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Enhancing Design Thinking through Artificial Intelligence (AI)-Augmented Curriculum to Support Sustainable Development Goals (SDGs) in Chinese Vocational Education: A Bibliometric and Mixed-Methods Study

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ABSTRACT

Traditional vocational art and design education in China often emphasizes technical skills while providing limited support for creative problem-solving. This study developed and evaluated an artificial intelligence (AI)-augmented curriculum to enhance design thinking and support Sustainable Development Goals in Chinese vocational education. A bibliometric and mixed-methods design was applied through curriculum mapping, pre-test and post-test measurement, and semi-structured interviews. The findings showed improvement in overall design thinking, especially collaboration, problem orientation, and test iteration. However, empathy developed more slowly because generative AI produced standardized outputs with limited emotional depth. The study highlights the value of integrating AI with human guidance, reflective practice, and ethical creative judgment.

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1. INTRODUCTION

Design thinking has become an important learning objective in art and design education because it strengthens creative problem-solving, human-centered innovation, and higher-order cognitive development (Glushchenko *et al.*, 2027). In vocational education, design thinking is especially relevant because students are expected to master professional skills while also responding creatively to complex workplace problems. Design thinking supports students in understanding user needs, framing problems, generating ideas, testing solutions, and reflecting on design decisions. These capabilities are essential for preparing students to become innovative and adaptive professionals in the twenty-first century (Razzouk and Shute, 2012; Zhao *et al.*, 2023).

The transformation of creative industries through digital technologies and artificial intelligence (AI) has changed the competencies required in education, work, and industry. AI has influenced academic writing, materials analysis, agriculture, urban forecasting, learning readiness, and broader educational practices, indicating that AI is becoming an important driver of interdisciplinary transformation (Abosede *et al.*, 2025; Katel, 2026; Nagaraju and Ramakrishna, 2025; Nandiyanto, 2026; Nnanguma, 2025). One educational sector affected by this transformation is vocational education, where curriculum innovation is increasingly directed toward digital competence, practical skill development, and Sustainable Development Goals (SDGs)-oriented learning (Fiandini *et al.*, 2024a; Fiandini *et al.*, 2024b; Nandiyanto *et al.*, 2022; Ragadhita *et al.*, 2023). This transformation is especially relevant to vocational art and design graduates because designers are now expected to combine artistic sensitivity, technological literacy, information processing, visual communication, and interdisciplinary problem-solving. In this context, AI-augmented design has become an important direction in design education because generative AI tools can support idea generation, rapid visualization, design iteration, and decision-making. Human-AI collaboration can improve creative performance when AI is positioned as a partner that supports human judgment rather than as a replacement for designers (Agboola, 2024; Fügener *et al.*, 2022).

In Chinese vocational art and design education, traditional instruction still tends to emphasize technical repetition, software operation, and product-oriented output. Although technical mastery is necessary, this approach may not sufficiently develop empathy, collaboration, problem orientation, and iterative thinking. The increasing availability of generative AI tools such as ChatGPT, Gemini, DeepSeek, and image-generation systems creates new opportunities for curriculum reform. However, AI is often used only as a shortcut for efficiency or output generation, rather than as a structured cognitive tool for improving design thinking. This creates a gap between the potential of AI-supported learning and the current implementation of AI in vocational design classrooms.

The integration of AI into vocational education is also relevant to the SDGs. AI-augmented curricula can support SDG 4 by improving the quality of education through innovative teaching and learning strategies. They can also support SDG 8 by preparing students for future creative industries that require digital and collaborative competencies. In addition, AI-supported design learning can contribute to SDG 9 by promoting innovation-oriented education and strengthening technological capability in vocational institutions. Therefore, AI-augmented curriculum development should not only focus on tool use but also on inclusive learning, employability, innovation, and responsible human-AI collaboration.

Despite the growing interest in AI in education and design thinking, several issues remain unresolved. First, limited empirical evidence explains how an AI-augmented curriculum affects different dimensions of design thinking among vocational art and design students. Second, many existing studies discuss AI tools, design thinking, or vocational reform separately, rather than integrating them into a coherent curriculum model. Third, the relationship between AI efficiency and human-centered design remains pedagogically challenging because generative AI may support rapid visualization but weaken empathy, originality, and emotional resonance. These issues show the need for a curriculum that uses AI as a creativity support tool while maintaining human agency, ethical awareness, and reflective judgment.

This study aims to develop and evaluate an AI-augmented curriculum for enhancing design thinking and supporting SDGs in Chinese vocational education. The study combines bibliometric analysis and mixed-methods evaluation to position the research within the broader development of AI, design education, and vocational curriculum reform. The mixed-methods component evaluates students' design thinking through pre-test and post-test data and explains the results through interview findings. The novelty of this study lies in integrating AI-augmented curriculum, design thinking, SDGs, bibliometric mapping, and mixed-methods evidence within the context of Chinese vocational art and design education. The study is guided by the following research questions:

(i) What curriculum components are needed to promote design thinking through AI-augmented learning in vocational art and design education?
(ii) Does the AI-augmented curriculum improve students' design thinking capabilities?
(iii) How do students perceive the impact of human-AI collaboration on their creative process and design thinking?
(iv) How does the bibliometric trend position AI-augmented design curriculum within SDGs-oriented vocational education research?

