SCIENTIFIC CULTURE

www.sci-cult.com

SCIENTIFIC CULTURE, Vol. 12, No. 2.1, (2026), pp. 13294-13313
Open Access. Online & Print

DOI: 10.5281/zenodo.20386728

THE EFFECT OF AI-ASSISTED LEARNING ON VISUAL COMMUNICATION DESIGN ACHIEVEMENT AND CREATIVITY AMONG UNDERGRADUATE ART AND DESIGN STUDENTS: A QUASI-EXPERIMENTAL STUDY

Li Xin[1], Chau Kien Tsong[1], and Wan Ahmad Jaafar Wan Yahaya[1]

[1]Centre for Instructional Technology and Multimedia, Universiti Sains Malaysia, 11800 Pulau Pinang, Malaysia.
lixin22@student.usm.my (L. Xin), chaukientsong@usm.my (Chau K. T.), wajwy@usm.my (W. Yahaya)
0009-0008-6217-669X (L. Xin), 0000-0003-1896-7239 (Chau K. T.), 0000-0002-8605-0062 (W. Yahaya)

Received: 01/03/2026
Accepted: 26/04/2026

Corresponding Author: Li Xin (chaukientsong@usm.my;)

ABSTRACT

Generative artificial intelligence is increasingly being adopted in creative education, but empirical evidence remains limited on whether structured image-generative tools improve undergraduate visual communication design outcomes. This study examined the effect of Adobe Firefly-assisted learning on visual communication design achievement (VCDA) and visual creativity among undergraduate art and design students. A quantitative quasi-experimental non-equivalent control group pretest-posttest design was employed with 90 students from two intact classes in a university in Shanxi Province, China. The experimental group (n = 45) received seven weeks of structured Adobe Firefly-assisted learning, while the control group (n = 45) received conventional instruction. Both groups studied the same weekly topics, including plane composition, colour composition, three-dimensional composition, pattern creation, typography, logo design, and poster design. VCDA was measured before and after the intervention, while creativity was measured at post-test using the adapted Scale of Visual Creativity in Art. Data was analyzed using ANCOVA with pre-test VCDA as the covariate. Descriptive results showed higher post-test scores for the Adobe Firefly group in VCDA (M = 75.94, SD = 7.45) than the conventional group (M = 70.98, SD = 8.58), and in creativity (M = 81.30, SD = 8.48) than the conventional group (M = 72.77, SD = 9.92). ANCOVA confirmed significant group effects for VCDA, $F(1, 87) = 14.475$, $p < .001$, $\eta^2 = .001$, and creativity, $F(1, 87) = 18.570$, $p < .001$, $\eta^2 = 0.002$. The findings indicate that structured Adobe Firefly-assisted learning can support achievement and creativity when embedded in guided design pedagogy. Future studies should use randomized designs, creativity pre-tests, longitudinal follow-up, and mixed-method evidence.

KEYWORDS: Generative AI; Adobe Firefly; Visual communication design; Design creativity; Quasi-experimental study; Text-to-Image Generation; design education innovation.

1. INTRODUCTION

The integration of artificial intelligence (AI) into higher education has gained significant momentum, especially following the rapid advancements in generative AI tools capable of generating text, images, audio, video, and design outputs based on natural language prompts (Wajeed, 2026). In educational contexts, generative AI has transcended its traditional roles of information retrieval and automatic teaching. This technology is currently employed to facilitate various processes, including idea generation, feedback provision, content creation, design exploration, and the development of personalized learning activities. UNESCO has highlighted the importance of incorporating generative AI into educational frameworks via a human-centered methodology that safeguards learner agency, encourages responsible usage, and ensures that the integration of technology aligns with pedagogical objectives, rather than supplanting human judgement (Tolosa et al., 2025).

In the realm of higher education, the integration of AI-assisted learning has garnered increasing interest due to its potential to enhance students' learning experiences. This technology facilitates immediate feedback, provides adaptive suggestions, and promotes repeated improvement in educational outcomes. Kasneci et al., (2023) posited that large language models and associated AI systems present opportunities for personalized learning, interaction, and the generation of educational content. However, they also introduce challenges concerning accuracy, dependency, ethics, and assessment. Additionally, Lee et al., (2024) identified that generative AI significantly influences teaching and learning within higher education, particularly in the ways educators reconsider instructional support, assessment design, and the learning practices of students.

The relevance of AI-assisted learning is especially strong in art and design education. In contrast to disciplines that focus solely on content, art and design programs require that students cultivate innovative concepts, investigate various visual alternatives, assess aesthetic choices, and refine their creations through a process of reflection. The field of visual communication design is fundamentally reliant on the synthesis of various elements, including creativity, composition, typography, color, visual hierarchy, symbolic meaning, and interpretation by the audience. Students are required to not only finalize a design product but also to participate actively in the design process. Consequently, the utilization of AI tools could prove advantageous in contexts such as thinking support, visual experimentation, style comparison, and gradual enhancement processes.

Recent investigations indicate that generative AI may hold significant promise in creative learning environments; however, the existing evidence is inconclusive and necessitates further empirical examination. Habib et al., (2024) investigated the influence of generative AI on student creativity, revealing that while AI can facilitate creative thinking, its imprudent application may negatively impact creative confidence and originality. Hwang and Wu (2025) indicated that generative AI is linked to the creative cognition of design students, with self-efficacy and anxiety reduction serving as interceding factors. The results indicate that AI has the potential to enhance creativity not only through the generation of output but also by influencing students' approaches to creative tasks, their self-perception of abilities, and their management of uncertainty throughout the design process.

Concurrently, the incorporation of AI within design education necessitates a cautious and methodical approach. The evaluation of creativity in art and design extends beyond merely quantifying the ideas produced or assessing the aesthetic appeal of the final product. The process contains elements such as originality, intentionality, critical judgement, problem framing, and the capacity to prove design decisions. In a study conducted by Wagler (2025) focusing on the application of generative AI within an advertising design and layout course, it was observed that students utilized AI to facilitate ideation and explore alternative workflows. However, they also acknowledged the importance of maintaining a balance between AI support and the preservation of originality and strategic creativity. The significance of this lies in the potential of AI-generated outputs to assist students in exploring visual possibilities; however, it remains essential for students to critically evaluate, adapt, and transform these outputs in alignment with specific design objectives.

In the current investigation, Adobe Firefly was chosen as the AI-assisted learning tool for the experimental group. Adobe Firefly represents a generative AI platform specifically engineered for the purpose of creative production (Quan, 2025). This system enables users to produce images based on textual prompts, generate variations of images, alter visual styles, modify color and lighting, affect composition using reference images, and enhance outputs with tools like Generative Fill. Adobe characterizes Firefly as a resource that facilitates creative exploration through the generation of

various image suggestions based on user prompts, while also enabling users to edit, regenerate, and refine the resulting outputs. This approach is particularly appropriate for educational activities in visual communication design, encompassing tasks such as concept development, mood-board creation, exploration of visual styles, poster design, advertising layout, and iterative design enhancement.

In the context of the experimental group within this study, Adobe Firefly was employed as a structured learning support tool, intentionally designed to complement rather than supplant student creativity or teacher instruction. Students employed Adobe Firefly to create preliminary visual references, investigate various design concepts, assess different stylistic approaches, and enhance visual compositions throughout their weekly design assignments (Jiang, 2024). The instructor facilitated critical learning with AI outputs by prompting students to articulate their choices of prompts, assess the generated visuals, adjust outputs in alignment with design principles, and create final works that reflect their individual design decisions. The control group, by contrast, was subjected to traditional instructional methods that did not incorporate the systematic application of Adobe Firefly.

While earlier research has explored the impact of generative AI on higher education and creative learning, there remains a scarcity of quantitative data regarding its influence on undergraduate art and design education, especially concerning learning creativity. A considerable number of current investigations concentrate on the overarching applications of artificial intelligence, educators' perceptions, writing assignments, or learners' attitudes towards AI. A limited number of investigations have focused on a particular generative AI design tool within the context of a controlled instructional intervention. This establishes a distinct area for investigation: it is still unclear if the systematic application of an AI-driven creative tool like Adobe Firefly can notably enhance the achievement and creativity of undergraduate art and design students in comparison to traditional teaching methods.

Table 1: Summary of recent studies on generative AI, art or design education, and creativity.

