the relationship between the instructional mode and student academic performance. relationship between instructional mode and students' academic performance.

The main effect of gender was not statistically significant, $F(1, 80) = 1.816, p = .182, \eta_p^2 = .022$. Although females ($M = 56.02$) scored slightly higher than males ($M = 52.49$), the evidence fails to reject the null hypothesis (H_{02}).

H₀₄ Gender does not significantly moderate the relationship between the instructional mode and student learning motivation.

The interaction between system and gender was also non-significant, $F(1, 80) = 1.194, p = .278, \eta_p^2 = .015$. Consequently, the study fails to reject the null hypothesis (H_{04}), indicating that the impact of the CMI-VR system is consistent across both genders.

Table 5.3 Two-Way ANOVA Results for Post-test Performance (System and Gender)

Source	Type III Sum of Squares	df	Mean Square	F	p	η_p^2
Instructional System	11318.465	1	11318.465	36.949	<.001	.316
Gender	556.163	1	556.163	1.816	.182	.022
System and Gender	365.753	1	365.753	1.194	.278	.015

Source	Type III Sum of Squares	df	Mean Square	F	p	η_p^2
Error	24505.845	80	306.323			
Total	287374.000	84				

5.2.2

Impact of Learning System on Learning Motivation (H_03)

H_03 There is no significant difference in learning motivation between students using the CMI-VR learning system and those using Traditional Project Based Instruction (TPI).

The effect of the instructional mode on student motivation was examined using One-Way

ANOVA (show in Table 5.4). The CMI-VR group reported a mean motivation score of 125.08 (SD = 13.57), while the TPI group reported 108.55 (SD = 13.81). The results revealed a statistically significant difference, $F(1, 82) = 30.527, p < .001$, with a large effect size ($\eta_p^2 = .271$). Based on these statistical findings, the study rejects the null hypothesis (H_03), indicating that the CMI-VR system significantly enhances learner motivation.

Table 5.4 Descriptive Statistics for Post-test Performance and Motivation

Variable	Group	N	Mean (M)	Std. Deviation (SD)
Post-test Performance	CMI-VR	40	67.10	19.190
	TPI	44	43.14	16.026
	Total	84	54.55	21.238
Learning Motivation	CMI-VR	40	125.08	13.567
	TPI	44	108.55	13.808
	Total	84	116.42	15.945

5.3

Summary of Hypothesis Results

The results of the inferential statistical analysis provide a comprehensive evaluation of the research hypotheses (show in Table 5.5).

Firstly, regarding academic performance, the study rejects the null hypothesis H_01 , as the CMI-VR learning system demonstrated a statistically significant and large positive effect on student performance compared to the traditional TPI model. However, the analysis fails to reject the null hypothesis H_02 and H_04 , as neither gender as

a main effect nor its interaction with the instructional system reached statistical significance. This implies that the CMI-VR intervention is a robust pedagogical tool that functions independently of the learner's gender.

Secondly, in terms of affective outcomes, the study rejects the null hypothesis H_03 . The significant increase in the IMMS scores within the experimental group confirms that the immersive and interactive nature of the CMI-VR system effectively fosters higher levels of learning

motivation. In conclusion, the CMI-VR system is empirically validated as an effective intervention

for enhancing both cognitive and motivational outcomes in the specified educational context.

Table 5.6 The Summary of Hypothesis Testing

Hypothesis	Null Hypothesis (H0)	Statistical Evidence	Decision
H ₀₁	No difference in performance between systems.	F=36.949, $p<.001$	Reject H ₀₁
H ₀₂	No difference in performance based on gender.	F=1.816, $p=.182$	Failed to reject H ₀₂
H ₀₃	No difference in motivation between systems.	F=30.527, $p<.001$	Reject H ₀₃
H ₀₄	No interaction effect (System $\times$ Gender).	F=1.194, $p=.278$	Failed to reject H ₀₄

6 Discussion And Conclusion

This chapter synthesizes the empirical findings with the theoretical foundations established in the literature review. By triangulating the statistical results with Cognitive Load Theory (CLT), Gagné's Nine Events of Instruction, and Self-Determination Theory (SDT), this discussion elucidates the mechanisms through which the CMI-VR system enhances academic performance and motivation.

6.1 Discussion of Academic Performance (H₀₁& H₀₂)

6.1.1 The Efficacy of the CMI-VR System (H₀₁)

The study successfully rejected H₀₁, revealing that the CMI-VR group significantly outperformed the TPI group ($F = 36.949$, $p < .001$, $\eta_p^2 = .316$). This finding supports the assertion by Radianti et al. (2020) and Makransky & Petersen (2021) that VR-based learning can substantially improve procedural knowledge and creative performance when strategically aligned with instructional goals.

