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Integration of Generative Artificial Intelligence in Design Education: Evidence Review (2020–2024)

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Abstract

Generative technologies are reshaping creative industries and design workflows. This transformation is rapidly reaching undergraduate, studio-based design programs but the empirical picture remains fragmented with inconsistent reporting. A formal synthesis of the emerging evidence is essential to map its course and support informed decision-making. This evidence review maps how generative AI (GenAI) is being integrated into undergraduate and studio-based design education, synthesizing classroom practices, enabling and constraining conditions, pedagogical framings, and directions for future research. As GenAI tools enter art and design programs at pace, evidence remains fragmented across contexts and methods; consolidating it can guide practice, streamline integration, and help set a focused research agenda for design education. We conducted a PRISMA-ScR–aligned evidence mapping of empirical studies published 2020–2024. Systematic searches in Web of Science and Scopus identified studies of GenAI in design-education settings that reported learner, process, or artefact outcomes. After screening, we charted context, use case, and outcomes and produced a narrative synthesis; given the heterogeneity of designs and measures, we did not conduct a formal risk-of-bias assessment. The review contributes a design-education–specific evidence map, classifying GenAI use cases, cataloguing adoption enablers and barriers, and outlining a practical agenda for assessment and study design. Findings show GenAI is being

embedded across the design process for ideation, iteration, visualization, and augmented critique. Adoption is supported by access to tools, staff development, and task scaffolds aligned with intended outcomes and rubrics; it is hindered by limited capacity building, curricular rigidity, and policy uncertainty. Few studies make explicit use of educational theory, and inconsistent measures, protocols, and reporting constrain effect estimation. Implications for practice include scaffolding prompting within briefs, aligning outcomes and rubrics with AI-supported processes, requiring disclosure of AI use and process evidence, and ensuring reliable access and support. Implications for research include employing validated measures, comparative and longitudinal designs, and richer reporting of context, tasks, and measures while grounding empirical work in established educational theory. Broader impact lies in encouraging responsible, effective GenAI use in creative education and supporting graduate readiness for AI-mediated design work. Priorities for future research include co-creative workflows and learner experiences, governance and authorship norms, fair AI-assisted assessment that balances the subjectivity of design with automated outputs, longitudinal effects on creative autonomy and artefact quality, and robust frameworks to scale integration.

Keywords: GenAI Integration, Design Education, Design Pedagogy, Design Teaching Strategies, Generative Design

Introduction

The rise of Generative Artificial Intelligence (GenAI) has transformed the landscape of creative industries, blurring the boundaries between human-led and machine-augmented creativity. Unlike earlier forms of AI that primarily served assistive functions, GenAI systems are now capable of producing novel outputs across art, music, literature, and design (Luckin, Rudolph, Grünert, & Tan, 2024). This paradigm shifts challenges traditional assumptions about creativity, positioning GenAI not just as a tool but as a co-creator in the design process (Choi, Kim, Lee, & Moon, 2024).

The creative industries—including film, advertising, content creation, and digital design—are experiencing rapid disruptions as workflows are redefined by AI integration (Anantrasirichai & Bull, 2022). Experts acknowledge that while GenAI streamlines technical tasks, it simultaneously demands enhanced critical thinking, ethical discernment, and conceptual creativity from human designers (Jie Li et al., 2024; Y. Wang & Zhang, 2023). Consequently, design education must evolve to prepare students for a landscape where GenAI is deeply embedded across all stages of creative practice.

Recent research emphasizes that curricula must move beyond technical training to cultivate hybrid competencies, combining conventional methods with AI literacy, data-driven decision-making, and computational creativity(Chee, Ahn, & Lee, 2024). Yet, the influx of generative technologies also raises new pedagogical challenges: how can educators preserve the depth of critical inquiry and original thinking while embracing AI-driven efficiency (Nguyen & Truong, 2025)?

The integration of GenAI in design education is an emerging field where research is trying to establish how design education may approach the intelligent and generative technologies and integrate them into design curricula (Jiang, 2024). Although recent studies on GenAI in design education are promising and research efforts are emerging across diverse

contexts (Melker, Gabrils, Villavicencio, Faraon, & Rönkkö, 2025; Özorhon, Nitelik Gelirli, Lekesiz, & Müezzinoğlu, 2025), but the field is still new foe effect analysis. Most studies are empirical with emphasis on experimenting with the technology rather than on measuring the effect or magnitude of the transformation. For this reason, an evidence mapping is required to reflect on the emerging research directions and the state of evidence.

There is a need for an evidence review that maps the factors that are advancing or impeding the integration of GenAI in design education, identifies persistent challenges, and proposes future research directions. Since this review will look for integration and adaptation trends, pedagogical approaches, challenges to effective integration, future research directions and recommendations for stakeholders, the following research questions were selected for the study:

RQ1: What factors enabling the adoption of Generative AI in Design education, and what are the challenges to fast and effective integration?
RQ2: What pedagogical approaches are being developed or adapted for integrating Generative AI into design education?
RQ3: What future research directions and gaps are identified by researchers for advancing the integration of Generative AI in design education?

The first Research Question investigates the enabling factors and barriers that influence the fast and effective integration of Generative AI (GenAI) into design education. It explores what drives the adoption of GenAI across design disciplines while also identifying the institutional, technical, and pedagogical challenges impeding its implementation. The second Research Question focuses on the pedagogical strategies being developed or adapted to embed GenAI into design curricula. It aims to understand how design educators are rethinking design teaching and learning processes in response to generative technologies. The third Research Question identifies research gaps and future directions proposed by scholars, offering insights and recommendations to support stakeholders in advancing the responsible, scalable, and pedagogically sound integration of GenAI in design education.

Materials and Methods

This paper is a systematic evidence map of papers published about integrating Generative AI in design education. It is an organized and standardized approach to finding out what research has been saying about certain questions on the subject area of study. The Preferred Reporting Items for Systematic Review and Mata-Analyses (PRISMA) 2020 flow diagram and PRISMA-ScR checklist was followed to maintain rigor of the review. An evidence review systematically assembles and synthesises published studies to describe the extent, range, and nature of what is known. By integrating findings across heterogeneous contexts and designs, it answers questions that single studies cannot, clarifies areas of consistent evidence, and flags gaps, uncertainties, and methodological weaknesses. Rather than estimating causal effects, it provides a high-level map that guides future research priorities and informs practice and policy.

Reporting Framework

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement was introduced in 2009 and updated in 2020 to reflect advances in review

methods. Because this study maps the literature rather than estimates effects, we also follow the PRISMA(Page et al., 2021) extension for scoping reviews (PRISMA-ScR)(Tricco et al., 2018). In line with these guidelines, we specify eligibility criteria, information sources and search strategies, and the study-selection process; selection is summarised in a PRISMA 2020 flow diagram, and a completed PRISMA-ScR checklist is provided in the Supplementary Materials. Consistent with an evidence-mapping aim, no formal risk-of-bias assessment was undertaken; results are synthesised descriptively to promote transparency and reproducibility.

Selection of Information Database

Scopus and Web of Science are the two databases that were searched for this review. These databases were selected for their relevance to the research topic. These databases cover a wide spectrum of quality peer-reviewed journals and provide a comprehensive and multidisciplinary consortium of research resources that are likely to yield high-quality studies pertinent to the research questions. The databases can be accessed through institutional subscriptions for most of the universities and other research institutions, so the intent is to cover the full range of significant papers published on the subject to enable a thorough literature review.

Identification of Studies

the inclusion and exclusion criteria for articles are listed under in

Table **1**. These criteria are designed to ensure that the systematic evidence review includes the most relevant and high-quality studies that contribute to answering the research questions.

Table 1
Inclusion and exclusion criteria for screening articles

Criteria	Inclusion	Exclusion
Period	Papers published from 2020 – 2024	Papers published before or after – EC1
Language	Studies published in English	Studies not published in English – EC2
Accessibility	Articles and conference proceedings that are peer-reviewed and accessible.	book chapters, websites, reports or studies that are not peer-reviewed or inaccessible. - EC3
Study design	Primary studies: Peer-reviewed Empirical papers and case studies	Editorials, commentaries, opinion pieces, review papers – EC4
Subject Relevance	Studies focusing on integration of generative AI in design education	Studies not specifically addressing integration of generative AI in design education – EC5
Population	Studies targeting design discipline in higher education	Studies targeting other disciplines or other levels of studies – EC6

Search Strategy

After choosing databases for papers and deciding upon a criterion for inclusion and exclusion, a robust search strategy must be designed to ensure that all relevant studies get identified precisely. The exact strategy is as follows:

Keyword Selection

Based on research questions asked in the review, five sets of keywords were selected, the keywords in each set matched each other in meaning or were synonyms or were used in same context. This was done to ensure that a wide range of keywords was covered through boolean operators to identify and retrieve all relevant studies.

