Enhancing the Creativity of Living Space Design Through Reflection on 3D Software Learning Experiences

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Abstract

This study explores how integrating reflective learning experiences into 3D software instruction can enhance creativity in residential space design. Although 3D software has become a fundamental skill in interior design education, technical proficiency alone does not necessarily lead to creative design outcomes. Therefore, this research examines the relationship between students' reflection on the 3D software learning process and their creative performance in residential space design. The study was conducted within interior design-related courses, where students developed 3D models based on residential design themes. Data were collected through mid-term design projects, reflective learning worksheets, and design performance assessments. The analysis focused on how students linked software learning experiences to design decisions and daily life contexts to examine the role of reflection in design creativity. Results show that students with higher creative performance moved beyond basic software operations to engage in deeper reflective thinking during the design process. These students actively searched for design precedents or imagined usage scenarios to infer user lifestyles, established clear design styles, considered psychological reactions triggered by spatial configurations, and explored material and color combinations to shape the overall spatial image. The findings indicate that design creativity stems from the integration of reflective learning, life experience, and design thinking, rather than simple technical skills. Therefore, integrating reflection-oriented learning strategies into 3D software instruction can effectively support the development of meaningful and creative spatial design outcomes.

Keywords: 3d software, reflective learning, creativity, interior design education, residential design

Introduction

In the digital age, 3D modeling software such as SketchUp, Rhino, and AutoCAD has transformed interior design education, allowing students to visualize complex spatial relationships with unprecedented precision (Wei & Phongsatha, 2026). These tools facilitate rapid prototyping and iteration, which are key to modern design workflows. However, an increasing concern in design education is that an overemphasis on technical mastery often leads to formulaic outputs, stifling the creative spark required for innovative residential spaces (Chen et al., 2024). Residential space design particularly requires creativity that resonates with the emotional and psychological needs of users, merging functionality with aesthetic and experiential depth.

This study addresses a critical gap: while 3D software proficiency is a fundamental competency, its potential to foster creativity remains under-explored, especially through reflective practice. Reflection, as defined by Schön (2017), involves "reflection-in-action" during the design process and "reflection-on-action" after the fact, allowing learners to connect technical actions to broader conceptual insights . We hypothesize that guiding students to reflect on 3D software experiences—linking tool constraints, iterative attempts, and personal life experiences—can elevate design creativity beyond the level of technical execution.

Based on an empirical study of interior design courses in Taiwan, this paper analyzes how reflective learning mediates the relationship between 3D software use and creative outcomes in residential space design. The findings provide educators with practical strategies to integrate reflection-oriented learning, ultimately nurturing human-centered designers who create living spaces that are not only feasible but also deeply touching.

Literature Review

Reflection on Software Learning Experiences and Creativity Enhancement

Applying reflective learning principles to 3D software learning experiences can effectively bridge the gap between technical tool operation and creative output.

Schoormann et al. (2020) investigated how software tools can support collaborative reflection in design thinking projects. They noted that by "actually doing something, tacit knowledge (i.e., knowing-in-action) of individuals is disclosed," which allows teams to draw on information and experiences beyond single individuals to solve "wicked problems". This suggests that 3D software learning environments should incorporate features that facilitate both individual and collaborative reflection to foster collective intelligence.

Kinik et al. (2025) explored the impact of structured reflective journaling in a modular furniture design course. They found that journaling "supported idea development and progress tracking," but highlighted that "reflection does not naturally occur at a deep level without structured guidance". The study emphasized that using a rubric played a key role in guiding deeper reflection, as students otherwise tend toward superficial task summaries. They recommended flexible milestones and alternative formats to overcome time constraints and engagement challenges.

Creativity Enhancement Strategies in Residential Space Design Education

In residential space design education, combining 3D software with reflective learning enables various pedagogical strategies to enhance creativity.

Couzens et al. (2026) reflected on using 3D simulations for practice-based learning, finding that 3D models can effectively "integrate technical, creative, and user-centered considerations" and provide a more intuitive learning experience than traditional case studies. This underscores the unique advantage of 3D software in providing an immersive practice environment that serves as the basis for reflection.