2. LITERATURE REVIEW

2.1. Vocational Education Curriculum Reform

Vocational education curriculum reform has become increasingly important due to digital transformation, labor market change, and the demand for interdisciplinary skills. The curriculum functions as a bridge between educational provision and industry needs, especially in programs that prepare students for professional and technical fields. Earlier vocational curricula emphasized standardized operational skills, while contemporary reform increasingly focuses on competencies, adaptability, creativity, and lifelong learning. This shift indicates that vocational education must prepare students not only to perform technical tasks but also to solve complex problems in changing professional contexts (Mulder *et al.*, 2007). However, curriculum reform should not be limited to skills training and employability indicators. Vocational education also needs to provide students with conceptual understanding, reflective capacity, and powerful knowledge that enables them to adapt beyond immediate job requirements. Excessive emphasis on instrumental skills can narrow the educational purpose of vocational learning and reduce students' capacity for deeper innovation. Therefore, vocational art and design curricula should balance technical practice with design cognition, creativity, and human-centered problem-solving (Mulder *et al.*, 2007). AI-augmented curriculum reform is therefore relevant when it supports higher-order thinking rather than merely accelerating production (Fiandini *et al.*, 2024a; Ragadhita *et al.*, 2023). The digital transformation of vocational education further requires new curriculum structures that integrate technology with pedagogy. In art and design programs, students need to learn not only how to operate digital tools but also how to use them critically and creatively. This is important because the creative industries increasingly demand graduates who can combine visual ability, digital fluency, collaboration, and innovation. AI-augmented curriculum reform is therefore relevant when it supports higher-order thinking rather than merely accelerating production.

2.2. Design Thinking as a Pedagogical Framework

Design thinking is widely recognized as a human-centered and iterative approach to innovation. It helps learners identify user needs, define problems, generate alternatives, develop prototypes, and evaluate solutions. In education, design thinking supports active learning because students engage in problem exploration, experimentation, feedback, and reflection. This makes design thinking suitable for vocational art and design education, where students need to connect creative concepts with practical design outcomes. Design thinking has evolved from a design method into a broader cognitive process for interdisciplinary problem-solving. Its educational value lies in helping students move beyond technical execution toward empathy, reasoning, iteration, and reflective decision-making. In art and design education, this process can strengthen students' ability to understand users, communicate ideas, and revise solutions based on feedback. These abilities are important for developing professional designers who can respond to complex social, cultural, and technological challenges (Razzouk and Shute, 2012). Nevertheless, design thinking is not free from criticism. Some studies argue that design thinking can become superficial when empathy is treated as a performance rather than a deep understanding of real users. This is especially important in AI-supported learning because generative AI can produce visually attractive outputs without necessarily capturing social meaning or emotional nuance. Therefore, design thinking instruction must include structured guidance, authentic user contexts, and reflective evaluation to prevent students from relying only on aesthetic output (Graf, 2021).

2.3. AI in Design Education

AI has become an important catalyst in education by supporting personalization, feedback, automation, and intelligent learning environments (Haristiani and Kusumawati, 2026). In design education, AI can assist students in idea generation, image production, style exploration, visual refinement, and design iteration. AI-augmented design refers to a human-centered creative process in which AI supports human designers in expanding possibilities, reducing technical barriers, and improving decision-making. This approach is educationally valuable when AI is used as a partner in learning rather than as a substitute for student creativity (Agboola, 2024). Generative AI can be especially useful for novice design students because it enables rapid visualization of ideas. Students who have limited drawing or software skills can use AI to externalize concepts, compare alternatives, and explore visual directions more quickly. This can reduce cognitive load related to technical execution and allow students to focus more on problem framing, aesthetic judgment, and iteration. Human-AI collaboration can also improve performance when students remain actively involved in directing, evaluating, and revising AI-generated outputs (Fügener *et al.*, 2022). However, AI also introduces limitations in design education. AI-generated outputs may be unpredictable, generic, or overly dependent on existing visual patterns. These limitations can reduce originality and weaken the emotional connection with users. AI also lacks lived experience, ethical judgment, cultural sensitivity, and authentic empathy. Therefore, AI-augmented design education must teach students how to use AI critically, evaluate outputs responsibly, and maintain human agency in the creative process (De Peuter *et al.*, 2023; Di Dio *et al.*, 2024).

2.4. Componential Theory of Creativity and Creativity Support Tools

The Componential Theory of Creativity provides a useful foundation for understanding how an AI-augmented curriculum can support design thinking. Creativity is shaped by domain-relevant skills, creativity-relevant processes, and task motivation. In art and design education, these components correspond to students' design knowledge, ability to generate and evaluate ideas, and motivation to engage in creative work. This theory suggests that creative performance can be strengthened when learning environments support knowledge development, divergent thinking, and intrinsic engagement (Amabile, 1983; Henriksen *et al.*, 2016). Creativity Support Tools are designed to assist users in generating, exploring, and refining ideas. Such tools can accelerate discovery and innovation when they provide low entry barriers, flexible exploration, and broad creative possibilities. Generative AI extends this concept because it can actively propose alternatives, visualize ideas, and stimulate divergent thinking. However, the value of AI as a creativity support tool depends on how humans guide, interpret, evaluate, and refine its outputs (Shneiderman, 2007). The integration of the Componential Theory of Creativity and Creativity Support Tools supports the framework of this study. AI can assist domain learning by providing examples and visual references. It can support creative processes by generating multiple design alternatives. It can also strengthen motivation by enabling students to see their ideas materialized quickly. However, AI cannot fully replace human contextual understanding, emotional judgment, and ethical reasoning. Therefore, the curriculum should position AI as a scaffold for design thinking while preserving human control and reflective practice.

