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Integrating virtual reality technology with project-based learning: The effect on creativity cultivation in visual communication majors in china

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Abstract

visual communication design education often involves project-based learning (PBL). Traditional teaching methods will lead to incomplete coverage of course content, weak student autonomy, and lack of practical application, which is limited because did not pay attention to the cultivation of students' creativity. Rapid development of virtual reality (VR) technology can help fill this gap. VR technology has the advantage of interactivity, immersion, experiential learning, so that in PBL students can get a richer, deeper design experience. This study examines how VR technology can be integrated in PBL to enhance Visual Communication Design students' creativity. Specifically, this research reviews recent studies on PBL and on the application of VR technology in education. It then reports an empirical study where VR technology is used in the PBL setting to enhance art students' creativity. Results from the study show that students immersed in the VR environment generate more creative ideas, and complete projects faster with higher quality. This research suggests VR technology can be an invaluable addition to traditional PBL. More broadly, it shows the great promise VR technology holds for improving quality of education across programs.

Keywords: Virtual reality technology; Visual Communication design education; project-based learning ;Creativity cultivation.

1. INTRODUCTION

Virtual reality (VR) technology, a significant digital tool, has garnered immense attention in various fields. In China's art education domain, traditional teaching methods often hinder students from grasping theoretical and technical steps [1], leading to perceptions of abstraction and complexity. This detrimentally affects teaching quality and diminishes students' learning enthusiasm. However, by seamlessly integrating project-based teaching with VR technology, we can unlock new dimensions of learning and creative exploration for students majoring in Visual Communication.

VR technology offers an alternative learning and creative environment compared to traditional methods, opening new avenues for cultivating creativity and innovative thinking within the context of project-based learning. As the demand for digitization and visual expression continues to surge in future society, the requirements for Visual Communication students become more intricate and varied. Consequently, cultivating innovation, diversity, and global competitiveness among university-level visual communication majors becomes a pivotal research focus, further enriched by the inclusion of project-based learning that incorporates the immersive potential of VR.

Despite VR technology's promising prospects in art education, its full integration and application in Chinese universities, especially within Visual Communication majors, remain unrealized. Traditional teaching approaches possess limitations in fostering students' creativity, including confined creative spaces, limited personalized experiences, and inadequate stimulation of creative potential. Hence, this study not only explores the potential of VR technology in nurturing creativity among university Visual Communication majors but also integrates the innovative framework of project-based learning to enhance its effectiveness.

The core objective of this study is to probe into VR technology's potential in enhancing creativity among Chinese Visual Communication students, within the context of project-based learning. It aims to provide scientific evidence and recommendations for refining teaching practices and curricula by capitalizing on the interactive and immersive qualities of VR. Building upon the "3P Learning Process Model Theory," we critically analyze the

pivotal role of learning interests and styles in fostering creativity, further enhanced by the incorporation of experiential project-based learning and VR technolog.

By gaining a profound understanding of students' learning preferences and styles, we explore VR technology's capacity to invigorate creativity, promote innovative thinking, and amplify creative expression within the framework of project-based learning. Through a comprehensive review of existing research on VR technology in education and by conducting surveys and experimental data collection from Visual Communication majors, our experimental teaching project, centered around VR technology and project-based learning, seeks to harness VR's expressive and emotional advantages in knowledge dissemination[2].

The experiment encompasses in-depth interactions with virtual objects, simulated shooting scenarios, interactive experiments, and emotional design experiences, all under the umbrella of project-based learning with VR. We delve into students' acceptance of VR technology, their cognitive perspectives on nurturing creativity, and their feedback on this innovative approach to education.

This research not only offers novel viewpoints and insights for teaching and innovation within Chinese Visual Communication majors but also provides evidence-based recommendations for fostering creative development and cultivating more innovative talents among students, through the combined lenses of project-based learning and VR technology. By integrating the concepts of digital learning and sustainable education, we emphasize the significance of incorporating VR technology within project-based teaching practices. This approach promotes educational system innovation and refining curricula within Visual Communication majors to meet evolving educational needs in the digital landscape, further enriched by the immersive and exploratory attributes of VR technology.