Notably, Almaz et al. (2024) explored the role of Artificial Intelligence (AI) integration in architectural and interior design education. He pointed out that AI can "generate initial project proposals" and assist cognitive tactics, thereby "improving efficiency, sustainability, and creativity". AI tools can serve as triggers for reflection, allowing students to critically evaluate diverse generated options rather than replacing the creative process itself.

Research Methodology

Participants and Context

This study recruited 48 second-year undergraduate interior design students from two courses at a university in Taiwan (First Semester, 2025). Participants included 32 females and 16 males, with an average age of 20.3 years. All participants had basic 2D drafting experience, including AutoCAD floor plan drawing, but limited 3D modeling proficiency, with most having only preliminary exposure. The courses focused on residential design themes, such as "Compact Urban Living for Young Families," using SketchUp as the primary modeling tool.

SketchUp was chosen as the instructional tool due to its user-friendly interface, gentle learning curve, and widespread application in interior design practice. The course design covered everything from basic operations to full project development, providing students with ample opportunities for learning and reflection.

Research Procedure

This study adopted a quasi-experimental design, integrating reflective intervention strategies throughout an 18-week course:

- Weeks 1–2: Understanding Learning Background This stage primarily collected students' learning backgrounds and prior competencies, including their 3D software experience, design learning history, and basic spatial representation abilities. Researchers used questionnaires, classroom observations, and preliminary interviews as a basis for subsequent teaching arrangements and comparative analysis.
- Weeks 3–8: Technical Instruction Phase This stage provided systematic software instruction, including lectures and hands-on exercises. Content covered basic 3D modeling skills, such as object creation, Push/Pull, material mapping, lighting settings, and basic rendering techniques. Students became familiar with the interface and tool logic through small exercises.
- Week 9: Wardrobe Project Development Phase Applying the 3D software operation techniques learned in class, students designed and modeled a wardrobe project as a mid-term test.

- Reflective Intervention Components Reflective learning worksheets were distributed weekly, guiding students to record their learning process. Prompt questions included: “How did software constraints shape your design decisions? Please link to real-life contexts.” “What design precedents or cases inspired your spatial layout?” “How do you imagine users' daily activities in this space?” These prompts encouraged students to move beyond technical aspects and think about the meaning and context behind the design.
- Weeks 10–16: Advanced Technical Instruction The mid-term submission included a complete 3D model, multi-angle renderings, floor plans, and sections, as well as a 1,500-word final reflection paper. The reflection paper required students to synthesize the entire design process, explain how software learning experiences influenced design decisions, and reflect on personal growth and challenges.
- Weeks 17–18: Assessment Phase Students created a 3D model of a 60-square-meter apartment based on the design brief provided in the course. The design brief emphasized the balance between function and aesthetics, requiring students to consider the needs of specific user groups (such as young couples, single professionals, or small families). Students underwent multiple iterations during this stage, adjusting designs based on peer feedback and instructor guidance.

Data Collection Methods

This study collected three types of data for multi-perspective analysis:

Design Project Works (n = 48): Evaluation of creativity performance in 3D models, floor plans, and renderings. Assessment dimensions included originality of spatial configuration, integration of function and aesthetics, appropriateness of material and color use, and completeness of the overall design concept.

Reflective Worksheets (n = 192 records): Each student submitted 4 worksheets during the 4-week project development period, totaling 192 records. Worksheet content was qualitatively coded to distinguish reflection depth: Surface Reflection (only describing operational difficulties), Process Reflection (linking attempts to decisions), and Deep Reflection (linking to life context and user experience).

Design Performance Assessment: Scoring used a structured scale, independently graded by two senior interior design teachers. Assessment dimensions included four categories, each scored 1–10:

Design Precedents and Lifestyle Inference: Whether appropriate cases were referenced and user life scenarios imagined.

Design Style Establishment: Whether a consistent and clear design vocabulary was presented.

Spatial Psychological Considerations: Whether the spatial configuration considered users' psychological feelings and emotional reactions.

Material and Color Exploration: Whether the combination of materials and colors created an overall spatial atmosphere.