Boolean Operation and Formation of Search String

As both Scopus and Web of Science support nested Boolean operators, a single nested Boolean string was formed using Boolean operators which could address all themes and fetch relevant papers for all research questions. Boolean operators OR/AND have been used as indicated in the logic diagram shown in Figure 1. Studies using a thematic keyword or a synonym of such keyword will be selected using the OR operator while ensuring that all studies about GenAI, design education AND any one of the themes are selected for final inclusion. The standard symbols used in Computer Science logic have been adopted for AND, OR operations to make the diagram quickly understandable. The AND operation is denoted by ∩ while OR operation is denoted by ∪ symbols.

Final Search String/Query: ("Generative AI" OR "Artificial Intelligence" OR "Machine Learning" OR “Generative Adversarial Networks” OR “GenAI”) AND ("Design Teaching" OR "Design Education" OR "Graphic Design Education" OR "Design classroom”) AND (("Adoption" OR "Implementation" OR "Integration" OR “Practice” OR "Challenges" OR "Barriers") OR ("Future Directions" OR "Research Gap" OR "Trends" OR "Emerging Practices") OR ("Pedagogy" OR "Teaching Methods" OR "Educational Strategies" OR "Curriculum Design" OR “Strategies” OR “Teaching”))

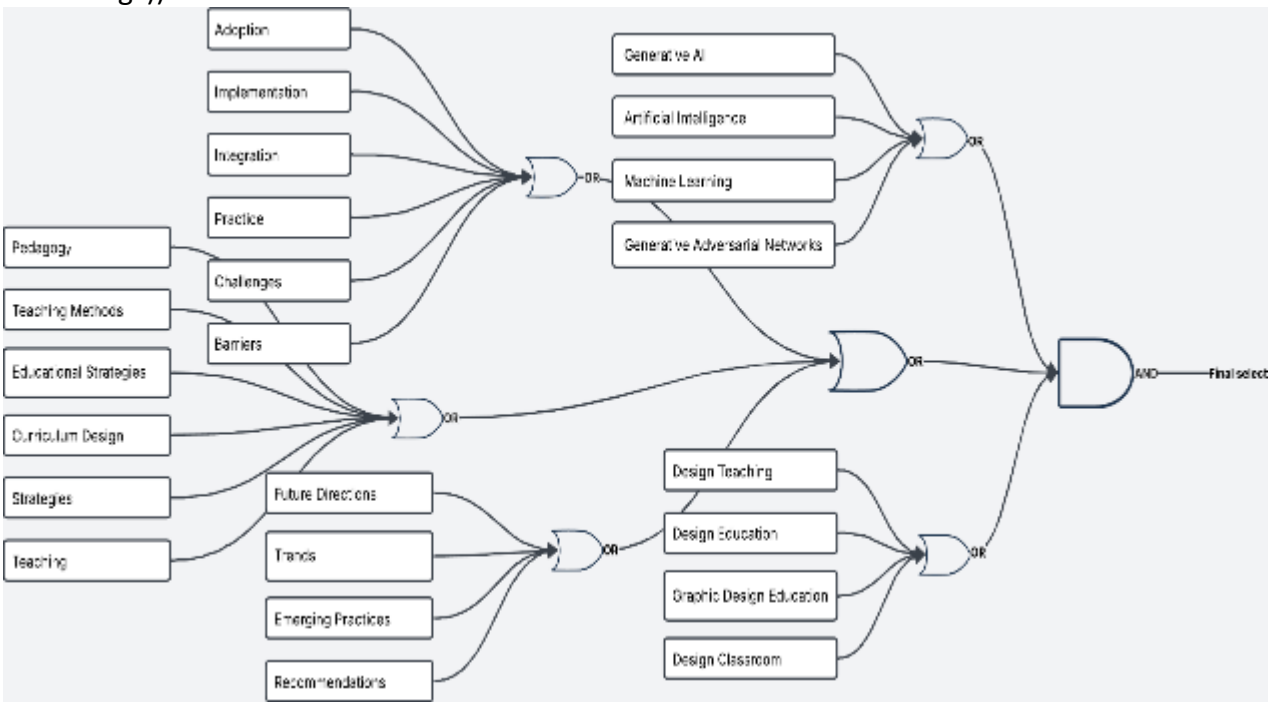

Figure 1. Logic diagram explaining search string formation using Boolean operators

Search Process

A systematic search was carried out using PRISMA guidelines for evidence or scoping review. The resulting papers were then filtered using the inclusion/exclusion criteria and the screening process was carried out to further shortlist relevant studies. The finally selected studies were then retrieved, and full-text versions were accessed for this review.

Data Extraction

The data extraction process was also systematic to ensure that all relevant information from each selected study was captured accurately and comprehensively. The data extraction focused on addressing the research questions. A standardized data extraction table was developed to standardize the information collected from each study. The table included fields corresponding to the research questions. Finally, the data was extracted from each selected study using the standardized table. Any inconsistencies were resolved by discussing them with another reviewer or consulting a third reviewer.

Data Synthesis

Data from the existing literature was synthesized using the thematic analysis approach by Braun & Clarke (2019)as it is a recent and structured approach for synthesis of finding. This phase involved identifying, analysing, and reporting patterns in the data which were then organized according to the research questions, allowing a seamless data result extraction through structured presentation of findings.

Results

The purpose of conducting this review was to get a bird-eye view of the state of contemporary research on integration of generative technologies in Design education. Given the up surge in research on Generative Ai in education in general and Generative AI in Design education in particular, it is critical to analyse the latest research systematically and organize it to understand the emerging patterns, the outcome and the areas for improvement. By examining primary studies published between 2020 and 2024, this review identifies emerging trends, comments on the rigor and robustness of current findings, and provide evidence-based recommendations for future researchers, design educators, AI professionals and policymakers.

A total of 230 search results were returned by both Web of Science and Scopus based on the search string as shown in

Table 2. At this stage only studies older than 2020, those which were not peer-reviewed article or conference proceedings and the ones not in English language were excluded or screened. Both searches were conducted on same day dated January 23, 2025.

The rigorous screening process ensured that the final data set contained only high-quality, relevant empirical studies focusing on the integration of Generative AI in design education. These studies were further screened and limited to narrow down to a total of 68 studies which

are highly relevant for evidence mapping on integration of Generative AI in design education, ensuring a comprehensive and robust analysis of the current state of research in this field.

Table 2
Search strategy and results

Search string	Documents obtained	
	WoS	Scopus
("Generative AI" OR "Artificial Intelligence" OR "Machine Learning" OR "Generative Adversarial Networks" OR "GenAI") AND ("Design Teaching" OR "Design Education" OR "Graphic Design Education" OR "Design classroom") AND (("Adoption" OR "Implementation" OR "Integration" OR "Practice" OR "Challenges" OR "Barriers") OR ("Pedagogy" OR "Teaching Methods" OR "Educational Strategies" OR "Curriculum Design" OR "Strategies" OR "Teaching"))	**100**	**130**

Screening and Selection

The search was carried out on Scopus and WoS databases using the filters for publication period to exclude papers published before 202 and after 2024 – EC1. The filter was also applied to limit the search results to only peer-reviewed journal articles and conference papers – EC2 and language was limited to English only – EC3. Further screening was carried out as a mirror reflection of the PRISMA guidelines. Initially, 230 studies were identified in both databases. The search results were transferred directly to reference management software, Mendeley, which specializes in eradicating duplicates. A total of 24 records (5 from Scopus and 19 from WoS) were duplicated and were therefore removed, while one file was retracted and hence excluded, reducing the number to 205 unique documents. Mendeley was also used for screening relevance from the title and abstracts of the papers included by carefully reviewing each study in accordance with the inclusion criteria and research questions to make sure they are relevant to the review. This screening revealed that 129 articles did not meet the criteria for this study and were excluded leaving 76 articles that were related to integration of Generative IA in design education in any branch of design or using any method of investigation. This screening confirmed a dearth of research on integration of generative AI into design education and specifically on teaching pedagogies.

The full text of the remaining 76 articles was then sought for, 50 records were open access while another 18 were retrieved using institutional login which led to further screening of 8 more articles due to inaccessibility. The remaining 68 were reviewed in full by the authors to ensure the comprehensiveness and impartiality of the assessment. In case of any ambiguity, the matter of including a study or otherwise was resolved through discussion or consultation with the third author. This through process resulted in further screening of 8 more articles for various reasons, leaving 60 full text articles that were selected as suitable for the study. The PRISMA flow diagram for this study is shown in Figure 2.

