

From Sketches to 360° Visualization and Rapid Mock-Ups: Integration GenAI for Improving Volumetric Perception

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Abstract

Generative artificial intelligence (GenAI) is reshaping design and engineering by combining algorithmic tools with human creativity, enabling faster experimentation and expanded workflows. This paper presents a pedagogical case study integrating GenAI into a product design course to support early-stage processes. The study explores a workflow from hand-drawn sketches to 360-degree visualizations and rapid physical mock-ups. Twenty-one undergraduate students participated in a three-hour session using tools such as Google AI Studio, KlingAI, and Gemini Banana. Quantitative and qualitative data were collected through a structured survey. Results show improvements in volumetric understanding, prototyping efficiency, and positive perceptions of usefulness and novelty, highlighting GenAI's role as a cognitive and visual scaffold in design learning.

Keywords: *Generative AI, Design Education, Pedagogical Exercise, Innovation Education*

1. Introduction

Generative artificial intelligence (GenAI) represents a paradigm shift in design and engineering by combining algorithmic reasoning with human creativity. This synergy enables broader experimentation, accelerated workflows, and expanded possibilities for ideation and visual exploration (A. Bartlett & D. Camba, 2024; Adhikari et al., 2025). Rather than replacing human knowledge, GenAI functions as an assistive and complementary tool that enhances designers' creative efficiency and supports exploratory thinking (Ye et al., 2025). As a result, GenAI is reshaping educational objectives by demanding new forms of literacy AI, digital, media, and information literacy alongside higher levels of critical thinking and evaluative judgment (Chiu,

2024). In creative disciplines, its primary value lies in the early conceptual stages of design, where ideas are generated, tested, and transformed into artifacts (Alkhasawneh et al., 2025; Mittal et al., 2024). From an instructional perspective, GenAI enables personalization, adaptive learning, and human–machine co-creation, while providing pedagogical scaffolding and instructional guidance (Giannakos et al., 2025). Its adoption has been shown to enhance teaching effectiveness through personalized materials, interactive strategies, and hybrid manual–digital exploration, strengthening domain-specific knowledge development (Merter & Güneç, 2025; Mulyani et al., 2025). From the student perspective, GenAI supports early ideation and visualization by facilitating the exploration of alternative design proposals (Huh et al., 2025). While it can reduce cognitive load and enhance creative focus (Chandrasekera et al., 2025), it also raises concerns related to authorship, originality, and overreliance on automated outputs (Merter & Güneç, 2025; Mittal et al., 2024). In design education (D.E.), image, video, and 3D-based outputs are especially relevant, as visual and spatial inputs increase acceptance and meaningful engagement with GenAI tools (Chandrasekera et al., 2025; Rojas, 2024). Text-based prompts help clarify design intent (Vartiainen & Tedre, 2023), while hand-drawn sketches enable richer transformations and position GenAI as a co-creative partner in ideation and collaborative learning (Merter & Güneç, 2025). Despite challenges including misconceptions about replacing creativity, dependency risks, and ethical concerns (A. Bartlett & D. Camba, 2024; Giannakos et al., 2025). GenAI also enables flexible learning, enhanced engagement, and responsible integration, motivating the present pedagogical study in product design (Casteleiro-Pitre, 2024; Holmström & Carroll, 2025).

2. Research Method

This study is part of a broader research program investigating the informed adoption of GenAI in D.E (see Figure 1, right). Its main objective is to observe, identify, and measure how GenAI tools integrate into the creative process, from hand-drawn sketches to 360-degree visualizations and rapid physical mock-ups. By focusing on this sequential workflow, the exploratory pilot examines how GenAI enhances volumetric perception and contributes pedagogical value to learning environments, particularly regarding perceived utility, novelty, and relevance.

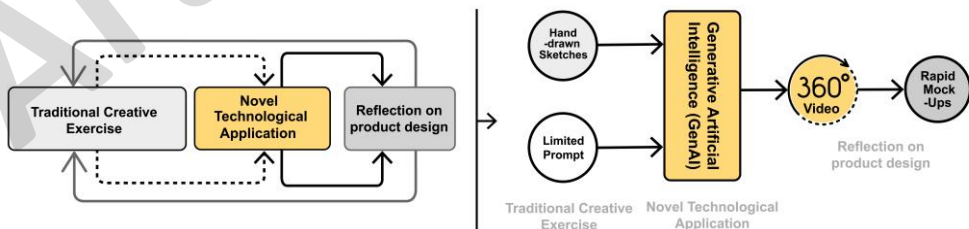


Figure 1. Pedagogical structure and Exercise process diagrams.

This work is structured around three research questions: RQ1: How does prior experience with AI influence students' perceptions of this exercise? RQ2: How do GenAI output affect students' perceptions of utility, novelty, and relevance within the design process? and RQ3: How does GenAI impact volumetric perception and the construction of rapid physical mock-ups?