Data Analysis Methods

This study used a mixed-methods analysis. Qualitative data used thematic analysis (Braun & Clarke, 2006) identifying reflection patterns through open coding, focused coding, and thematic induction. Two researchers coded independently and then discussed to reach a consensus.

Quantitative data analysis used Pearson correlation analysis to examine the relationship between reflection depth scores and total creativity scores as well as scores for each dimension. Inter-rater reliability tests showed high consistency (Cronbach's $\alpha = 0.87$), ensuring scoring reliability.

Research Results

Overall Creativity Performance Profile

The average total creativity score for the 48 students was 7.2 (out of 10, SD = 1.4). According to the score distribution, 35% of students (17) scored 8 or above, classified as the High Creativity Group; 42% of students (20) scored 6 or below, classified as the Low Creativity Group; the remaining 23% (11) were the Medium Creativity Group.

Works from the High Creativity Group demonstrated clear design concepts and integration abilities, skillfully combining functional requirements with aesthetic expression. In contrast, designs from the Low Creativity Group relied heavily on classroom teaching examples, lacking personal interpretation and innovative elements, presenting more formulaic spatial configurations.

Thematic Analysis of Reflection Patterns

Through qualitative coding of 192 reflective worksheet records, three levels of reflection were identified:

- Surface Reflection (41% of records): These reflections focused on software operation difficulties and technical issues, such as “layer management is hard to grasp,” “computer is slow during rendering,” or “don't know how to adjust material parameters.” These records remained at the level of problem description without further thinking about the meaning behind the problems or solution strategies. For example, Student A stated, “Initially, I did not feel obvious operational difficulties during the design process,” showing that their understanding of software steps remained at the basic execution level.
- Process Reflection (32% of records): These reflections began to link the trial process with design decisions. For example, Student B stated, “Through multiple corrections in SketchUp, I found that an open kitchen better fits the circulation needs.” Student A also stated, “After adjusting the window position, the light distribution improved the brightness of the living room,” representing students' preliminary understanding of the relationship between tools and design at this level.
- Deep Reflection (27% of records): These reflections linked software experience to real-life contexts and user experiences. For example, Student C stated, “The shadow effects in the software reminded me of Taipei's rainy climate, so I chose warm lighting tones to create a sense of home comfort.” Student B also stated while building the 3D model, “I imagined an old couple drinking tea and chatting in the living room, which influenced

me to lower the furniture height to enhance intimacy." These reflections demonstrate design empathy and contextual sensitivity.

Correlation Between Reflection Depth and Creativity

Statistical analysis showed that high-creativity students generated 62% of deep reflection records, showing a significant positive correlation with total creativity scores ($r = 0.68$, $p < 0.01$). In contrast, low-creativity students generated only 12% of deep reflections, mostly staying at the surface and process reflection levels. This indicates that reflection depth is an important predictor of creativity performance.

Detailed Analysis of Reflection

Four reflection categories showed excellent performance in the High Creativity Group:

1. Design Precedents and Lifestyle Inference (Avg. 8.5): 78% of high-creativity students actively searched for online design cases or magazine images as sources of inspiration, including Japanese minimalist residences, cozy Nordic styles, and modern industrial styles. More importantly, they did not just imitate forms but deeply imagined usage scenarios, such as "a reading corner for a retired teacher couple" or "a play space for a young mother accompanying a toddler." This lifestyle inference demonstrates a deep understanding of user needs.
2. Design Style Establishment (Avg. 8.2): High-creativity students established clear and consistent design themes, such as "Biophilic Modern Style" integrating indoor plants and natural materials, "Minimalist Japanese" emphasizing white space and rustic aesthetics, or "Urban Light Luxury" combining metal elements and dark tones. These styles were not superficial collages but complete systems throughout spatial configuration, material selection, and color planning.
3. Spatial Psychological Considerations (Avg. 8.0): Students showed sensitivity to how spatial configuration affects psychological feelings. For example, using curved walls to alleviate urban life stress, creating spatial hierarchy through ceiling height changes, and using open and semi-open spaces to balance privacy and interaction needs. One student mentioned: "I deliberately designed the bedroom entrance in a more hidden place from the living room view, giving users a psychological transition from public to private."
4. Material and Color Exploration (Avg. 7.9): High-creativity students were not satisfied with software default materials and actively explored different combinations to shape the spatial atmosphere. For example, "matte earth tones paired with wood textures to create tactile warmth" or "dark gray stone and copper-colored metal to create a steady modern feel." Students understood that materials are not just visual elements but also affect the tactile imagination and emotional keynote of the space.

