

Generative AI in Project-Based 3D Modeling: Effects on Creativity, Critical Thinking, and Workflow

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Abstract

Generative Artificial Intelligence (Gen-AI) has sparked significant debate within creative industries and educational settings. This study examined the effect of integrating Gen-AI tools into project-based 3D Modeling on students' creativity, critical thinking, processes, and workflows. A mixed-method research design with a sequential explanatory approach was employed, involving 19 students from a Malaysian creative arts institution specializing in 3D design, selected through convenience sampling. Quantitative data were gathered from students' creative scores based on Amabile's Componential Model for Creativity and timeline worksheets documenting the time spent on artwork creation. Qualitative data were collected through interviews to assess critical thinking, and through self-reflection forms to evaluate processes and workflows. Insights were also gained from two industry experts regarding their use of Gen-AI tools. Findings indicated that Gen-AI tools enhanced creativity and accelerated the creative process, thereby improving workflow efficiency. However, mixed reactions were observed regarding the implementation of Gen-AI tools in education, highlighting concerns about academic integrity and ethical considerations. This study provides valuable insights into the opportunities and challenges associated with the use of Gen-AI tools in educational contexts.

Keywords: Generative AI, creativity, critical thinking, process and workflow, 3D modeling

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Digital transformation has significantly reshaped the educational landscape by incorporating advanced technologies to support innovative teaching and learning environments (Bender, 2023; Hutson & Cotroneo, 2023). The rise of the internet and artificial intelligence (AI) has provided educators with access to a wide range of knowledge and tools, enabling the creation of engaging learning experiences that encourage independent and personalized exploration (Ouyang & Jiao, 2021).

AI in education can be categorized into three paradigms; AI-directed, where the learner acts as a recipient of information; AI-supported, where the learner collaborates with AI; and AI-empowered, where the learner takes on the leadership role of decision-making based on AI-driven insights (Ouyang & Jiao, 2021). These paradigms represent varying levels of learner engagement and autonomy in relation to AI. This study focuses on the AI-supported and AI-empowered paradigms, which use AI tools to enhance student learning through more collaborative and student-centered approaches.

Generative AI (Gen-AI), a branch of artificial intelligence, introduces new possibilities in content creation (Chiu, 2023; Tong et al., 2023). Gen-AI employs advanced algorithms to produce new content, such as text and images, based on data it has been trained on. Tools like ChatGPT and MidJourney are common examples of Gen-AI applications (Chiu, 2023). Within the context of 3D modeling, Gen-AI tools offer the potential to accelerate the creative ideation process by enabling rapid content generation and visual communication of ideas (Hutson & Cotroneo, 2023; Epstein et al., 2023; Shi et al., 2023).

Bhaduri et al. (2019) found that providing students with access to a variety of 3D modeling platforms increases their engagement and interest. In the current digital era, these platforms now include Gen-AI tools, which are transforming creative practices across multiple disciplines. The integration of Gen-AI in the 3D modeling process challenges traditional distinctions between human and machine creativity, offering new opportunities for innovation (Bender, 2023; Cheng, 2022). This may be particularly beneficial for students who struggle with generating ideas or visualizing design concepts (Tong et al., 2023; Bender, 2023).

Although previous research has demonstrated the potential benefits of Gen-AI (Hutson & Cotroneo, 2023; Grassini, 2023; Tahiru, 2021), its practical application within 3D modeling courses remains limited (Chiu et al., 2023; Grassini, 2023). This study aims to investigate the effects of project-based 3D modeling activities enhanced by Gen-AI on students' creativity, critical thinking, and workflow in the context of the 3D computer graphics industry.

To provide structure, this article begins with a review of relevant literature, followed by an explanation of the research methodology. The findings are then presented and critically discussed. The paper concludes with a summary of the key results, a discussion of the study's limitations, and suggestions for future research.

Literature Review

AI in Education

Definitions of artificial intelligence (AI) vary depending on the research context, but many compare it to human intelligence in terms of decision-making and problem-solving capabilities (Dobrev, 2005; Kong, 2020). In the field of education, AI plays a growing role in supporting and empowering learners by helping them become more digitally and technically literate. This literacy equips students with the ability to adapt, innovate, and create solutions in an increasingly digital world (Grassini, 2023). As AI technologies continue to evolve, their integration into educational settings has the potential to fundamentally transform how students learn and how educators teach.

Several studies (Baidoo-Anu & Owusu Ansah, 2023; Chiu, 2023; Grassini, 2023; Han & Cai, 2023) have investigated both the benefits and challenges of AI integration in education. For example, Baidoo-Anu and Owusu Ansah (2023) argue that incorporating generative AI tools, such as ChatGPT, can enhance learning by providing personalized tutoring experiences. The adaptive nature of AI makes learning more flexible and interactive (Chiu et al., 2023). AI is also widely used to create gamified educational activities that engage students and improve their learning outcomes.

Beyond student engagement, AI technologies support educators in developing more effective teaching strategies. For instance, AI systems can generate personalized learning content and provide real-time feedback, offering insights into student progress. This allows educators to focus on designing impactful and responsive learning experiences (Chiu et al., 2023). Grassini (2023) notes that AI can also automate routine tasks, enabling educators to allocate more time to developing creative and innovative lesson plans. These personalized environments, supported by AI, are made possible by data-driven algorithms that analyze student learning patterns to deliver tailored instruction (Chiu et al., 2023).

As AI continues to advance, its role in enhancing creativity has become an area of growing interest. Gen-AI, which is designed to support rather than replace human creativity, has opened new opportunities in education, particularly in creative and visual fields. This leads to a deeper discussion about Generative Adversarial Networks (GANs) and their relationship to creativity in educational contexts.

