A SYSTEMATIC REVIEW OF THE ROLE OF AI ARTIFICIAL INTELLIGENCE IN DESIGN EDUCATION

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ABSTRACT
With the advent of GPT-3 in 2020 and the development of artificial intelligence (AI), scepticism persists among educators regarding its role in design education. This study uses a systematic literature review to locate and summarize the core papers from 2020 to 2023, categorizing the role of AI in design education. Following the PRISMA method, 38 papers were selected for review. The research reveals the potential impacts of AI on developing students' design skills, perceptions of AI applications among students and teachers, and challenges in implementing AI technologies. Drawing from these findings, the study proposes implications of AI on both the practice and theory of design education. By shedding light on the current state of AI integration in design education, this research aims to inform educators, policymakers, and stakeholders about the opportunities and challenges presented by AI technologies. Based on the research results, this study proposes the impact of artificial intelligence on design education.

Keywords: Design education, systematic literature review, Artificial intelligence (AI)

1 INTRODUCTION
Don Norman highlighted the increasing complexity of modern design, which traditional education does not cover. What we need is not "teaching outdated methods and skills" [], but rather education that addresses the inherent instability of the current environment. To ensure design makes a constructive contribution, design education must continuously evolve []. Since the advent of GPT-3 in 2020 [], AI-based methods have the potential to reduce the complexity and subjectivity of tasks in design education. AI is an emerging interdisciplinary field [], transforming teaching design and student learning in modern design education []. From a technical point of view, AI focuses on specific applications that support learning, teaching, or management []. From the user's perspective, AI assists teachers in facilitating student learning []. Educators believe that using AI can enhance the effectiveness of learning structures and academic systems []. The application of AI in design education can provide technical support and data information for teaching [7]. Currently, the potential of AI in teaching design education is just beginning to be explored []. There is limited understanding of AI's complex role in teaching and learning processes []. Therefore, this paper focuses on outlining the current applications and potential shortcomings of AI in design education. It specifically addresses the following research questions.
Sub-Question 1: What AI tools and techniques have already been used in the learning and teaching of the design discipline?
Sub-Question 2: What new changes have been brought to the learning and teaching of the design discipline through the introduction of AI tools and techniques?
Sub-Question 3: What difficulties and challenges do educators and students face when using AI tools and techniques in design classrooms?

2 METHOD
Systematic literature reviews, compared to traditional literature reviews, involve a more rigorous process of literature retrieval and selection. They are aimed at identifying, collecting, analysing, and synthesizing all available publications relevant to a specific research topic or question through unbiased search strategies []. Therefore, this study adopts this method to (1) summarize the existing evidence of the impact of AI on design education, (2) address the sub-questions posed earlier.

2.1 Search strategy

In the first stage, we queried the core journals in the Web of Science and Scopus databases using the refined search strings shown in Table 1. We recorded and collected the initial search results from the databases using Excel sheets, eliminating duplicate versions. Following the criteria in Table 2, we evaluated the relevance of abstracts and conclusions; if they were irrelevant, we reviewed the introduction section. For cases that remained uncertain, a thorough examination of the full text was conducted to ensure the selected studies were highly relevant.

Table 1. WoS and Scopus search queries

Database resource	Queries
WoS	Topic = ("AI" OR "AIGC" OR "Generative AI" OR "Artificial intelligence") AND Topic = ("design education" or "design course" or "design courses" or "design student" or "design learner" or "future designer" or "design students" or "design learners" or "future designers" or "design teaching" or "teach design" or "teaching design" or "design learning" or "learn design" or "learning design")
Scopus	Keywords, title, Abstract: "AI" OR "AIGC" OR "Generative A" OR "Artificial intelligence" AND keywords, title, abstract: "design education" OR "teach design"

In the second stage, a manual screening of references from candidate literature, known as snowballing [], was conducted. The purpose of this manual search was to enhance the representativeness of the literature and ensure that all important studies were noticed. Google Scholar was used for this stage, and the full texts were evaluated based on the criteria in Table 2. Eventually, 38 articles were selected to be included in this study.