Through a comprehensive exploration of VR technology's application in fostering students' creativity within the framework of project-based learning, this research strives to contribute wisdom and theoretical support to the advancement and sustainable growth of higher education and art education. By converging project-based learning with VR technology, we create a holistic and innovative approach to education that not only addresses the challenges of traditional teaching but also propels students toward more creative and impactful learning experiences.

2. LITERATURE REVIEW

Virtual Reality in Education

The term "VR" was coined in the 1960s, and since then, this technology has evolved to simulate the natural world diversely. VR provides a unique three-dimensional virtual environment for educational purposes, aiming to replicate real-world objects and phenomena. It adheres to immersion, interaction, and user participation principles in both environment and narrative, enhancing learning motivation and showing substantial educational potential[3]. In a simulated VR context, educators can demonstrate learning activities impossible in traditional labs.

Traditional teaching, somewhat monotonous, leads to a gap between teacher-student learning experiences, with limited classroom interactions. Consequently, issues arise: waning student course interest, challenges for teachers in engaging students, deficient student initiative, creativity, aesthetic appreciation, and innovative design skills [4].

Virtual Reality in Art Education

In recent decades, VR technology has gained extensive use across various educational sectors. The rapid pace of technological progress has led to the gradual advancement of VR capabilities and associated equipment, resulting in reduced costs compared to earlier stages. Consequently, the integration of IVR into art and design education is predicted to experience rapid growth in the upcoming years. According to a recent study[5], incorporating VR technology in arts education enhances deep learning engagement among students. Additionally, from a psychological perspective, it significantly boosts students' concentration and creativity.

Another study examined student and teacher experiences in art education through IVR (Immersive Virtual Reality). The Tilt Brush app was utilized to construct virtual worlds, enabling interaction and yielding positive results in terms of immersion, interaction, and imagination[6]. These findings suggest that integrating VR technology can be advantageous in artistic design creation.

Moreover, research underscores the mounting pressure on design education. The use of virtual reality technology in graphic design has been shown to enhance students' cognitive skills and ideation[7]. The study presents a methodology for integrating proposed virtual reality-focused course content into existing graphic design courses. This innovative approach empowers undergraduate students to base decisions on their ideas at various design process stages. Throughout the experiment, VR technology is integrated into development courses across design disciplines to enhance users' three-dimensional visualization of the design process and its practical application. Research findings validate that VR technology can shift design concepts from a 2D to an interactive 3D environment, offering users a more immersive and enriching learning experience.

The research results indicate that integrating VR technology into constructivism-based teaching can boost the learning enthusiasm and motivation of visual design majors, harnessing their imagination, creativity, sensitivity, and comprehensive design abilities [8].

College art instructors can incorporate VR as a supplementary tool to enhance teaching materials in design-focused courses. This approach enables teachers to facilitate a deeper understanding of artworks among college students compared to traditional textbook methods, as students can directly engage with the artworks. Furthermore, VR technology provides visual aids that immerse students in a simulated VR environment, undeniably enhancing engagement and enthusiasm during the learning process, particularly for those pursuing visual communication design majors [9].

Project-based learning in arts education

Project-based learning (PBL) has gained prominence in arts education for its potential to enhance creativity, critical thinking, and problem-solving skills[10]. PBL immerses students in real-world projects, allowing them to apply theoretical knowledge practically[11]. In arts education, PBL encourages hands-on artistic projects, fostering a deeper grasp of concepts and techniques. Studies show PBL aligns with constructivist theory, where active engagement leads to meaningful learning[12].

3. METHODOLOGY

Research Subjects

The study focused on second-year students who are pursuing a major in Visual Communication Design at a public university situated in Zhejiang, China. These students are enrolled in the School of Architecture and Art. The selection of these participants was driven by several factors. Firstly, the researchers themselves are instructors within the Visual Communication Design program, responsible for teaching core courses like Packaging Design, Poster Design, and Information Visualization Design. This proximity facilitates observation and data collection. Secondly, the study's subject matter directly aligns with the students' academic path and their keen interest, ensuring the feasibility of the research process. Additionally, the annual intake of students in this major remains relatively constant, and the students follow a fixed study duration, guaranteeing a sufficient sample size and research efficiency.

The study encompassed a total of 80 second-year students, including 29 males and 51 females, with an average age of 21 years and a standard deviation of 0.71.