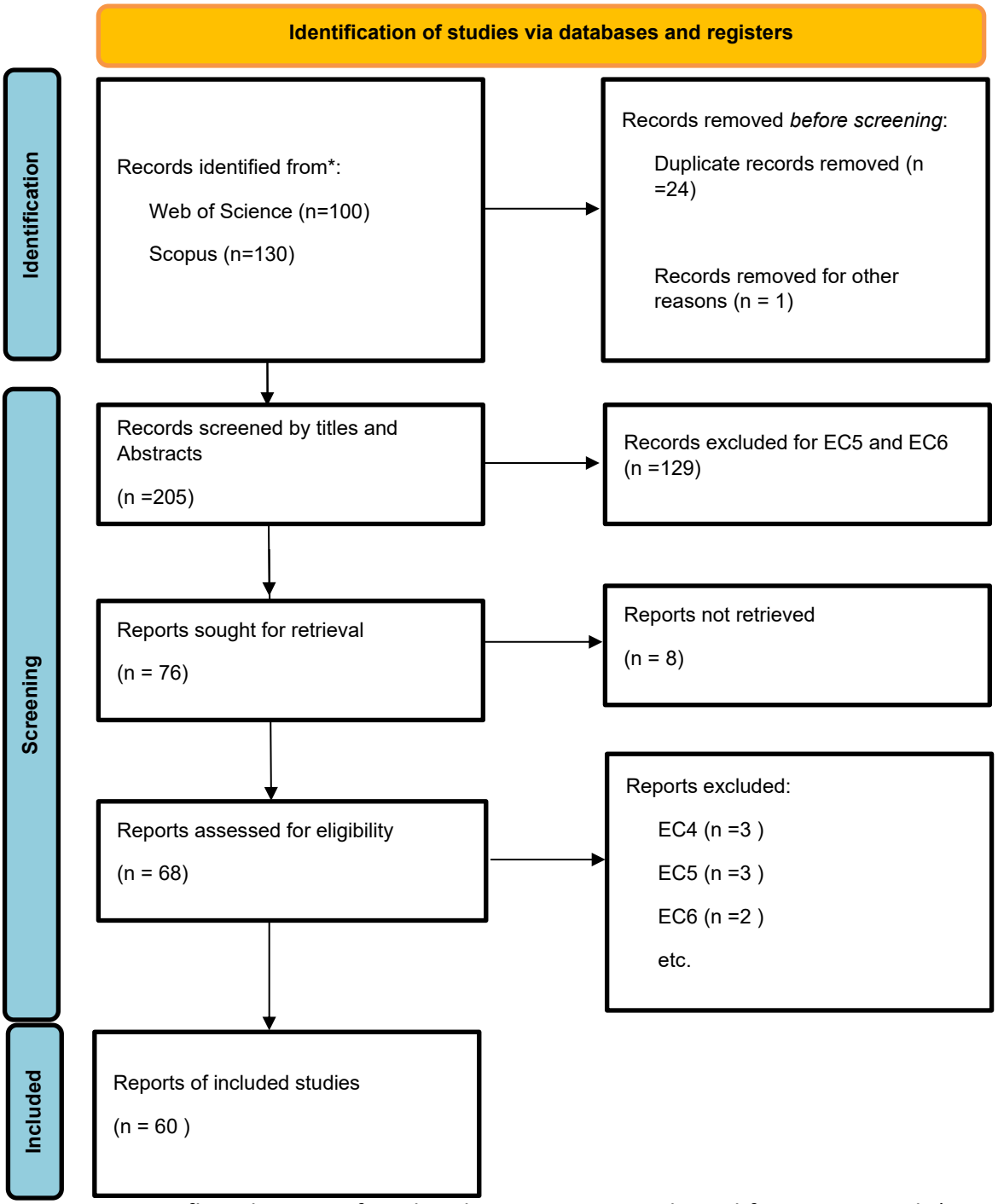

Figure 2. PRISMA flow diagram of study selection process. Adapted from Page et al. (2021), licensed under CC BY-NC.

Evidence Profiling

The research area of integration of GenAI in design education is fast evolving with a surge of innovative thinking sometimes revealing gaps, at others, proposing solutions or looking for innovative practices or the impact of these innovative practices. As shown in Figure 3, Out of the 60 articles selected for inclusion in this review, 38 were peer-reviewed articles while 22 were conference proceedings. The significantly high proportion of conference proceedings indicate that the subject is intriguing interest in contemporary research discourse and new ideas are being discussed and explored.

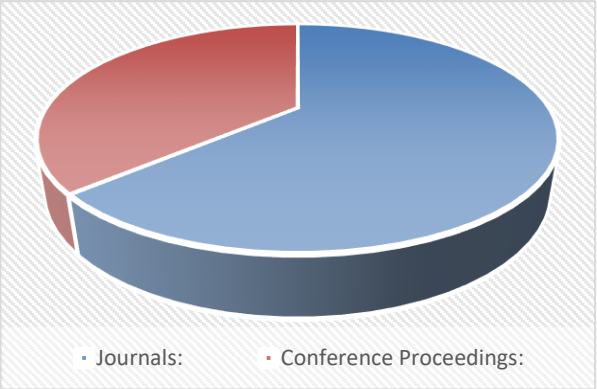

Figure 3 Ratio of Journal Articles to Conference Proceedings

Another important finding was pertaining to the high number of conceptual/ reflective papers being published which also indicate that innovation is being appreciated, and novel ideas are emerging worldwide. As can be seen in Figure 4, a considerable number of empirical studies, (nearly 87%) although generating new data, were not empirical in terms of method and should be called mixed studies as they reflected upon data or used it to build ground for the conceptual debate that followed. This trend also indicates that the field is evolving, and research is needed. The large number of empirical studies also speak of need for definite quantifiable answers to research questions about optimizing the integration of Generative technologies in design education in different design discipline.

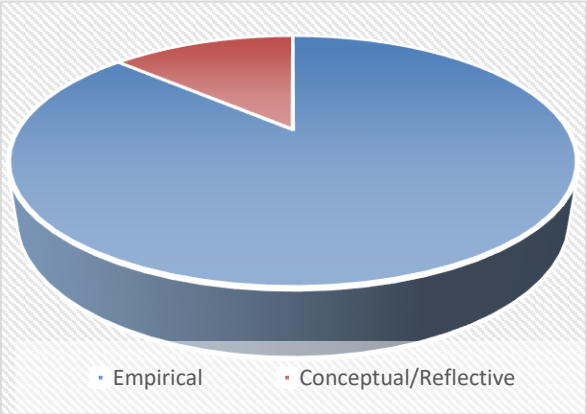

Figure 4 Types of studies

The study only focused on
literature from last five years as the advent of generative technologies in design education is a new concept and the publication trends indicate an increasing growth in publications over the last five years with a total of 02 publications in 2020 to a surprising total of 34 in 2024 as can be seen in Figure 5. Both journal articles and conferences are multiplying in number which indicates that the researchers' community have spotted potential for more research in the area.

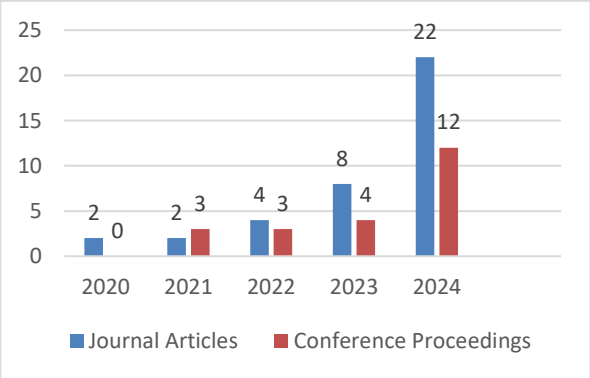

Figure 5 Year-wise publications of Journal Articles & Conference Proceedings

The integration of Generative AI in design education has an international appeal as research is pouring in from diverse geographical locations *(Figure 6)*. Even though China has a huge lead over other countries in terms of number of publications, USA, Australia, Taiwan and Turkey are also publishing on the subject.