Correlation Analysis of Reflection and Creativity

Statistical analysis further revealed the correlation between reflection depth and each creativity dimension:

Table 1

Pearson Correlation Matrix of Reflection and Creativity Dimensions

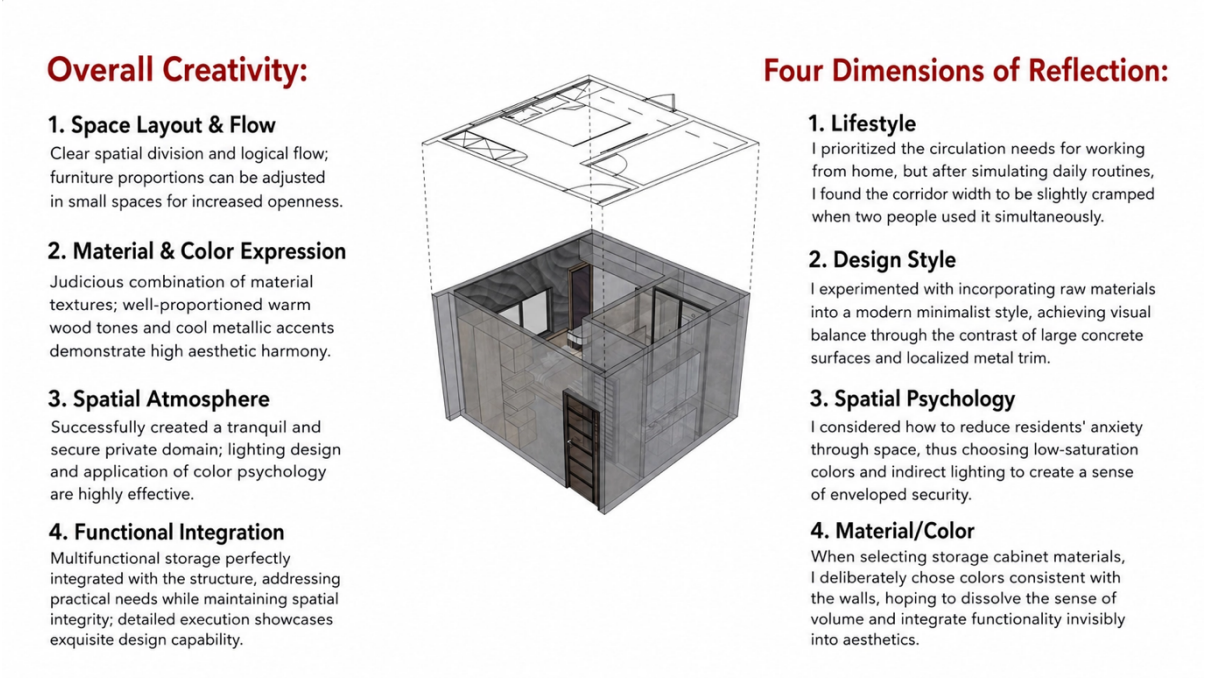
Dimension	Deep Reflection	Precedent/Lifestyle	Style	Psychology	Material
Deep Reflection	1.00	0.72**	0.65**	0.59**	0.61**
Total Creativity	0.68**	0.81**	0.77**	0.74**	0.70**

Note: *p < 0.01; n = 48

Results show that deep reflection is significantly positively correlated with all creativity dimensions, with the highest correlation being with "Design Precedents and Lifestyle Inference" ($r = 0.72$, $p < 0.01$). Furthermore, among all creativity indicators, total creativity had the highest correlation with lifestyle ($r = 0.81$, $p < 0.01$), indicating that if students can deeply deliberate on users' life contexts through reflection and concretely imagine their daily needs, it will be more helpful in enhancing overall design creativity.