Research Instruments

The research employed process-oriented scales and evaluative scales as its primary instruments. The process-oriented scales encompassed the Student Learning Interest Scale and the Student Primary Learning Method Scale. Meanwhile, the evaluative scale employed the Torrance Tests of Creative Thinking (TTCT) to evaluate students' creativity.

During the scale development process, the researchers drew on the "3P Learning Process Model Theory," which emphasizes learning interests and styles. This process encompassed three phases: Open-Ended Collection, Associative Collection, and Expert Evaluation.

Open-Ended Collection: The research team surveyed 20 teachers' teaching scenarios to gather descriptions linked to students' learning interests, methods, and instructor guidance. These descriptions were condensed into "meaning units." The researchers distilled these units into key terms or concepts, cross-referencing them with keywords or concepts from existing literature related to students' learning interests, methods, and teacher guidance. This yielded a total of 32 key terms or concepts.

Associative Collection: High-frequency key terms from the previous phase were logically organized and categorized into a word list containing 26 key terms. This list included 10 key terms concerning learning interests and 16 related to learning methods. These key terms were defined as observation items, accompanied by explanations and illustrative behaviors. Through observations of Visual Communication majors from different universities on three separate occasions, the researchers further refined these to 6 observation items for learning interests and 8 for learning methods.

Expert Evaluation: The compiled word lists underwent review by six experts and six instructors. Incorporating their feedback, the lists were further honed, culminating in the creation of the Student Learning Interest Observation Form and the Student Learning Method Observation Form. These forms facilitated the recording and collection of information pertaining to observation subjects, dimensions, methods, duration, observers, time, and location.

The above scales underwent rigorous testing for both reliability and validity. In terms of structural validity, the scales exhibited a KMO (Kaiser-Meyer-Olkin) value of 0.667 and a P-value of 0.000 (<0.05) for Bartlett's sphericity test. This indicated the extraction of six factors with eigenvalues exceeding 1, accounting for a cumulative variance of 62.233%. In the context of reliability, the Cronbach's α values for the scales ranged from 0.598 to 0.780 (>0.500), indicative of strong reliability. This supports their use in subsequent empirical research.

Application and Reliability Analysis of the Evaluative Scale:

For assessing students' creativity, the Torrance Tests of Creative Thinking (TTCT) were chosen, measuring creativity across four dimensions: fluency, flexibility, originality, and elaboration. This study's TTCT comprised three tests:

Test 1: Participants were tasked with creating imaginative drawings based on an egg-shaped template.

Test 2: Participants were presented with ten simple line-drawn shapes, requiring them to complete and name these shapes.

Test 3: Participants were provided with 30 circles or 30 pairs of parallel lines and instructed to use them as a foundation for generating various objects.

Statistical analysis revealed Cronbach's α values for the TTCT ranging from 0.80 to 0.90, indicating that the "Torrance Tests of Creative Thinking (TTCT)" can be effectively employed in subsequent empirical research. These values reflect strong reliability, assuring the suitability and consistency of TTCT as an assessment tool for students' creativity.

Research Procedure

The research was conducted over one semester, spanning from September 2022 to January 2023. As observers, the instructors closely monitored classroom dynamics in both the experimental and control groups, based on students' real-time classroom engagement. They recorded 45-minute video sessions for each class and employed the Student Learning Interest Observation Form and the Student Learning Method Observation Form to quantify the frequency of behavior indicators exhibited by students during different course segments at equidistant intervals. The observation process employed a one-minute interval sampling method, where three observers simultaneously observed a single student to calculate the average value. Subsequently, the collected data were entered into SPSS for thorough analysis and processing.

A distinctive feature of Visual Communication Design instruction is the extensive practical training involved, requiring students to fully immerse themselves in the learning environment to complete assigned course projects and skill training. During VR training and teaching sessions, students engaged with digital resources through a smartphone app, following the instructions outlined in the course training guidebook for knowledge preview. The instructor utilized VR technology to elucidate practical content, guiding students through training activities via the smartphone app.

