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Project Design and Learning of Interior Residential Space Based on 3D Cloud Platform Technology

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Abstract

Background and Aim: Teaching interior design through 3D drawing presents challenges. While 3D cloud platforms offer new learning pathways, their effectiveness in project-based courses requires validation. This research evaluates the applicability of the Kujiale 3D cloud platform in teaching residential space design, specifically assessing its impact on student design outcomes.

Materials and Methods: The mixed-methods approach with 89 purposively sampled Environmental Art Design students. Within a project-based learning (PBL) framework, students used the Kujiale platform. Their project performance was measured across five variables: design creativity, visual representations, design drawings, sustainable design, and smart home integration. To understand 3D cloud platform use and learning perceptions, the research integrated Task-Technology Fit (TTF) and Learning-Technology Fit (LTF) theories to analyze the alignment between design tasks, learning activities, and the technology. The research also applied Cognitive Affordance (CA) theory to evaluate the platform's usability and its support for design learning through interaction.

Results: It is found that for beginners in interior design, learning based on the Kujiale 3D cloud platform can effectively improve the project performance in the process of residential space design. There are significant differences in visual representations, design drawings, and smart homes, but there are no obvious differences in design creativity and sustainable design.

Conclusion: The research confirms the suitability of Kujiale 3D cloud platform technology for foundational interior design teaching. By providing empirical evidence of performance differences and exploring the interplay between technology and learning, this research offers valuable insights and a stronger foundation for applying 3D cloud technologies in design education.

Keywords: Kujiale 3D Cloud Platform; Interior Residential Space; Project Design; Interactive Experience

Introduction

With the advancement of internet technology and the widespread adoption of cloud computing, intelligent cloud platforms can be rapidly deployed and expanded within the design industry. Internet-driven, distributed design and large-scale collaboration are essential in realizing next-generation design and manufacturing (Arowoiya et al., 2020). The 3D cloud design, built through the internet, functions as a shared platform for design information, with online design conducted through a network-based interface. In the educational realm, cloud computing applications allow users to access and utilize a variety of scalable information resources stored in the cloud, without limitations. A successful cloud platform can effectively support distance learning by providing the necessary technical assistance. Universities and colleges are rapidly adopting e-learning platforms for course delivery and academic use (Thavi et al., 2024). The Kujiale 3D cloud platform, featured in this research, represents such a technology, offering online collaboration, resource access, VR experiences, data computation, and more, enabling modular design synchronization. This cloud design platform incorporates computer-aided design as its foundation, facilitating the integration of tasks and design resources, monitoring design work in real time, quickly identifying different types of work, and enabling collaborative design by multiple users (Zanbouri & Navimipour, 2020).

In interior design education, achieving the curriculum goals for residential space project design requires students to possess a certain level of design ability and the skill to complete systematic drawings. The assessment criteria typically include five key aspects: design creativity, visual representations, design drawings, sustainable design, and smart home. Completing the project design involves extensive space modeling and both two-dimensional and three-dimensional drawings. Students typically use software like

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SketchUp and AutoCAD for their designs, with the conventional process being to first create two-dimensional drawings, then model and render in three dimensions, and finally compile the design documentation. However, in the context of a limited course timeline, the complexity of using advanced drawing software can put considerable pressure on students, leading to a loss of interest and even boredom (Hamurcu et al., 2020). Additionally, the high-precision rendering required for interior spaces often demands more advanced computer configurations, making it challenging for some students to complete high-quality drawings on their laptops.

In the context of design learning, the interaction with traditional 3D software technology based on images often lacks sufficient interactivity and fails to effectively support a real-space experience during the design process. Moreover, in today's e-commerce supply chain, personalized selection and customization of household goods have become essential, and the lack of interaction hinders the ability to support customization functions (Zhang, 2019). In contrast, the interactive experience provided by the 3D cloud platform offers an intuitive spatial experience for interior design beginners. The 3D technologies, such as VR and panoramic displays, not only showcase spatial renderings but also provide an immersive experience by allowing changes to interior furnishings. The development of 3D visualization has a significant potential impact on home interior design projects (Rajab et al., 2019) and offers more expressive presentations for audiences and consumers (Joy & Raja, 2024). Furthermore, digital visualization facilitates collaborative tasks (Li et al., 2019) and is considered a promising tool to address design and construction challenges (Bashabsheh et al., 2019).

In this research, the Kujiale 3D cloud platform is selected as the teaching technology for the interior residential space design course to explore its effectiveness in teaching through the integration of real-world projects. The platform offers an educational version that enables both students and teachers to collaborate on online drawing and share resources via the network.

The research questions of this research are:

1. How effective is the Kujiale 3D cloud platform in enhancing short-term learning outcomes within an interior residential space design course?

2. What is the difference between using Kujiale 3D cloud platform technology and traditional software technology in the design of interior residential space projects?

3. How does the use of the Kujiale 3D cloud platform impact students' sustainable design practices within the context of interior residential space teaching?

Objectives

RO1 To determine the effectiveness of the Kujiale 3D cloud platform in improving students' short-term learning outcomes in an interior residential space design project.