2.1. Procedure and implementation

This pedagogical exercise was conducted during a three-hour class session with 21 third-year Product Design students (18 women and 3 men). Participation was voluntary, unpaid, and not linked to course assessment, with informed consent obtained from all participants. The activity focused on a design challenge involving the development of a piece of furniture intended for CNC (Computer Numerical Control) manufacturing, following a structured set of instructions introduced at the beginning of the session (see Figure 2).

1. Each student uses one of the design-ideas represented in a hand-drawn isometric sketch (prepared before this exercise), then photograph or scan the selected sketch.
2. Access one of the suggested AI-based video generation platforms and enter the prompt provided for the activity.
3. Generate a 360-degree video, analyze it, and begin constructing a rapid mock-up in the left time.
4. Upon completing the mock-up, complete the final survey.

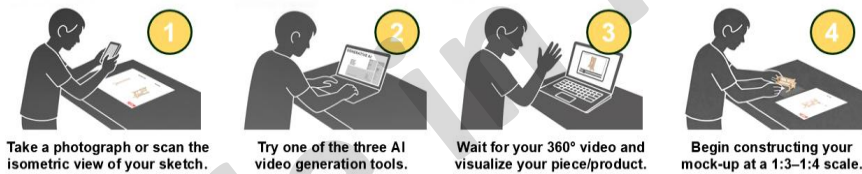


Figure 2. Student activity workflow (seen by the students).

GenAI tools capable of generating 360-degree visualizations were selected, including Google AI Studio (aistudio.google.com), KlingAI (app.klingai.com), or Gemini Banana (gemini.google.com). All platforms were pre-tested using a constrained prompt (*Create a 360° video of this drawn product, following the style of the drawing shown in the image*) to ensure consistent outputs aligned with the original sketches. These tools supported the visualization workflow illustrated in Figure 1(left).

2.2. Assessment Survey

After completing the rapid mock-up, students responded to the following questions in order to assess their experience with the exercise. Two type or answered questions: Likert scale (from 1 to 5, where 5=Strongly agree and 1=Strongly disagree) or multiple choice.

1) *Prior Experience*: Without considering the exercise you just completed, answer the following questions using a Likert scale.

- Did you have prior experience using GenAI tools before this activity?
- Did you have prior knowledge of the potential applications of GenAI in design projects?
- Had you consciously applied GenAI tools to solve a design project problem before this activity?

2) *During process*: Answer the following questions based on the process you followed during the exercise.

- Were you able to generate the 360° video using any tool? A) Yes, B) No
- Did you complete the mock-up in less than two hours? A) Yes, B) No
- Which phase of the design process do you associate this activity with? A) Exploration / Ideation, B) Definition / Design, C) Development / Testing and D) Delivery / Feedback

3) *Assessing the experience*: Considering the exercise carried out, please answer to the following questions using a Likert scale.

- How would you assess the utility of GenAI in your design process?
- How would you assess the novelty of GenAI in your design process?
- How would you assess the relevance of GenAI in your design process?
- Do you consider that using GenAI contributed to a more efficient mock-up construction process?
- Do you consider that GenAI influenced your spatial understanding of volumes and geometries?

4) *Open Reflection*: Write any thoughts you would like to share about your experience with this exercise.

3. Data analysis and Results

The data were analyzed through four complementary stages using SPSS 27.0 for Windows™ (IBM SPSS Inc., Chicago, IL, USA). Table 2 illustrates five representative examples from the total set of 21 hand-drawn sketches, their corresponding 360-degree videos, and the resulting rapid physical mock-ups. The first stage focused on students' prior experience with GenAI, aiming to identify their level of familiarity with these tools before the exercise. As shown in Table 1, results indicated a moderate degree of prior knowledge and exposure. The second stage examined students' experiences during the activity, analyzing three key aspects: the successful generation of the 360-degree video, the time required to construct the rapid mock-up, and the design process phase with which students associated the exercise. These results are presented in Figure 3. This stage also assessed students' perceptions of GenAI in terms of utility, novelty, and relevance, as well as its perceived impact on mock-up construction efficiency and volumetric understanding, with results summarized in Table 1.

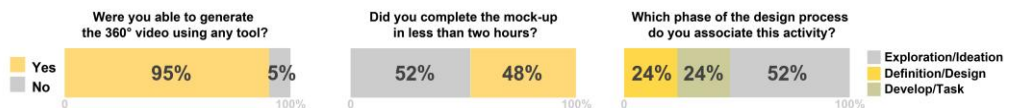


Figure 3. Participant response graphs.

The third stage focused on the open reflection responses. Students' written comments were transcribed and analyzed using ATLAS.ti Scientific Software Development GmbH (v.22, 2022). A thematic analysis was conducted through systematic coding and categorization to identify recurring concepts and patterns, as well as code co-occurrence relationships, which are further discussed in the discussion section. Building on these analyses, a final examination explored the relationship between mock-up construction time and students' assessed experience. A one-way ANOVA revealed significant differences between students who completed the mock-up within two hours and those who did not. Students who finished the mock-up rated the utility of GenAI significantly higher ($M=4.40$ vs. 3.64 ; $F=8.356$, $p=0.009$) and perceived a greater contribution of GenAI to construction efficiency ($M=4.60$ vs. 3.73 ; $F=5.198$, $p=0.034$).