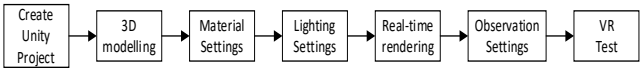

figure1 Packaging Design Model Development Process

For instance, within the context of the "Packaging Design" course, specifically during the project focused on biscuit packaging design (as illustrated in Figure 1: Packaging Design Model Development Process), students were afforded the opportunity to collaborate in groups. Their task encompassed sketching three distinct views of the biscuit packaging and subsequently constructing a three-dimensional model of the biscuit box. This modeling was executed employing tools like Unity or other 3D modeling software. In this phase, students were required to consider elements such as box dimensions, structural design, shape, and decorative embellishments. They engaged with a range of materials and textures, spanning from basic solid colors to intricate patterns and labels. By doing so, students were able to preview the visual impact of varying materials on the box's appearance, subsequently making necessary adjustments and enhancements.

Subsequently, the designed biscuit box model was integrated into the VR development environment. Through integration with VR devices including VR headsets and controllers, students were enabled to virtually manifest the box's visual and interactive attributes, garnering a heightened level of realistic visual and tactile feedback. VR presentations facilitated group discussions and intuitive learning among peers. Furthermore, the VR environment allowed students to directly assess the design's effects. They could tangibly experience the box's size, texture, and overall visual presence, thereby evaluating its alignment with their initial expectations. Informed by insights gleaned from instructor feedback, which encompassed explanations and recommended modifications, students refined their designs through necessary optimizations and adjustments, thereby progressing their work to a higher standard.

4. DATA ANALYSIS

Overall Analysis

Using SPSS software, the overall situation before and after the experiment was tested and compared. This included changes in students' positive and negative learning interests, changes in their learning methods, and changes in their creativity. The specific results are shown in Table 1.

Table1 Comparison of students Interests Before and After the Test

		Mean	SD	Proportion
Pre-test	Positive	22.91	13.57	82.27
	Negative	5.39	5.68	17.73
Post-test	Positive	32.37	12.56	92.10
	Negative	2.98	3.69	7.90

As depicted in Table 1, the pre-test results reveal that the average scores for students' positive and negative learning interests were 22.91 (SD=13.57) and 5.39 (SD=5.68) respectively. Following the implementation of the semester-long experiment, the post-test data demonstrated an elevation in both the values and proportions of positive learning interests, accompanied by a reduction in the values and proportions of negative learning interests. Specifically, the mean values for positive learning interests were 32.37 (SD=12.56), while the mean values for

negative learning interests were 2.98 (SD=3.69). This substantiates the notion that the integration of VR devices within Visual Communication Design classrooms led to a noticeable enhancement in students' learning interests.

Table2 Comparison of Changes in students Learning Styles

	Pre-test			Post-test		
	Mean	SD	Proportion %	Mean	SD	Proportion %
Observation	0.21	0.72	2.73	0.35	0.98	4.56
Listening	4.1	5.31	53.25	2.84	4.45	34.01
Discussion	0.43	1.05	5.58	1.06	2.03	12.69
Questioning	0.25	0.66	3.25	0.50	0.82	6.00
Experience	0.00	0.00	0.00	0.09	0.34	1.08

Referring to Table 2, concerning students' learning methodologies, the item "listening" displayed mean values of 4.1 (SD=5.31) in the pre-test and 2.84 (SD=4.45) in the post-test. The data underscores that "listening" stood as the predominant learning approach, yet its prevalence declined in the post-test phase. Conversely, notable enhancements were observed in the learning strategies encompassing "observation," "discussion," "questioning," and "experience." Remarkably, a significant advancement was registered within the "experience" category, signifying a transformative effect stemming from the incorporation of VR devices within conventional Visual Communication Design classrooms. Notably, students showcased heightened proactivity and autonomy. The utilization of VR engendered a shift from the conventional teaching paradigm of "teachers speak, students listen" toward a more dynamic and interactive learning experience, augmenting the teaching efficiency.

Table3 Comparison of Students' Creativity Before and After the Test

	Pre-test		Post-test	
	Mean	SD	Mean	SD
Fluency	62.21	43.00	32.45	13.22
Flexibility	19.98	9.20	36.78	17.91
Originality	29.23	18.61	53.63	28.00
Elaboration	62.76	42.97	102.33	56.60
Creativity	173.18	63.59	225.19	107.56

Examining Table 3, it becomes evident that distinct shifts occurred across the four dimensions of students' creativity. Collectively, the pre-test yielded an average creativity score of 173.18 (SD=63.59), which notably increased to 225.19 (SD=107.56) in the post-test phase. This conspicuous augmentation underscores that the integration of VR had a substantial impact in elevating students' creativity.\

Differential Analysis

Pre-test Comparison between Experimental and Control Groups (ANOVA). Employing SPSS statistical software for one-way analysis of variance (ANOVA), the investigation unveiled non-significant disparities in students' creativity, learning methods, and learning interests between the experimental group and the control group during the pre-test phase. This outcome signifies an absence of notable differentiation in the learning trajectory and creativity progression among students within the experimental and control groups. This serves as a foundational point for subsequent empirical exploration. Comprehensive details can be found in Table 4.