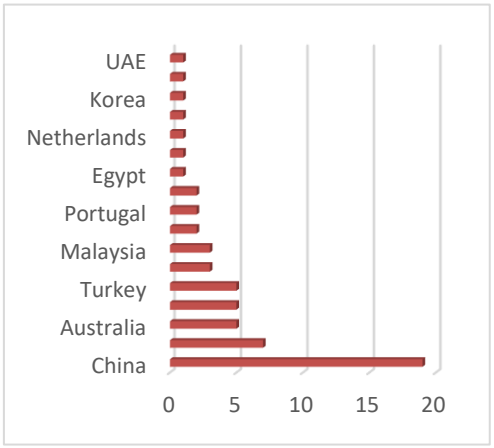

Figure 6: Countries publishing on GenAI integration in Design Education

The selected studies were published in a variety of research sources, including journals from the field of education & learning, design & architecture, computer science & IT, just to name a few.

Table 3 shows the number of studies published in journal categories and it can easily be established that the research area is diversified and multidisciplinary.

Table 3
Table showing number of studies published in multidisciplinary journal categories

Discipline	Number of Studies
Education and Teaching & Learning	14
Computer Science & IT	14
Design & Architecture	9
Engineering & Applied Sciences	4
Psychology & Cognitive Science	3
Interdisciplinary / Other	16

The multidisciplinary appeal of the research in this area is also evident from

Table **4** where only 5 out of 53 total research sources had more than one published paper included in this review.

Table 4
Journals having more than one publication selected.

Journals	Number of Studies
Proceedings of the International Conference on Education and Research in Computer-Aided Architectural Design in Europe	3
ACM International Conference Proceeding Series	3
International Journal of Technology and Design Education	2
Journal of Physics: Conference Series	2
Design Journal	2

For deeper analysis into the themes of the study, papers were searched according to each research question. And answers were sought for. As all studies were empirical in nature, they were focusing on the mechanism and results of GenAI integration in design education, they did not explicitly focus on the factors affecting the integration, but many factors were implicitly highlighted. Similarly, most studies did not explicitly discuss and specific pedagogical approach, but implicit suggestion were ample and were picked upon by the reviewers using inductive analysis approach. For better organization of the results, the findings have been stated according to research questions.

RQ1: What factors enable the adoption of Generative AI in Design education, and what are the barriers to its fast and effective integration?

Adoption of GenAI in Design Education

After analysing the papers published on the subject it is safe to state that there is a swift upsurge in adoption of generative technology in nearly all disciplines of design education. Design education constitutes of multiple design disciplines, each having its own niche but still standing on the same foundational principles. For example, the students studying architecture design maybe learning to design beautiful buildings whereas a website or UI/UX designer maybe learning to design an interface, but the design considerations for both remain the same where both need the design to look appealing and work perfectly. At the heart of each design discipline is the art of problem-solving with an exceptional ability to handle complexity. This is where Generative technologies come to the rescue.

According to the 60 studies selected for the review, researchers from a diverse range of design disciplines were involved in conducting empirical research and other primary research in the integration of GenAI in design education as shown in figure 7. The biggest number of papers were published on general design teaching related subjects like pedagogical considerations, curriculum development and evaluation of design projects, while the rest of the studies targeted one or two specific design discipline to empirically study the integration of generative AI tools or models for design teaching and learning in that design discipline. The figure under gives an overview of research produced in prominent design disciplines over the last five years.

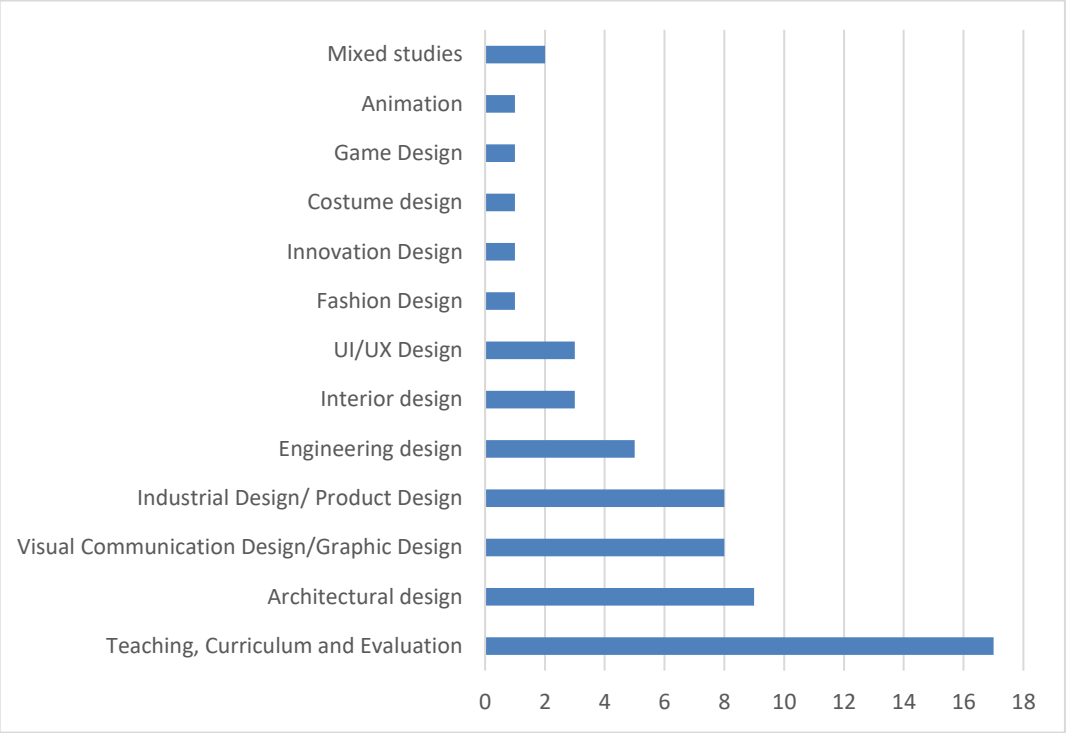

Figure 7: Number of studies published on various fields of design education

The figure 7 clearly indicates that generative tools are being studied with most interest in more technological branches of design like Architectural, Visual Communication, Industrial & product and Engineering design. Other more frequently published studies were from Interior design and UI/UX design. Only one study each was included for Fashion design, Innovation design, costume design, game design, and Animation design etc.

Factors enabling Integration of GenAI in Design Education

Although students and teachers are engaged in using Generative technologies individually for design practice and design teaching, the mainstream integration of GenAI into mainstream teaching and learning can only be achieved by developing a proper understanding of the contributors to this integration. Davis (1989) identified the importance of the perceived usefulness and perceived ease of use for successful implementation of digital technology. This section inspects the selected studies to look for factors that were seen as useful catalysts to the integration of GenAI in design teaching and learning. The figure 8 displays the proportionate mention of enabling factors pointed out in the selected studies, along with the percentages of occurrence of each factor.