2.5. AI-Augmented Curriculum and SDGs-Oriented Vocational Education

AI-augmented curriculum is relevant to SDGs-oriented vocational education because it can improve learning quality, digital competence, employability, and innovation capacity. In relation to SDG 4, AI-supported learning can provide students with new ways to access knowledge, visualize ideas, and receive feedback. In relation to SDG 8, vocational students can develop future-oriented skills needed in digitally transformed creative industries. In relation to SDG 9, AI-augmented design education can support innovation and technological capability in vocational institutions. These contributions show that AI curriculum reform is connected to broader sustainable education and workforce development. At the same time, SDGs-oriented AI curriculum must consider equity, ethics, and human-centered values. AI tools may improve access and efficiency, but they can also reproduce standardization, bias, and dependence if students are not guided critically. Therefore, an AI-augmented curriculum should combine technical training with ethical awareness, reflective learning, and social responsibility. In design education, this means that students should learn not only how to generate outputs but also how to evaluate whether those outputs are meaningful, inclusive, and responsive to user needs. Based on this gap, the present study develops and evaluates an AI-augmented curriculum for enhancing design thinking in Chinese vocational education. The study contributes by combining curriculum design, bibliometric mapping, quantitative testing, and qualitative interpretation. This integrated approach provides both field-level positioning and classroom-level evidence on how AI can support design thinking and SDGs-oriented vocational learning.

Table 1. Synthesis of literature and research gap.

THEME	MAIN IDEA FROM LITERATURE	RELEVANCE TO THIS STUDY	IDENTIFIED GAP
Vocational curriculum reform	Vocational education is shifting from operational skills toward competence, adaptability, and industry relevance.	The study develops a curriculum that integrates AI skills with creative and cognitive development.	Limited curriculum models connect AI, design thinking, and vocational art and design education.
Design thinking	Design thinking supports empathy, problem framing, ideation, prototyping, testing, and reflection.	The study evaluates design thinking as the main learning outcome.	Design thinking is often applied superficially without sufficient evidence on dimension-level improvement.
AI in design education	AI supports visualization, iteration, creativity, and human-AI collaboration.	The curriculum uses AI as a learning partner and creativity support tool.	AI is often treated as an efficiency tool rather than a structured cognitive scaffold.
Creativity theory and CSTs	Creativity develops through domain skills, creative processes, motivation, and supportive tools.	The curriculum framework combines creativity components and AI-supported design activities.	Few studies operationalize creativity theory through an AI-augmented vocational curriculum.
SDGs-oriented education	Sustainable education promotes quality learning, employability, innovation, and responsible technology use.	The study connects AI curriculum to SDG 4, SDG 8, and SDG 9.	Limited studies explicitly link AI-augmented design curriculum with SDGs in vocational education.
Bibliometric positioning	Bibliometric analysis maps research trends and identifies the development of a field.	The study uses bibliometric analysis to position AI-augmented design curriculum within the wider research landscape.	Limited studies combine bibliometric mapping with mixed-methods curriculum evaluation.

3. METHOD

3.1. Bibliometric Procedure

Bibliometric analysis was conducted to examine the publication trend and research positioning of AI-augmented curriculum, design thinking, vocational education, and SDGs. The bibliographic data were collected from the Scopus database using a title, abstract, and keyword search strategy. The search terms were developed based on the main concepts of the study, including AI, AI-augmented design, design thinking, vocational education, curriculum, and Sustainable Development Goals. The bibliometric analysis was conducted using the Scopus database with the search query TITLE-ABS-KEY (artificial AND intelligence AND vocational). The search covered publications from 1939 to 2025 and identified 1,050 documents. The analysis focused on annual publication trends to position the present study within the growing research landscape of AI and vocational education. The bibliometric analysis focused on publication trends, keyword distribution, and thematic relevance to the present study. The results were used to show how research on AI-supported design learning and vocational curriculum development has evolved. The bibliometric component also supported the discussion of how an AI-augmented curriculum can contribute to SDGs-oriented education, especially quality education, decent work, and future skills, and innovation-oriented vocational learning.

3.2. Research Design

This study used a bibliometric and mixed-methods design to evaluate an AI-augmented curriculum for enhancing design thinking in Chinese vocational education. The bibliometric component was used to map the research trend and position the study within AI, design thinking, vocational education, and SDGs-oriented curriculum development. The mixed-methods component was used to examine the effectiveness of the curriculum and explain students' learning experiences. The mixed-methods component followed a quasi-experimental one-group pre-test and post-test design supported by qualitative interviews. Quantitative data were collected before and after the curriculum intervention to measure changes in students' AI-enhanced design thinking. Qualitative data were collected after the intervention to explain the statistical results and provide deeper insight into students' perceptions of human-AI collaboration. This design was appropriate because mixed-methods research combines numerical evidence with contextual interpretation. The research process consisted of curriculum development, curriculum implementation, and curriculum evaluation. The curriculum development stage produced the AI-augmented design learning framework. The implementation stage applied the curriculum in classroom activities. The evaluation stage analyzed quantitative test results and qualitative interview data to determine the impact of the curriculum.