RO2: To identify the applicability of using different technical software in the design of an interior residential space.

RO3 To specify the influence of the Kujiale 3D cloud platform on students' sustainable learning.

Literature review

In this research, the theories of task-technology fit (TTF), learning-technology fit (LTF), project-based learning (PBL), and cognitive absorption (CA) are employed. PBL allows for the achievement of specific learning objectives through time-bound project tasks (Gunarathna et al., 2024). By integrating actual interior residential space projects, this approach aligns technology closely with students' learning needs, enabling them to gain hands-on experience in design practice using the cloud platform. TTF and LTF refer to how well cloud-based e-learning systems support students in performing their learning activities (Cheng, 2022). To determine whether the 3D cloud platform is suitable for completing tasks in interior design teaching and to assess its effectiveness in promoting students' learning processes, research investigates whether the immersive learning experience facilitated by the technology enhances students' focus and interest in the learning content, ensuring they can learn efficiently throughout the project

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implementation. Guided by this theoretical framework, and in conjunction with five key variables for evaluating interior residential space project design, the research evaluates the use of the Kujiale 3D cloud platform.

Project-Based Learning (PBL) as the Pedagogical Foundation:

Project-Based Learning (PBL) is a systematic educational approach centered around projects, where students are motivated to learn by solving real-world problems (Parrado-Martinez & Sanchez-Andujar, 2020).

In interior design education, projects are typically completed by teams of 2-4 students. The Project-Based Learning (PBL) model fosters collaboration, enhances project planning, emphasizes time management skills, and strengthens students' ability to apply their knowledge in real-world contexts (Murat, 2014). Project-based learning engages students to play the role of a researcher around real-life problems based on the decomposition points of the project, search for project information, identify key issues, propose design strategies, and finally solve the corresponding situations and problems, which strengthens the students' transversal competence based on the set-up that there is no single correct answer to the project solution ((Parrado-Martinez & Sanchez-Andujar, 2020).

In this study, PBL provides the essential pedagogical context: the interior residential space design project defines the tasks students undertake and the learning activities they perform. This project structure creates the specific environment against which the fit of the technology (TTF/LTF) and the user experience (CA) are evaluated.

Task-Technology Fit (TTF) and Learning-Technology Fit (LTF) for Evaluating Alignment:

Building upon the foundational work of Goodhue and Thompson (1995), Task-Technology Fit (TTF) examines the congruence between a technology's functionality and the requirements of the task's users need to perform. Learning-Technology Fit (LTF), an extension of TTF, specifically focuses on the alignment between technology and the demands of learning activities (McGill & Klobas, 2009). It assesses how well technology supports learners in performing combinations of learning tasks. In design education, task awareness drives cognitive processes; understanding specific requirements guides designers' actions (Goel et al., 2011). Within this PBL framework, TTF/LTF theory is applied to assess: How well does the Kujiale 3D cloud platform support students in completing the specific tasks inherent in the residential design project? How effectively does it facilitate the core learning activities required by the PBL approach?

Task-driven design allows designers to understand the specific requirements in residential space design, with task awareness guiding their actions and engaging cognitive processes. Through the analysis of related tasks, this research studies the learning motivation and fun of students in interior residential teaching on the Kujiale 3D cloud platform.

Cognitive Absorption (CA) for Assessing the Experience:

Cognitive Absorption (CA), rooted in psychology, refers to a state of deep personal engagement with information systems (IS) or information technology (IT), or with the overall experience (Leong, 2011; Reychav & Wu, 2015). Agarwal and Karahanna (2000) further improved the concept of cognitive absorption and defined five dimensions related to psychology: temporal dissociation, focused immersion, heightened enjoyment, control, and curiosity.

In this research, CA is used to evaluate the quality of the student experience when using the Kujiale 3D cloud platform within the PBL tasks. According to the cognitive theory, task awareness shapes the possibility of action, and as individuals assign meanings to what can be done in the environment, space, and its contained objects, they become aware of and assign meaning to task-related cues and are cognitively engaged (Goel et al., 2011). In this research, time separation, curiosity, and immersion are the core dimensions of cognitive absorption. In the research on the combination of design teaching and cloud platform technology, "time separation" refers to the degree of time lapse in the application of technology, "curiosity" refers to the degree to which the cutting-in of this technology arouses students' desire for continuous use and research, and "concentration and immersion" refers to the perceived investment level and cognition of space when using interactive technologies such as cloud platform design drawing and VR.

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Guided by this integrated framework, where PBL defines the context, TTF/LTF evaluates the functional alignment, and CA measures the experiential outcome, this research investigates the impact of the Kujiale 3D cloud platform on project performance across five key variables within the interior residential space design course.

Conceptual Framework

This study employs a conceptual framework (see Figure 1) centered on investigating the relationship between the application of the Kujiale 3D cloud platform and student learning outcomes in interior design. Central to this framework are five key assessment variables used to evaluate student design projects. These variables are theorized to be directly influenced by specific features of the Kujiale platform, such as its real-time 3D visualization, extensive material library, collaborative tools, and rapid iteration capabilities. The framework posits that these features enhance aspects like spatial comprehension and design efficiency by enabling faster visualization of changes, ultimately impacting the overall design outcome as measured by the five variables.