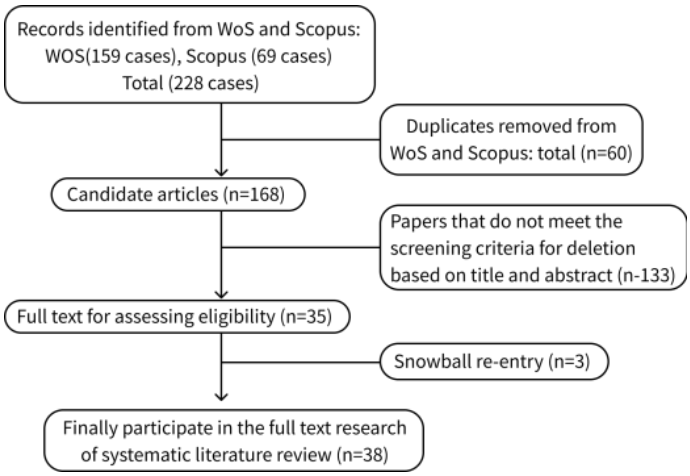

Figure 1. PRISMA flow chart

2.2 Literature screening criteria

The final 38 articles retrieved were subjected to full-text reading, data extraction, and mutual comparison, followed by the calculation of reliability among the raters. The purpose of data extraction was to analyse and extract useful information from each study, while data synthesis involved organizing and synthesizing the extracted data to provide an overview of the results [].

Table 2. Description of inclusion and exclusion criteria

Includes the following publications	Excluded publications
These studies should be relevant to AI-enabled design education.	It is not closely related to our research background and questions.
Provide the full text in the target database	No full text
English writing	Duplicate version, other languages
Published in the last four years (2020, 2021, 2022, 2023)	Published in 2019 and before

WoS core literature	Non-WoS core literature
These studies should be published publicly.	Unfinished and unpublished research.

We utilized the PRISMA method table to ensure comprehensive and transparent reporting of this review []. The SPIDER qualitative evidence synthesis tool was employed to guide the development of a systematic search strategy suitable for addressing non-quantitative research questions. The MMAT method was used to assess the quality of each accepted paper, and scores were categorized as high, moderate, or low quality based on the matrix [].

3 DATA ANALYSIS AND FINDINGS

After carefully reviewing the full text of the original research, data extraction is conducted to analyse and extract useful information from each study. Data synthesis involves organizing and synthesizing the extracted data to provide an overview of the results [14]. During the data synthesis process, studies with similar research topics are grouped, such as related concepts or impacts. Previous studies have identified three basic modes of AI in knowledge processing: knowledge representation, knowledge acquisition, and knowledge deduction []. Building upon this foundation, the study categorizes the searched papers into three dimensions: (a) Design Representation: using AI to enhance the presentation of design outcomes; (b) Design Deduction: using AI to assist in design education; (c) Design Acquisition: using AI to support the design process. By further organizing and synthesizing the extracted data, statistical results for the years 2020 to 2023 are summarized as follows: In terms of the target audience, there are 30 papers targeting university student design education and 6 targeting professional designers. Among the papers, 11 are theoretical research, and 27 are empirical studies, with 11 being quantitative research and 27 being qualitative research. Detailed analysis results will be provided in the next section.

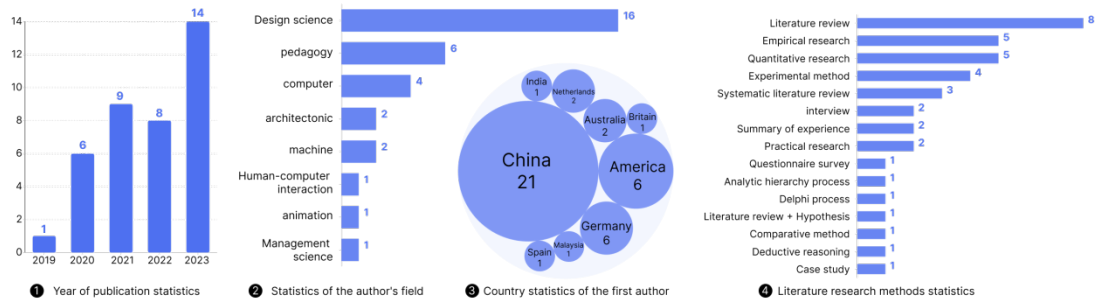

Figure 2. Search document classification schematic

Design education is an emerging interdisciplinary field, and the intervention of AI has complex and diverse impacts on it. AI has the potential to fundamentally transform educational practices by altering the roles of teachers and students and enhancing assessments [9]. AI's influence on teaching in the design discipline will manifest in three aspects: providing new perspectives on sensory experiences, introducing new concepts for products and services, and shaping new discourses on lifestyles. With the deepening application of AI technology, the field of design is poised to undergo significant changes in artistic presentation []. While AI can liberate designers from many traditionally logic-based tasks, the core decisions still rely on human designers. AI significantly enhances the originality, practicality, manufacturability [], and novelty of design outcomes, and it may also lead to the next paradigm shift in design aesthetics [27].