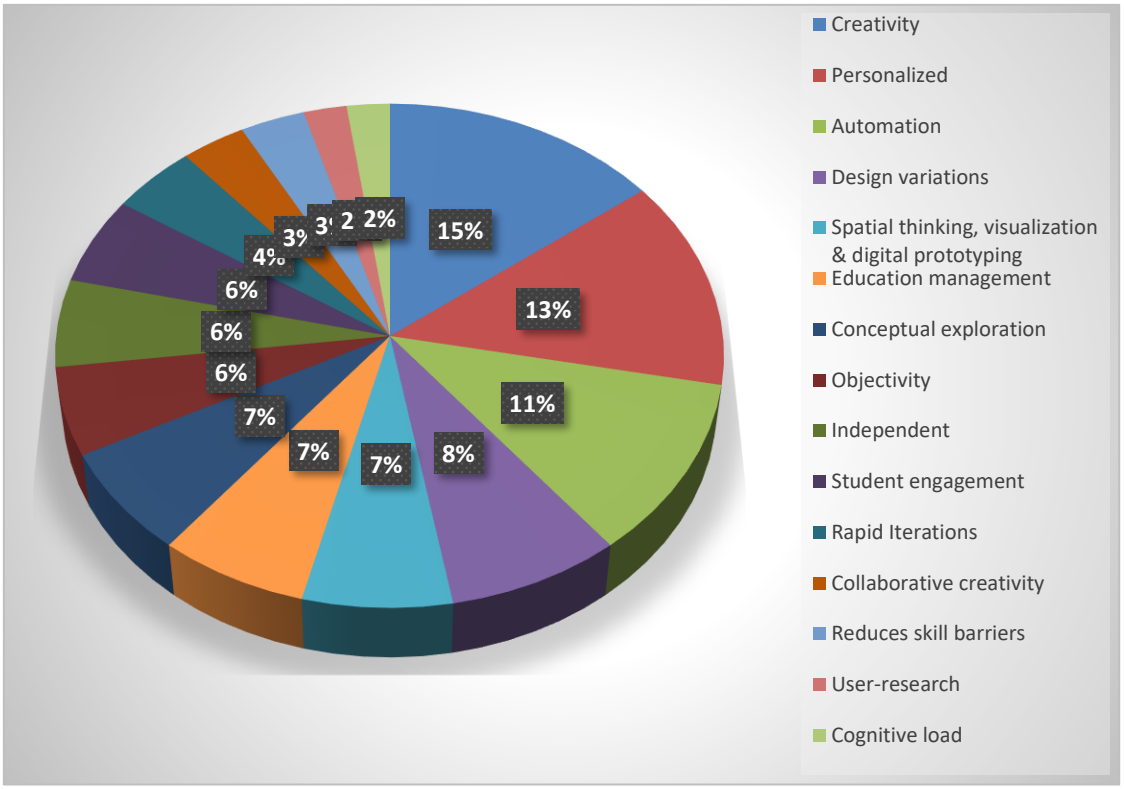

Figure 8 Factors enabling GenAI integration in Design Education

All selected studies were thoroughly reviewed and factors that could contribute to or hinder the integration were identified. Firstly, considering the enablers contributing to the students' design work will be considered and then the factors contributing to teaching and learning will be listed. As the ultimate goal of design education is achieving creative solution to complex design problems (Cropley & Cropley, 2010), the positive and enabling effect of GenAI on enhancing creativity was reported by over 13 studies (Almaz, El-Agouz, Abdelfatah, & Mohamed, 2024; Basarir, 2022; Chellappa & Luximon, 2024; Chumiran & Abidin, 2021; Chung, He, Lin, & Liang, 2024; Cudzik, Nyka, & Szczepański, 2024; Do Amaral, 2024; Giretti et al., 2023; Kahraman, Şekerci, & Develier, 2023; Q. Liu, 2024; Shang, 2021; Wei, 2024; Zhao, Peng, & Wu, 2024) making the highest 15% of the total Contributors mentioned by researchers. The researchers mentioned how the integration of GenAI polished students' creative abilities by providing efficient data retrieval, an opportunity to critically reflect and contextually analyze the responses. Other enabling qualities of integrating GenAI in design education for students were when researchers mentioned the ability of generative models to provide countless design variations to choose from(mentioned 8 times) (Brown et al., 2024; Iranmanesh & Lotfabadi, 2024; Lee & Suh, 2024; Lu, Huang, Liu, & Gong, 2021; Montenegro, 2024; Ning, Gao, & Luo, 2024; Omran Zailuddin et al., 2024; Tong et al., 2023), along with the power of performing multiple iterations of a design task with immaculate efficiency, mentioned at least 4 times (Chien & Yao, 2020; Gao, Mei, Duh, & Zhou, 2024; Iranmanesh & Lotfabadi, 2024; Yang & Shin, 2024).

The idea that generative AI can enhance spatial thinking or improve visualization or generate enhanced digital prototypes of design solutions was floated by 6 studies making 7% of all contributors (Bartlett & Camba, 2024; Tilanka Chandrasekera, Hosseini, & Perera, 2024;

Fastabend, Müller, Roth, & Kreimeyer, 2024; Montenegro, 2024; Samad, Izani, Razak, & Rosli, 2024; Stevens, Dedushkov, & Ionoescu, 2023) whereas an equal number of studies advocated GenAI integration in design education by emphasizing the ability of this technology to facilitate conceptual exploration (Agkathidis, Song, & Symeonidou, 2024; Bartlett & Camba, 2024; Doumpioti & Huang, 2024; Giretti et al., 2023; Harun, Syed, & Abdullah, 2024). Yet another five studies mentioned that involving GenAI into design classroom can enhance student engagement and can result in deeper creative engagement and more active learning (Basarir, 2022; Hsieh & Wu, 2023; Ruan, 2024; Yang & Sha, 2021; Yang & Shin, 2024). Three studies stated that GenAI enhanced collaborative creativity by working with the students as a team member, augmenting their creative abilities (Doumpioti & Huang, 2024; Fleischmann, 2024b; Kavakoglu, Almac, Eser, & Alacam, 2022). Three studies stated that GenAI can help reduce skill barriers for students and designers which may result in democratization of design (Doumpioti & Huang, 2024; Hsieh & Wu, 2023; Huang, Liu, Dong, & Lu, 2024). Two studies mentioned that GenAI can make efficient user research possible by providing a holistic picture from user perspective which may aid UI/UX designers (Chung et al., 2024; H. Liu et al., 2024). Yet another contributor was spotted where two studies mentioned that using GenAI in design classroom can reduce cognitive load on students or professional designers (Calixto & Croffi, 2024; T. Chandrasekera, Hosseini, Perera, & Bazhaw Hyscher, 2024).

The second most significant area where many factors were reported to contribute positively was the teaching and learning of design and the most recurring mention was GenAI's ability to offer personalization. Twelve studies mentioned this attribute of generative technologies to be effective for individual or adaptive learning or for offering personalized assessment and efficient, actionable feedback on designer work (Do Amaral, 2024; Hutson, Fulcher, & Ratican, 2024; Li, Liu, Zheng, & He, 2024; Liu & Yao, 2023; Noortman, Lovei, & Funk, 2022; Samad et al., 2024; Shang, 2021; Wei, 2024; Xu & Jiang, 2022; Zhao et al., 2024; Zhao & Gao, 2023). Another aligned area of GenAI contribution was identified by four studies which reported that GenAI enables the student to involve in self-directed, interactive and adaptive learning at the student's own pace which can facilitate the learning process (Ambikairajah, Sirojan, Thiruvaran, & Sethu, 2024; Fan & Li, 2023; Yang & Sha, 2021; Z. Yang & Shin, 2024). Six studies highlighted that GenAI can contribute positively to education management of design education (Li et al., 2024; Liu & Yao, 2023; Meron & Tekmen Araci, 2023; Xu & Jiang, 2022; Zhao & Gao, 2023), including mentions of how GenAI can facilitate curriculum development, administration, classroom management, and task allocation for design educators. Another five studies cautiously suggested that GenAI may have the potential to help with objective evaluation of design work (Chaudhuri & Dhar, 2023; Chung et al., 2024; Fan & Li, 2023; Hsieh & Wu, 2023; Zhang et al., 2024). whereas a total of ten studies mentioned that GenAI can bring automation in design workflow and evaluation of design work, which can ensure transparency and efficiency(Basarir, 2022; Calixto & Croffi, 2024; Chaudhuri, Dhar, & Yammiyavar, 2022; Gao et al., 2024; Hutson et al., 2024; Ning et al., 2024; Samad et al., 2024; Tang, Li, & Tang, 2022; Vahdat & Mansoori, 2020; Zhang et al., 2024).

Barriers to the integration of GenAI in Design Education

The selected studies were not only positive about the integration of GenAI in design education, but instead they also pointed out some major concerns that surround the practitioners, educators, students and researchers. Research points out to some hinderances

that block the way of GenAI integration into Design education. These factors are displayed in figure 9, with some elaboration under it.