From a theoretical perspective, cultural and creative design learning inherently imposes a high intrinsic cognitive load due to the integration of cultural heritage and spatial reasoning. As

identified by Wang and Qu (2024), students in traditional settings often struggle with the “disconnect” between two-dimensional sketches and three-dimensional realization. The CMI-VR system addressed this by providing 3D digital reconstructions that allowed for real-time interaction, effectively mitigating the cognitive barriers of spatial comprehension. Furthermore, by strictly operationalizing Gagne's Nine Events of Instruction, the system managed the extraneous cognitive load that Parong and Mayer (2018) warned that can hinder performance in immersive environments. This validates that structured pedagogical scaffolding is essential for converting sensory immersion into meaningful cognitive gains.

6.1.2 The Non-Significance of Gender on Performance (H₀₂)

The analysis failed to reject H₀₂ ($p = .182$), indicating that the CMI-VR system's effectiveness was not moderated by gender. This addresses the research gap identified by Wu et al. (2020). regarding individual differences in VR-based design education. Although some literature suggests gender-based disparities in spatial ability within digital contexts, our results suggest that the cognitive scaffolding provided by Gagne's instructional events acted as an “equalizer,”

providing sufficient support to normalize performance across genders.

6.2 Discussion of Learning Motivation (H₀₃ & H₀₄)

6.2.1 Enhancement of Motivation via the ARCS Model (H₀₃)

The rejection of H₀₃ confirms that the CMI-VR system significantly enhanced motivation ($F = 30.527, p < .001$). At the system design level, this success is attributed to the application of Self-Determination Theory (SDT). By allowing students to explore virtual spaces autonomously and practice skills in a safe environment, the system satisfied the psychological needs for autonomy and competence, as emphasized by Ryan and Deci (2017).

On the assessment level, the ARCS motivation scale revealed significant improvements in the “Attention” and “Confidence” dimensions. This indicates that the SDT-driven design features successfully translated into measurable motivational gains. As noted by Hou and Hu (2021), such interactive digital experiences prevent the “superficial understanding” of cultural symbols found in traditional courses. The results confirm that satisfies the need for competence (SDT) is directly reflected in increased learner confidence (ARCS).

6.2.2 Consistency of Motivational Impact (H₀₄)

The failure to reject H₀₄ ($p = .278$), confirming that the motivational benefits were universal across genders. This finding aligns with the evidence provided by Gim et al. (2022), suggesting that the satisfaction of basic psychological needs through immersive technology specifically autonomy and competence is a robust phenomenon that transcends individual demographic differences. The consistency of these motivational gains across both male and female participants in this study further validates the universal applicability of SDT-driven VR system design.

6.3 Implications

6.3.1 Theoretical Implications

This study contributes to the existing body of knowledge by providing an empirical validation of the CMI-VR framework, which successfully integrates Cognitive Load Theory (CLT), Gagne’s Nine Events, and Self-Determination Theory (SDT). Theoretically, this research extends Sweller’s (1988) work by demonstrating how structured instructional events can effectively convert potential extraneous load into germane cognitive load within a high-complexity design context. By bridging the “2D to 3D gap” identified by Wang and Qu (2024), the study offers a new cognitive mechanism for understanding how immersive technology supports cultural translation and spatial reasoning. Furthermore, the findings challenge the assumption of gender-based performance disparities in virtual environments, suggesting that inclusive, theory-driven design can mitigate demographic gaps and promote pedagogical equity in digital learning spaces.

6.3 Pedagogical Implications

From a practical perspective, the findings advocate for a systemic shift from traditional “teacher-centered” models to technology-empowered project-based learning (PBL) to facilitate the “creative inheritance” of intangible heritage. Educators are encouraged to utilize VR systems not merely as visualization tools, but as environments for rapid prototype iteration, which significantly reduces material waste and encourages student risk-taking in cultural innovation. Most importantly, the study suggests that instructional designers should prioritize satisfying students’ psychological needs for autonomy and competence (SDT) over mere visual fidelity. By integrating cognitive scaffolding with motivational support, schools can ensure higher market viability for student products while sustaining long-term learner engagement throughout the design lifecycle.

6.4 Limitations

Despite the significant findings, several limitations must be acknowledged. First, the

sample size ($N=84$), while sufficient for the statistical power of a 2×2 ANOVA, was drawn from a single institution, which may limit the generalizability of the results to other educational contexts or cultural backgrounds. Second, the study utilized a semi-immersive desktop VR system due to its cost-effectiveness and ease of implementation in a classroom setting. Consequently, the findings regarding cognitive load and motivation might differ if fully immersive Head-Mounted Displays (HMDs) were used, as higher levels of sensory immersion can introduce different cognitive challenges. Finally, this research focused on short-term intervention within a specific project cycle. This makes it difficult to determine whether the positive motivational gains were partially influenced by the “novelty effect” of the technology rather than a permanent shift in learning behavior.