Operationalized through quasi-experimental and quantitative methods, the research compares the applicability and impact of the Kujiale 3D cloud platform technology versus traditional software on students' interior design learning. The five assessment variables form the core dependent measures within the quasi-experiment. Over 5 weeks (totaling 60 hours), an experimental group utilizes the Kujiale platform for residential interior space design projects, while a control group employs traditional software. Upon completion, project designs from both groups are evaluated and scored based on the five predefined assessment variables. Additionally, semi-structured interviews are conducted with the experimental group to gather in-depth insights into their experiences applying the Kujiale technology within the design process.

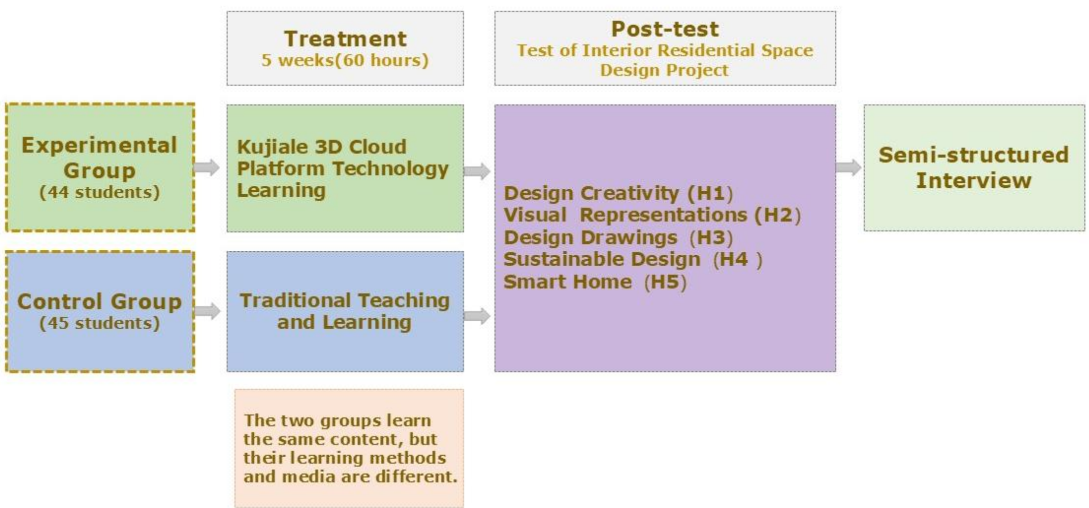

Figure 1 Research Framework

Table 1 The Specific Content of Scoring of The Variables in This Research

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Variables	Definition	This research is a reference to the evaluation content	Percentage of scores
Design Creativity	Design creativity is the capacity of a person or team to generate novel and useful ideas to solve a proposed problem.	1. Design concept 2. Space planning	20%
Visual Representations	Visual representations communicate meaning symbolically. This helps to articulate, exchange, and understand design ideas.	1. Design sketches 2. Interior renderings 3. Roaming videos	30%
Design Drawings	Design drawing is a physical manifestation of architectural ideas of space. The drawing process generates lines, planes, sections, elevations, etc.	1. Two-dimensional drawings 2. Three-dimensional drawings 3. Drawing quantity 4. Drawing standards	30%
Sustainable Design	Sustainable design aims to remove all negative environmental impacts through innovative, considerate design, requiring renewable resources and creativity to have a minimal environmental impact and link people to the natural environment.	1. A conceptual framework for the deployment of sustainability functions in the design phase. 2. The use of ecologically sustainable building materials.	10%
Smart home	Smart Home contains several highly advanced smart technologies and interconnected devices. The environment of a Smart Home has the abilities of perception, cognition, analysis, reasoning, and anticipation about a user's activities and can accordingly take proper reactions.	1. Interactive system 2. Smart system 3. Smart furniture	10%

Table 2 Semi-structured Interview Content

Interview (Given to the Experimental group only)			
Student Engagement	A student's behavioral engagement is reflected in their presence online with a positive mindset and participation in online activities. (Tetteh et al., 2023)	1. Can you tell us your experience as far as learning in a 3D cloud platform is concerned? 2. How did the instructional videos help you understand more about the platform? 3. What enabling factors inspire you to research consistently and participate in 3D cloud platform learning? 4. How important was social interaction with peers to your learning experience? 5. How did 3D cloud platform technology help you with your learning? 6. How did working with your peers on group assignments and tasks help you learn more in the interior residential space design course?	(Tetteh et al., 2023)

Methodology

To address the research questions, a mixed-methods research design was employed. In this research, experimental methods were used for quantitative research, and semi-structured interviews were employed for qualitative research. Quantitative data were analyzed using SPSS 26 software, while qualitative data

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were analyzed with NVivo 20 software, establishing relationships between descriptive data sets and digital data.