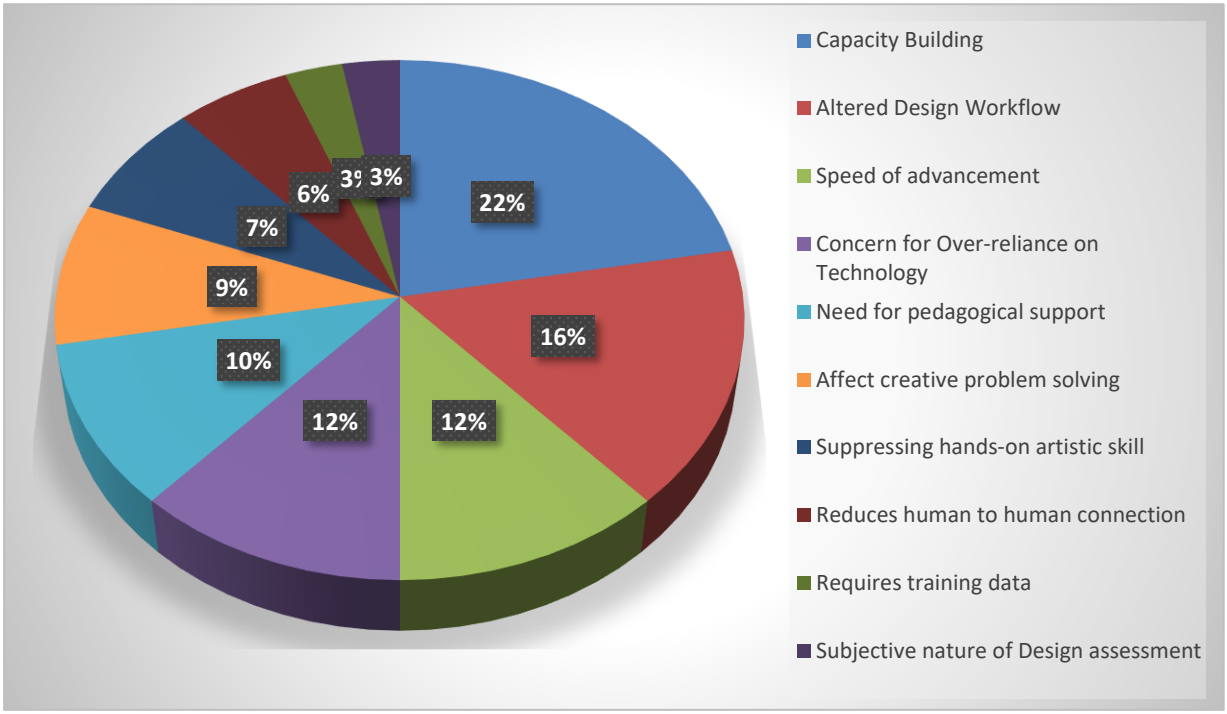

Figure 9 Barriers to GenAI integration in Design Education

The most significant barrier or challenge identified by these studies is the lack of capacity to effectively use this technology. 21% of the barriers, which was a total of 15 studies, pointed out new competencies needed to efficiently manoeuvre the evolving design workflow. The need for competency in effective prompt engineering was highlighted by eight studies (Chaudhuri et al., 2022; Chellappa & Luximon, 2024; Cudzik et al., 2024; Kahraman et al., 2023; Lee & Suh, 2024; Montenegro, 2024; Tong et al., 2023; Yang & Shin, 2024) while another four studies mentioned the need for structured AI literacy, which would enable users to tailor the generative responses to be as close to their needs as possible (Agkathidis et al., 2024; Almaz et al., 2024; Flechtner & Stankowski, 2023; Zhang et al., 2024). Another competency that was considered important by three studies was the need for capacity building in computational thinking (Calixto & Croffi, 2024; Kavakoglu et al., 2022; H.-H. Wang & Wang, 2024), which the researchers deemed necessary to benefit from the full potential of the generative tools.

Generative design process differs immensely from the conventional design process and the drastic change is hard to come by and adapt to. This was the second biggest barrier identified in the selected studies. Out of 60 studies, 11 studies which made 16% of all barriers identified, mentioned that GenAI has altered the design workflow and the new ways of doing design need realignment of thought and comprehensive understanding of generative tools (Ali & Maynard, 2021; Chumiran & Abidin, 2021; Cudzik et al., 2024; Doumpioti & Huang, 2024; Fleischmann, 2024b; Iranmanesh & Lotfabadi, 2024; Kavakoglu et al., 2022; Liu & Yao, 2023; Omran Zailuddin et al., 2024; Tien & Chen, 2024).

Another obstacle to integration of GenAI is the speed of advancement and growth in Generative design technology as the educators and policy makers are constantly trying to

catch-up before a new more efficient method or evolved workflow sweeps the previous practices (Fastabend et al., 2024; Flechtner & Stankowski, 2023; Gao et al., 2024; Giretti et al., 2023; Lee & Suh, 2024). Additionally, researchers, educators and students have mentioned in more than five of the selected studies that the use of generative tools may suppress or undermine the development of hands-on artistic skill (Fleischmann, 2024b; Hsieh & Wu, 2023; Wei, 2024; Xu & Jiang, 2022; Zhao et al., 2024) while six others believed that GenAI can affect creative problem solving and hinder independent design thinking in students, as student maybe more inclined to accept the answers without much critical evaluation if they are not able to structure the output of a generative model according to their requirements (Bartlett & Camba, 2024; Chellappa & Luximon, 2024; Huang et al., 2024; Li et al., 2024).

Another major concern that surfaced through researcher insights was for the downside of possible over-reliance on technology. 12% of the total reported barriers or concerns which was 8 studies, were for over-reliance of students on generative technology (Ambikairajah et al., 2024; Chaudhuri & Dhar, 2023; Hutson et al., 2024; Lee & Suh, 2024; Li et al., 2024; Ning et al., 2024; Shang, 2021; Zhao & Gao, 2023), which could lead to surficial and limited learning and possible deskilling of aspiring designers. Four studies voiced the concern for reduced human to human engagement because of this new technology where it can be utilized for brainstorming, discussing or feedback, reducing the need for human interaction (Ambikairajah et al., 2024; Bartlett & Camba, 2024; Chien & Yao, 2020; Zhao & Gao, 2023).

Another important trajectory of concern was exposed by seven studies which stressed the need for pedagogical support and presence of critical guidance while students use generative technologies so that the output can be structured and channelized for design efficiency (Ali & Maynard, 2021; Basarir, 2022; Brown et al., 2024; Chellappa & Luximon, 2024; Fleischmann, 2024b; Meron & Tekmen Araci, 2023; Tang et al., 2022). The concern for critical guidance was also raised when two studies discussed the use of GenAI for automating design assessments, as they highlighted the subjective nature of design evaluation (Chaudhuri & Dhar, 2023; Chaudhuri et al., 2022). Another shortcoming of GenAI use in Design is the need for training data. Two studies pointed out that GenAI based assessment, and generative design can be more effective and contextually correct if large amount of training data was made available to it (Chaudhuri & Dhar, 2023; Kahraman et al., 2023). Ethical considerations pertaining to the use of generative tools in design education will be discussed in a separate section of this review.

RQ2: What pedagogical approaches are being developed or adapted for integrating Generative AI into design education?

Pedagogical Approaches and Insights

Pedagogical approaches play a crucial role in shaping effective learning experiences in design education. As a field inherently linked to technological advancements, design education has evolved from manual to digital competencies, increasing in complexity while maintaining its core emphasis on problem-solving, critical thinking, and creative yet functional solutions. This constant evolution places significant demands on educators, requiring them to stay ahead of emerging technologies. The rapid integration of generative AI (GenAI) into design workflows presents a new pedagogical challenge: how can design education adapt to incorporate GenAI while preserving fundamental design principles? This review examines how educators have

approached this challenge over the past five years, exploring strategies for integrating GenAI into design pedagogy.

Majority of selected empirical studies have used AI to assist in the teaching and learning of design by experimenting with design workflow, using AI- assisted methods, pedagogies, evaluation procedures etc. and the process did not require any computational competency. However, about eight studies did involve a more technical route where AI models were programmed and trained on data from design discipline to help in design teaching (Chaudhuri & Dhar, 2023; Kavakoglu et al., 2022; Yang, 2021) evaluation (Chaudhuri et al., 2022; Han et al., 2023), personalized or adaptive learning(Fan & Li, 2023; Xu & Jiang, 2022) or to help early career designers in user research (Zhang et al., 2024). Most researchers, however, focus on the application of AI instead of the computational part.

The research originating in the field of GenAI integration in Design Education is mostly by researchers from a computational science, design or interdisciplinary background and majority of the empirical studies selected, focused on the integration of GenAI in design teaching or practice, rather than on the pedagogy or educational setting of the experiment. Most studies lacked a strict educational setup or an educational theory or framework to be followed, rather an implicit mention and frequent commentary on pedagogical practices and teaching & learning methods was observed. The pedagogical discussion in the selected studies have been organized or grouped into themes to better comprehend and make sense of the research insights.

The use of GenAI in all educational disciplines is common for objective assessment, personalization of teaching and feedback, Curriculum development etc. however, for design discipline in specific, GenAI is also being used to assist in the process of creative development and paramount impact of this technology is experienced in the field of design where GenAI is making its way into every stage of design development, hence redefining design workflow. The papers selected for this review also discussed pedagogy with relevance to these themes and detailed insights of each research are listed in Table 5, along with a complete reference of the paper.