Generative Adversarial Network (GAN), Gen-AI, and Creativity

The development of Generative Adversarial Networks (GANs) and Gen-AI has led to major breakthroughs in AI, particularly in the domain of artistic creativity. GANs operate through two neural networks: a generator that creates output based on data samples, and a discriminator that evaluates and refines these outputs. Through iterative feedback, the system produces increasingly realistic content (Goodfellow et al., 2020). These tools are frequently used in text-to-image generation, where descriptive prompts yield highly detailed and lifelike visuals. This rapid advancement has generated concern within the creative arts community, as it challenges long-standing assumptions about creativity as a uniquely human trait (Shi et al., 2023).

Creativity, however, remains a deeply human cognitive function, essential for innovation, expression, and demonstrating mastery (Cheng, 2022; Esling & Devis, 2020). Gen-AI tools do not replace human creativity but instead support it by encouraging new ways of thinking and

visualizing ideas (Bender, 2023; Notaro, 2020). This collaborative dynamic between humans and machines is aligned with Conceptual Blending Theory, which posits that combining multiple sources of information leads to the generation of novel and original ideas (Tunmer & Fauconnier, 1995).

By generating content in response to text-based prompts, Gen-AI tools facilitate creativity, ideation, and collaboration (Hutson & Cotroneo, 2023). These tools act as partners in the creative process by supporting visual communication and expanding the boundaries of imagination (Esling & Devis, 2020). Although Gen-AI tools demonstrate impressive creative capabilities, they rely entirely on human input to function. Without the user's imaginative ideas and prompts, these tools remain passive. As noted by Hutson and Harper-Nichols (2023), AI cannot replace artists but can serve as a valuable collaborator in enhancing and extending human creative potential.

Gen-AI Applications in Creative Art Education

The integration of Gen-AI into creative arts education has been explored in recent studies, which highlight its potential to foster creativity and critical thinking while emphasizing ethical use and the maintenance of academic integrity (Dehouche & Dehouche, 2023; Hutson & Harper-Nichols, 2023; Hutson & Cotroneo, 2023). Scholars such as Betker et al. (2023), Hutson et al. (2023), and Tong et al. (2023) discuss how Gen-AI can enhance visual expression and help students represent ideas more effectively. Kong (2020) outlines three key strategies for incorporating AI into arts education: adapting AI for instructional use, improving intelligent teaching methodologies, and enriching student experiences through AI-enhanced creative tasks.

Similarly, Dehouche and Dehouche (2023) describe how AI can be used to recreate historical art pieces, enabling students to explore the stories behind artwork through interactive and immersive learning. Successful implementation of Gen-AI in this context encourages students to experiment with creative solutions and develop sustainable, innovative designs (Hutson & Lang, 2023; Anam & Fathoni, 2023). These tools also enhance students' visual communication abilities and support ideation and sketching processes, allowing learners to blend their own ideas with AI-generated suggestions (Betker et al., 2023; Hutson et al., 2023; Tong et al., 2023). This collaborative approach helps cultivate aesthetic literacy and creative thinking (Bender, 2023).

While concerns exist that Gen-AI tools might dominate the creative process, they are still highly dependent on human input, such as descriptive prompts and artistic intention (Hutson & Lang, 2023; Kong, 2020). Though these tools can support innovation and critical thinking, they do not replicate the depth and nuance of human creativity. Instead, many researchers advocate for a co-creative model in which Gen-AI complements human abilities (Dehouche & Dehouche, 2023; Shi et al., 2023; Tsai et al., 2023). This human-AI partnership offers opportunities to overcome creative limitations and explore ideas that might otherwise remain unrealized (Esling & Devis, 2020; Anam & Fathoni, 2023).

Pedagogical Challenges in 3D Modeling and Ethical Practices of AI

Teaching and learning 3D modeling present notable challenges for both educators and students. The complexity of 3D software and technical processes can be overwhelming for beginners, often leading to disengagement, especially among learners who lack spatial awareness or critical thinking skills (Bhaduri et al., 2019).

Achieving competence in 3D modeling requires not only technical skills but also creativity and cognitive flexibility. Studies show that instructional strategies such as cognitive apprenticeship can enhance metacognition and practical skill development (Huang et al., 2019). Similarly, goal-driven training approaches have been found to improve learners' cognitive abilities and problem-solving strategies (Benzer & Yildiz, 2019). When implemented effectively, Gen-AI tools can provide additional support by guiding students toward clear and achievable outcomes.

Project-Based Learning (PjBL) has proven to be an effective approach in promoting both creativity and critical thinking by immersing students in real-world challenges. According to Jeon et al. (2014), the PjBL cycle includes five stages: Orientation, Identifying and Defining, Planning, Implementing, and Reporting and Evaluating. This model supports self-directed learning, encouraging students to actively seek out solutions, often with the help of Gen-AI tools.

When aligned with PjBL and constructivist learning theories, Gen-AI tools offer personalized and collaborative learning experiences. These tools enhance active participation by supporting creative workflows, preventing stagnation during ideation, and promoting reflection through iterative design. In this setting, educators serve not only as facilitators but also as technological guides, helping students use AI ethically, uphold academic integrity, and stay engaged throughout the creative process.

Despite the potential of Gen-AI to support creativity, many students experience creative blocks when faced with the “blank slate” problem, uncertainty about how to begin or develop ideas without a clear concept. Gen-AI tools can help overcome these barriers by providing visual prompts and suggestions that stimulate the early stages of ideation.

However, the use of AI in education also raises ethical concerns. Chiu (2023) points out a lack of research on AI ethics in educational contexts, while Koubaa et al. (2023) highlight mixed perceptions of Gen-AI tools, particularly around issues such as plagiarism, misuse of copyrighted material, academic dishonesty, and dependence on unreliable content. These concerns emphasize the importance of developing ethical guidelines for AI integration in educational settings (Grassini, 2023; Zhai, 2022).