Tests and semi-structured interviews were used as research tools. Over five weeks, students were required to complete a set of interior design schemes for residential spaces based on actual projects. During the process, students can collaborate in groups of 2 to 4. The evaluation of their design schemes focuses on five aspects: design creativity, visual representations, design drawings, sustainable design, and smart home, which also serve as the five variables for this research. The curriculum standards for interior residential space design, specific to the Environmental Art Design major, were used as the evaluation criteria. After the test, semi-structured interviews were conducted with the experimental group to gather students' perspectives on the use of the Kujiale 3D cloud platform technology.

The population for this research consists of students majoring in Environmental Art Design at the School of Art and Design, Zhejiang Business College, located in Hangzhou, Zhejiang Province, China. The sample includes 89 second-year students from two classes in the Environmental Art Design program, selected through purposive sampling. These students are beginners in interior design, having completed foundational courses such as design sketching and color theory, but lacking prior practical experience in residential space design projects. One class is randomly selected as the experimental group, while the other serves as the control group.

In the curriculum, the role of the teacher is that of a facilitator and guide. At the start of the course, an overview of residential space project design is provided, along with an evaluation form that includes five key variables. Teachers assign different design tasks at various stages of the project to ensure its effective completion. At the end of the course, students present their design work and submit a project design document. Three interior design instructors then evaluate the students' projects and calculate the average score for data analysis. Additionally, a selection of students from the experimental group participated in semi-structured interviews. The students' project design scores ranged from 70 to 90, and the interview data were analyzed through systematic collation. The interview protocol focused on their experiences using the Kujiale platform, perceived benefits, challenges, and its impact on their design process and learning. Interview recordings were transcribed verbatim. Thematic analysis was employed for data analysis using NVivo 20, and it is shown visually.

Results

The sample participating in the experiment consists of 89 learners majoring in Environmental Art Design from Zhejiang Business College in Hangzhou, Zhejiang Province, China. The experimental group includes 13 male students and 31 female students, totaling 44 participants, which accounts for approximately 49% of the overall sample size. The control group consists of 15 male students and 30 female students, totaling 45 participants, which makes up about 51% of the sample. In total, the sample comprises 28 males (31%) and 61 females (69%). The age range of the participants is from 19 to 21 years. Of the sample, 47 students are 19 years old, accounting for 53%; 37 students are 20 years old, making up 41.5%; and 5 students are 21 years old, representing 5.5%.

To ensure the accuracy of data collection, the grading process involves three evaluators. In addition to the teachers responsible for grading the students' design projects, two interior design instructors independently assess the results without interference. The final grade for each project is calculated by averaging the scores given by the three teachers. This includes the overall score as well as the scores for five specific variables: design creativity (20), visual representations (30), design drawings (30), sustainable design (10), and smart home (10), with a maximum total score of 100 points. Preliminary analysis of the collected data indicates that the significance value (sig.) is less than 0.05, suggesting a non-normal distribution. As a result, the Mann-Whitney U test, a nonparametric method, is employed to compare the five variables across the two groups.

A comparison of the design creativity data reveals that $Z = -0.146$ and $P = 0.295>0.05$, indicating no significant difference in design creativity between the two groups. The median score for the experimental group was 16, with the upper and lower quartiles at 16 and 17, respectively. For the control group, the median was also 16, with the upper and lower quartiles at 16 and 18. The differences between the two

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groups were minimal. This suggests that the technology has not demonstrated significant advantages in terms of design concept or space planning for interior residential space project design.

Table 3 Data summary of Design Creativity

	Design Creativity	Z	P
Experimental	16（16~17）	-1.046	0.295
Control	16（16~18）		

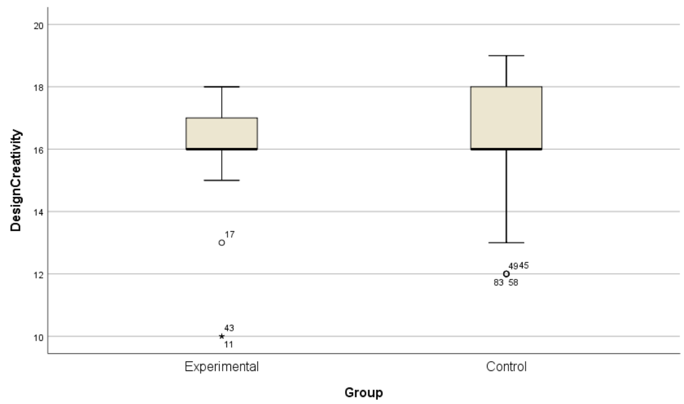

Figure 2 Box Diagram of Design Creativity

A comparison of the visual representations data shows that Z = -2.563 and P = 0.002<0.05, indicating significant differences between the two groups in visual representations. The median score for the experimental group was 28, with the upper and lower quartiles at 27 and 28, respectively. In contrast, the median score for the control group was 27, with the upper and lower quartiles at 25 and 28. The differences between the two groups were notable. This suggests that the technology has significant advantages in design sketches, interior rendering, and roaming videos.