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Table 4 Differences between Experimental Class and Control Class in Pre-test

		F	p
Creativity		1.32	0.26
Learning Methods		3.42	0.52
Learning Interest	Positive	7.44	0.70
	Negative	1.31	0.25

Post-test Comparison between Experimental and Control Groups (ANOVA). Leveraging the SPSS statistical software for one-way analysis of variance (ANOVA), the analysis yielded noteworthy outcomes. The findings revealed significant disparities ($p<0.01$) in students' creativity ($F=14.96$, $p=0.000$), positive learning interests ($F=86.70$, $p=0.000$), and negative learning interests ($F=12.07$, $p=0.000$) between the experimental group and the control group in the post-test phase. The discerned data underscored that subsequent to the experiment, the experimental group exhibited notably elevated levels of creativity and more robust positive learning interests when compared to the control group. For a comprehensive breakdown, please refer to Table 5.

Table5 Differences between Experimental Class and Control Class in Post-Test

		F	p
Creativity		14.96**	0.000
Learning Methods		1.96	0.166
Learning Interest	Positive	86.70**	0.000
	Negative	12.06**	0.000

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Pre-test and Post-test Comparison within the Experimental Group (Paired Samples T-Test). By employing paired samples t-tests within the SPSS statistical software, noteworthy findings emerge. Specifically, significant disparities ($p<0.01$) were observed in students' creativity ($T=-15.42$, $p=0.000$), learning methods ($T=-2.03$, $p=0.044$), positive learning interests ($T=-10.77$, $p=0.000$), and negative learning interests ($T=6.43$, $p=0.000$) between the pre-test and post-test phases within the experimental group. This compellingly indicates that the incorporation of VR within Visual Communication Design curricula yielded marked enhancements. The utilization of VR notably ameliorated students' learning methods and engendered a more pronounced positive disposition toward learning, simultaneously leading to a reduction in negative learning interests. A comprehensive breakdown of these results can be found in Table 6.

Table6 Differences within Experimental Class between Pre-test and Post-test

		F	p
Creativity		-15.42**	0.000
Learning Methods		-2.03*	0.044
Learning Interest	Positive	-10.77**	0.000
	Negative	6.43**	0.000

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5. FINDINGS

The integration of project-based learning has proven highly effective in this process. Through a semester of incorporating virtual reality (VR) into the visual communication design course, the discipline has transcended two-dimensional boundaries, venturing into immersive three-dimensional spaces. This shift yields a more comprehensive visual communication content presentation. As students explore, they encounter diverse learning experiences, facilitated by innovative VR use. This interactive environment empowers deeper engagement with creative expression and design principles. Students embrace creative concepts and paradigms, fostering innovative design abilities, leading to heightened experimental group creativity.

Moreover, as project-based learning infuses this process, three advancements emerge. VR sparks experimental group creativity, encouraged by hands-on learning. The study's influence drives a significant rise in positive learning interests. As students navigate VR-enhanced content, they encounter a new learning landscape, sparking enthusiasm aligned with project-based learning. VR spurs engagement, autonomy, cooperative learning, boosting learning interests. VR devices enhance the learning experience, embedding project-based learning principles.

Additionally, virtual reality technology shifts learning approaches, particularly in observation, discussion, questioning, and experiential learning. VR empowers multisensory engagement, enriching understanding. VR broadens topics, fueling dynamic discussions. Immersive VR fosters richer communication, deep dialogue. VR's curiosity-triggering aspect prompts questioning and exploration, refining design work. Experiencing design in VR augments sensory connection, aligning with project-based learning principles. This immersive approach enhances practical application of theoretical knowledge. virtual reality technology and project-based learning reshape visual communication design education. Liberated from convention, students embrace creativity, curiosity, autonomy. Merging immersive tech with hands-on exploration transforms creative education, nurturing innovative thinkers prepared for future challenges.