Table 1. Descriptive statistics for Prior and Assesses.

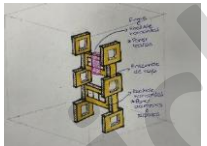
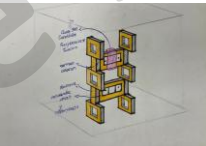
<i>Prior Experience questions</i>	<i>Mean</i>	<i>Std.Dev</i>
Did you have prior experience using GenAI tools before this activity?	3.00	1.095
Did you have prior knowledge of the potential applications of GenAI in design projects?	3.14	1.153
Had you consciously applied Gen AI tools to solve a design project problem before this activity?	2.57	1.207
<i>Assessing the experience questions</i>	<i>Mean</i>	<i>Std.Dev</i>
How would you assess the utility of GenAI in your design process?	4.00	0.707
How would you assess the novelty of GenAI in your design process?	4.19	0.750
How would you assess the relevance of GenAI in your design process?	3.48	0.928
Do you consider that using GenAI contributed to a more efficient mock-up construction process?	4.14	0.964
Do you consider that GenAI influenced your spatial understanding of volumes and geometries?	4.29	0.644

4. Discussion

This exploratory study highlights the value of integrating GenAI as a complementary tool in D.E, reinforcing the role of traditional exercises as meaningful inputs for emerging technologies rather than replacements (A. Bartlett & D. Camba, 2024; Ye et al., 2025). Addressing RQ1, students demonstrated awareness of GenAI and its potential applications, although systematic use in design projects was limited. Mean scores indicated an intermediate level of familiarity, providing a favorable baseline for engaging in the exercise. Regarding the design process, most participants (95.2%) successfully generated a 360-degree video, evidencing a smooth adoption of immersive digital tools. However, fewer students (47.6%) completed the physical mock-up within two hours, revealing greater demands associated with hands-on prototyping. Over half of the participants (52.4%) associated the activity with exploration and ideation, while others linked it to later design stages. With respect to RQ2, students' assessments of the GenAI tools provide clear insights into their perceived value within the design process. Overall, the tools

were evaluated positively, particularly for supporting volumetric understanding during mock-up construction. GenAI was perceived as useful ($M=4.00$) and novel ($M=4.19$), while perceived relevance was more moderate ($M=3.48$), suggesting that prior experience or sustained exposure may shape perceived value. These findings highlight the pedagogical potential of GenAI as a facilitator of visualization and conceptual exploration (Chandrasekera et al., 2025). ANOVA results further indicate that students who completed the mock-up rated the tool as significantly more useful and efficient, although perceptions of novelty, relevance, and volumetric perception were consistent across the sample.

Table 2. Example of exercise results.

<i>Hand-drawn sketches</i>	<i>360-degree video (GenAI)</i>	<i>Rapid mock-ups.</i>
		
		
		
		
		

Regarding RQ3, thematic analysis of student reflections supports the role of GenAI in enhancing volumetric perception and rapid prototyping. Students reported improved understanding of structural and mechanical aspects of their designs, particularly when GenAI outputs were guided by clear prompts. A notable positive effect was the tool's ability to replicate the student's drawing style and stroke, generating multiple perspectives as if produced by the student, which created familiarity and facilitated the identification of design errors. Co-occurrence analysis

revealed strong relationships between help-understanding, understanding-form, and tool-interesting, indicating that GenAI promotes formal comprehension, exploratory thinking, and positive adoption within this exercise. These findings align with prior research highlighting GenAI's contribution to volumetric reasoning and reflective design learning (Adhikari et al., 2025).

5. Limitations and Future Research

This preliminary study has limitations inherent to its exploratory nature. The sample was restricted to a single group of students, limiting the generalizability of the findings. In addition, participants' prior knowledge and skill levels with AI tools were not examined in depth, which may have influenced results. The evaluation also focused on a limited set of design outputs, suggesting the need to include additional artifacts, such as technical drawings, to better assess conceptual understanding. Despite these constraints, the study outlines clear directions for future research, including the incorporation of control groups, larger and more diverse samples, application to varied product design objectives, and comparative analyses across multiple GenAI platforms.

6. Conclusion

This study explored the informed integration of GenAI in a product design course, examining its role in early-stage creative workflows from hand-drawn sketches to 360-degree visualizations and rapid physical mock-ups. The pedagogical exercise proved effective for analyzing GenAI's contribution to volumetric perception, prototyping efficiency, and students' perceptions of utility, novelty, and relevance. Findings indicate that GenAI acts as a complementary visual and cognitive scaffold rather than a substitute for traditional design practices, supporting conceptual exploration and volumetric reasoning when guided by clear prompts. The adoption of these tools in our project was also due to the familiarity of the output; 360-degree videos created in the students' own style led to a more conscious approach to mock-up construction, with a focus on materials and practical skills. Overall, the results highlight the pedagogical value of integrating GenAI within studio-based D.E to enrich reflective learning and creative development.

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