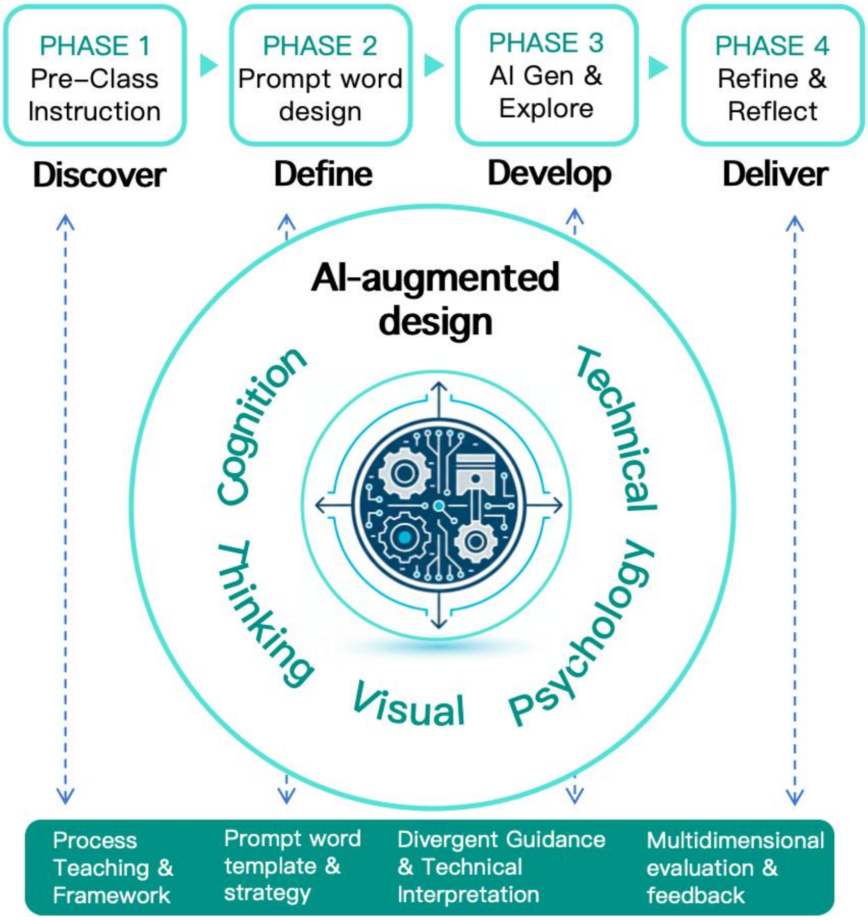

Figure 1. Application framework in an AI-augmented design classroom.

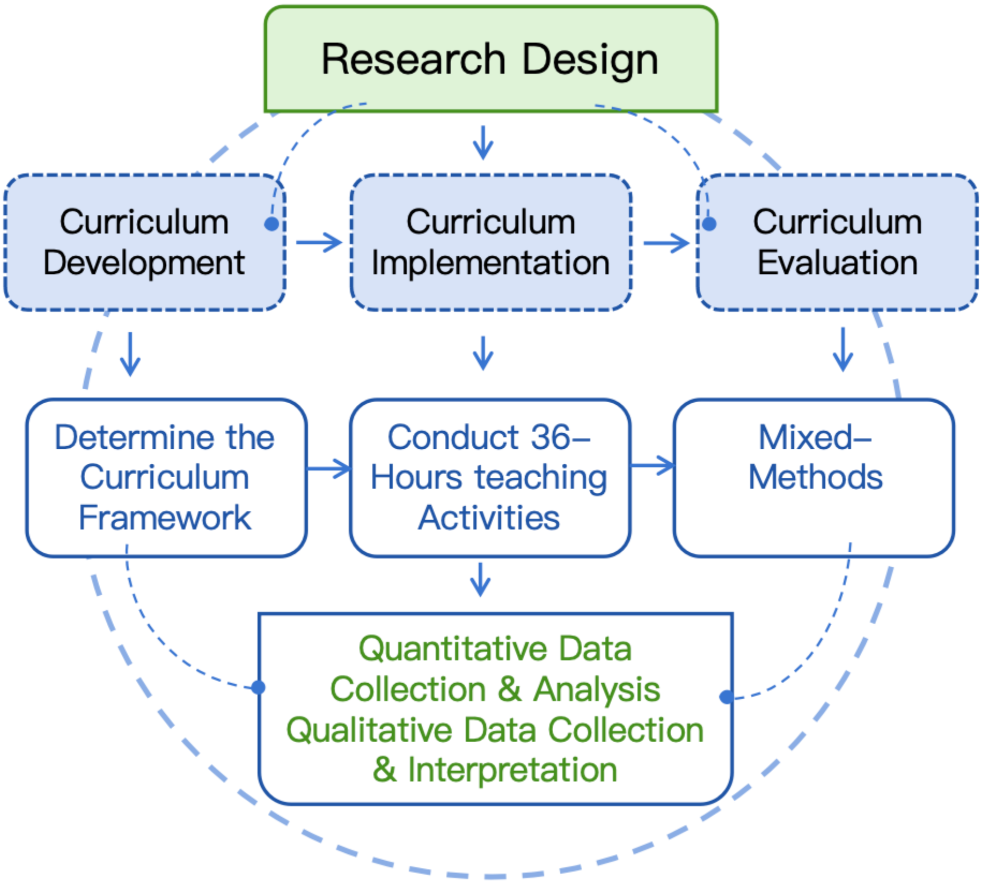

Figure 2. Research design.

3.3. Participants

The participants were first-year art and design students at a higher vocational college in Guangzhou, China. Convenience sampling was used because the study was implemented in an intact classroom setting. Initially, 33 students participated in the study. After data screening, three invalid responses were removed because the response duration was too short and the answer pattern was repetitive. The final quantitative sample consisted of 30 valid participants. For the qualitative phase, five students were purposively selected to participate in semi-structured interviews. The interview participants were selected to provide explanatory insight into the quantitative results and to describe their learning experiences during the AI-augmented curriculum. This qualitative sample was used to explore students' perceived benefits, limitations, and reflections on human-AI collaboration.

3.4. Curriculum Intervention

The AI-augmented curriculum was implemented over two weeks with a total of 36 class hours. The curriculum was designed to enhance design thinking through structured human-AI collaboration. It consisted of four instructional stages: pre-class guidance, prompt word design, AI generation and exploration, and refinement and reflection. In the pre-class guidance stage, students were introduced to the course objectives, research procedures, online learning platform, and communication channels. In the prompt word design stage, students learned how to communicate with generative AI systems through structured prompt writing. In the AI generation and exploration stage, students used AI tools to generate visual outputs, explore design alternatives, and refine initial ideas. In the refinement and reflection stage, students selected, evaluated, and improved AI-generated outputs through traditional design software, peer discussion, instructor feedback, and self-reflection. The curriculum integrated five AI-augmented design components: cognition, thinking, technology, vision, and psychology. Cognition refers to domain knowledge and design understanding. Thinking refers to idea generation, divergence, and problem-solving. Technology refers to the operation of AI tools and digital expression. Vision referred to aesthetic judgment and visual optimization. Psychology referred to motivation, engagement, and confidence in the creative process.