Table 5
Themes and detailed insights on pedagogical discourse in selected studies

Themes	Pedagogical Discussion and Insights	References
AI for Objective Assessment of design	AI-driven assessment can enhance fairness in grading creative aptitude by reducing subjectivity and inconsistency.	(Chaudhuri et al., 2022)
	The study Advocates deep-learning based novelty assessment model for transparency and consistency in evaluation of creativity. The model only evaluates text-based creativity through checking grammar, relevance and uniqueness objectively but points out the loss of human-intuition in assessment.	(Chaudhuri & Dhar, 2023)
	The study explores AI-driven stereoscopic image quality assessment in visual communication education, demonstrating how it can enhance objective design	(Han et al., 2023)

Table 5
Themes and detailed insights on pedagogical discourse in selected studies

Themes	Pedagogical Discussion and Insights	References
	evaluations, image analysis skills, and analytical thinking in students.	
AI-based Teaching & Learning	Study suggests a hybrid design learning framework, which includes design ideation, digital visualization, presentation methods, personalized learning and a feedback mechanism.	(Liu & Yao, 2023; Omran Zailuddin et al., 2024)
	Highlights how Generative AI transforms art and design education, promoting digital intelligence in teaching. AI supports creative teaching concepts and helps implement	(Ning et al., 2024)
Curriculum Development	AI and automation necessitate a curriculum shift in architectural education, integrating data-driven design, digital fabrication, and automation skills to align with industry	(Vahdat & Mansoori, 2020)
	AI-driven curriculum restructuring and continuous learning frameworks are suggested. study proposes a research-based undergraduate course model embedding AI applications in architectural design, assessing learning outcomes to align with evolving industry demands.	(Basarir, 2022)
	Explores an AI-augmented curriculum integration in costume design pedagogy, enhancing fabric selection, digital sketching, and accuracy but raising concerns about creative autonomy.	(Harun et al., 2024)
GenAI-Assisted Creativity	Using TPACK framework for enhancing student engagement and creativity through the structured use of prompt engineering using existing GenAI tools for design but concerns	(Lee and Suh, 2024)
	Image-to-image GenAI tools like DALL-E, Stable Diffusion, and Midjourney to enhance architectural creativity by stimulating concept development.	(Agkathidis et al., 2024)
	AI integration in architectural education was evaluated and the role of AI in enhancing creativity was acknowledged with three distinct approaches, AI as inspiration, AI-human hybrid design process and AI-assisted interactive design loops.	(Cudzik et al., 2024)
	Cognitive engagement of students with Generative technologies is studied and paper highlights the role of reflective thinking for enhancing creativity and ideation while voicing a possible depletion of deep learning and original thinking in some cases.	(Liu et al., 2024)
	Visual Generative AI is enhancing collaborative creativity by accelerating ideation and producing efficient digital prototypes. Techniques like collage can be effective strategy for collaborating with GenAI which is involving a say of the non-designers in design process but there is need for a balanced creative workflow.	(Doumpioti & Huang, 2024)
	An AI-assisted drawing guidance system is used in a technology-enhanced, student-cantered approach, helping students translate abstract ideas into concrete images, enhancing creativity and problem-solving. The study uses questionnaires and exploratory factor analysis to assess	(Hsieh & Wu, 2023)

Table 5
Themes and detailed insights on pedagogical discourse in selected studies

Themes	Pedagogical Discussion and Insights	References
	student engagement and learning outcomes. Concerns about dependency and standardization were observed.	
Application in Design Workflow	Uses a collage-based AI design framework, where students combine AI-generated imagery with physical and digital sketches to refine their concepts. Employs a before-and-after	(Doumpioti & Huang, 2024)
	The study reflects on the use of AI-generated imagery in 221 public jury sessions, where design variation and rapid ideation were seen as helpful, but there is need for critical thinking as AI solutions may Lack real-world feasibility hence there is need for structured AI framework.	(Iranmanesh & Lotfabadi, 2024)
	Introduces AI-human hybrid workflows, where students use AI-generated images for ideation but manually refine final designs. Discourse on understanding originality and ethical concerns surrounding AI are encouraged.	(Bartlett & Camba, 2024)
	Uses the Technology Acceptance Model (TAM) to evaluate how students engage with AI tools for space planning and visualization. Conducts an interior design classroom study with 32 sophomore students, assessing how different learning styles interact with AI-based tools.	(T. Chandrasekera et al., 2024)
	Uses Technology-Mediated Learning Theory to assess AI's effect on design cognition, self-efficacy, and ideation quality. Conducts an empirical study with 119 product design students, analysing AI's role in creativity and conceptual development. Study found that Higher-proficiency students benefited more, while lower-proficiency students required personalized AI support. Highlights the need for blended AI-human ideation approaches.	(Huang et al., 2024)
	AI-supported design exercises to generate concepts for interior designs, enhancing ideation and inspiration. However, prompts can lead to inconsistent visual representations if not articulated	(Kahraman et al., 2023)
	Implements a four-phase AI-driven architectural design workflow, including site analysis, AI-generated illustrations, 3D modeling, and translation into architectural solutions. Evaluates effectiveness via student surveys and expert reviews.	(Agkathidis et al., 2024)
	New Approaches toward GenAI at different stages of the design process to improve problem solving, behavior analysis, practical skills and reduce subjectivity.	(Brown et al., 2024; Chung et al., 2024)
	Implementing a five-stage recursive design process where students train AI models to enhance computational creativity or co-creativity.	(Kavakoglu et al., 2022)
	Introduces no-code ML tools (Weka) into design ideation and problem-solving exercises to stress the need for building computational competencies in design students.	(Wang & Wang, 2024)

Table 5 shows majority of published literature on the subject is directed toward the need to evolve design education to deal with the evolving design workflow (Iranmanesh & Lotfabadi, 2024), to propose new ways of teaching design using a Human-AI collaborative workflow (Bartlett & Camba, 2024; Doumpioti & Huang, 2024) which is contained through structured prompt engineering (Kahraman et al., 2023) to help students navigate the creative potential of GenAI technologies (Huang et al., 2024), bringing it under strict critical evaluation by human collaborators rather than it becoming the lead designer itself.

The role of GenAI on creative development of humans is the next most explored phenomenon in the selected studies. A surprising majority of studies present a positive impact of GenAI on creative development but warn against technology dependency or over-reliance (Lee & Suh, 2024; Liu et al., 2024) which may lack critical appraisal of the generative output, resulting in trivial designs (Hsieh & Wu, 2023). Few of the studies used established statistical and quantitative measures of change in creative output because of using Generative technologies (Agkathidis et al., 2024; Brown et al., 2024; Huang et al., 2024; Liu et al., 2024; Ning et al., 2024) but most of the studies measured creativity using subjective or qualitative methods which lack research rigor.

It can also be inferred from the table of pedagogical findings shared above that research trends in GenAI integration in education in general like the use of GenAI for objective assessment (Chaudhuri & Dhar, 2023; Chaudhuri et al., 2022), curriculum development (Basarir, 2022; Vahdat & Mansoori, 2020), personalized T&L (Ning et al., 2024; Omran Zailuddin et al., 2024)are also reflected in design education research. Four of sixty studies selected for the review followed a specific pedagogical or educational theory, model or framework. Fleischmann (2024a) conducted a longitudinal quasi-experimental study where he used project-based learning strategy for studying the effect of use of GenAi on design outcome and student learning. Similarly, Lee & Suh (2024) took guidance and structure from the Technological, Pedagogical and Content Knowledge framework for studying student engagement and creativity. Chandrasekera et al. (2024) used the Technology Adoption Model from educational technology research to evaluate hoe students engage with this technology while Huang et al. (2024) studied the intervention using the lens of Technology-Mediated Learning theory. Overall, the proportion of research focusing more on the teaching and learning of design is only 15% while the majority of 85% of the selected studies on GenAI integration into design education focus on structing a new design workflow by integrating GenAI and the impact of such integration on creativity and teaching and learning of design.

RQ3: What future research directions and gaps are identified by researchers for advancing the integration of Generative AI in design education?

Future Research Direction and Gap Identification

The primary objective of reviewing existing research on GenAI integration in design education is to channelize and direct the ongoing research towards areas that can benefit the field and need to be explored in the future. Although GenAI is being incorporated across stages of design ideation, prototyping, and evaluation, there is little consensus on standardized or structured integration approaches. Future direction and gaps were extracted from the selected papers inductively by analysing and looking for recurring ideas and suggestions. Following the process data-reduction and synthesis for all 60 studies, a total of 17 recommendations were developed for integration of GenAI in Design Education.