Study	Context and participants	AI tool/ Intervention	Method	Main findings	Limitation/Gap related to the present study
Bian et al. (2025)	Visual art education with 78 fifth-grade students	AI-generated images using Stable Diffusion	Quasi-experimental treatment-control design	The treatment group showed higher classroom engagement and self-efficacy, with no significant increase in cognitive load. Student artworks were also evaluated for technical skill, theme adherence, composition, creativity, effort, and improvement.	The research concentrated on elementary school visual art, excluding university visual communication design. It did not analyze Adobe Firefly or design accomplishments in higher education.
Hwang and Wu (2025)	Design students in universities in southern China, n = 121	General generative AI use in design education	Quantitative survey with mediation analysis	Generative AI positively influences innovative thinking. Self-efficacy and anxiety reduction mediated the relationship between AI use and creative cognition.	The research was survey-based and did not include structured classroom intervention involving experimental and control groups.
Abrusci et al. (2025)	Design students, n = 31	AI4Design system using ChatGPT and image generation	Exploratory field evaluation	The system supported course-project development and improved conceptual clarity, visual outputs, and creativity over a short intervention period.	The intervention was brief, lasting just two to three days, and was exploratory in nature. The authors emphasized the need for more extensive experimental validation.

Fleischmann (2024)	Graphic design students, n = 17	Generative AI in graphic design education	Student survey	Students showed pragmatic acceptance of GenAI and wanted more guidance on how to use it effectively and ethically in studio practice.	The research focused on student attitudes instead of assessing learning results, creativity, or design accomplishments.
Georgieva and Georgiev (2025)	Students in a creative design course, mainly non-design students	Text-based generative AI for design creativity inquiries	Structured inquiry and iterative prompt-based creative tasks	Students used prompts, interacted with AI outputs, and refined creative ideas through iteration. The study showed that AI can stimulate imagination and support design ideation.	The emphasis was mostly on text-based AI and brainstorming, rather than on visual communication design accomplishments or visual production using Adobe Firefly.
Medel-Vera et al. (2025)	Architectural education context	Generative AI image tools, including Midjourney	Mixed-methods study using prompt analysis, image evaluation, Creativity Support Index, and sentiment analysis	GenAI supported exploratory and goal-directed creativity. The study emphasized prompt literacy and reflective design as important parts of AI-supported design pedagogy.	The setting pertained to architecture education, rather than undergraduate visual communication design. It emphasized perception and creative assistance instead of pretest-posttest accomplishment evaluation.
Chen and Hung (2026)	Master's students in a Digital Culture course, n = 14	Generative AI integrated with design thinking and narrative-based aesthetic education	Qualitative instructional design-based research	GenAI lowered technical barriers, supported rapid visualization, and strengthened narrative immersion and emotional engagement.	The research was qualitative, used a limited graduate sample, and did not employ a quasi-experimental methodology or compare AI-assisted learning with traditional education.

This research examines the impact of AI-assisted learning on the levels of achievement and creativity in undergraduate students specializing in art and design. A quantitative quasi-experimental design featuring a non-equivalent control group with pretest and posttest measurements was utilized. The research comprised a sample of 90 undergraduate students, divided equally into an experimental group of 45 participants and a control group of 45 participants. The duration of the intervention was seven weeks. The experimental group engaged with Adobe Firefly within the framework of structured AI-assisted learning activities, whereas the control group was subjected to traditional instructional methods. The analysis of covariance (ANCOVA) was employed to assess the differences between the two groups, while simultaneously controlling the pre-test scores (Dugard & Todman, 1995).

Based on the above discussion, this study addresses the following research questions:

- RQ1: To what extent does AI-assisted learning using Adobe Firefly influence undergraduate art and design students' visual communication design achievement, when compared with conventional instruction?
- RQ2: To what extent does AI-assisted learning using Adobe Firefly influence undergraduate art and design students' creativity,

when compared with conventional instruction?

Based on these questions, the following null hypotheses were tested:

- $H_0$1: There is no significant difference in visual communication design achievement between students who receive AI-assisted learning using Adobe Firefly and those who receive conventional instruction, after controlling for pre-test scores.
- $H_0$2: There is no significant difference in creativity between students who receive AI-assisted learning using Adobe Firefly and those who receive conventional instruction, after controlling for pre-test scores.

This research holds significant implications for curriculum developers and design educators, as it offers a scalable model for integrating generative AI into studio-based pedagogy while maintaining a focus on human-centric design principles. By providing empirical evidence regarding the efficacy of AI-assisted tools on specific learning outcomes, this study serves to demystify the tension between technological adoption and creative integrity. In this work, literature review provides a comprehensive review of the relevant literature on AI-integrated design education. Research methodology includes experimental design, data collection instruments, and the specific pedagogical procedures used. Results present the statistical findings and analyses of the study, while discussion part presents the implications of these results, offers pedagogical recommendations, and addresses the limitations of the current study.

2. LITERATURE REVIEW

2.1. AI-Assisted Learning in Higher Education

The integration of AI-driven technologies in educational contexts serves to systematically enhance the pedagogical process (Sajja et al., 2025). This is achieved through mechanisms such as adaptive guidance, repeated frameworks, and the generation of creative content. The landscape of higher education has shifted significantly with the rapid emergence of generative AI, moving the conversation from merely assessing the Practicality of AI integration in educational settings to emphasizing the imperative for its responsible, organized, and purposeful application (Gruenhagen et al., 2024). The development of contemporary generative tools enables the synthesis of intricate visual concepts and facilitates repeated feedback mechanisms. Their utilization exceeds conventional information-processing functions, presenting considerable implications for practice-oriented fields, particularly in visual communication design.

Studies suggest that the incorporation of AI within higher education presents a complex array of challenges that Instructional requires, ethical, and institutional governance factors. Chan (2023) proposed a framework for AI ecological education policy, arguing that universities should transcend sporadic technological implementation to tackle fundamental challenges related to accountability, privacy, and infrastructure. This viewpoint is essential for the current investigation, as it positions AI-assisted learning not merely as a related, unregulated tool, but as a purposeful element of instructional design characterized by distinct pedagogical goals and limitations.

Moreover, UNESCO emphasizes the importance of adopting a human-centered approach, promoting the implementation of AI that focuses on learner agency, equitable access, and ethical integrity. The guidance provided by UNESCO indicates that the rapid advancement of AI technology has surpassed the capabilities of numerous current institutional policies, frequently resulting in a lack of frameworks for educators to assess the effectiveness of tools or safeguard intellectual property (Tolosa et al., 2025) This discrepancy indicates that current studies should shift from informal or perception-based narratives to a thorough investigation of particular instructional interventions, evaluating the operational effectiveness of identifiable AI tools within structured, domain-specific educational settings.

This study defines AI-assisted learning as a systematic instructional Interference, contrasting it with the notion of an open, unsupervised tool application. The proposed design positions Adobe Firefly as a facilitator for visual ideation, style exploration, and incremental enhancement. This approach emphasizes the role of technology as a collaborator in the creative process, rather than a replacement for human decision-making. Transitioning from unstructured, high-dependency usage, which frequently leads to superficial results and diminished authorship, this structured methodology necessitates that students critically assess AI-generated outputs, substantiate their creative choices in accordance with design principles, and uphold intellectual oversight throughout the design process.

2.2. Generative AI and Art and Design Education

Art and design education is fundamentally process-driven, requiring a transition from issue

analysis to conceptualization, visual experimentation, critical evaluation, and final refining. In visual communication design, this repetitive procedure necessitates that students integrate creativity with fundamental skills such visual literacy, composition, typography, and color theory. Generative AI rapidly generates a wide range of visual options from natural language indications, acting as a robust framework for the first phases of the design process, such as Creative thinking, mood-board creation, and layout exploration (Süner-Pla-Cerdà et al., 2025).

Adobe Firefly is especially relevant to this research since it is designed exclusively for creative production processes, seamlessly integrating with industry-standard apps (Lee, 2025). These talents correspond with the instructional demands of visual communication design, whereby students often assess several visual directions prior to arriving at a solution. The educational value of Adobe Firefly is not in automating final output production, but in broadening the student's creative capacity, a process aptly termed "creative scaffolding." The student retains the essential duty for design judgement, assessing the alignment with communication purpose and adjusting outputs to conform to fundamental standards. The "human-in-the-loop" criterion is crucial for guaranteeing that students Adapt design thinking instead of depending on the technology as a passive generator.

The transition to AI-integrated learning also cut down the cognitive stress linked to initial design activities. Employing generative AI to visualize many conceptual "what-if" possibilities enable students to swiftly externalize their internal mental models, facilitating a quick comparative study of design trajectories. This capacity enables a greater frequency of repeated loops, a characteristic of professional design practice, which were previously limited by time-consuming manual drawing or software-intensive prototyping. Thus, the tool functions as a cognitive collaborator, allowing students to investigate diverse thinking methodologies while concurrently enhancing their skills in curating and assessing superior visual results (Kirschner & Erkens, 2006).