3.1 Artificial intelligence tools and technologies involved in design education

The literature search reveals that AI-Generated Content (AIGC) is the primary AI technology used in design education. Students utilize tools such as ChatGPT [], Stable Diffusion [19][20][21][22], Midjourney [19] [][][], DALL [20][21][22], and Kinectt [10] for classroom assistance, coursework, and self-study. AIGC is the most common application of AI in design education, with its content generation technologies encompassing text, images, audio, video, code, games, 3D, and multimodal content. AIGC is integrated into various design teaching scenarios. It is becoming a more efficient and convenient content creation method, following Professional Generated Content (PGC) and User Generated Content (UGC).

3.2 Changes brought about by artificial intelligence technology

AI provides students in design classes with unique visual stimuli and design concepts, aiding in the development of sustainable and innovative designs and enhancing creativity. Fiebrink et al. found that machine learning-based courses and tools can offer students new creative outputs, means of self-expression, and better economic benefits []. AI-ADT studied the optimization of art and design curricula in higher education institutions within an AI context, finding that AI-enhanced design education methods exhibit characteristics such as intelligence (98.1%), flexibility (96.5%), performance (93.6%), engagement (94.9%), and interactivity (95.1%) [].

AI has transformed art and design education, providing new ways to create, explore, and learn in non-traditional design classrooms [20]. The target audience for design education includes students, professional designers, and design enthusiasts. Amateur designers can access a wealth of information through the internet and social networks, enabling informal, non-institutionalized learning practices []. In design projects, designers' roles are increasingly diverse, focusing on core interactive tasks and data-centric responsibilities [].

Additionally, AI tools can detect plagiarism in art and design projects, promoting academic integrity [20]. The application of AI in art and design education will evolve in several directions: facilitating creative collaboration through intelligent tools and platforms, supporting real-time cooperation, providing creative inspiration, and enhancing teamwork [10].

3.3 Stakeholders face difficulties and challenges in the use of AI

Many design students worry about their careers being replaced by AI, as AI can generate designs directly. This raises questions about the role of teachers in design courses. When students rely too heavily on AI, how can teachers ensure they maintain independent thinking and creativity? The emergence of AI demands higher capabilities from students and teams, prompting changes in teaching methods and curriculum content.

AI's integration into design education has caused professional anxiety among stakeholders, with growing public discourse on mitigating AI's negative impacts [26]. There is a mismatch between industry needs and AI-generated products [19], leading to anxiety among design students about AI-driven job loss. Some studies predict that 20% to 50% of future jobs could be "lost" to AI [25].

The teaching paradigm for AI in design education is still undeveloped. There is no consensus on what AI knowledge design students should learn or how to integrate this knowledge with creative and aesthetic design skills []. While progress has been made in providing accessible resources for beginners, there is a lack of specialized materials or courses to guide designers, and many are unsure how to envision AI's future in diverse ways [24]. A significant issue in design education is that "traditional design" skills and computer-aided design (CAD) skills are often taught as separate paradigms that do not overlap with traditional teaching systems [25].

With the rapid development of AI technology, design students and collaborative teams face higher demands. Communication barriers and differences in AI tool usage are becoming more prominent [26]. Students encounter challenges in AI-assisted design, and some teams avoid engaging with AI altogether []. To address these trends, design students need not only design expertise but also interdisciplinary integration, lifelong learning abilities, and foundational knowledge in AI and big data. Senior designers, in particular, should master AI programming and data modeling algorithms to guide machine design [].

4 DISCUSSION

This literature review summarizes three new ways AI has been integrated into design education over the past four years: design representation, design deduction, and design derivation. It systematically outlines the impact of AI on design education. The influence of AI in this field is evident in practical outcomes, the roles of teachers and students, and issues of social reputation. In design representation, design students can use AI to develop innovative solutions, improve user experiences, and optimize design outcomes. In design derivation, AI serves as a supplementary tool to enhance learners' creative toolkits []. In design deduction, AI can transform design education practices by altering the roles of teachers and students and refining assessments. Additionally, AI involvement positively impacts educational equity, public aesthetic improvement, and the democratization of design education.

Most studies in this review focus on analysing and identifying patterns in existing models to summarize trends and make predictions. At this stage, there is almost no evidence directly linking AI-driven design teaching to improved teaching and learning quality. An important function of this systematic review is

to describe the current situation and explain the impact. It encourages researchers to explore more empirical studies on the development and implementation of AI in design education, aiming to broaden our understanding of the reasons and mechanisms behind this dynamic evolution.

5 CONCLUSIONS

AI and related machine learning concepts and technologies have expanded design education [27]. AIGC, an emerging mode of multimodal content generation, has been fully integrated into design education. This integration demands higher standards, including interdisciplinary integration, lifelong learning, and collaborative human-computer interaction skills. Consequently, designers must not only master design expertise to solve problems using AI tools in team collaborations but also adapt to the challenges brought by technological innovations. Future research could explore the impact of AI on stakeholders in design education, using quantitative and empirical studies to measure the extent of this influence.

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