Educators' perspectives are essential in determining how AI tools are implemented. As the education sector increasingly adopts a skills-based approach in line with industrial demands, AI tools are seen as valuable assets in course design, collaboration, and innovation (Bender, 2023). In creative arts education, in particular, AI holds promise for enhancing student engagement, creativity, and learning outcomes.

Despite a growing body of literature on AI in education, there remains a noticeable gap in research on its integration into 3D modeling courses (Chiu et al., 2023; Grassini, 2023). This study addresses that gap by investigating the impact of project-based 3D modeling activities enhanced by Gen-AI on students' creativity, critical thinking, and workflow. Specifically, it examines how AI influences students' creative processes, time management, and problem-solving strategies in the context of 3D computer graphics education.

Creativity and Critical Thinking Theories

As the definition of creativity continues to evolve, it is increasingly understood as a multifaceted concept involving both cognitive and developmental dimensions. This study focuses on *developmental creativity* and *cognitive creativity*, both of which are shaped by internal factors—such as individual motivation and thinking strategies—and external influences, including tools and environmental conditions (Kozbelt et al., 2010). One of the foundational models used in this study is Amabile’s Componential Model of Creativity (Amabile & Pratt, 2016), which defines creativity as the result of producing novel and useful ideas that lead to successful implementation. The model highlights three key components that influence creativity: domain-relevant skills (knowledge), creativity-relevant processes (thinking strategies), and task motivation.

Creativity is not limited to artistic or visual expression but also encompasses the ability to develop innovative and resourceful solutions to problems (Sternberg et al., 2019). The theory of conceptual combination further supports this view by proposing that synthesizing different sets of information can stimulate creative ideation (Kozbelt et al., 2010). In this context, Gen-AI acts as a collaborative tool that facilitates idea generation and exploration by expanding the user’s cognitive reach.

As AI becomes more deeply embedded in creative processes, its influence can also be interpreted through the Four C Model of Creativity, developed by Kaufman and Beghetto (2007). This model identifies four levels of creativity: Mini-c (personal insight), Little-c (everyday problem-solving), Pro-c (professional-level creativity), and Big-C (eminent, domain-transforming creativity). While Gen-AI tools are particularly effective in supporting Mini-c and Little-c creativity, their capabilities also contribute to the development of higher-level creative outcomes (Pro-c and Big-C), especially when integrated with structured learning and mentorship (Markauskaite et al., 2022).

Critical thinking is another essential cognitive skill that is often acquired through real-world experiences rather than formal instruction (Ellerton, 2022). This study draws on Facione’s Critical Thinking Model (2015), which emphasizes the development of six core cognitive skills: interpretation, analysis, inference, evaluation, explanation, and self-regulation. These skills enable individuals to make reasoned judgments and solve problems effectively. Facione (2015) further argues that the cultivation of these abilities enhances not only academic performance but also quality of life.

The relevance of this model to the current research lies in its alignment with the objective of enhancing critical thinking through the use of Gen-AI tools. For example, as students interact with AI-generated content, they must evaluate, revise, and apply this content critically within their projects, activities that mirror Facione’s framework.

Both creativity and critical thinking are also deeply rooted in constructivist learning theory, which posits that learners actively construct knowledge through engagement and interaction with their environment. Gen-AI tools support this theory by enabling students to access, remix, and reframe information in ways that promote deeper understanding. For instance, students can experiment with image generation tools to visualize ideas, combine different concepts, and reflect on their outcomes. These actions not only reinforce creative thinking but also foster self-directed learning (Baidoo-Anu & Owusu Ansah, 2023).

Research Questions

This study aims to explore the impact of generative AI in project-based 3D modeling through the following research questions:

1. What is the effect of project-based 3D modeling activities integrated with Generative AI on students' creativity?
2. How much time do students spend on creating 3D modeling artwork when using Generative AI tools?
3. In what ways do project-based 3D modeling activities, enhanced by Generative AI, influence students' critical thinking skills?
4. What are the overall processes and workflows students follow when creating 3D modeling artwork with the aid of Generative AI tools?

Methodology

Research Design

This study employed a mixed-methods design with a sequential explanatory approach (Creswell & Clark, 2007), integrating both quantitative and qualitative data to provide a comprehensive understanding of the research problem. This approach enhances the validity of findings by enabling qualitative insights to explain quantitative results (Creswell, 2012).

One challenge associated with this design is obtaining ethical approval, particularly when participants for the qualitative phase are not identified in advance. However, in this study, ethical approval was not required, as all participants had provided prior informed consent to take part in the research.

Research Setting and Participants

The research was conducted at a private college in Petaling Jaya, Malaysia, selected for its qualified educators and well-equipped facilities that support 3D modeling and animation software. Participants were selected through convenience sampling, with voluntary participation. The selection criteria were:

- Enrolment in a 3D Animation course that included a 3D Modeling subject, ensuring foundational knowledge relevant to the study.
- Prior experience or interest in using digital tools for creative projects, enabling meaningful engagement with Gen-AI applications.

Out of 27 eligible students, 19 consented to participate in the study, which took place over the course of one semester (14 weeks). The remaining eight students declined, expressing strong opposition to the use of Gen-AI tools in their creative processes.

The convenience sampling method was appropriate as the study targeted students who were both willing and available to participate, consistent with Creswell's (2012) justification for using convenience sampling. Additionally, participants needed to be genuinely interested in and open to using Gen-AI tools in their 3D Modeling projects.

To minimize bias, sample variability was controlled by selecting students from the same course, thereby ensuring a comparable level of prior knowledge. As this study is exploratory in nature, its findings are not intended for generalization.

Two industry experts were also interviewed to enrich the qualitative data. They were selected purposefully based on their expertise. Expert 1 (E1) had over 15 years of experience in the creative industry, transitioning from traditional to digital methods and using Gen-AI tools to innovate creative workflows. Expert 2 (E2) had 9 years of experience in the Games and Animation industry and 5 years of teaching experience, offering valuable insights from both industry and academia.