Contemporary research underscores the need to examine AI as a creativity-enhancing system rather than just a productivity tool. Hwang and Wu (2025) said that generative AI impacts creative cognition by enhancing self-efficacy and diminishing creative anxiety, thereby enabling learners to tackle open-ended design challenges with more confidence. Medel-Vera et al. (2025) illustrated that in design contexts, prompt literacy serves as a crucial mediator for effective integration, converting the student from a passive consumer of AI output into an active participant who must critically evaluate, refine, and transform raw material into purposeful, significant work.

However, despite these insights, a research gap persists while these studies highlight the potential benefits of AI on cognition and anxiety, there is a lack of quantitative evidence on the direct effects of a structured pedagogical intervention, specifically one using Adobe Firefly, on visual communication proficiency and creative quality in an undergraduate context. This work tries to systematically quantify these consequences by moving from the promise of theory to real verification.

Table 2: Integration of Adobe Firefly into the Visual Communication Design Process.

Design Stage	Traditional Workflow	AI-Enhanced (Adobe Firefly) Workflow	Pedagogical Value
Ideation	Hand sketching / Brainstorming	Rapid visual prompt generation	Increases divergent thinking speed
Mood-boarding	Manual gathering / Curation	AI-assisted mood-board expansion	Broadens aesthetic exploration
Iterative Refinement	Manual revisions / Editing	Generative Fill / Variation creation	Accelerates the critique-revise cycle
Design Evaluation	Instructor-led feedback	Critical appraisal of AI outputs	Fosters design judgment/intent

2.3. Theoretical Framework

This research is based on the principles of constructivist learning theory and cognitive load theory (Vogel-Walcutt et al., 2011). The two perspectives presented offer a robust framework for clarifying the potential impact of Adobe Firefly-assisted learning on the visual communication design achievements and creative capacities of undergraduate art and design students. The framework conceptualizes generative AI as an enhancement to student creativity rather than a substitute, serving as a systematic learning aid that facilitates the exploration, evaluation, and refinement of visual concepts throughout the design process (Khlaif et al., 2025).

The constructivist learning theory posits that learners engage in the active construction of knowledge through various processes, including experience, interaction, experimentation, and reflection (Kaufman, 1996). In the realm of visual communication design education, it is evident that students engage in a learning process that transcends

mere information reception from the instructor. Individuals engage in the process of understanding a design challenge, formulating concepts, exploring visual alternatives, obtaining critiques, refining their outputs, and rationalizing their ultimate design choices. This process holds significant importance in studio-based learning, wherein the comprehension of design evolves through iterative cycles of ideation, critique, and refinement. Viewed through this lens, Adobe Firefly may serve as a tool for visual structure. This process enables students to create initial visual references, evaluate various styles, experiment with diverse compositions, and enhance design concepts through interaction driven by prompts. The implementation of these activities facilitates active exploration, prompting students to engage in more intentional design decision-making rather than solely depending on static examples or instructor-led demonstrations.

The principles of cognitive load theory clarify the impact of AI-assisted learning on design tasks (Alam et al., 2026). Visual communication design necessitates that students navigate multiple cognitive challenges concurrently, encompassing aspects such as concept development, composition, typography, color, visual hierarchy, technical execution, and audience interpretation. First-time designers often encounter challenges during the initial phases of a design task, especially when they face difficulties in converting abstract concepts into visual representations. Adobe Firefly has the potential to simplicity cognitive load by facilitating the rapid externalization of initial design concepts among students. The generation of multiple visual possibilities from text prompts allows students to allocate reduced effort towards the creation of initial visual references. This enables them to focus more on the evaluation, selection, modification, and enhancement of design solutions. AI-assisted learning has the potential to enable students to dedicate greater cognitive resources to advanced design thinking processes, including originality, communication objectives, aesthetic evaluation, and conceptual precision.

The theoretical framework of this study is guided by the notion of human-AI co-creation (Chandra & Rahman, 2024). This research utilizes Adobe Firefly as a creative support mechanism within a structured instructional framework. It is not anticipated that students will present AI-generated outputs as final designs without any alterations. Rather than simply executing tasks, individuals are tasked with crafting prompts, evaluating generated images, contrasting various alternatives, modifying visual components, and providing rationales for their design decisions in alignment with established principles of visual communication. The instructor's position is crucial, as students require direction in assessing the appropriateness, originality, significance, and alignment of AI-generated visuals with the design brief. Consequently, the educational framework operates in a human-in-the-loop model, where AI expands the space of visual options and learners are responsible for creative evaluation and final design decisions (Fajardo-Ramos et al., 2025).

Utilizing this framework, it is anticipated that Adobe Firefly-assisted learning will impact visual communication design achievement by enhancing students' capabilities to formulate clearer concepts, create stronger compositions, select more appropriate visual styles, and produce more comprehensive design outcomes. The anticipated impact on creativity is linked to the enhancement of students' exposure to a variety of visual possibilities, coupled with the promotion of iterative refinement processes. Consequently, the framework posits that the educational efficacy of Adobe Firefly is contingent not solely upon access to the tool, but also on its structured pedagogical application, critical reflection, and the creativity of students.

This study's conceptual framework posits that learning facilitated by Adobe Firefly functions as the independent instructional variable, whereas visual communication design achievement and creativity are identified as the primary dependent variables (ZAMBRI et al., 2024). The pre-test scores are adjusted to mitigate the impact of initial disparities observed between the experimental and control groups. This framework supports the implementation of a quasi-experimental pretest-posttest control group design to investigate the extent to which structured Adobe Firefly-assisted learning leads to quantifiable enhancements in design achievement and creativity among undergraduate art and design students, in contrast to traditional instructional methods.

3. Methodology

3.1. Research Design

This research utilized a quantitative quasi-experimental non-equivalent control group pre-test and post-test design to investigate the impact of AI-assisted learning on visual communication design achievement and creativity in undergraduate art and design students. A quasi-experimental design was deemed suitable due to the selection of participants from pre-existing intact classes, making random assignment of individual students impractical within

the institutional teaching framework (Gheysari et al., 2024). In this study, one intact class was designated as the experimental group, while another intact class was designated as the control group. Both groups underwent pre-test and post-test assessments prior to and following the seven-week instructional intervention.

The implementation of a non-equivalent control group pre-test and post-test design is prevalent in educational intervention studies, as it facilitates the comparison of learning outcomes between an intervention group and a comparison group, while also accounting for initial variations between the groups. According to Shadish et al., (2002), quasi-experimental designs are suitable in scenarios where researchers implement an intervention but are unable to randomly assign participants to different conditions. In a similar vein, Miller et al., (2020) observe that quasi-experimental designs frequently incorporate pre-post designs alongside a non-equivalent control group, particularly within the realms of applied education and health research.

The research was carried out in a real university teaching context hence it was not possible to randomly assign students to the experimental and control groups. Therefore, the study employed two intact classes. The study applied the non-equivalent control group design. To enhance methodological openness and eliminate possible risks to internal validity, both groups followed the same course schedule, learning objectives, weekly topics, task requirements, structure of teacher supervision, and evaluation processes. The only difference between the two groups was the instructional condition, in which the experimental group employed Adobe Firefly as a structured learning support tool, whereas the control group received traditional instruction without the systematic usage of Adobe Firefly. The ANCOVA models used pre-test VCDA scores as a covariate to account for baseline variations in visual communication design achievement between the two intact classes.

Table 3: Experimental design.

Groups	Pre-test	Intervention (7 weeks)	Post-test
Experimental group: (n = 45)	Pre-test visual communication design achievement (VCDA)	Adobe Firefly-assisted learning	❿ Post-test visual communication design achievement (VCDA)
			❿ Scale of Visual Creativity in Art (SVCA)
Control group: (n = 45)	Pre-test visual communication design achievement (VCDA)	Conventional learning	❿ Post-test visual communication design achievement (VCDA)
			❿ Scale of Visual Creativity in Art (SVCA)

3.2. Participants

In order to enhance the transparency of the group comparison, both groups were instructed on the same weekly material and were assigned comparable learning assignments. The final dataset consisted solely of students who successfully completed the mandatory pre-test, participated in the intervention activities, and completed the post-test measures. The final analysis excluded students who failed to complete the mandatory assessment procedures. Ninety undergraduate art and design students from a university in Shanxi Province, China, comprised the participants. The cohort was selected from two intact sections that were accessible for the visual communication design course during the intervention period. The number of pupils in each session was 45. Individual-level random assignment was not feasible due to the intervention's implementation within the standard classroom schedule. One of the intact classes was allocated to the conventional learning condition, while the other was assigned to the Adobe Firefly-assisted learning condition. This allocation was in accordance with the quasi-experimental non-equivalent control group design employed in the investigation.