Table 4 Data summary of Visual Representations

	Visual Representations	Z	P
Experimental	28（27~28）	-3.115	0.002
Control	27（25~28）		

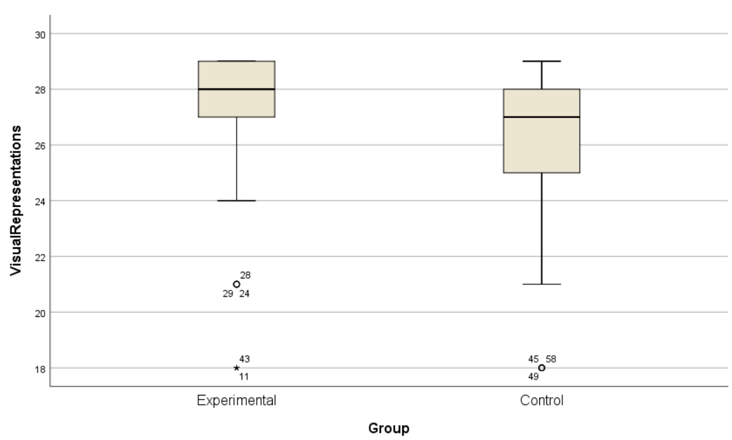

Figure 3 Box Diagram of Visual Representations

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A comparison of the design drawings data reveals that Z = -1.999 and P = 0.046<0.05, indicating significant differences between the two groups in terms of design drawings. The median score for the experimental group was 28, with the upper and lower quartiles at 26.25 and 29, respectively. In contrast, the median score for the control group was 26, with the upper and lower quartiles at 25 and 28. The differences between the two groups were substantial. This indicates that the technology has clear advantages in producing two-dimensional and three-dimensional drawings, as well as in terms of drawing quantity and standards.

Table 5 Data summary of design drawings

	Design Drawings	Z	P
Experimental	28（26.25~29）	-1.999	.046
Control	26（25~28）		

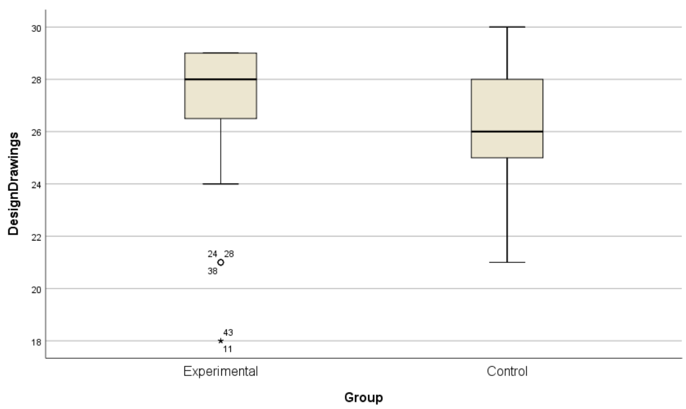

Figure 4 Box Diagram of design drawings

A comparison of the sustainable design data shows that Z = -0.475 and P = 0.635>0.05, indicating no significant difference between the two groups in terms of sustainable design. The median score for the experimental group was 8, with the upper and lower quartiles at 7 and 8, respectively. The median score for the control group was also 8, with the upper and lower quartiles at 7 and 9. The difference between the two groups was minimal. This suggests that the technology did not demonstrate clear advantages in the construction of a sustainable design framework.

Table 6 Data summary of sustainable design

	Sustainable Design	Z	P
Experimental	8（7~8）	-0.475	0.635
Control	8（7~9）		

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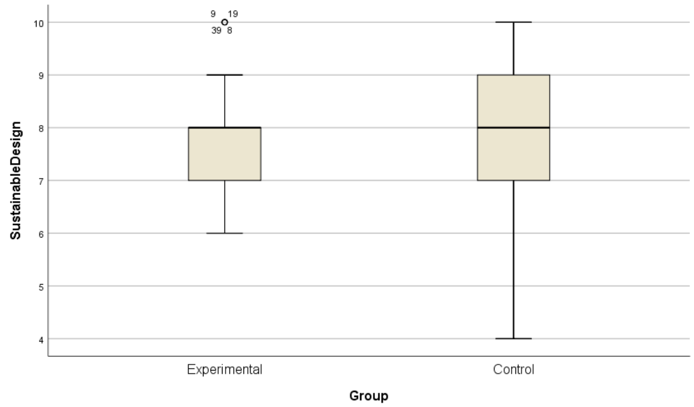

Figure 5 Box Diagram of Sustainable Design

A comparison of the smart home data reveals that Z = -6.768 and P = 0.000<0.05, indicating significant differences between the two groups. The median score for the experimental group was 9.5, with the upper and lower quartiles at 8.25 and 10, respectively. The median score for the control group was 6, with the upper and lower quartiles at 6 and 7.5. The difference between the two groups was substantial. This suggests that the interactive system, intelligent systems, and smart furniture exhibited clear advantages.