Data Collection

Data collection occurred in two phases: Initially, quantitative data were gathered, followed by the collection of qualitative data to further elucidate the results. In the quantitative phase, participants completed Pre-Post Projects. Prior to the study, students were provided with informed consent forms to confirm voluntary participation. A total of 19 students participated, while 8 opted out. The project-based learning (PjBL) activity, based on Jeon et al. (2014), involved a Pre-Post Project task under the theme “Stylized Diorama Building.” This activity was selected due to its alignment with industry practices and suitability for integrating Gen-AI tools.

The Pre-Post Project was divided into two parts: Part 1 focused on the pre-production phase, where students designed conceptual art, and Part 2 involved the production phase, including modeling, UV mapping, texturing, and rendering. Students’ creativity levels were measured using Susan Brookhart’s Creativity Rubric (Brookhart, 2010) and they tracked their time using a Timeline worksheet to monitor progress and optimize their creative process.

In the qualitative phase, participants were interviewed using questions based on Facione’s Holistic Critical Thinking Rubrics (Facione & Facione, 1994) and completed a self-reflective form inspired by Kleon’s “Steal Like an Artist” rubrics (Kleon, 2012) to gain insights into their critical thinking and overall process. Qualitative data were collected through interviews and a self-reflection form. Interviews followed open-ended, flexible questions to gather in-depth insights (Maguire & Delahunt, 2017; Ruslin et al., 2022). A self-reflection form encouraged students to articulate their experiences and self-assess their learning, helping to foster constructive discussion (Martinez-Villagrassa et al., 2020).

All rubrics used in the study were selected based on Dawson’s (2017) rubric design criteria, which include specificity, scoring strategy, evaluative criteria, quality levels, quality definitions, quality processes, and presentation.

Data Analysis

The demographic data of the participants were analyzed descriptively using percentages. Quantitative data collected from Susan Brookhart’s Creativity Rubric were analyzed descriptively using mean and standard deviation to identify students’ creativity scores before and after using Gen-AI. To examine differences in scores, Wilcoxon’s Signed-Rank Test and Effect Size r were employed.

Data from the timeline worksheet were also analyzed descriptively using mean and standard deviation to determine the average time spent and efficiency in the creative process. The

Wilcoxon's Signed-Rank Test and Effect Size r were again used to analyze significant differences in the time taken to complete projects before and after using Gen-AI.

For the qualitative data collected from interviews and self-reflection forms, thematic analysis was employed (Williamson et al., 2018). This approach helped identify recurring patterns and relationships within the data, offering deeper insights into students' critical thinking and creative processes. Data from both sources were triangulated to strengthen findings. The frequency and percentage of theme occurrences were also recorded to support interpretation.

Ethical Considerations

Given ongoing concerns in the creative community surrounding the use of Gen-AI tools, this study adhered to strict ethical guidelines. Participation was voluntary, with students given the option to consent or decline without any academic consequences.

All student data remained anonymous, and analysis was conducted collectively using overall means and themes. The study was conducted outside regular class hours and was not associated with any graded coursework or specific subject, ensuring it did not affect students' academic performance. As such, formal ethical approval was not required, since informed consent was obtained, and no identifiable or sensitive data were used.

Results

Background of the Participants

Table 1 presents the demographic characteristics of the participating students in this research, suggesting a diverse sample in terms of age, gender, and educational background. The variety among students in this sample enhanced the generalization of the findings to a broader population.

Table 1

Analysis of Participating Students' Demographic Background

		Frequency	Percentage
Gender	Male	10	52.6%
	Female	9	47.4%
Age Gap	20 – 21 years	8	42.1%
	22 – 23 years	7	36.8%
	24 – 25 years	2	10.5%
	26 – 27 years	1	5.3%
	28 years and above	1	5.3%
Education Level	High School Graduates	15	78.9%
	Diploma	2	10.5%
	Degree	1	5.3%
	Masters	1	5.3%

Effects of Gen-AI on Student's Creativity

The assessment of the effectiveness of Project-Based 3D Modeling Learning Activities embedded with generative AI verified that most of the students displayed significant improvements in their scores (see Table 2), as measured by the Creative Rubrics (Brookhart, 2017). This indicated the success of the project activities.

Table 2

Student's Pre-Post Creativity Scores

	Project Creativity Part 1		Project Creativity Part 2	
	Pre	Post	Pre	Post
<i>Mean</i>	9.79	13.16	56.89	73.68
<i>Standard Deviation</i>	2.59	1.57	12.49	9.18
<i>Median</i>	10.0	13.0	57.0	73.0
<i>n (Total)</i>	19		19	

Based on Table 2, the students' average scores in Project Part 1 improved from 9.79 to 13.16, while in Part 2, the results increased from 56.89 to 73.68. The statistical findings revealed a decrease in standard deviations from 2.59 to 1.57 for Part 1 and from 12.49 to 9.18 for Part 2. The decrease indicated stronger consistency in scores, with data clustering more closely around the mean after the project activities. The increased median scores reflected a general improvement in student creativity, with half of the students scoring from 10 to 13 marks or higher in Part 1 and from 57 to 73 marks or higher in Part 2. This substantial improvement demonstrated a positive impact of the project intervention on students. These findings not only illustrate the improvements in student scores but also highlight the statistical significance of the results, as shown in the subsequent analysis.

According to Table 3, the Wilcoxon signed-rank test revealed significant increases in creativity scores for both Part 1 and Part 2. The analysis indicated large effect sizes of 0.747 for Part 1 and 0.877 for Part 2. Furthermore, the asymptotic significance (2-tailed) value was less than 0.001, which is below the threshold of 0.05, confirming a significant improvement following the implementation of generative AI tools in the learning activities.