One class was designated as the experimental group and was provided with Adobe Firefly-assisted learning, whereas the other class was designated as the control group and received traditional instruction (Jiang, 2024). Both groups engaged with identical visual communication design course content, executed the same learning tasks, and underwent assessment through the same pre-test and post-test instruments. The final analysis comprised participants who successfully completed the necessary pre-test, intervention activities, and post-test assessments.

The involvement of participants was on a voluntary basis, and prior to the collection of data, students were made aware of the objectives of the research. All participants provided informed

consent. Approval for ethical considerations was secured from the appropriate institutional ethics committee. Given that the sample was obtained from two intact classes within a single university, it is essential to evaluate the generalizability of the findings in relation to the specific context of undergraduate art and design education in China.

3.3. Instruments

This study utilized two instruments for data collection: a researcher-developed Visual Communication Design Achievement Instrument (VCDA) and an adapted Scale of Visual Creativity in Art (SVCA). The Visual Design Achievement Instrument was employed to evaluate students' visual design achievement prior to and following the intervention, whereas the adapted SVCA was utilized to assess students' visual creativity in the context of visual communication design learning.

3.3.1. Visual Communication Design Achievement Instrument (VCDA)

The achievement of students in visual communication design was assessed utilizing an instrument developed by the researcher, which included both pre-test and post-test forms. The instrument was developed to evaluate students' knowledge and performance in visual design prior to and following the seven-week intervention. This research defines the visual communication design achievement Instrument (VCDA) as the capacity of students to comprehend, implement, analyze, develop, and assess visual design concepts and solutions in connection with the designated learning tasks (Sun & Zhu, 2022).

The creation of the Visual Communication Design Achievement Instrument (VCDA) was informed by the course objectives, instructional content, and anticipated learning outcomes associated with the visual design course. The pre-test and post-test were designed in accordance with Bloom's Taxonomy, encompassing six cognitive levels: knowledge, comprehension, application, analysis, synthesis, and evaluation. The selection of these levels is predicated on the understanding that visual design education necessitates a depth of comprehension that extends beyond mere factual recall. It is anticipated that students will grasp design concepts, implement visual principles, examine design challenges, integrate visual ideas, and assess the efficacy of visual design results.

The evaluation material concentrated on essential elements of visual design, encompassing visual communication, composition, color application, visual hierarchy, cultural representation, design problem-solving, and the suitability of design choices. The pre-test was conducted prior to the intervention to determine the baseline visual design achievement of the students. The post-test was conducted after the intervention to assess variations in achievement resulting from Adobe Firefly-assisted learning compared to traditional instructional methods.

To maintain consistency in the evaluation process, both the pre-test and post-test were constructed in accordance with the identical assessment blueprint. Both forms evaluated the identical construct and cognitive levels, although the specific tasks were modified to mitigate practice effects. This methodology facilitated the assurance that any variation observed between pre-test and post-test scores was indicative of alterations in students' visual design achievement, rather than discrepancies in test structure or task difficulty.

The instrument was subjected to content validation through the evaluation of a panel comprising subject matter experts in the field of art and design education (Fahrenbach, 2022). The evaluation involved a thorough analysis of the assessment tasks' relevance, the clarity of the provided instructions, the suitability of the task difficulty, and the degree of alignment among the items, course objectives, and Bloom's cognitive levels. Modifications were implemented in response to the feedback provided by experts prior to the utilization of the instrument in the primary study.

3.3.2. Scale of Visual Creativity in Art (SVCA)

The measurement of students' creativity was conducted utilizing the Scale of Visual Creativity in Art (SVCA), which was adapted from the original version created by Akca and Kavak (2021). The SVCA was modified to assess students' visual creativity within the framework of learning about Chinese cultural artefacts. The adaptation was essential due to the current investigation's emphasis on visual design learning within higher education, wherein creativity manifests through design concepts, visual organization, cultural interpretation, and the communicative value of the final output.

The modified SVCA evaluated students' creativity through various dimensions, including originality, visual expression, elaboration, aesthetic organization, conceptual development, and relevance to the designated cultural theme. The selected dimensions were deemed suitable, as creativity in visual design extends beyond merely generating aesthetically pleasing images. The process

encompasses the capacity to produce significant concepts, convert cultural references into visual representations, systematically arrange visual components, and convey a distinct design purpose.

The wording and contextual focus of the original SVCA items were modified to align with the learning tasks and cultural content pertinent to the current study. The modified version underwent evaluation by specialists in the field to confirm that the scale retained conceptual alignment with the original tool, while also being appropriate for undergraduate students in visual design.

3.3.3. Validity and Reliability

A variety of procedures were implemented to enhance the validity and reliability of the research instruments. The Visual Communication Design Achievement Instrument (VCDA), developed by researchers, comprises 10 items and is structured in alignment with the course learning outcomes and Bloom's Taxonomy (Arneson & Offerdahl, 2018). The items encompassed six distinct cognitive levels: knowledge, comprehension, application, analysis, synthesis, and evaluation. This framework facilitated the evaluation of both fundamental and advanced cognitive skills pertinent to the acquisition of visual design knowledge.

The assessment of content validity was conducted by a panel consisting of three subject matter experts. The evaluation conducted by the experts focused on the relevance, clarity, difficulty level, and alignment of the items with the course objectives, learning outcomes, and intended cognitive levels. The feedback provided was instrumental in refining the wording, task requirements, and assessment criteria prior to the administration of the instrument in the study. The internal consistency reliability of the Visual Design Achievement Instrument demonstrated an acceptable level, indicated by a Cronbach's alpha coefficient of 0.82.

The modified Scale of Visual Creativity in Art (SVCA) comprised 21 items and was employed to evaluate students' visual creativity within the framework of Visual Communication Design education (Akca & Kavak, 2021). The revised SVCA underwent evaluation by the same trio of subject matter experts to confirm that the items were suitable for undergraduate visual design students and aligned with the creative dimensions necessary for the current study. The researchers conducted an analysis of the clarity, contextual relevance, and appropriateness of the modified items intended for assessing visual creativity within design-based learning tasks.

The examination of the internal consistency reliability of the adapted SVCA was conducted utilizing Cronbach's alpha. The modified SVCA demonstrated substantial reliability, evidenced by a Cronbach's alpha coefficient of 0.85. The findings suggest that both instruments demonstrated satisfactory internal consistency in assessing visual design achievement and visual creativity. The combination of the expert validation process and reliability analysis yielded substantial evidence indicating that the instruments were appropriate for application in the current quasi-experimental study.

3.4. Research Procedure

The intervention was conducted over a period of seven weeks, consisting of one lesson per week, each lasting one hour. The experimental group and the control group engaged in the same visual design topics and undertook similar learning tasks. The weekly topics were systematically organized in a progressive sequence: plane composition, color composition, three-dimensional composition, pattern creation, typography design, logo design, and poster design.

The participants in the experimental group were provided with learning facilitated by Adobe Firefly. Throughout each instructional session, learners engaged with Adobe Firefly to facilitate visual ideation, generate visual references, explore various styles, and refine their work iteratively. The instructor facilitated a critical evaluation of AI-generated outputs among students, encouraging them to revise their design works in alignment with established design principles and to exercise independent decision-making in their design processes. The output generated by AI was utilized as educational resources instead of being regarded as conclusive submissions.

The control group was subjected to traditional instructional methods. The students engaged with the same material via various instructional methods, including teacher-led explanations, visual demonstrations, manual sketching, design exercises, classroom discussions, and feedback from the instructor, all conducted without the systematic application of Adobe Firefly. The two groups received instruction according to an identical weekly schedule and were evaluated through consistent pre-test and post-test methodologies.

This methodology guaranteed that the two cohorts varied predominantly in their instructional strategies: The experimental group utilized Adobe Firefly-assisted learning, while the control group received conventional instruction. To reduce

instructional bias, both groups adhered to an identical teaching schedule, shared learning objectives, consistent design topics, uniform task requirements, and standardized assessment procedures. The same instructor provided instructions to both groups. The sole intended distinction between the two groups was the incorporation of Adobe Firefly within the experimental group.

Table 4: Seven-week learning content.