6.5 Recommendations for Future Research

Based on the aforementioned limitations, future research should consider the following directions:

1. **Longitudinal Impact:** Future studies should employ a longitudinal design to investigate whether the gains in intrinsic motivation and academic performance driven by the SDT-based system persist over multiple semesters after the initial novelty of VR wears off.
2. **Comparative Immersive Tech:** A comparative study between semi-immersive desktop VR and fully immersive HMD systems would provide deeper insights into how the degree of immersion interacts with Gagne’s instructional events to affect cognitive load.
3. **Generative AI Integration:** Following the suggestions of Du and Fan (2025), further research should explore how AI-assisted brainstorming and pattern generation can be integrated into the VR environment to further enhance the “creative performance” of students in cultural innovation tasks.
4. **Diverse Demographic Variables:** Beyond gender, future research should investigate how prior digital literacy, spatial ability, and artistic background interact with the CMI-VR system to create even more personalized and adaptive instructional frameworks.

In conclusion, the CMI-VR system is empirically validated as a robust pedagogical intervention that enhances both cognitive and affective outcomes. By systematically integrating Cognitive Load Theory, Gagne’s Nine Events, and Self-Determination Theory, the system successfully addresses the traditional bottlenecks in project-based cultural and creative design education. These findings provide a theoretical and practical roadmap for educators seeking to harness immersive technology to foster inclusive, high-performance, and highly motivated learning environments.

Statements and Declarations

Funding

This research was conducted as part of an independent teaching research project.

Competing Interests

The authors have no relevant financial or non-financial interests to disclose. The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethics Approval

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Academic Ethics Committee of Guangzhou College of Technology and Business (Date: January 2026 / No. LLSC2026016).

Consent to Participate

Informed consent was obtained from all individual participants included in the study. All participants provided written informed consent prior to their involvement, which explicitly

covered voluntary participation and the use of de-identified data for research purposes.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the

corresponding author on reasonable request. To ensure participant privacy, all data have been fully anonymized.

References

- Avilés-Castillo, F., Buele, J., & Palacios-Navarro, G. (2025). Virtual reality and user experience Current trends and future challenges. *IEEE Access*. doi.org/10.1109/ACCESS.2025.3554434
- Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences* (2nd ed.). Routledge. https://doi.org/10.4324/9780203771587
- Du, Y., & Fan, X. (2025). An Exploration of Innovative Teaching Methods for Regional Cultural and Creative Product Design Based on Artificial Intelligence: A Case Study of Liyang Jiangtang Lantern Dance Cultural and Creative Product Design. *Tian Gong*, (23), 126–128.
- Gim, G., Bae, H. K., & Kang, S. A. (2022). The effect of self-determination and quality of vr-based education in the metaverse on learner satisfaction. In *Emotional artificial intelligence and Metaverse* (pp. 41-54). Cham: Springer International Publishing.
- Han, D. (2025). Virtual reality and augmented reality technology in cultural and creative product design. In *Frontier Computing: Volume 2: Proceedings of FC 2024* (pp. 105–114).
- He, L. (2024). Knowledge graph analysis of VR applications in domestic vocational education in the past 20 years. *Digital Education*, 1(55), 34–40.
- Hou, Y., & Hu, Q. (2021). Exploring the Application of Digital VR Technology in Blended Learning Reform in Cultural and Creative Product Design Courses. *Art Education Research*, (14), 142–143.
- Leadleo. (2022). *2021 China VR industry overview*. https://www.leadleo.com/
- Lin XP, Li BB, Yao ZN, Yang Z and Zhang M (2024) The impact of virtual reality on student engagement in the classroom—a critical review of the literature. *Front. Psychol.* 15:1360574. doi: 10.3389/fpsyg.2024.1360574
- Lou, M. (2017). A virtual reality teaching system for graphic design course. *International Journal of Emerging Technologies in Learning (iJET)*, 12(9), 117. https://doi.org/10.3991/ijet.v12i09.7492
- Lu, N. (2023). Practice and innovation of project-based teaching in cultural and creative design courses. *Journal of Weifang University*, 23(4), 95–98. https://doi.org/10.3969/j.issn.1671-4288.2023.04.024
- Makransky, G., & Petersen, G. B. (2019). Immersive virtual reality and learning: A meta-analysis. *Educational Psychology Review*, 31(4), 937–971. https://doi.org/10.1007/s10648-019-09497-9
- Makransky, G., Terkildsen, T. S., & Mayer, R. E. (2019). Adding immersive virtual reality to a science lab simulation causes more presence but less learning. *Learning and Instruction*, 60, 225–236. https://doi.org/10.1016/j.learninstruc.2017.12.007
- Makransky, G., & Petersen, G. B. (2021). The Cognitive Affective Model of Immersive Learning (CAMIL) A theoretical research based model of learning in immersive virtual reality. *Educational Psychology Review*, 33(4), 937-958. doi.org/10.1007/s10648-020-09586-2
- Mei, W. (2024). Research on the “Integrated Engineering-Education-Business” Training Path Based on the Integration of “Creative Design + Digital Technology”. *Guangdong Provincial Education Resource Public Service Platform*. http://zy.gdedu.gov.cn/studio/index.php?r=studio/post/view&sid=300016&id=66666
- Mohamed, T. I., & Sicklinger, A. (2022). An integrated curriculum of virtual/augmented reality for multiple design students. *Education and Information Technologies*, 27(8), 11137-11159. doi.org/10.1007/s10639-022-11069-6
- Parong, J., & Mayer, R. E. (2018). Learning science in immersive virtual reality. *Journal of Educational Psychology*, 110(6), 785–797. https://doi.org/10.1037/edu0000241