Table 3

Wilcoxon Signed-Rank Test for Creativity

	Mean	Z	Sig.	Effect size r
Pre-Project Part 1	9.79	-3.258	0.001	0.747
Post-Project Part 1	13.16			
Pre-Project Part 2	56.89	-3.826	0.001	0.877
Post-Project Part 2	73.68			

Time Used by Students by Implementing Gen-AI Tools

During the overall process of the study, students recorded their timelines in the provided worksheets to determine the number of days used to produce their artwork. The variation in pre-project time suggested differences in the complexity of the artwork created by each student, as well as individual learning curves. It was also expected that students would perform faster in the post-project phase after their prior experience in the pre-project.

Table 4 details the results from the Wilcoxon signed-rank Test. The significant decrease in time from 10 days to 1.84 days during Part 1 and from 44.89 days to 20.26 days indicates the efficiency and effectiveness of the project intervention, including the utilization of Gen-AI tools, in optimizing the artwork creation process. Participating students likely benefited from the experience gained during the pre-project phase, as well as the guidance and training provided as part of the project activities.

Table 4

Wilcoxon Signed-Rank Test for Time Used

	Mean	Z	Sig.	Effect size r
Pre-Project Part 1	10.00	-3.831	0.001	0.878
Post-Project Part 1	1.84			
Pre-Project Part 2	44.89	-3.829	0.001	0.878
Post-Project Part 2	20.26			

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According to the results from the Wilcoxon signed-rank test, there is a significant difference in the time spent, with the effect size for both parts at 0.878 indicating large effects and a significant reduction in time spent. The average time spent on both parts of the activity decreased significantly in the post-project phase, indicating improved workflow and productivity among students. This suggests that the intervention utilizing Gen-AI tools not only facilitated the ideation process in pre-production but also optimized time and resource management during the production stage.

Influence of Gen-AI tools towards Student's Critical Thinking

The data in Table 5 reveals varied perceptions among students regarding the use of generative AI tools in their 3D modeling projects. A significant portion of the participants, 84.6%, reported having used Gen-AI tools, indicating a strong engagement with this technology. However, opinions on its practicality were mixed: while 38.5% found the tools useful, a notable 46.2% remained undecided, and 15.4% viewed them as unethical. This uncertainty suggests a need for further education on the ethical implications and practical applications of Gen-AI in creative work.

Regarding the impact of Gen-AI on critical thinking, opinions were nearly evenly split. While 53.9% of students believed that Gen-AI positively influenced their critical thinking skills, 46.1% disagreed. This dichotomy reflects a complex relationship between technology use and the development of critical thinking abilities, highlighting the necessity for careful integration of Gen-AI in educational practices to maximize its benefits.

Additionally, the influence of Gen-AI on motivation was generally positive, with 61.5% of students affirming that it enhanced their motivation to engage with their projects. This indicates that the integration of Gen-AI tools may lead to greater student engagement in learning activities.

When asked about problem-solving strategies, students utilized a variety of resources, with 30.8% relying on online resources, followed closely by seeking help from friends and lecturers (both at 23.3%). This shows that while Gen-AI tools were utilized, students still turned to traditional methods and peer support for problem-solving.

In summary, the findings suggest that while students are generally receptive to using Gen-AI tools, there are mixed feelings about their ethical implications and their specific impact on critical thinking. This highlights the importance of fostering discussions around ethical use and providing support to enhance students' critical thinking skills in conjunction with new technologies.

Table 5

Perception of Participating Students Towards Gen-AI Tools

		Frequency	Percentage
<i>Practicality</i>	Useful	5	38.5 %
	Undecided	6	46.2 %
	Unethical	2	15.4 %
<i>Used Gen AI</i>	Yes	11	84.6 %
	No	2	15.4 %
<i>Impact Towards Critical Thinking</i>	Yes	7	53.9 %
	No	6	46.1 %
<i>Gen AI on Motivation</i>	Yes	8	61.5 %
	No	5	38.5 %
<i>How Students Solve Problems Initially</i>	Online Resources	4	30.8 %
	Friends	3	23.3 %
	Lecturers	3	23.3 %
	AI Tools	2	15.4 %
	Misc	1	7.7 %
<i>Total</i>		13	100%

The qualitative data gathered from interviews revealed mixed reactions from students regarding their use of Gen-AI tools, despite the positive quantitative findings. The thematic analysis indicated that most students drew inspiration from themes related to food and culture. They reported using Gen-AI tools to further develop these initial ideas, particularly when facing challenges like creative blocks in traditional artistic expression. For instance, S16 stated,

“Conveying the ideas and expectations from my imagination into words commands,” while S17 noted, “When I am stuck, I ask AI to generate images to know what details to model.”

In addressing their creative challenges, students frequently utilized online resources alongside Gen-AI tools to generate references that supported their projects. They encountered some technical issues, such as modeling with nGon (polygonal faces with more than four edges), UV projections, and texturing outcomes. Overall, students utilized Gen-AI tools to stimulate ideation, facilitate referencing, and accelerate project timelines. For example, S11 highlighted this efficiency:

It helped me model out my ideas without me thinking of them first. It saved me a lot of time... without AI, I would take long hours thinking of different ideas, but with AI, I can see what it generates and sketch it out.

While many students found that Gen-AI tools allowed them to bypass difficulties in sketching their thoughts, which led to improved productivity, they also acknowledged the risk of complacency through over-reliance on technology. This suggests a dual impact on critical thinking: Gen-AI tools can enhance efficiency and idea generation but may also hinder deeper engagement in the creative process.

Students re-stated that Gen-AI played a vital role in ideation during the pre-production phase, helping them generate innovative ideas from initial text prompts by combining multiple elements. This process enabled them to view their projects from different perspectives and expand their creative horizons. S16 remarked, “AI can generate a lot of art, so I can use them as references and combine the elements I like from there.” Similarly, S10 noted, “It gives me freedom from lecturer comments,” indicating a desire for autonomy in their creative work.