Week	Learning content	Experimental group: Adobe Firefly-assisted learning	Control group: conventional learning	Lesson duration
Week 1	Plane composition	Students used Adobe Firefly to explore visual balance, rhythm, contrast, and spatial arrangement through prompt-based visual references.	Students learned plane composition through teacher explanation, examples, sketching, and manual composition exercises.	1 hour
Week 2	Color composition	Students used Adobe Firefly to generate and compare color schemes, mood references, and visual atmosphere related to design tasks.	Students studied color theory, color matching, and emotional expression through conventional examples and manual exercises.	1 hour
Week 3	Three-dimensional composition	Students used Adobe Firefly to explore form, volume, spatial relationship, and visual depth as references for design development.	Students learned three-dimensional composition through teacher demonstration, visual examples, and traditional design practice.	1 hour
Week 4	Pattern creation	Students used Adobe Firefly to generate pattern references, compare motif variations, and refine cultural or decorative design ideas.	Students created patterns through manual ideation, sketching, reference analysis, and instructor feedback.	1 hour
Week 5	Typography design	Students used Adobe Firefly to explore visual style, typographic atmosphere, and possible integration between text and image.	Students learned typography design through conventional instruction, examples, layout practice, and teacher feedback.	1 hour
Week 6	Logo design	Students used Adobe Firefly to generate visual references for symbolic form, abstraction, and brand-related design directions.	Students developed logo concepts through brainstorming, sketching, simplification, and conventional critique.	1 hour
Week 7	Poster design	Students used Adobe Firefly to support final visual exploration, composition refinement, and integration of image, text, color, and message.	Students completed poster design through conventional design processes, including sketching, layout development, and instructor feedback.	1 hour

3.5. Data Analysis

The analysis of data was conducted utilizing IBM SPSS Statistics (Xiao et al., 2015). The initial examination of the dataset involved an assessment for the presence of missing values, identification of coding errors, detection of outliers, and evaluation of assumption violations. Descriptive statistics were computed, encompassing means and standard deviations, for the visual design achievement and visual creativity scores across both groups.

Analysis of Covariance (ANCOVA) was employed to investigate the influence of instructional conditions on the post-test results of students (Li & Chen, 2019). The independent variable identified in this study was group membership, which comprised an experimental group and a control group. The dependent variables included visual design

achievement measured through post-test assessments and visual creativity evaluated via post-test outcomes. The pre-test visual design achievement was incorporated as a covariate to account for the students' initial visual design proficiency.

Two ANCOVA models were implemented in the analysis (Philippas, 2024). The dependent variable in the initial model was the post-test visual design achievement. In the second model, the dependent variable was post-test visual creativity. In both models, group membership was incorporated as the fixed factor, while pre-test visual design achievement was included as the covariate.

Prior to the interpretation of the results, an examination of the assumptions underlying ANCOVA was conducted. This included assessing the normality of residuals, the linearity of relationships, the homogeneity of regression slopes, the homogeneity of error variances, and the identification of any influential outliers. The threshold for statistical significance was established at $p < .05$. Reported were the adjusted means, standard errors, F values, p values, and partial η^2 values.

The measurement of creativity was conducted solely at the post-test stage, leading to the interpretation of the creativity analysis as an adjusted comparison between groups at post-test, rather than as a change in creativity from pre-test to post-test. Table 5 represents the variable structure.

Table 5: Variable structure.

Independent variable	Covariate	Dependent variable
Experimental group: Adobe Firefly-assisted learning	Pre-test visual communication design achievement	Visual design communication achievement
Control group: Conventional learning	Pre-test visual communication design achievement	Creativity

4. RESULTS

4.1. Descriptive Statistics and Homogeneity of Variance Test

Table 6 presents the descriptive statistics for the Adobe Firefly-assisted learning group and the conventional learning group. Each group included 45 students. For the pre-test VCDA scores, the Adobe Firefly-assisted learning group obtained a mean score of 63.27 (SD = 7.441), while the conventional learning group obtained a mean score of 62.16 (SD = 8.423). The small difference between the two pre-test means suggests that the two groups were relatively comparable before the intervention.

Table 6: Descriptive statistics.

Variable	Groups	N	Minimum	Maximum	Mean	Std. Deviation	Std. Error
Pre-test VCDA	Adobe Firefly-assisted learning	45	49	80	63.27	7.441	1.109
	Conventional learning	45	38	76	62.16	8.423	1.256
Post-test VCDA	Adobe Firefly-assisted learning	45	59	91	75.94	7.452	1.107
	Conventional learning	45	46	86	70.98	8.575	1.278
Post-test SVCA	Adobe Firefly-assisted learning	45	59	98	81.30	8.481	1.264
	Conventional learning	45	55	90	72.77	9.915	1.478

After the intervention, the Adobe Firefly-assisted learning group showed higher mean scores than the conventional learning group in both outcome measures. For post-test VCDA, the Adobe Firefly-assisted learning group obtained a mean score of 75.94 (SD = 7.452), compared with 70.98 (SD = 8.575) for the conventional learning group. For post-test SVCA, the Adobe Firefly-assisted learning group also reported a higher mean score of 81.30 (SD = 8.481), compared with 72.77 (SD = 9.915) for the conventional learning group. These descriptive results indicate a higher post-test performance trend for students who received Adobe Firefly-assisted learning.

Before conducting further inferential analysis, the homogeneity of variance assumption was examined using Levene's test. As shown in Table 6, the results were non-significant for pre-test VCDA, $F(1, 88) = 0.772$, $p = .382$, post-test VCDA, $F(1, 88) = 1.690$, $p = .197$, and post-test SVCA, $F(1, 88) = 3.316$, $p = .072$. Since all p-values were greater than .05, the assumption of homogeneity of variance was satisfied. Therefore, the data was considered suitable for subsequent inferential analysis. Table 7 presents Levene's Test for Homogeneity of Variance.

Table 7: Levene's Test for Homogeneity of Variance.

		Levene Statistic	df1	df2	Sig.
Pre-test VCDA	Based on Mean	.772	1	88	.382
Post-test VCDA	Based on Mean	1.690	1	88	.197
Post-test SVCA	Based on Mean	3.316	1	88	.072

4.2. Visual communication design achievement (VCDA)

Table 8 presents the ANCOVA results for post-test visual communication design achievement (VCDA), with pre-test VCDA entered as the covariate. The overall ANCOVA model was statistically significant, $F(2, 87) = 74.151$, $p < .001$, indicating that the model explained a significant proportion of variance in post-test VCDA scores. The model accounted for 63.0% of the variance in post-test VCDA, with an adjusted R^2 value of .622.

The covariate, pre-test VCDA, was statistically significant, $F(1, 87) = 127.084$, $p < .001$. This result indicates that students' baseline VCDA scores were significantly associated with their post-test VCDA performance. After controlling pre-test VCDA, the effect of instructional approach was also statistically significant, $F(1, 87) = 14.475$, $p < .001$. This finding shows that there was a significant difference in post-test VCDA scores between the Adobe Firefly-assisted learning group and the conventional learning group after adjusting for initial achievement levels.

Table 8: ANCOVA Results for Post-test VCDA after Controlling for Pre-test VCDA.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	η^2
Corrected Model	1691.202[a]	2	845.601	9.894	<.001	0.002
Intercept	6977.849	1	6977.849	81.644	<.001	0.032
Pre-test VCDA	54.508	1	54.508	.638	.427	0.000
Group	1587.147	1	1587.147	18.570	<.001	0.002
Error	7435.611	87	85.467			
Total	543168.100	90				
Corrected Total	9126.813	89				
[a] R Squared = .185 (Adjusted R Squared = .167)						

4.2.1. Dependent Variable: Post-test VCDA.

1. R Squared = .630 (Adjusted R Squared = .622)

Together with the descriptive statistics, these results suggest that Adobe Firefly-assisted learning was associated with higher visual communication design achievement compared with conventional learning when baseline VCDA performance was controlled.

4.3. Creativity

Table 9 presents the ANCOVA results for post-test creativity, with pre-test VCDA entered as the covariate. The overall model was statistically significant, $F(2, 87) = 9.894$, $p < .001$, indicating that the model explained a significant proportion of variance in post-test creativity scores. The model accounted for 18.5% of the variance in post-test SVCA, with an adjusted R^2 value of .167.

The covariate, pre-test VCDA, was not statistically significant, $F(1, 87) = 0.638$, $p = .427$. This result indicates that students' baseline VCDA scores were not significantly associated with their post-test creativity scores. However, the effect of group was statistically significant, $F(1, 87) = 18.570$, $p < .001$. This finding shows that there was a significant difference in post-test creativity between the Adobe Firefly-assisted learning group and the conventional learning group after controlling pre-test VCDA.

Table 9: ANCOVA Results for Post-test Creativity (SVCA) after Controlling for Pre-test VCDA.