3.5. Instruments

The quantitative instrument was the AI Enhanced Design Thinking Level Test Scale (AI-DTLS). The instrument measured students' AI-enhanced design thinking across four dimensions: AI-assisted empathy, AI-assisted collaboration, AI-assisted problem-solving, and AI-assisted test iteration. The test included objective and subjective items to assess theoretical understanding and applied design ability. The objective items included multiple-choice, true-or-false, and fill-in-the-blank questions, while the subjective item required students to complete a design-related task. The instrument was reviewed by two education experts with more than ten years of experience to support content validity. The expert review ensured that the test items were aligned with the course objectives, design thinking dimensions, and AI-augmented learning context. The qualitative instrument was a semi-structured interview protocol. The interview questions explored students' perceived gains, limiting factors, changes in design thinking, and opinions about the AI-augmented curriculum. The interview protocol was informed by creativity support tools, design cognition, and reflective practice perspectives (Shneiderman, 2007).

3.6. Data Collection Procedure

Before the curriculum intervention, students completed a pre-test to measure their initial AI-enhanced design thinking level. The AI-augmented curriculum was then implemented through classroom teaching, online learning support, WeChat communication, and project-based design activities. After the intervention, students completed a post-test using the same measurement framework. Semi-structured interviews were then conducted with five selected students to obtain qualitative explanations of their learning experiences. The intervention began with pre-training activities to explain the course objectives, experimental procedures, submission requirements, and assessment process. Students were also introduced to communication channels and learning platforms. During the curriculum implementation, students completed AI-supported design tasks and participated in guided reflection. After completing the course, quantitative and qualitative data were collected for analysis.

3.7. Data Analysis

Quantitative data were screened before analysis to ensure validity and reliability. Invalid responses were removed based on short response duration and repeated answer patterns. After screening, complete paired data from 30 participants were analyzed. The normality assumption was examined using the Shapiro-Wilk test. Because the data met the normality assumption, paired-samples t-tests were conducted to compare pre-test and post-test scores. Cohen's d was calculated to determine the effect size of the curriculum intervention. Qualitative interview data were analyzed using thematic analysis. The analysis followed six steps: data familiarization, initial coding, theme searching, theme reviewing, theme defining, and reporting. The qualitative findings were used to explain the quantitative results, especially differences among the design thinking dimensions. This integration enabled the study to identify both the measurable effect of the curriculum and the students' perceived experiences of AI-supported design learning (Braun and Clarke, 2006).

4. RESULTS AND DISCUSSION

4.1. Data Screening and Preparation

Before statistical analysis, the collected data were screened to ensure validity and reliability. A total of 33 students completed the pre-test and post-test. Three responses were removed because they showed invalid response patterns, including very short completion times and identical answer choices across items. Therefore, complete paired data from 30 students were retained for quantitative analysis. The normality assumption was examined using the Shapiro-Wilk test. The difference scores were normally distributed. This result supported the use of paired-samples t-tests to evaluate the effect of the AI-augmented curriculum on students' design thinking.

4.2. Overall Improvement in AI-Augmented Design Thinking

The paired-samples t-test results showed that students' overall design thinking improved after participating in the AI-augmented curriculum. As shown in Table 2, the mean score increased from the pre-test to the post-test, and the difference was statistically significant. The effect size indicated a moderate practical effect, suggesting that the curriculum had a meaningful impact on students' design thinking development. This finding supports the assumption that AI can function as a creativity support tool when it is integrated into structured learning activities rather than used only as an efficiency shortcut. The result also aligns with the view that AI-supported learning can expand students' design exploration and support creative problem-solving when human judgment remains central to the process (Shneiderman, 2007).

Table 2. Paired-samples t-test results of design thinking ability.

TEST	M	SD	MD	t	p	COHEN's d
Pre-test	51.93	12.25	-9.20	-2.55	.016*	0.46
Post-test	61.13	11.06				

Note: M = Mean; SD = Standard Deviation; MD = Mean Difference. *$p < 0.05$.

The improvement in overall design thinking indicates that the curriculum helped students connect technical AI use with cognitive design processes. Students were not only introduced to AI tools but were also guided to use prompts, generate visual alternatives, evaluate outputs, and refine design decisions. This structure reduced the gap between technical operation and design cognition. Therefore, the AI-augmented curriculum contributed to vocational education reform by shifting learning from tool-based production toward reflective, iterative, and problem-oriented design learning.

4.3. Comparison of Four AI-Augmented Design Thinking Dimensions

The dimension-level analysis showed that students improved differently across the four dimensions of AI-augmented design thinking. As presented in Table 3, AI-augmented collaboration, AI-augmented problem orientation, and AI-augmented test iteration showed statistically significant improvement after the curriculum intervention. The greatest improvement was found in problem orientation, followed by test iteration and collaboration. These results suggest that AI was particularly effective in helping students define design problems, generate alternatives, communicate ideas, and revise outputs through repeated experimentation.

Table 3. Comparison of four AI-augmented design thinking dimensions.

DIMENSION	TEST	M	SD	t	p	COHEN's d
AI-augmented empathy	Pre-test	10.17	2.36	-1.80	0.083	0.33
	Post-test	11.43	2.18			
AI-augmented collaboration	Pre-test	13.03	3.66	-2.20	0.036*	0.40
	Post-test	15.27	3.24			
AI-augmented problem orientation	Pre-test	15.47	4.09	-3.00	0.006**	0.55
	Post-test	18.77	3.54			
AI-augmented test iteration	Pre-test	13.27	3.16	-2.50	0.018*	0.46
	Post-test	15.67	3.07			

Note: N = 30; *$p < 0.05$; **$p < 0.01$.