Figure 1

Correlation Between Total Creativity and Four Reflection Dimensions



Typical Case Analysis

High Creativity Case: Student A's Multi-functional Living Space

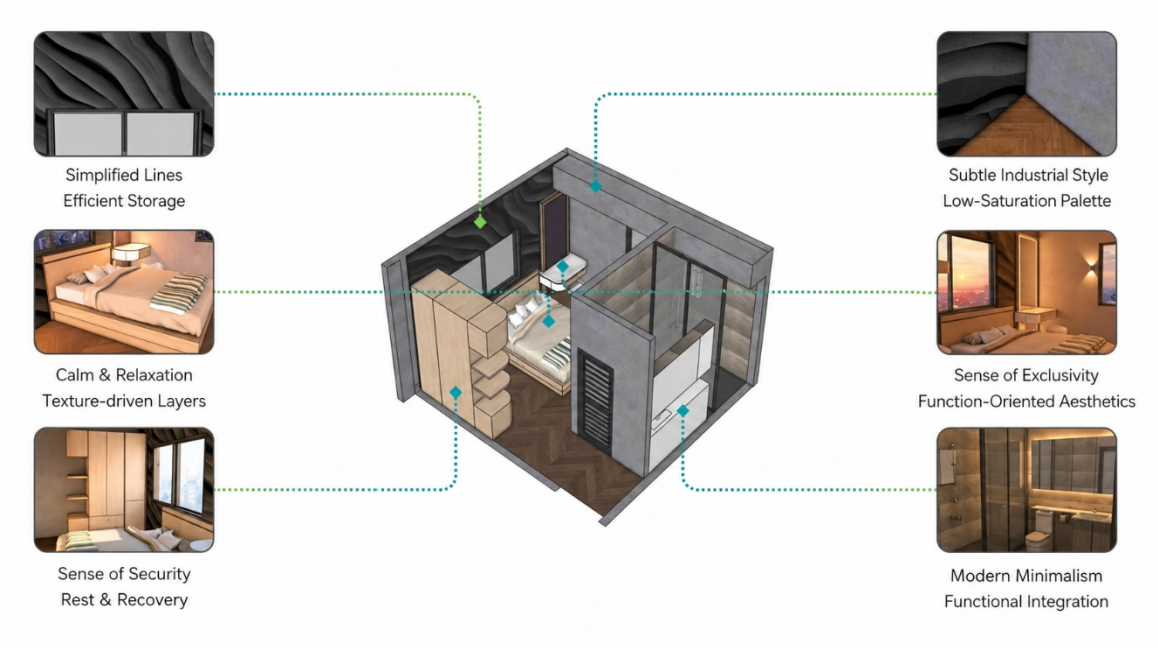
Student A designed a 20m² studio for a young single professional with the core concept of "flexible life scenarios." The highlight was a rotating multi-functional wall that served as a soft divider between the workspace and living room by day, and rotated to become the bedroom's headboard by night.

In the reflection questionnaire, Student A wrote:

> While modeling in SketchUp, I tried the Rotate function multiple times to rotate objects but kept failing. These virtual failures made me think: What if the wall itself could rotate? I thought of many small studios near MRT stations where single residents need to switch between work and rest modes in limited space. This idea came from software frustration but became the core of the design.

This case demonstrates how deep reflection transforms technical frustration into creative insight.

Figure 2
Exemplary Design From the High Creativity Group



Low Creativity Case Comparison

In contrast, designs from the low-creativity group followed classroom examples, such as standard one-bedroom layouts and formulaic furniture arrangements, lacking imagination for specific users. Their reflective worksheets mostly contained operational descriptions like “learned how to use the material library” or “completed the floor plan drawing,” without showing deep thinking.

Discussion

Reflection as a Catalyst for Creativity

The results confirm that reflection transforms 3D software from a mere technical tool into a catalyst for creativity. The deep reflection of high-creativity students echoes (Schön, 2017) reflective practitioner model, where they transform software “backtalk” (e.g., rendering failures, operational constraints) into insights about user life. This process is particularly vital in Taiwan's dense urban context, where students must understand how to create rich life experiences within limited space.