Dependent Variable: Post-test SVCA.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	η^2
Corrected Model	1691.202[a]	2	845.601	9.894	<.001	0.002
Intercept	6977.849	1	6977.849	81.644	<.001	0.032
Pre-test VCDA	54.508	1	54.508	.638	.427	0.000
Group	1587.147	1	1587.147	18.570	<.001	0.002
Error	7435.611	87	85.467			
Total	543168.100	90				
Corrected Total	9126.813	89				
[a] R Squared = .185 (Adjusted R Squared = .167)						

Together with the descriptive statistics, these results indicate that students in the Adobe Firefly-assisted learning group achieved higher creativity scores than those in the conventional learning group. Since creativity was measured only at post-test, this result should be interpreted as an adjusted group difference in post-test creativity rather than as a change in creativity over time.

4.4. Discussion

4.4.1. Interpretation of the VCDA Findings

The analysis of covariance (ANCOVA) indicated a statistically significant difference in post-test visual communication design achievement (VCDA) between the group utilizing Adobe Firefly for learning and the group engaged in conventional learning methods, after adjusting pre-test VCDA scores. The covariate, pre-test VCDA, demonstrated statistical significance, $F(1, 87) = 127.084$, $p < .001$, $\eta^2 = .59$, suggesting that students' prior achievement is a robust predictor of their post-test achievement. The observed outcome aligns with the hypothesis that students possessing a higher baseline of visual communication design knowledge prior to the

intervention tend to exhibit improved performance after the intervention (Liu et al., 2017).

The instructional group demonstrated a notable impact on post-test VCDA, $F(1, 87) = 14.475$, $p < .001$, $\eta^2 = .14$. This suggests that, after controlling students' initial achievement levels, participants who engaged in Adobe Firefly-assisted learning demonstrated superior VCDA scores compared to their counterparts who underwent traditional instruction. Consequently, the results substantiate the hypothesis that the utilization of Adobe Firefly in learning contexts correlates with enhanced outcomes in visual communication design achievement (Huang, 2024).

The findings indicate that Adobe Firefly potentially facilitated students' learning by enabling them to generate design concepts, investigate visual alternatives, enhance compositions, and evaluate various stylistic approaches with greater efficiency. In the field of visual communication design, it is essential for students to engage in critical decision-making regarding layout, color, hierarchy, imagery, and the conveyance of meaning. The implementation of Adobe Firefly likely facilitated enhanced visual support throughout these processes, enabling students to progress past the preliminary stages of idea generation and concentrate more on assessing and refining their design results.

4.5. Interpretation of the Creativity Findings

The results of the ANCOVA indicated a statistically significant difference in post-test creativity (SVCA) when comparing the Adobe Firefly-assisted learning group to the conventional learning group, following the adjustment for pre-test VCDA scores. The analysis revealed a statistically significant group effect, $F(1, 87) = 18.570$, $p < .001$, $\eta^2 = .18$. The findings suggest that students utilizing Adobe Firefly-assisted learning demonstrated superior post-test creativity scores compared to those who underwent traditional instructional methods (Muharni et al.,2025).

In contrast to the VCDA analysis, the covariate of pre-test VCDA did not demonstrate statistical significance concerning creativity, $F(1, 87) = 0.638$, $p = .427$. The findings indicate that the initial achievements of students in visual communication design did not serve as a significant predictor for their creativity scores on the post-test. The findings of this study indicate that the performance in creativity was not significantly accounted for by the students' previous achievements in VCDA. The instructional condition seemed to play a more significant role in elucidating the variance observed in post-test creativity.

The results indicate that the integration of Adobe Firefly in the learning process may have enhanced students' creative performance by providing increased opportunities for visual exploration, idea generation, style experimentation, and iterative refinement. In the context of design education, the manifestation of creativity is contingent upon a combination of technical proficiency and the capacity to generate innovative ideas, develop visual concepts, and refine design alternatives. Adobe Firefly appears to have facilitated students in comparing various visual directions and fostering a more adaptable approach to idea development compared to traditional instructional methods alone.

Creativity findings can be interpreted through the lens of creativity theory, particularly the role of divergent thinking, idea generation, elaboration, and iterative refinement. In visual communication design, creativity is not limited to the production of visually appealing outcomes. It also involves generating multiple possible solutions, transforming initial ideas into meaningful visual concepts, evaluating alternatives, refining compositions, and justifying design decisions. Adobe Firefly may have supported these processes by expanding students' exposure to visual possibilities and enabling rapid comparison of alternative styles, layouts, colors, and symbolic forms. This process likely encouraged students to move beyond a single initial idea and engage in repeated cycles of exploration, selection, modification, and reflection.

From a human-AI co-creation perspective, the tool functioned as a creative scaffold rather than as an autonomous source of final design work. Students were required to construct prompts, evaluate AI-generated images, revise outputs, and align final designs with visual communication principles. This supports the view that generative AI can enhance creativity when it is embedded in guided pedagogy and when students remain responsible for originality, judgment, and final design decisions. Therefore, the significant group effect for creativity suggests that Adobe Firefly-assisted learning may have improved creative performance by strengthening students' opportunities for divergent exploration and reflective refinement within the design process.

Nevertheless, it is essential to approach this result with a degree of caution in interpretation. The measurement of creativity exclusively at the post-test stage necessitates caution in interpreting the findings as direct evidence of improvement in creativity over time. The findings indicate that the group utilizing Adobe Firefly for learning achieved notably higher

post-test creativity scores compared to the traditional learning group, after adjusting for pre-test VCDA scores. Consequently, the findings lend support to the hypothesis that structured learning facilitated by Adobe Firefly correlates with enhanced creativity performance in post-test assessments.

4.5.1. Theoretical and Pedagogical Implications

The results present significant theoretical and pedagogical implications regarding the incorporation of generative AI within the realms of art and design education. From a theoretical standpoint, the findings indicate that the learning process in visual communication design is enhanced when students engage in active knowledge construction through exploration, experimentation, and iterative revision. The integration of Adobe Firefly in the learning process afforded students the chance to create visual alternatives, evaluate various design options, and enhance their projects through iterative engagement. This process aligns with the principles of constructivist learning, emphasizing that students cultivate understanding through active learning instead of merely receiving information passively (Wang et al., 2025).

The results indicate that generative AI may serve as a type of visual scaffolding. In traditional design education, learners often dedicate significant time to generating preliminary concepts or converting abstract ideas into visual representations. Adobe Firefly has the potential to alleviate certain challenges encountered in the initial stages by enabling students to generate preliminary visual outputs with greater efficiency. This enables students to concentrate more on advanced design considerations, including composition, visual hierarchy, color selection, symbolic significance, and audience engagement. In this context, artificial intelligence does not supplant the learning process; rather, it serves to assist students in achieving more advanced levels of design thinking.

From a creativity standpoint, the notable group effect observed in the post-test SVCA indicates that AI-assisted learning could facilitate divergent thinking and iterative development. Students who engaged with Adobe Firefly experienced enhanced opportunities for exploring various visual directions and refining their concepts. The significance of this matter lies in the fact that creativity within design education is contingent not merely upon the generation of original work, but also on the assessment of alternatives, the enhancement of concepts, and the rationale behind design choices. Consequently, generative AI ought to be regarded as an instrument for creative inquiry instead of a provider of definitive solutions (Abrusci et al., 2025).

The findings suggest that the integration of AI tools into design courses should be facilitated through carefully structured learning activities. Merely permitting students to utilize Adobe Firefly does not meet the necessary requirements. It is essential for educators to develop assignments that compel students to articulate their prompts, analyze AI-generated outputs, refine visual results, and contemplate the effectiveness of specific design decisions. This facilitates the maintenance of students as active participants in the decision-making aspects of the design process.

The results further underscore the ongoing significance of educator support. It is essential for educators to assist learners in critically assessing AI-generated images, recognizing deficiencies in visual composition, mitigating excessive dependence on automated outputs, and preserving originality in their creations. It is essential to establish clear assessment criteria to ensure that students recognize that the quality of their final design is contingent upon several factors, including concept development, visual reasoning, the refinement process, and the ethical application of AI, rather than solely on the aesthetic appeal of AI-generated images.

4.5.2. Practical Implications for Art and Design Education

The results yield numerous practical implications for the field of art and design education. Initially, Adobe Firefly serves as an auxiliary resource in visual communication design curricula, particularly in the preliminary phases of the design workflow. Students frequently encounter challenges in the ideation phase, the selection of visual styles, and the conversion of abstract concepts into tangible visual representations. Adobe Firefly facilitates the exploration of various design possibilities for students, potentially enhancing the processes of idea development, visual experimentation, and design refinement.

Secondly, the integration of generative AI into studio-based learning should occur through the implementation of structured tasks, rather than employing it as an unstructured tool devoid of guidance. Educators have the capacity to develop activities that necessitate students to formulate prompts, produce visual alternatives, analyze various outputs, refine chosen designs, and articulate their final design rationale. This methodology facilitates the integration of AI into educational

experience, enabling students to enhance their visual judgment and creative reasoning skills concurrently.