- Pozzo, D. N., Roa, I. G., Gonzalez Beleño, C. A., Arévalo Fajardo, B. Y., Herrera Cantillo, C. P., & Guerrero, V. C. (2024). Perspectives and applications of virtual reality in higher education: An analysis of Latin America's publications. *Procedia Computer Science*, 238, 962–967. <https://doi.org/10.1016/j.procs.2024.06.120>
- Qiao, W. (2024). Research on innovative teaching mode in design education based on VR/AR technology. *Technology and Education*.
- Radiani, J., Majchrzak, T. A., Fromm, J., & Wohlgenannt, I. (2020). A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. *Computers & Education*, 147, 103778. <https://doi.org/10.1016/j.compedu.2019.103778>
- Samala, A.D., Rawas, S., Rahmadika, S. *et al.* Virtual reality in education: global trends, challenges, and impacts —game changer or passing trend?. *Discov Educ* 4, 229 (2025). <https://doi.org/10.1007/s44217-025-00650-z>
- Shandong Agricultural University. (2022). *Shandong Agricultural University undergraduate professional talent training program*. <http://xxgk.sdau.edu.cn/2023/1102/c6422a226786/page.htm>
- Shanghai Jiao Tong University. (2021). *Wang Shouzhi: Development trends and directions of design education*. School of Design, Shanghai Jiao Tong University. <https://designschool.sjtu.edu.cn>
- Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science*, 12(2), 257–285. https://doi.org/10.1207/s15516709cog1202_4
- Sweller, J., Ayres, P., & Kalyuga, S. (2011). *Cognitive load theory*. Springer. <https://doi.org/10.1007/978-1-4419-8126-4>
- Technavio. (2025). *Augmented reality and virtual reality market analysis: North America, APAC, Europe, Middle East and Africa, South America – US, UK, China, Japan, Canada, Germany, India, France, Italy, Brazil: Size and forecast 2025–2029* (pp. 1–243). <https://www.technavio.com/report/augmented-reality-and-virtual-reality-market-industry-analysis>
- Wang, N., & Qu, P. (2024). Research on the Teaching Reform of Cultural and Creative Product Design Course under the Background of Digital Empowerment. *Art Education Research*, (16), 151–153.
- Wang, S., Cai, X., & Zhang, H. (2025). Research on Teaching of 3D Printing-Enabled Product Structural Innovation Design in the Knowledge Network Era. *Art Education Research*, (21), 118–120.
- Wu, B., Yu, X., & Gu, X. (2020). Effectiveness of immersive virtual reality using head mounted displays on learning performance A meta analysis. *British Journal of Educational Technology*, 51(6), 1991-2005. doi.org/10.1111/bjet.13028
- Wu, D. (2024). Research on the Teaching Reform of Cultural and Creative Product Design Course in the Context of the Digital Age. *Screen Printing Industry*, (10), 118–120.
- Wu, X. (2024). *Introduction to the course "Cultural and Creative Product Design."* Wuxi Commercial Vocational College. <http://meiyu.js.cn/CourseHome/courseDetail/285>
- Wu, X., & Tu, Y. (2023). Project based learning as a constructivist practice in design education Enhancing creativity through digital collaboration. *International Journal of Art and Design Education*, 42(1), 55-71.
- Wuhan University of Technology. (2025). *Product design major* (pp. 1–17). <https://ads.wit.edu.cn/xyxw2/xbsz1/cpsj.htm>
- Xu, B. (2021, March 10). How can Chinese design education find its own way? *Guangming Daily*. <https://m.gmw.cn/>
- Xu, C. (2024). Course design of visual cultural and creative design. The 7th Guangdong Provincial Higher Vocational Colleges Young Teachers' Teaching Competition
- Yan, W. J., & Li, K. R. (2023). Sustainable cultural innovation practice heritage education in universities and creative inheritance of intangible cultural heritage craft. *Sustainability*, 15(2), 1194. doi.org/10.3390/su15021194