The significant improvement in collaboration can be explained by the role of AI-generated visual outputs as shared communication objects. Students could use AI outputs to explain ideas, compare alternatives, and discuss design directions with peers and instructors. The improvement in problem orientation suggests that AI helped students move from technical execution to higher-order thinking because students were required to define prompts, clarify design goals, and evaluate whether generated outputs matched user needs. The improvement in test iteration indicates that AI reduced the time needed to create visual prototypes, allowing students to conduct repeated design trials more efficiently. These findings support the argument that AI can enhance design learning when it supports ideation, visualization, and revision within a guided pedagogical structure (Fügener *et al.*, 2022). However, the AI-augmented empathy dimension did not show statistically significant improvement. Although the mean score increased, the change was not strong enough to indicate a significant effect. This finding is important because it shows that AI can support visual exploration and iteration, but it does not automatically strengthen deep user understanding. Empathy requires sensitivity to lived experience, social context, emotional nuance, and human values. Generative AI can simulate visual styles and produce attractive outputs, but it may not fully capture users' complex emotional and cultural needs. This limitation supports the criticism that design thinking can become superficial when empathy is performed through tools rather than developed through authentic human engagement (Graf, 2021).

4.4. Visual Comparison of Pre-Test and Post-Test Scores

Figure 3 presents a radar chart comparing pre-test and post-test scores across the four dimensions of AI-augmented design thinking. The post-test profile expanded beyond the pre-test profile in all dimensions, indicating overall improvement after the curriculum intervention. The largest expansion appeared in AI-augmented problem orientation, confirming the statistical result that this dimension experienced the strongest growth. AI-augmented collaboration and test iteration also showed visible improvement, supporting the conclusion that AI helped students communicate and revise design outputs more effectively.

In contrast, the smallest expansion appeared in AI-augmented empathy, confirming that this dimension remained the weakest area of improvement.

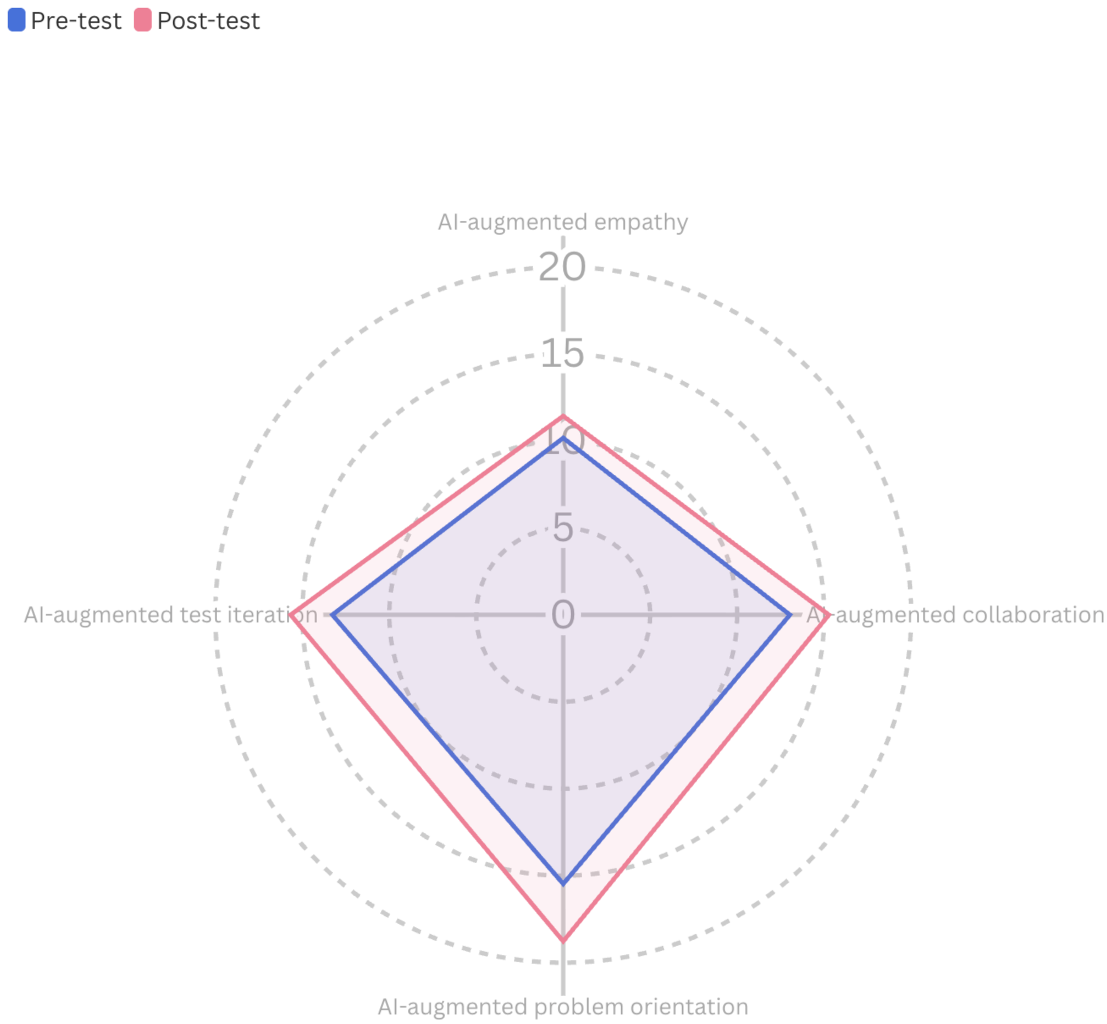

Figure 3. Radar chart comparing pre-test and post-test scores of four AI-augmented design thinking dimensions.