Third, Adobe Firefly has the potential to facilitate differentiated learning within design classrooms. Students exhibiting less proficiency in technical skills could potentially gain from AI-generated visual references that facilitate their comprehension of layout, color, composition, and style. Concurrently, students possessing more developed design skills may utilize the tool to explore advanced visual directions and enhance their conceptual frameworks. AI-assisted learning has the potential to offer adaptable support tailored to students exhibiting varying degrees of design proficiency.

Instructors are encouraged to provide a clear delineation of the function of AI within the context of assessment. It is imperative that students are assessed beyond merely the aesthetic appeal of AI-generated outputs. The evaluation criteria must encompass the uniqueness of the concept, the caliber of prompt development, alignment with the design brief, the refinement process, the efficacy of visual communication, and the student's capacity to articulate the rationale behind their design decisions. This is crucial to mitigate the risk of passive reliance on images generated by artificial intelligence (Khlaif et al., 2025).

It is essential that art and design programs incorporate AI literacy into their curriculum. It is essential for students to comprehend not only the operational aspects of Adobe Firefly but also to engage in a critical evaluation of its outputs. This encompasses an understanding of authorship, originality, bias, copyright considerations, ethical practices in image generation, and the responsible utilization of prompts. This training is instrumental in equipping students to utilize AI tools in a professional and ethical manner within their future design practices.

4.5. Limitations

It is essential to acknowledge several limitations that may influence the interpretation of the findings presented in this study. The research employed a quasi-experimental design utilizing intact classes. While ANCOVA was employed to account for pre-test VCDA, it is important to note that the students were not randomly assigned to the groups. Consequently, the presence of uncontrolled variations between the two classes, including factors such as motivation, prior design experience, digital literacy, or familiarity with AI tools, could have impacted the outcomes observed in the study.

The intervention was implemented over a duration of seven weeks within a singular institutional context. This timeframe was suitable for investigating immediate learning outcomes; however, it does not provide insights into the persistence of the effects associated with Adobe Firefly-assisted learning over an extended duration. The applicability of the findings may be constrained when considering other universities, diverse student populations, various design courses, or differing cultural contexts.

The assessment of creativity was conducted solely at the post-test phase. This study facilitates a comparison of creativity scores between the two groups following the intervention; however, it does not enable a direct assessment of whether there was an improvement in students' creativity from the pre-test to the post-test. Subsequent research should incorporate both pre-test and post-test assessments of creativity to yield more robust evidence regarding the development of creative abilities.

The investigation concentrated explicitly on the learning facilitated by Adobe Firefly. Various generative AI tools may yield distinct learning outcomes due to differences in their interface design, output quality, accessibility, and usability within educational settings. Consequently, it is imperative that the results are not indiscriminately applied to all AI-based design tools.

The research primarily utilized quantitative test scores to assess VCDA and SVCA. This approach, while yielding quantifiable evidence of group disparities, fell short of comprehensively documenting students' design methodologies, prompting strategies, revision behaviors, or their perceptions regarding AI-assisted learning. The incorporation of qualitative data, including student reflections, design portfolios, prompt records, and interviews, would yield a more comprehensive understanding of the ways in which Adobe Firefly facilitates or constrains learning within the context of design education.

The study used a quasi-experimental design based on intact classes rather than random assignment of individual students. Although ANCOVA was applied to control pre-test VCDA scores, this procedure cannot fully eliminate the possibility of pre-existing differences between groups. Factors such as prior design experience, motivation, digital literacy, familiarity with generative AI tools, and students' baseline creative confidence may have influenced the outcomes. Therefore, the findings should be interpreted as evidence from a controlled classroom-based intervention rather than as causal evidence

equivalent.

4.6. Future Research Directions

Subsequent investigations ought to build upon this study by employing more robust experimental frameworks. Conducting randomized controlled trials would yield more robust evidence regarding the impact of Adobe Firefly-assisted learning on students' achievements in visual communication design and their creative capabilities. In scenarios where random assignment cannot be implemented, it is imperative for future research to incorporate supplementary control variables. These may include factors such as prior design experience, digital literacy, motivation, familiarity with AI, and the baseline creative abilities of students.

Subsequent investigations ought to explore the enduring impacts of AI-assisted learning. The current investigation assessed outcomes following a seven-week intervention; however, it is still uncertain if the noted differences will persist in the long term. Longitudinal studies could explore the extent to which students maintain the advantages gained from Adobe Firefly-assisted learning in subsequent design tasks, advanced studio courses, or professional design environments.

Another significant avenue for exploration involves the incorporation of both pre-test and post-test assessments of creativity. The current investigation assessed creativity exclusively during the post-test phase. Subsequent investigations ought to assess creativity levels prior to and following the intervention to ascertain the extent to which AI-assisted learning facilitates genuine development of creativity over time. This would yield more robust evidence for assessing the impact of generative AI on creative development.

Subsequent investigations ought to employ mixed-method approaches to gain insights into the ways in which students engage with Adobe Firefly throughout the design process. Quantitative results may indicate the presence of group differences; however, they do not provide a comprehensive understanding of the mechanisms underlying those differences. The examination of student reflections, prompt histories, design drafts, portfolio analyses, classroom observations, and interviews may provide insights into the processes by which students generate ideas, revise their outputs, evaluate visual alternatives, and arrive at final design decisions.

Furthermore, subsequent research should conduct comparative analyses of Adobe Firefly alongside other generative AI tools utilized within the context of design education. Various tools may provide varying degrees of visual control, usability, output quality, and educational significance. Comparative analyses may facilitate the identification of the most beneficial features of AI tools in relation to ideation, composition, visual refinement, and creativity enhancement.

Future investigations ought to focus on the ethical and pedagogical challenges associated with AI-assisted design learning. The topics encompass authorship, originality, awareness of copyright, biases present in AI-generated images, the potential overreliance on automated outputs, and considerations of fairness in assessment. Future research should explore methodologies for guiding students in the responsible use of AI, while simultaneously fostering their independent design thinking, critical judgment, and creative confidence.

5. CONCLUSION

This study investigated the impact of structured learning supported by Adobe Firefly on the visual communication design achievement and creativity of undergraduate art and design students. The findings of a seven-week quasi-experimental intervention with 90 students demonstrated that the Adobe Firefly-assisted learning group did better than the conventional learning group on both post-test outcomes. The experimental group had higher mean scores for VCDA ($M = 75.94$, $SD = 7.45$) than the control group ($M = 70.98$, $SD = 8.58$), and higher SVCA scores ($M = 81.30$, $SD = 8.48$) than the control group ($M = 72.77$, $SD = 9.92$).

The ANCOVA results revealed the significant group effects after correcting for pre-test VCDA. The effect of the instructional technique was significant on visual communication design achievement, $F(1, 87) = 14.475$, $p < .001$, $\eta 2 = .001$. The group effect was likewise significant on creativity, $F(1, 87) = 18.570$, $p < .001$, $\eta 2 = .002$. These data show that structured Adobe Firefly-assisted learning was positively linked with post-test achievement and creativity compared to conventional training.

In a qualitative sense, the findings indicate that Adobe Firefly has the potential to facilitate design learning by aiding students in idea generation, the exploration of visual alternatives, the comparison of stylistic options, the refinement of compositions, and the ability to make more educated design choices. But its value in terms of education depends on its structured pedagogical application. Adobe Firefly should not be viewed as a replacement for student creativity or instructor direction, but as a support tool within a human-centered design learning process.

Future study should build upon these findings

with randomized or more tightly controlled designs, longer intervention periods, measurement of creativity at pre-test and post-test, mixed-method analysis of students' design processes, and comparisons across other generative AI tools. Further work is also required to explore ethical concerns such as authorship, originality, copyright awareness, overreliance on AI-generated outputs, and fair assessment in AI-assisted design education.

Acknowledgement: The author (Li Xin) thankfully acknowledged the "Centre for Instructional Technology and Multimedia, Universiti Sains Malaysia.

Conflicts of interest: There are no conflicts of interest.

Author Contributions: Li Xin: Conceptualization, Methodology, Software, Formal analysis, Investigation, Writing – original draft.

Chau Kien Tsong: Writing—review & editing, project administration, validation, supervision.

Wan Ahmad Jaafar Wan Yahaya: Resources, Writing—Review & Editing, Validation, Supervision.

Funding Statement: This research received no external funding.

REFERENCES

Abrusci, L., Dabaghi, K., D'Urso, S., & Sciarrone, F. (2025). AI4Design: A generative AI-based system to improve creativity in design–A field evaluation. Computers and Education: Artificial Intelligence, 8, 100401.