Table 7 Data summary of smart home

	Smart Home	Z	P
Experimental	9.5（8.25~10）	-6.768	0.000
Control	6（6~7.5）		

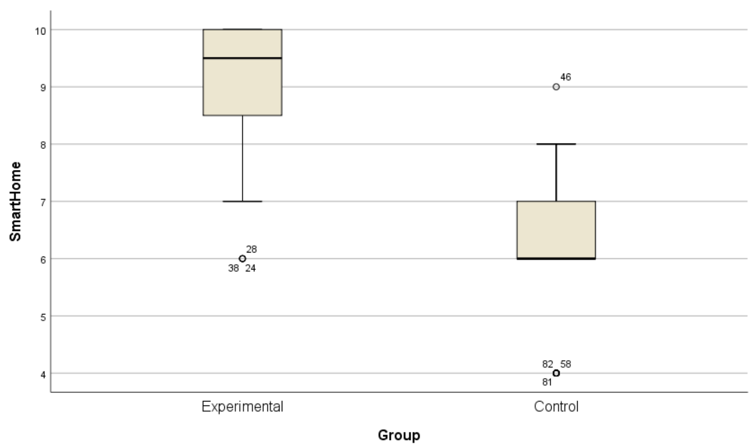

Figure 6 Box Diagram of a Smart Home

The semi-structured interview explores several key dimensions: students' learning experience on the online platform, their understanding of technology use, motivational factors, social interaction, the assistance of technology in learning, and the influence of group cooperation on learning.

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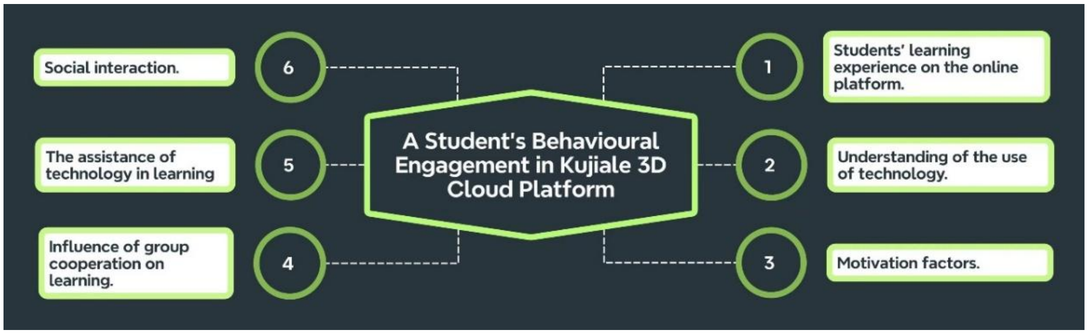

Figure 7 Mind Map of Qualitative Research

For behavioral participation, participants were asked about their experiences and engagement with the Kujiale 3D cloud platform, and their responses varied. However, several recurring themes emerged from the analysis, including the platform's user-friendly interface, fast rendering speed, enhancement of relevant professional knowledge, improvement in interior design skills, increased homework completion rates, broader design perspectives, encouragement of knowledge sharing, and stimulation of learning motivation.

Excerpts from the presentations of some interviewed students:

This platform can help me model and plot more quickly, which is very helpful in my homework.

This platform broadens the horizon, helps to discuss together, accumulates a lot of practical experience, and lays a foundation for future work experience.

I think it is much more convenient to learn. The operation is relatively simple; it is easier to get started, the speed of rendering and drawing is also fast, and the setting of lighting is relatively easy. The models and materials in the library can give us some inspiration in the design process.

The VR experience of the platform makes the abstract design concept visible, which makes me intuitively feel the actual effect of the space and check the rationality of the design.

I think the real-time collaboration and sharing of the platform prompted me to improve the project design. The adjustment of design parameters for renderings on the platform is easy and produces effective results.