The radar chart strengthens the interpretation that an AI-augmented curriculum is more effective for cognitive, technical, and iterative aspects of design thinking than for emotional and empathic aspects. This does not mean that the curriculum failed to support empathy. Instead, it indicates that empathy requires more direct human-centered learning activities, such as user interviews, field observation, persona development, and reflective discussion. Therefore, future AI-augmented design curricula should combine AI-supported visualization with structured human empathy training to avoid overdependence on algorithmic outputs.

4.5. Qualitative Findings from Student Interviews

The qualitative findings provided deeper explanations for the quantitative results. The interview data were analyzed using thematic analysis and summarized in **Table 4**. Three main themes emerged: efficiency and visualization, cognitive expansion, and human-AI friction. These themes explain why collaboration, problem orientation, and test iteration improved significantly, while empathy improved more slowly.

Table 4. Analysis of interview results based on thematic coding.

THEME	THEME CODE	NUMBER OF TIMES MENTIONED
Efficiency and visualization	Rapid visualization	5
Efficiency and visualization	Time efficiency	4
Efficiency and visualization	Skill compensation	2
Cognitive expansion	Inspiration and divergence	5
Cognitive expansion	Breaking aesthetic limits	3
Cognitive expansion	Logic structuring	1
Human-AI friction	Uncontrollability or randomness	4
Human-AI friction	Homogenization or generic output	3
Human-AI friction	Technical barrier	3

Note: N = 5.

The first theme, efficiency and visualization, showed that students perceived AI as useful for accelerating design production. Students reported that AI helped them visualize ideas quickly and overcome limitations in hand-drawing skills. This finding explains the improvement in test iteration because students could generate and compare multiple design alternatives within a shorter time. AI also reduced the technical barrier for first-year students, allowing them to focus more on design logic, selection, and refinement.

The second theme, cognitive expansion, showed that students believed AI supported divergent thinking. Students reported that AI provided unexpected visual directions, alternative styles, and new inspiration. This theme explains the strong improvement in problem orientation because AI prompted students to rethink their initial ideas and refine design problems through prompt adjustment and output evaluation. AI, therefore, acted as a cognitive partner that expanded the range of possible solutions, although the final interpretation and selection remained dependent on human judgment.

The third theme, human-AI friction, explained why AI-augmented empathy did not improve significantly. Students described AI outputs as sometimes uncontrollable, generic, and visually homogeneous. Some students felt that AI-generated images were attractive but lacked personal style and emotional depth. This finding indicates that AI can produce polished visual results without necessarily reflecting specific user needs or authentic human experiences. The limitation is consistent with the view that AI may simulate empathy at the surface level but cannot replace human emotional understanding and contextual interpretation (Pelau *et al.*, 2021).

4.6. Discussion of Human-AI Collaboration in Design Thinking

An AI-augmented curriculum can enhance design thinking when AI is positioned as a supportive learning partner. AI helped students generate visual ideas, test alternatives, and communicate design concepts. These functions are closely related to the role of creativity support tools, which aim to accelerate creative exploration and innovation. In this study, AI did not merely automate design production; it created opportunities for students to practice problem framing, prompt refinement, visual comparison, and reflective judgment. This supports the theoretical connection between Componential Theory of Creativity and Creativity Support Tools because AI helped activate domain skills, creative processes, and motivation within the design learning environment (Amabile, 1983; Shneiderman, 2007). At the same time, the findings reveal a boundary of AI-supported creativity. AI was effective in supporting collaboration, problem orientation, and iteration, but it was less effective in developing empathy. This result suggests that AI can strengthen technical and cognitive aspects of design thinking, but it cannot independently produce deep human-centered understanding. Human designers remain responsible for interpreting user needs, evaluating social meaning, and ensuring emotional relevance. Therefore, AI-augmented design education should not blindly pursue efficiency. It should train students to critically evaluate AI outputs, identify generic patterns, and reconnect visual production with human experience.

4.7. Bibliometric Analysis

The bibliometric analysis was conducted using the Scopus database with the search query TITLE-ABS-KEY (artificial AND intelligence AND vocational). The search covered publications from 1939 to 2025 and identified 1,050 document results. The annual publication trend is presented in **Figure 4**. The results show that research related to AI and vocational education remained very limited for several decades, followed by gradual growth after the 2010s. A stronger increase appeared after 2019, indicating that AI integration in vocational education has become a rapidly expanding research topic. **Figure 4** shows that the number of documents increased from 9 documents in 2017 to 19 in 2018, 30 in 2019, 67 in 2020, 87 in 2021, 97 in 2022, 81 in 2023, 172 in 2024, and 414 in 2025. This sharp increase indicates growing scholarly attention to the relationship between AI and vocational education, especially in recent years. The trend supports the relevance of this study because AI-augmented curriculum is no longer an isolated innovation but part of a broader research movement toward digitally transformed vocational learning.