Despite the array of Gen-AI tools available, students maintained a sense of independence by integrating their prior knowledge and techniques into their projects. They acknowledged that while Gen-AI was enjoyable and interesting, they still valued the personal touch in their designs. S03 stated, “AI is a fun and interesting way to approach designing, but I still prefer to come up with the design myself; it doesn’t hurt to have some references.”

In conclusion, the students exhibited mixed perceptions of Gen-AI tools. While they found these tools useful in overcoming creativity blocks and time constraints, they expressed caution regarding their overuse. Students anticipated that future developments in Gen-AI would introduce more features, although they recognised that the technology is not yet mature enough to fully replace traditional creative processes. Throughout the interviews, students demonstrated awareness of the ethical and legal challenges posed by Gen-AI, as well as ongoing debates within the creative community regarding its use. This indicates their recognition of the complexities surrounding this transformative technology.

Overall Process and Workflow with the Implementation of Gen-AI Tools

Table 6 provides insights into students’ experiences with Gen-AI tools in their creative workflows. A majority (53.8%) indicated that they utilized these tools for ideation in concept art, while a significant portion (46.2%) expressed uncertainty about their overall effectiveness. Additionally, 61.5% of students recognised changes in their workflows due to Gen-AI tools, suggesting that these tools have a meaningful impact on their creative processes. However,

nearly 39% felt that there were no notable changes, highlighting a divide in acceptance and integration of these technologies.

Regarding critical thinking, 53.9% of students believed that Gen-AI tools positively influenced their analytical skills, although 46.1% did not see a significant impact. The practical use of Gen-AI was predominantly focused on ideation and concept art, with 76.9% of students employing these tools in this phase, while applications in modeling, UV texturing, and lighting and rendering were minimal (7.7% each). This indicates that while students find Gen-AI tools valuable for generating ideas, their effectiveness in technical stages of the creative process is limited. Overall, the findings suggest a generally positive yet cautious view of Gen-AI tools, emphasizing their primary role in the early phases of artistic development.

Table 6

Students' Overall Process and Workflow with Gen-AI Tools

		Frequency	Percentage
<i>Usability</i>	Ideation for Concept Art	7	53.8 %
	Undecided / Maybe	6	46.2 %
<i>Changes with Gen AI</i>	Yes	8	61.5 %
	No	5	38.5 %
<i>Impact towards Critical Thinking</i>	Yes	7	53.9 %
	No	6	46.1 %
<i>Practical use On Gen AI</i>	Ideation & Concept Art	10	76.9 %
	Modeling	1	7.7 %
	UV Texturing	1	7.7 %
	Lighting & Rendering	1	7.7 %
	Composition	0	0.0 %

The thematic analysis revealed that most students completed their projects using traditional production methods, even while incorporating Gen-AI tools into their workflows. This integration did not significantly alter their established processes, which typically progressed from ideation to concept art, model blocking, UV unwrapping, texturing, and finalizing materials, lighting, and rendering. While some students utilized platforms like Sketchfab for online 3D viewing, the overall workflow remained consistent with conventional practices.

Students effectively employed Gen-AI tools during the planning stages, where these tools aided in artistic decision-making and influenced the final outcomes. By blending elements from cultural references, such as food and anime, students crafted detailed prompts that guided the generation of images. This approach enabled them to think creatively and explore innovative ideas, as illustrated by S03's statement: "Taking parts of the images I like the most and merge

them into one design,” and S06’s imaginative concept description: “Describe a concept I want with ideas like a huge bao on a roof with keywords like diorama, miniature, cute.”

Despite the advantages of Gen-AI tools, students encountered several challenges, such as finding the right tools for their specific needs. While Gen-AI could produce images quickly, the outputs often had issues like pixelation and structural flaws, complicating their translation into 3D models. The inconsistency in generated images posed difficulties, particularly for beginners, leading students to rely on traditional methods and tutorials to address these shortcomings. Statements like S02’s critique—“Sometimes their generation doesn’t make the structure rationalization, and some small detail isn’t clear enough”—and S03’s concerns—“Some images created are not very stable if in real life it would not be able to support its own weight; it makes it hard to try changing the idea into something more realistic/stable”—highlight these obstacles.

However, students acknowledged the utility of Gen-AI in accelerating the ideation process and facilitating smoother workflows. Many expressed a cautious optimism regarding the ethical use of Gen-AI tools, recognizing their potential to assist primarily in the early phases of pre-production. Overall, while Gen-AI tools were valuable for generating ideas, the students’ reliance on traditional methods underscores their limited impact during the later stages of production.

The insights gathered from conversations with industry experts highlighted a cautious perspective on the use of generative AI tools in creative processes. Both experts agreed that Gen-AI allows for an expression of freedom to visually communicate ideas, but most of these applications are limited to internal experiments. The rapid production of sketches for ideation is not advisable when dealing with clients due to the randomization of generated images, which lacks user control over the outcome. In developing and brainstorming ideas, the experts noted that they use Gen-AI tools to cross-reference and mix elements from prompted images with other resources. However, they also pointed out that the repetition of styles from generated images lacks originality and contributes to market saturation, leading users to lose focus on their original ideas and creativity. Expert 1 stated, “It is very easy to lose your focus with Gen AI tools. It is important to pull back to your original ideas and creativity,” while Expert 2 emphasized the need for ethical use, mentioning that they would only engage with Gen-AI after conducting extensive studies on how the tool operates.