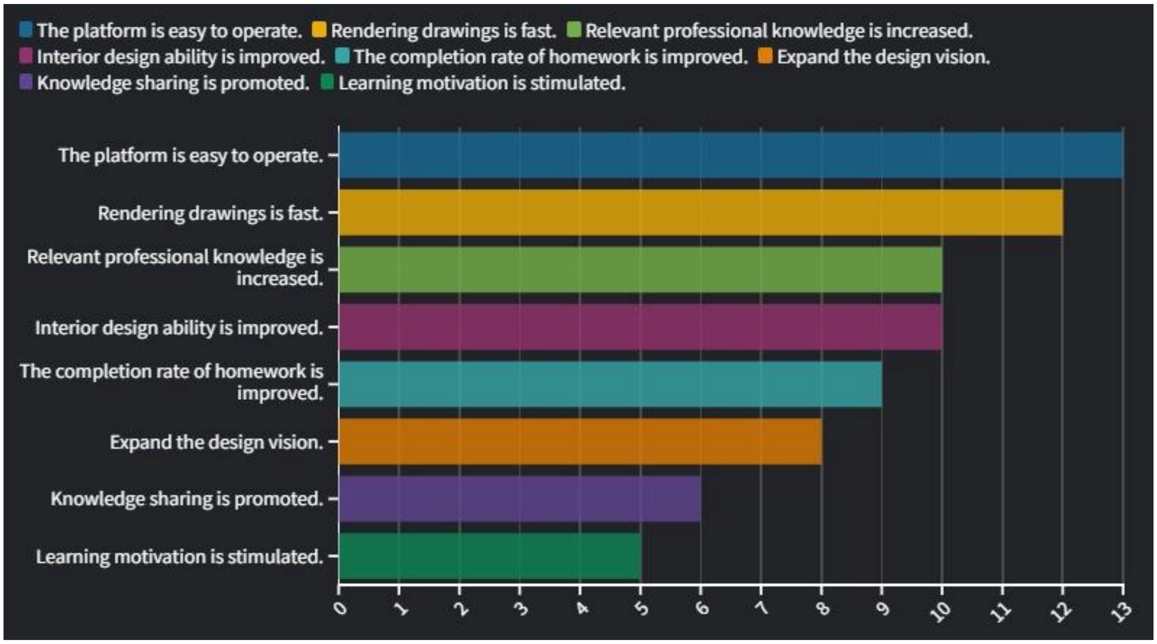

Figure 8 Behavior participation keyword analysis diagram

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In terms of sustainable learning, participants highlighted the platform's extensive resource pool, interactive learning experience, VR scene capabilities, and ability to showcase design work as all contributing positively to their learning. The online learning videos also helped them to better understand the operational steps of the technology after class. In terms of motivational factors, the platform's interactive design and visualization features sparked enthusiasm for interior design. The social interaction aspects of the platform further increased their motivation to learn. In addition, online rendering requires minimal computer specifications and offers flexible usage time, making it more accessible.

In the process of using the Kujiale 3D cloud platform, some students mentioned:

Every time I draw on the platform, the progress of my work is recognized with a sense of accomplishment, which urges me to continue to study deeply.

With the help of the material library on the platform, I can deeply understand the design style, exercise my spatial thinking ability, and accurately grasp the interior space, which is conducive to creating a high-quality living space.

The video on the platform is convenient for self-learning some other skills of designing and drawing.

I think the update of resources on the platform promotes my continuous learning.

I think the interactive learning experience of the platform helps me to understand interior design and urges me to study further.

I can use my computer notebook with a low configuration to complete the design and drawing with a good effect.

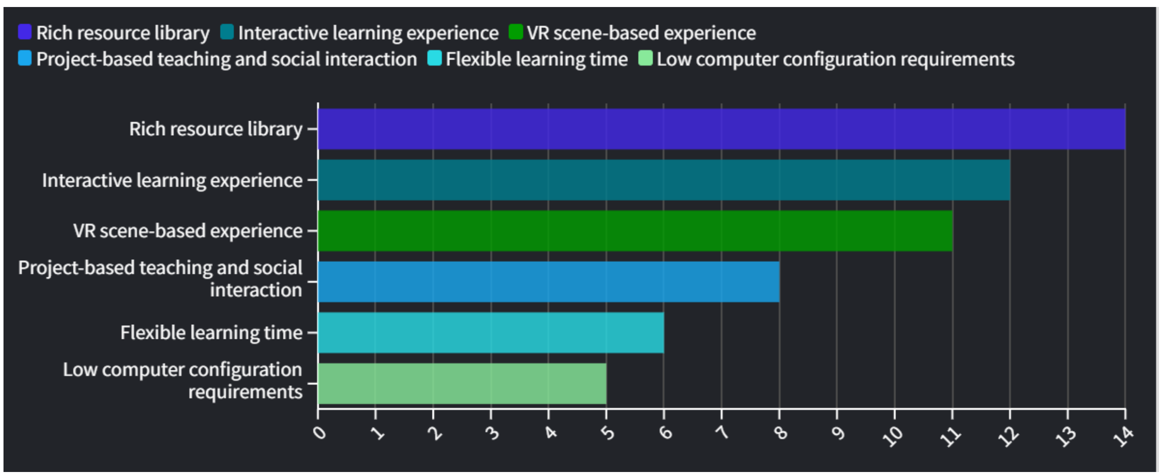

Figure 9 Sustainable learning keyword analysis diagram

The analysis of these open-ended responses reveals that the Kujiale 3D cloud platform technology used by students in designing interior residential space projects effectively supports their learning, particularly in technical operations and design presentations. The interactive features of the teaching videos and platform help students get up to speed more quickly, while social interaction and peer collaboration on project tasks enhance deeper learning and skill development. Students are motivated to engage in sustainable learning related to interior design on this platform.

Discussion

The research results indicate that the Kujiale 3D cloud platform has a significant positive impact on visual representations, design drawings, and smart home aspects of interior residential design. However, it does not show a significant impact on design creativity and sustainable design.