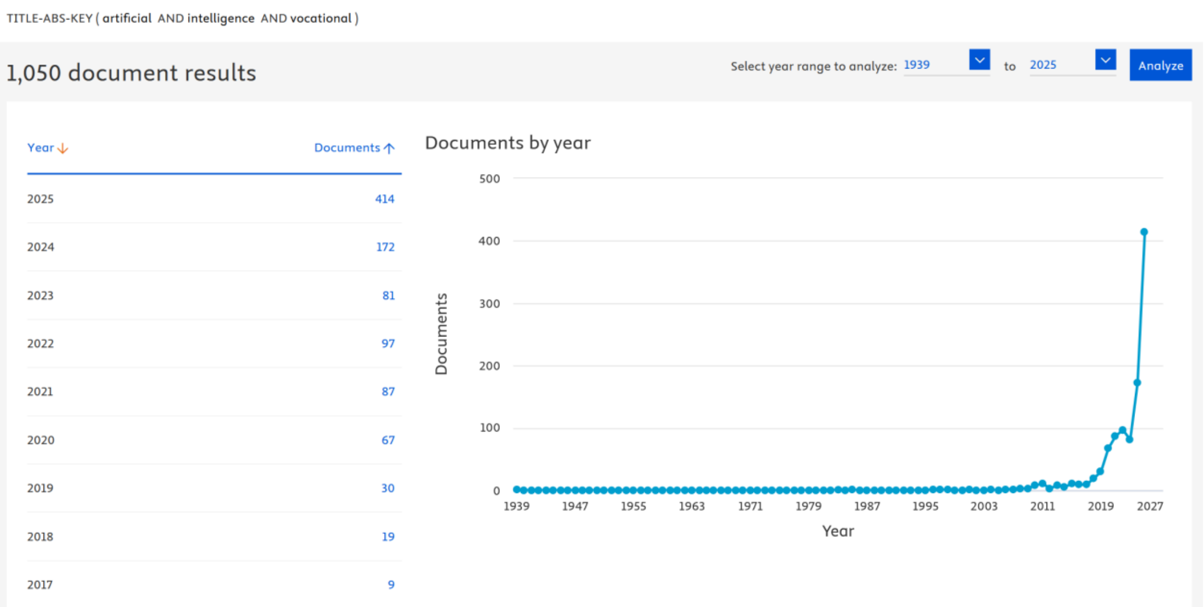

Figure 4. Bibliometric trend of publications related to AI and vocational education based on the Scopus search query TITLE-ABS-KEY (artificial AND intelligence AND vocational) from 1939 to 2025. Data was taken in June 2026.

In the context of this study, the bibliometric trend strengthens the urgency of developing an AI-augmented curriculum for Chinese vocational art and design education. The rapid growth of publications suggests that vocational institutions are increasingly expected to respond to AI-driven changes in teaching, learning, and future work competencies. Therefore, the present mixed-methods findings contribute classroom-level evidence to a growing field by showing how AI-supported curriculum can enhance design thinking, especially collaboration, problem orientation, and iterative testing. At the same time, the limited improvement in empathy highlights the need for human guidance in AI-supported vocational education.

4.8. SDGs Relevance

The AI-augmented curriculum developed in this study is relevant to SDGs because it supports quality learning, future-oriented employability, and innovation capacity in vocational education. The study contributes most directly to SDG 4, SDG 8, and SDG 9. The curriculum supports SDG 4 because it promotes innovative teaching, design thinking, and AI-supported learning in vocational education.

It supports SDG 8 because students developed future work skills, including human-AI collaboration, prompt communication, creative problem-solving, and iterative design. It also supports SDG 9 because the curriculum strengthens technological integration and innovation-oriented learning in vocational institutions.

The relevance of the SDGs to this study is summarized in **Table 5**. The findings show that AI can help students visualize ideas, expand design alternatives, and improve collaboration during the learning process. However, the results also show that AI-supported learning must be guided by human-centered pedagogy because empathy and emotional understanding cannot be fully developed through generative AI outputs alone. Therefore, the contribution to SDGs should be understood not only as the use of advanced technology but also as the responsible integration of AI with reflective learning, ethical awareness, and human guidance.

This study connects classroom-level AI curriculum intervention with broader sustainable development priorities. The AI-augmented curriculum can improve vocational learning quality and prepare students for AI-transformed creative industries. Nevertheless, the findings also indicate that sustainable AI integration requires more than technical access. It requires pedagogical design that preserves human agency, strengthens ethical awareness, and guides students to critically evaluate AI-generated outputs.

5. CONCLUSION

This study demonstrated that an AI-augmented curriculum can enhance design thinking among Chinese vocational art and design students. Quantitative results showed significant improvement in overall design thinking, especially collaboration, problem orientation, and test iteration. Qualitative findings explained that AI accelerated visualization, expanded ideas, and reduced technical barriers, but empathy remained limited because AI outputs tended to be standardized and emotionally shallow. Bibliometric positioning and SDGs mapping indicate that this curriculum supports quality education, future work skills, and innovation-oriented vocational learning. Future implementation should combine AI training with human guidance, ethical awareness, and reflective design practice to ensure more sustainable classroom integration.

Table 5. Relevance of AI-augmented curriculum to selected SDGs.

SDG	RELEVANCE TO THIS STUDY	CONTRIBUTION OF THE AI-AUGMENTED CURRICULUM
SDG 4: Quality education	Vocational education needs innovative learning strategies that develop higher-order thinking and digital competence.	Supports design thinking, problem orientation, collaboration, and iterative learning through structured AI-assisted activities.
SDG 8: Decent work and economic growth	Creative industries increasingly require graduates with digital, collaborative, and adaptive skills.	Develops future-oriented competencies, including human-AI collaboration, prompt communication, visual exploration, and creative problem-solving.
SDG 9: Industry, innovation, and infrastructure	Vocational institutions need stronger innovation capacity and technological integration.	Promotes AI-supported curriculum innovation and strengthens the connection between design education and digital industrial transformation.
SDG 10: Reduced inequalities	Students may enter design programs with different levels of drawing, software, and visualization ability.	Reduces technical barriers by helping students quickly visualize ideas and participate more actively in design exploration.
SDG 17: Partnerships for the goals	Sustainable curriculum development benefits from collaboration among educators, students, institutions, and technology systems.	Encourages collaborative learning ecosystems that combine teacher guidance, peer feedback, AI tools, and institutional curriculum support.

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7. AUTHORS’ NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

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