Leveraging Gen-AI tools has proven efficient for certain artistic projects, but the experts indicated that these tools may not assist effectively in more controlled processes within the games and animation industries. The time saved in the pre-production phases can become counterproductive, as the destructive nature of generated images can complicate modifications. Expert 1 pointed out, “Time saved at the beginning is spent on the later parts of production. Challenges in consistency and specific details. The more detailed it is, the harder for Gen-AI tools to produce.” They observed that the most time-consuming aspect of projects is often the detailing and finishing phases, particularly when clients have specific requirements. Both experts recognised that Gen-AI tools have not yet matured sufficiently, often confusing beginners who lack foundational skills in art and design. Expert 1 noted, “The current Gen-AI tools are not matured enough; it is still difficult to control for young students,” while Expert 2 added, “I think Gen-AI tools will confuse the students more than helping them, without understanding the key elements of what should be extracted by Gen-AI.”

Furthermore, ethical practices surrounding Gen-AI tools remain contentious; the experts acknowledged these concerns and agreed that current tools are only suitable for ideation and inspiration but should never be used as final outcomes. Expert 1 commented, “I also educate my clients on ethical and copyright issues from the beginning to make sure that we’re on the same page,” and Expert 2 reiterated, “I will never use Gen-AI generated work as a final image.” Overall, they argued that developing foundational skills and understanding design principles should take precedence over quick solutions that lack context, warning against an over-reliance on Gen-AI tools in educational settings.

Discussion

The quantitative data reveals a significant improvement in students’ creativity scores, suggesting that project-based 3D modeling activities integrated with Gen-AI enhance both creativity and critical thinking. This aligns with constructivist principles and Amabile’s model of creativity (Amabile & Pratt, 2016). Similar findings by Tong et al. (2023) show how students using Gen-AI tools to visually communicate ideas and generate images rapidly improve design quality. This supports the ideation process, fostering creativity, as also confirmed by other studies (Kong, 2020; Zhai, 2022). Gen-AI tools offer multiple perspectives that help students overcome creative barriers and stimulate innovation (Anam & Fathoni, 2023). In particular, research by Dehouche and Dehouche (2023) indicates that integrating Gen-AI into artistic education could revolutionize how creativity is nurtured, addressing the theoretical gap regarding the role of AI technologies in creative education. This study contributes to this gap by providing concrete evidence of the effects of Gen-AI on creativity, especially in project-based learning contexts.

Although Gen-AI tools showed clear benefits during the pre-production phase, where they supported ideation and conceptual art (Amabile & Pratt, 2016), their utility declined beyond this stage. Similar studies, such as Cheng (2022), also suggest that while Gen-AI aids average students during pre-production, its impact in later creative stages remains limited (Hutson & Lang, 2023). This research concurs, acknowledging Gen-AI’s current limitations in advanced stages of the creative workflow, though future developments may address these shortcomings.

Utilizing Gen-AI tools may churn out unlimited outcomes, but this could be counterproductive. During the study, having that many options and choices delivered, potentially divert from the original rationale. Gen-AI may spark countless ideas, but it could also be difficult for users to make the final selection. Experts interviewed for this study expressed mixed opinions on Gen-AI tools in the creative process. One expert praised the creative freedom afforded by these tools, while another took a more cautious stance, voicing concerns about the market saturation of AI-generated works diminishing originality (Dehouche & Dehouche, 2023).

Both experts agreed that although Gen-AI offers exciting opportunities for inspiration, there is a risk of over-reliance, which could lead to a loss of students’ creative direction. This echoes findings by Hutson and Cotroneo (2023), who stress the importance of students retaining control over their artistic processes while using AI tools to expand their creative horizons. These expert perspectives fill the theoretical gap by highlighting the need to balance AI use with creative independence, reinforcing Amabile’s model, which emphasizes originality as central to creativity.

Despite the concerns highlighted by the experts, the research demonstrated that students using Gen-AI tools were able to reduce time spent on pre-production and increase efficiency

during production (Grassini, 2023; Kong, 2020). Students reported that Gen-AI facilitated their projects by providing references and sparking creativity, a finding consistent with constructivist learning theories (Mota-Valtierra et al., 2019). However, experts pointed out that the time-saving benefits of Gen-AI were not consistent across different projects, especially beyond the pre-production phase. AI-generated outputs, often compressed into single layers, restrict flexibility in later stages, such as production and post-production, complicating the creative workflow.

The study revealed mixed results regarding the influence of Gen-AI tools on critical thinking. While some students benefited from the tools' ability to break through creative blocks and inspire innovative solutions (Bender, 2023; Facione, 2015; Anam & Fathoni, 2023), others tended to rely more on their prior knowledge and technical skills when confronted with challenges. This suggests that Gen-AI may not uniformly impact critical thinking across all contexts, as many students adopted a self-directed approach, turning instead to real-world simulations and online tutorials for guidance (Jeon et al., 2014). This aligns with constructivist theory, which emphasizes the ability of students to think critically and adapt independently when faced with challenges (Ouyang & Jiao, 2021). These findings contribute to addressing the research gap by providing empirical evidence that, although limited in scope, Gen-AI tools can foster self-directed learning and enhance creativity.

Experts also noted the difficulty in measuring Gen-AI's impact on critical thinking, as its effectiveness depends heavily on how individuals engage with the tools. This observation adds to the research gap regarding AI's role in fostering critical thinking, a topic that has not been deeply explored in prior studies. The advantage of the randomization in Gen-AI tools is also an adversity for the creative process. One expert highlighted that the more specific the creative requirement, the harder it is for Gen-AI to provide satisfactory results, often requiring users to experiment extensively. Both experts concluded that Gen-AI may not be ideal for promoting critical thinking in the creative process, as the tools often lack the depth required for complex problem-solving.

From a Project-Based Learning (PjBL) perspective, the use of Gen-AI tools aligns well with PjBL principles, helping students better define their design requirements and facilitating smoother project planning (Han & Cai, 2023). Gen-AI tools enabled students to research references, develop rationales, and avoid stagnation in the creative process. As a result, students were able to complete their final artworks more efficiently and with higher quality (Han & Cai, 2023). These findings support PjBL theories by demonstrating how real-world tools like Gen-AI enhance active learning and planning, thus addressing a theoretical gap in the understanding of AI's role in PjBL practices in creative fields.