This study extends prior literature: unlike the tool fixation phenomenon noted by Kvan & Jia (2005), reflective intervention strategies successfully shifted students' attention from the interface to the external real world, promoting divergent thinking (Guilford, 1967). When guided to reflect on the link between software experience and life, students naturally began searching for precedents, imagining usage scenarios, and considering psychological feelings—the core elements of creativity.

Spatial Psychology and Environmental Empathy

The spatial psychological consideration dimension found in the study echoes core concepts of environmental psychology. Wilson (1993) noted that spatial configurations can trigger restorative psychological responses, reducing stress and enhancing well-being. The "reflective spatial empathy" shown by high-creativity students allowed them to foresee users' emotional reactions, such as reducing stress through curves, creating drama through light and shadow, and balancing social interaction and privacy through openness.

This empathy is not innate but cultivated through reflection. When asked to "imagine how users feel in this space," students shifted from self-centered technical operation to other-oriented design care—a key difference between professional designers and novices.

Integration of Life Experience and Design Knowledge

Another characteristic of deep reflection is integrating personal life experience into design, such as Taipei's rainy season, spatial constraints of apartments in Banqiao, or cultural habits of family tea gatherings. This localized life knowledge allows designs to move beyond superficial imitation of international styles to present authentic cultural appropriateness.

Schön (2017) experiential learning theory emphasizes that learning is a cycle of experience, reflection, conceptualization, and experimentation. This study shows that if 3D software courses can guide students to combine software experience (concrete experience) with life observations, forming design concepts (abstract conceptualization) through reflection (reflective observation), and then experimenting through modeling (active experimentation), a complete creative learning cycle can be achieved.

Research Limitations and Future Directions

This study has several limitations. First, the sample was drawn from only two courses at a single university, limiting representativeness; future research could include different schools and grade levels. Second, reflective worksheets are self-reported data, which may involve social desirability bias. Future studies could use eye-tracking technology to observe actual attention distribution during modeling or use interviews for deeper exploration.

Furthermore, this was an 18-week short-term intervention. Longitudinal tracking could observe if reflective habits continue to influence creativity in advanced courses or practice. Finally, different software (e.g., Rhino, Revit) might generate different reflective experiences. Despite these limitations, this study provides important evidence that reflection-oriented teaching strategies effectively enhance design creativity.

Practical Implications and Pedagogical Suggestions

Integrating Reflection-Oriented Teaching Strategies

Based on the findings, it is suggested that interior design 3D software courses adopt the following strategies:

1. Design of Weekly Reflective Prompts: Regularly provide structured prompts such as "Which software constraints made you rethink your design direction this week?" or "How did a life experience influence your spatial layout decision?"
2. Integrating AI Tools for Precedent Exploration: Encourage using AI image generation (e.g., Midjourney) to quickly collect precedents and analyze their underlying lifestyle assumptions.
3. Portfolio Assessment over Single Tests: Shift from assessing only the final 3D model to a portfolio assessment that integrates models with reflection papers, emphasizing the process of failure and adjustment.

Implications for Interior Design Education in Taiwan

This study supports integrating educational technology with humanistic reflection. As urbanization intensifies, Taiwan's living spaces become more compact, requiring students to create quality of life in limited space. This requires empathy, cultural sensitivity, and reflection beyond pure technical training. It echoes the core value of "human-centered" design, nurturing professionals who understand human behavior and care for society through their tools.

Cultivating Reflective Practitioners

The ultimate goal of design education is to cultivate lifelong reflective practitioners. Schön (2017) emphasized that professional competence lies in the habit of "reflection-in-action". When students develop this habit, they will naturally pause, question, and seek innovative solutions when facing complex problems in their careers.

Conclusion

This study demonstrates that design creativity stems from the integration of technical ability, reflective thinking, life experience, and design empathy. High-creativity students transform technical frustrations and constraints into insights about user lifestyles, producing spatial designs that are both aesthetic and deeply humanistic.

Reflection depth is significantly positively correlated with all dimensions of creativity. These findings challenge the view of 3D software courses as pure technical training and argue for integrating reflective practice into the core of instruction. The role of the educator is not just to teach software commands but to guide students to transform technology into creativity, operation into care, and virtual models into poetic imaginations of real life.

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