Visual representations and design drawings are two key components in the evaluation of interior design, and they form the foundation of interior space planning. The integration of cloud platform technology has proven effective in enhancing the outcomes of primary interior design tasks, yielding positive results. Its intuitive visualization features facilitate a better understanding of spatial layout, proportions, and the relationships between design elements. With the support of intelligent tools and templates, design drawings can be generated quickly, thus improving the quality and effectiveness of the design. Although smart home design does not hold a major weight in the evaluation, its presence in interior

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design highlights the application of emerging technologies. The cloud platform's assisted generation of smart home designs simplifies the design process, reducing the difficulty for novice learners. Design creativity and sustainable design reflect the creativity and ecological considerations in interior design evaluations. However, there was no noticeable improvement following the introduction of the technology, indicating that the correlation between these two elements and the cloud platform is weak. The very tools that boost efficiency in visual representation and drawing generation, namely, the extensive library of pre-built templates and standardized elements, may inadvertently stifle creativity. These features encourage conformity and the replication of existing solutions, potentially limiting students' exploration of novel ideas, unconventional forms, or unique aesthetic expressions that define creative design. The Kujiale platform, in its current form, appears primarily optimized for visualization and technical documentation. It may lack the specific features or workflows necessary to actively stimulate, support, and evaluate the higher-order thinking and iterative experimentation crucial for creativity and sustainability. Its strengths lie in executing ideas, not necessarily in generating innovative or ecologically conscious ones.

Conclusion

This study demonstrates that the Kujiale 3D cloud platform significantly enhances graphic expression skills for beginner-level interior residential space design. The Kujiale 3D cloud platform technology has a positive impact on students' sustainable learning. From a teaching practice perspective, project-based learning (PBL) fosters the development of sustainable abilities and encourages the completion of goal-oriented learning tasks (Belwal et al., 2020). In the context of interior residential space design projects, students are required to design spaces while addressing project breakdown points, and their lateral thinking skills need to be strengthened throughout the design process (Sanchez-Muñoz et al., 2020). Key findings include:

1. Improved Foundational Skills

Students achieved higher proficiency in core technical outputs, such as visual representations, design drawings, and smart home integration, compared to traditional 2D methods. The platform's intuitive visualization tools, real-time feedback, and user-friendly interface enabled faster grasp of design concepts, quicker project completion, and demonstrably higher scores in these areas.

2. Enhanced Engagement and Efficiency

The platform's interactivity and real-time rendering capabilities sparked student interest and motivation. Features enabling collaboration and immediate feedback fostered problem-solving abilities and significantly improved overall design efficiency by shortening drawing times.

3. Sustainable Learning Behaviors

The platform supported behaviors conducive to sustainable learning. Students valued the abundant, flexible resources and the convenience of self-paced practice. Features like the VR space experience and multi-party collaboration tools enhanced engagement with e-learning and facilitated continuous improvement through online feedback and task sharing.

While the platform proved highly effective for developing core technical skills and fostering engagement in beginner education, its impact on higher-order competencies like design creativity and sustainable design principles was not significant. Therefore, for future practice and research:

1. Pedagogical Integration

Educators should leverage the Kujiale platform's strengths in visualization, efficiency, and foundational skill development within beginner curricula, but consciously complement it with pedagogical strategies specifically targeting creativity, conceptual thinking, and deep sustainability integration, which the platform alone does not inherently foster.

2. Tool Development & Research

Future development of such platforms could explore integrating features that more actively support creative exploration and sustainability analysis. Further research is needed to investigate how digital literacy levels and structured guidance can optimize the platform's use for broader learning objectives beyond technical proficiency.

Recommendation

Although the Kujiale 3D cloud platform provides an abundance of design tools and resources, its role in enhancing design creativity and sustainable design remains limited. One possible reason for this is that the platform's technical functions are more focused on the realization and visualization of designs, which

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may not adequately stimulate creative thinking. Instructors should consciously integrate pedagogical strategies that mitigate the potential creativity-stifling effects of templated tools.

Regarding sustainable design, while the platform supports some environmental design elements, students may lack sufficient environmental awareness and technical expertise when working on actual projects, leading to inadequate support for sustainable design. These observations highlight the need to balance design creativity with technology in teaching. Over-reliance on technology could constrain students' creative thinking. Additionally, relying too heavily on the platform's automation features to complete design tasks might result in designs that are overly simplified and standardized, thus lacking challenging and innovative elements. Teachers should break away from their comfort zone in teaching design by enhancing the stimulation of design creativity while simultaneously strengthening the focus on sustainable design training. Advocate for the development and integration of dedicated sustainability modules within the Kujiale platform.

In conclusion, this research suggests that the Kujiale 3D cloud platform technology has a significant impact on improving students' design scores for interior residential space projects in a short period. It is particularly suitable for the early stages of interior design education, offering greater flexibility and scalability for beginners during the learning process. However, a limitation of this research is that it focuses solely on residential space design and has not been tested in other courses, such as interior commercial space design, office space design, or furniture design. Further exploration is needed to assess the platform's adaptability and benefits across various design fields.

Additionally, this research targets only beginner interior design students, not experienced designers; thus, the scope of the research needs to be expanded. This research contributes to the growing application of 3D cloud platforms in design education by providing data support and a research framework to identify effective methods for integrating related technologies into interior design learning. This work provides a foundation and framework for integrating 3D cloud technology into design curricula. Realizing its full potential to advance design education towards a more holistic, creative, and sustainable digital future requires continued exploration of both technological enhancements and innovative, complementary teaching methodologies.

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