6. DISCUSSION

In this study, the integration of Unity and other software with VR devices in the packaging design segment of visual communication design has provided students with a completely new learning experience, subtly weaving in the concept of project-based learning. Visual art forms are composed of elements like lines, colors, and space, and virtual reality technology enhances spatial intuition in art creation. By leveraging multidimensional sensory experiences formed by 2D images and 3D space, students' visual perception is cultivated, and their comprehension of the three-dimensionality and realism of design is refined. Through simulating packaging design and display processes in a virtual environment, students can immerse themselves in the authentic presentation of their design works, gaining a deeper grasp of the design's tridimensionality and realism, thereby effectively elevating design creativity and skills. Students transition from passive knowledge recipients to proactive explorers, practitioners, and discoverers within the virtual environment, nurturing more forward-thinking and innovative design aptitudes.

In conventional packaging design courses, students typically convey their design creations through paper or digital 2D images. However, with the advent of VR technology, visual communication design takes on sensory dimensions, enabling students to exhibit their designs in a virtual 3D realm, thereby facilitating a more genuine and immersive learning experience. This interactive, hands-on learning approach spurs students to actively participate in the learning process, intensifying their grasp of design theories and the application of design skills in tangible settings.

Moreover, delivering design projects through VR empowers students to better assess and advance their design concepts. Within the virtual environment, they can observe real-time effects and presentations of their designs, effecting alterations and optimizations to finesse and meet the stipulated design requirements. This real-time feedback loop serves to stimulate students' creativity and innovative thinking, empowering them to confidently express and showcase their design works.

Furthermore, VR provides educators with a broader array of teaching tools and resources. Teachers can exploit the virtual environment to structure a diverse array of thought-provoking teaching activities and to conceive more engaging project tasks, thereby nurturing students' curiosity and motivation to learn.

Nonetheless, the application of virtual reality technology in the teaching of visual communication design also encounters certain challenges and limitations. Primarily, the cost of technical equipment and software is relatively high, necessitating substantial investment and support from educational institutions. Secondarily, instructors need to undergo specialized training and attain proficiency in the application of VR technology to optimize teaching effectiveness. Additionally, the continual evolution and progress of virtual reality technology require institutions and educators to remain vigilant, consistently learning new technologies to meet the demands of a dynamically shifting landscape. This integration of the project-based learning concept seamlessly fosters opportunities for students to tackle challenges, innovate, and explore within practical contexts, ultimately nurturing a more proactive and inventive design capability.

7. CONCLUSION

The purpose of this study was to explore the potential application of virtual reality (VR) technology in fostering creativity among students majoring in visual communication at Chinese universities, meeting the growing demand in the digital and visual expression fields, while incorporating the concept of project-based learning. By comprehensively reviewing existing research on the use of VR technology in education and conducting surveys and experiments with students majoring in visual communication, this study delved into the impact of VR technology on fostering creativity in students.

Traditional teaching methods have had limitations in nurturing student creativity, such as restricted creative space and a lack of personalized creative experiences. However, the results of this study demonstrate that by fully leveraging the advantages of VR technology, we can explore its innovative application in fostering creativity among students majoring in visual communication at universities. The interactivity and immersion in the VR environment enable students to freely explore creative ideas and expand their creative thinking, thereby inspiring more creative design works.

VR technology simulates design works and their environments, reproducing real-life scenarios, allowing students to immerse themselves in an experiential learning environment, enhancing the spatial intuition in visual communication design courses. It not only supplements teaching but also integrates artistic aesthetics with education, enriching teaching scenarios and improving learning methods. Furthermore, the "embodied cognition" function provided by VR technology offers students experiences that traditional teaching cannot provide, fostering and stimulating their imagination and creativity, increasing their interest in learning, and deepening cognitive understanding.

In conclusion, this study holds significant importance in promoting the application of virtual reality technology in fostering creativity among students majoring in visual communication at Chinese universities, within the framework of project-based learning. As a crucial digital tool, VR technology provides new avenues and possibilities for the teaching and development of students' creativity in visual communication majors at universities, offering beneficial exploration and practice for the widespread application of virtual reality technology in arts and design education in the future.

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