Generated content from Gen-AI tools provides amazing images for references and inspiration, however participating students encountered discrepancies in the actual perspectives and structures of the design, thus, making it difficult to model in the actual 3D space. Certain realistic details were not convincing to support the idea that is being generated. An example observed during the study indicated that some participating students experienced difficulty aligning a circular top with an angular bottom, which led to a lack of functional coherence in the design. Students acknowledged Gen-AI tools—despite their limitations—as useful for sparking creativity and overcoming creative blocks (Tong et al., 2023) by accelerating the ideation stage to engage the artist with a direction to move forward within an allocated timeframe. The complex nature of producing 3D artworks, which requires both artistic and technical solutions, pushed

students to develop their metacognitive skills and critical thinking (Bhaduri et al., 2019; Huang et al., 2019).

At the time of the study, Gen-AI tools are limited to the pre-production conceptual art and ideation stage. This is because the produced outcome from Gen-AI tools is due to its' destructive nature of its workflow, making it difficult to make customized detailed adjustments when the layers are all collapsed into one. During this study, participating students expressed their interest in Gen-AI tools to assist in complex technical and automated tasks in other parts of the creative process. As the development of Gen-AI tools is still in its infancy, assimilating as supportive tools into the 3D software to be part of the process rather than the final outcome would be more productive.

Experts cautioned against over-reliance on Gen-AI tools, advising students to focus on strengthening their creative foundations and design principles. It is essential to understand that Gen-AI tools could only be replicated from existing data. This reminds us of the fact that Gen-AI is not here to replace but to assist in the production of creativity and expand our imagination. They emphasized that creative works should go beyond aesthetics to reflect deeper meanings, values, and personal expression, encouraging originality. This highlights the importance of students balancing technology with the development of their unique artistic voices.

Conclusion

This research conclusively demonstrated the impact of Gen-AI tools on students' creativity, time spent, critical thinking, processes, and workflow within Project-Based 3D Modeling. Statistical findings indicated positive results in enhancing creativity development and reducing the time spent on projects. Students drew inspiration from images generated by Gen-AI tools, which effectively sparked ideation for their designs. The support provided by Gen-AI accelerated project progress, particularly during the pre-production stage of conceptual art development, enabling students to allocate more time to tackle technical challenges in later phases.

However, the study also revealed mixed reactions concerning the development of critical thinking skills and the overall influence of Gen-AI on the creative process. While Gen-AI tools were effective in supporting the early stages of the creative workflow, their influence appeared to diminish in the later phases of production. Students nonetheless demonstrated resourcefulness, often relying on their prior knowledge and problem-solving abilities to overcome challenges. Furthermore, the study highlighted ethical concerns related to the potential over-reliance on Gen-AI tools, raising important questions about their long-term implications for creative education and industry practices.

These findings align with the theories underpinning this study. Amabile's Componential Model (Amabile & Pratt, 2016) and the Four C Model (Kaufman, 2007) highlight external influences in fostering creativity, reflected in students' use of Gen-AI during ideation. Conceptual combination theory (Kozbelt et al., 2010) supports how students synthesized AI-generated images with cultural references, reinforcing cognitive creativity. However, inconsistencies in AI outputs emphasized the importance of Facione's Critical Thinking Model (2015), particularly in analysis and self-regulation. The students' problem-solving approaches

also align with constructivist learning theory, which emphasizes active learning, and Project-Based Learning (PjBL) (Jeon et al., 2014), which promotes adaptive problem-solving. While Gen-AI enhanced ideation, its limitations reinforce the need for foundational skills and critical engagement, as emphasized by these models.

Recommendations

As Gen-AI continues to play a growing role in creative processes, this study suggests that 3D modeling education should embrace Gen-AI through activities specifically tailored to fit the course's objectives. Rather than treating Gen-AI as a replacement for traditional methods, educators should use it as a collaborative tool to support students in brainstorming ideas, solving problems, and improving workflow efficiency. By designing structured activities that combine AI-assisted creativity with hands-on technical skill development, students can benefit from AI while still building a strong foundation in essential skills.

Educators and university administrators are also encouraged to explore how Gen-AI can enhance learning outcomes. By integrating AI-driven approaches, they can create learning experiences that inspire creativity and critical thinking, helping students develop both technical expertise and flexible problem-solving abilities. Looking ahead, future research should focus on identifying the best ways to incorporate Gen-AI into education while upholding academic integrity and addressing ethical concerns.

Limitations and Future Research

This study faced limitations due to a small sample size, influenced in part by anti-AI sentiments within the current creative community. The limited number of participants was the result of a low response rate from students willing to be involved in the study. While it is commendable that students upheld ethical practices to protect their artistic and academic integrity, the findings are based solely on data from one institution and a limited demographic (Hutson & Lang, 2023). Furthermore, the study observed limited diversity within the sample, particularly in terms of age range, as participants were exclusively college students aged between 20 and 30 years.

Future research should aim to increase the sample size, broaden participant demographics, and extend the study duration to explore the long-term effects of Gen-AI tools. At the time of this study, the availability of AI tools aligned with the 3D production process was still limited. As noted by Chiu et al. (2023) and Hutson et al. (2023), further research and development of these tools is needed to address this gap and enhance their practical integration into creative workflows.

Given the current divide between the anti-AI movement and artists who embrace Gen-AI tools, it would be valuable to revisit this topic once the landscape has stabilized (Tong et al., 2023). Future studies are encouraged to explore the perceptions and perspectives of students, educators, and the wider community to promote constructive dialogue and address misunderstandings about Gen-AI tools (Shi et al., 2023; Chiu et al., 2023).

Declarations**Conflict of Interest**

All authors declare that they have no conflict of interest.

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