Akca, F., & Kavak, G. (2021). Scale of Visual Creativity in Art: A Study on Scale Development and Construct Validity. International Journal on Social and Education Sciences, 3(3), 439-456.

Alam, M. N., Islam, M. A., Babiker, M. O., Siddiqui, M. S., Amin, M. B., & Oláh, J. (2026). AI-assisted learning tools and student learning outcomes: A cognitive load theory perspective. Computers in Human Behavior Reports, 21, 100986.

Arneson, J. B., & Offerdahl, E. G. (2018). Visual literacy in Bloom: Using Bloom's taxonomy to support visual learning skills. CBE—Life Sciences Education, 17(1), ar7.

Bian, C., Wang, X., Huang, Y., Zhou, S., & Lu, W. (2025). Effects of AI-generated images in visual art education on students' classroom engagement, self-efficacy and cognitive load. Humanities and Social Sciences Communications, 12(1), 1-14.

Chan, C. K. Y. (2023). A comprehensive AI policy education framework for university teaching and learning. International journal of educational technology in higher education, 20(1), 38.

Chandra, B., & Rahman, Z. (2024). Artificial intelligence and value co-creation: a review, conceptual framework and directions for future research. Journal of Service Theory and Practice, 34(1), 7-32.

Chen, M. Y., & Hung, S. Y. (2026). Integrating Generative AI and Design Thinking in Aesthetic Education: A Narrative-Based Instructional Model in a Digital Culture Course. European Journal of Educational Research, 15(2), 579-601.

Dugard, P., & Todman, J. (1995). Analysis of pre-test-post-test control group designs in educational research. Educational Psychology, 15(2), 181-198.

Fahrenbach, F. (2022). A design science approach to developing and evaluating items for the assessment of transversal professional competences. Education+ Training, 64(1), 21-40.

Fajardo-Ramos, D. C., Chiappe, A., & Mella-Norambuena, J. (2025, October). Human-in-the-loop assessment with AI: implications for teacher education in Ibero-American universities. In Frontiers in Education (Vol. 10, p. 1710992). Frontiers Media SA.

Fleischmann, K. (2024). Generative artificial intelligence in graphic design education: a student perspective. Canadian Journal of Learning and Technology, 50(1), 1-17.

Georgieva, I., & Georgiev, G. V. (2025). Exploring the use of generative text AI in design creativity inquiries. Computers in Human Behavior: Artificial Humans, 100219.

Gheysari, S., Hasanshahi, M., Ghaemmaghami, P., & Vizeshfar, F. (2024). Impact of blended teaching on academic achievement and well-being in operating room students: a semi-experimental study. BMC nursing, 23(1), 697.

Gruenhagen, J. H., Sinclair, P. M., Carroll, J. A., Baker, P. R., Wilson, A., & Demant, D. (2024). The rapid rise of generative AI and its implications for academic integrity: Students' perceptions and use of chatbots for assistance with assessments. Computers and Education: Artificial Intelligence, 7, 100273.

Habib, S., Vogel, T., Anli, X., & Thorne, E. (2024). How does generative artificial intelligence impact student creativity? Journal of creativity, 34(1), 100072.

Huang, J. (2024). The Art of AI: A Human-Centered AI (HCAI) User Study of Integrating Image-Generative Tools in Visual Art Workflows: The Case Of Adobe Firefly.

Hwang, Y., & Wu, Y. (2025). The influence of generative artificial intelligence on creative cognition of design students: A chain mediation model of self-efficacy and anxiety. Frontiers in Psychology, 15, 1455015.

Jiang, J. (2024). When generative artificial intelligence meets multimodal composition: Rethinking the composition process through an AI-assisted design project. Computers and Composition, 74, 102883.

Kasneci, E., Seßler, K., Küchemann, S., Bannert, M., Dementieva, D., Fischer, F., ... & Kasneci, G. (2023). ChatGPT for good? On opportunities and challenges of large language models for education. Learning and individual differences, 103, 102274.

Kaufman, D. (1996). Constructivist-based experiential learning in teacher education. Action in teacher education, 18(2), 40-50.

Khlaif, Z. N., Alkouk, W. A., Salama, N., & Abu Eideh, B. (2025). Redesigning assessments for AI-enhanced learning: A framework for educators in the generative AI era. Education Sciences, 15(2), 174.

Kirschner, P. A., & Erkens, G. (2006). Cognitive tools and mindtools for collaborative learning. Journal of Educational Computing Research, 35(2), 199-209.

Lee, D., Arnold, M., Srivastava, A., Plastow, K., Strelan, P., Ploeckl, F., ... & Palmer, E. (2024). The impact of generative AI on higher education learning and teaching: A study of educators' perspectives. Computers and Education: Artificial Intelligence, 6, 100221.

Lee, J. (2025). Empowering students through generative AI and cultural diversity in interdisciplinary fashion design education. Research Journal of Textile and Apparel.

Li, Y., Tolosa, L., Rivas-Echeverria, F., & Marquez, R. (2025). Integrating AI in chemical education: Navigating UNESCO global guidelines, emerging trends, and its intersection with sustainable development goals.

Li, Z., & Chen, M. Y. (2019). Application of ANCOVA and MANCOVA in language assessment research. In Quantitative data analysis for language assessment volume I (pp. 198-218). Routledge.

Liu, M., McKelroy, E., Corliss, S. B., & Carrigan, J. (2017). Investigating the effect of an adaptive learning intervention on students' learning. Educational technology research and development, 65(6), 1605-1625.

Medel-Vera, C., Britton, S., & Gates, W. F. (2025). An exploration of the role of generative AI in fostering creativity in architectural learning environments. Computers and Education: Artificial Intelligence, 100501.

Miller, C. J., Smith, S. N., & Pugatch, M. (2020). Experimental and quasi-experimental designs in implementation research. Psychiatry research, 283, 112452.

Muharni, A., Mahanal, S., Zubaidah, S., & Susanto, H. (2025). Implementation and Empirical Analysis of ACCA Model Optimized by Learning Management System to Enhance the Students' Creative Thinking Skills. JOIV: International Journal on Informatics Visualization, 9(4), 1493-1502.

Philippas, D. (2024). Analysis of covariance (ANCOVA). In Encyclopedia of quality of life and well-being research (pp. 179-183). Cham: Springer International Publishing.

Quan, W. (2025). Artificial Intelligence in the Creative Industries: A Systematic Literature Review. Int. J. Latest Res. Humanit. Soc. Sci, 8, 23-31.

Sajja, R., Sermet, Y., Cwiertny, D., & Demir, I. (2025). Integrating AI and learning analytics for data-driven pedagogical decisions and personalized interventions in education. Technology, knowledge and learning, 1-31.

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). Quasi-experiments: interrupted time-series designs. Experimental and quasi-experimental designs for generalized causal inference, 1, 171-205.

Sun, Q., & Zhu, Y. (2022). Teaching analysis for visual communication design with the perspective of digital technology. Computational and Mathematical Methods in Medicine, 2022(1), 2411811.

Süner-Pla-Cerdà, S., Şen, G., Kumbasar, E., Şahin, B., & Ünlü, C. E. (2025). Designer experiences and perspectives on the role of generative AI in industrial design. AI & SOCIETY, 1-24.

Vogel-Walcutt, J. J., Gebrim, J. B., Bowers, C., Carper, T. M., & Nicholson, D. (2011). Cognitive load theory vs. constructivist approaches: which best leads to efficient, deep learning?. Journal of Computer Assisted Learning, 27(2), 133-145.

Wagler, A. (2025). Exploring generative AI as part of the design and creative process. Journal of Advertising Education, 29(2), 118-132.

Wajeed, M. A. (2026). Revolutionizing Higher education with generative AI: prospects, challenges, and future directions. In Generators, Bots, and Tutors: Creative Approaches to Human-AI Synergy in Classroom

Instruction (pp. 131-160). IGI Global Scientific Publishing.
Wang, D., Dong, X., & Zhong, J. (2025). Enhance college AI course learning experience with constructivism-based blog assignments. Education Sciences, 15(2), 217.
Xiao, X., Xu, H., & Xu, S. (2015). Using IBM SPSS modeler to improve undergraduate mathematical modelling competence. Computer Applications in Engineering Education, 23(4), 603-609.
ZAMBRI, N. A., NOOR, N. M., RASHID, N. A. M., & GHAFAR, L. A. (2024). Enhancing Creative Thinking in Non-Major Computer Science Students Through Interactive Visual Learning Environments. Quantum Journal of Social Sciences and Humanities, 5(SI1), 226-238.