1. Research points out a need for deeper integration of Generative AI into design tools and workflows at all stages of design process to enhance creative ideation, automation, and real-time assistance (Huang et al., 2024; H.-H. Wang & Wang, 2024).
2. Studies highlighted the need for AI-powered co-creative systems that support the design process rather than replace designers, in other words to utilize AI as a collaborator rather than a sole creator (Chellappa & Luximon, 2024).
3. Research is putting a great emphasis on role of AI-assisted novelty assessment models in evaluating and enhancing design originality and quality(Chaudhuri & Dhar, 2023)
4. There is a need for improving user experience (UX) in AI-integrated tools to make them seamless and intuitive when integrated in design workflows (Omran Zailuddin et al., 2024).
5. There is an urgent need to redefine design curricula to include basic AI literacy, teach data-driven decision-making, and computational design thinking skill to student to be able to benefit from the integration (Omran Zailuddin et al., 2024; Samad et al., 2024; Z. Yang & Shin, 2024).
6. Studies are suggesting that future design education must equip students with a hybrid skill set, where they are combining traditional design expertise with AI fluency (Shang, 2021b; Vahdat & Mansoori, 2020).
7. The need for capacity building of faculty for AI related competencies should be carried out to ensure educators can effectively integrate AI-powered pedagogies into their teaching (L. Wei, 2024).
8. Further research must explore the role of GenAI to assist with personalized learning experiences, enabling students to adapt and tailor their design workflows according to their needs and aptitude(H. Liu et al., 2024).
9. Ethical considerations of human-AI collaboration are another important area, future research must ensure that AI serves as an assistive tool rather than an autonomous creator(Calixto & Croffi, 2024; Flechtner & Stankowski, 2023) .
10. Studies raise concern for AI bias and indicate that future work must contribute towards the problem of bias in AI-generated creative content and how design students must navigate this bias, specifically regarding cultural representation and ethical decision-making in design outputs (Huang et al., 2024).
11. Moreover, there is a growing demand for AI governance models that establish clear ethical guidelines for AI use in creative education (Chellappa & Luximon, 2024). This includes research on bias mitigation, intellectual property concerns, and the role of AI in creative authorship (Liu et al., 2024).
12. Another area for future research is the call for curriculum reforms to incorporate AI-driven design methodologies specially requiring institutions to rethink assessment criteria (Huang et al., 2024).
13. There is need for new pedagogical strategies, such as AI-enhanced project-based learning, flipped classrooms, and real-world AI design challenges(Fleischmann, 2024b; Tang et al., 2022) .
14. Research on adaptive learning systems, where AI tailors instructional content based on individual student needs are also being pursued with interest (Liu & Yao, 2023).
15. The role of AI in grading and evaluation is another potential area for exploration, particularly in developing fair and objective assessment systems for creative work (Chaudhuri et al., 2022).
16. Another broader future direction involves AI policymaking for design education, ensuring

that institutions establish clear guidelines for responsible AI use in design (Stevens et al., 2023).

17. Future research should also assess AI's long-term impact on design creativity and innovation, particularly how over-reliance on AI might influence creative intuition and originality (Chellappa & Luximon, 2024).

To develop a better understanding of the future research directions and goals, inductive thematic analysis approach has been employed on these items as shown in

Table **6**, the recommendations and future directions for the field of GenAI integration in design education have been grouped into five broad categories and 18 sub-categories.

Table 6
Thematic analysis of future research directions from the reviewed literature

Category	Sub-category	Reference
Facilitating AI Integration in Design Tools and Workflow	creative ideation, automation, and real-time assistance	(Huang et al., 2024; H.-H. Wang & Wang, 2024)
	co-creative systems	(Chellappa & Luximon, 2024)
	novelty assessment models	(Chaudhuri & Dhar, 2023)
	user experience (UX) in AI-integrated tools	(Omran Zailuddin et al., 2024)
Building AI Literacy and adopting new Skillsets	AI literacy and computational design thinking	(Omran Zailuddin *et al.*, 2024; (Samad et al., 2024b; Yang & Shin, 2024)
	hybrid skill sets	(Shang, 2021; Vahdat & Mansoori, 2020)
	faculty training	(Wei, 2024)
	personalized learning experiences	(Liu *et al.*, 2024)
Ethical AI in Design education	human-AI collaboration	(Calixto & Croffi, 2024; Flechtner & Stankowski, 2023)
	investigate bias in AI-generated content	(Huang et al., 2024)
	ethical guidelines for AI use in creative education	(Liu et al., 2024)
Reshaping Pedagogical Frameworks and Curriculum	curriculum reform	(Huang et al., 2024)
	pedagogical strategies	(Fleischmann, 2024b; Tang et al., 2022)
	adaptive learning systems	(Liu & Yao, 2023)
	automated assessment systems	(Chaudhuri et al., 2022)
Policy Development and Long-Term Research role of AI	guidelines for responsible AI use	(Stevens et al., 2023)
	long-term impact on design creativity and innovation	(Chellappa & Luximon, 2024)

The thematic analysis of these elements reveals some prominent dimensions or future directions given by researchers in the field of GenAI and Design education from 2020-2024. These themes have been derived from the selected studies using Braun and Clarke's reflexive approach (2019) to draw the major themes or categories that may be defined as under:

Facilitating AI Integration in Design Tools and Workflow as future research needs to look for ways to facilitate and improve the IA integration in design tools and processes. Majority of empirical research in the area is looking at the refining and re-define Generative design process to include these tools effectively but are still looking to achieve a standardized, structured or decisive method.

Building AI Literacy and adopting new Skillsets by identifying skills and competencies that can then be incorporated by design curricula all over the world to speed up the integration with improved results. One debate is about the need or otherwise for designers learning computational skills based on whether it will improve designers' efficiency so much that it should be included in design curricula, or it can be overlooked to contain the workload on designers.

Ethical AI in Design education talks about issues pertaining to academic integrity on part of the students as the question of academic integrity remains in the limelight. Students may opt for simpler, more trivial solutions instead of deep thinking and this concern needs to be navigated by pedagogical support or other way around. Ethical concerns also revolve around the digitalization of design evaluation system as concerns prevail about the inability of these technologies to critically evaluate the subjective nature of design products.

Reshaping Pedagogical Frameworks and Curriculum also needs a lot of revision in the wake of generative design technologies. Generative technology is making fundamental changes to the design process, eliminating the need for certain competencies all together while introducing new ones. Design educators and researchers must reevaluate the worth of their design course and restructure them to become AI-centric in order to address the needs of future design education.

Policy Development and Long-Term Research role of AI needs to be explored to suit the changing ways of the GenAI-enabled design world. New processes, new curricula, new workflow necessitate new regulations. There is a need for a code of conduct for the use and integration of these tools. Copyright regulations also need to be revised and rules for academic integrity as well as assessment of AI generated design assignments also need to be reviewed.

Discussion

This evidence review maps how Generative AI (GenAI) is rapidly emerging in design education and what outcomes are reported across heterogeneous contexts (2020–2024). Given the variability in study designs and the limited methodological detail in many reports, meta-analysis and effect estimation were not appropriate; we therefore provide a descriptive, PRISMA-ScR–aligned synthesis. We discuss patterns by research question and conclude with practice-facing implications.

Factors Enabling and Impeding Integration

Across the corpus of selected studies, adoption is reportedly encouraged by researchers and curriculum developers to enhance student creativity, achieve student autonomy, independence and personalization and to support task scaffolding like ideation or iteration and prototyping (the relevant studies are cited in the section above). Studies after the period

of the review also emphasize these factors and acknowledge the presence of GenAI as a potential teaching and learning aid for design students when supported by suitable pedagogical strategies and clear guidance on when and how GenAI is appropriate within courses and assessments(Wong, Tan, & Ooi, 2025). Barriers commonly noted by majority of studies (the relevant studies are cited in the section above) include limited faculty preparedness, curricular rigidity, policy uncertainty, and student or staff scepticism about GenAI's role in creative work and fear of technology dependency as also confirmed by certain studies published after the period of review.(Kim et al., 2025; Tellez, 2025).

Ethics-related issues typically surfaced under policy/assessment alignment rather than as stand-alone topics. Authors expressed concerns about over-reliance on tools(Ambikairajah et al., 2024; Hutson et al., 2024), potential erosion of foundational making skills, and the difficulty of capturing nuanced judgement in AI-assisted assessment. Several studies called for hybrid assessment models that retain qualitative critique while documenting process and disclosure (Chaudhuri & Dhar, 2023; Chaudhuri et al., 2022). Similar discussion appears in a recent paper around creativity and authorship, with calls for transparent disclosure and attribution practices within coursework (Rana, Verhoeven, & Sharma, 2025).

Pedagogical Approaches to integration

Owing to the interdisciplinarity of the researchers in the reported studies, few studies highlight a specific pedagogical theory, approach or framework(T. Chandrasekera et al., 2024; Lee & Suh, 2024). Most of the empirical studies focused on exploration of best practices in a truly experimental setting. We observe heterogeneity in nature of studies and approaches taken towards pedagogy. Mostly pedagogical practices clustered around AI-supported ideation (e.g., sketch or mood-board generation and variation), iterative refinement with structured and guided prompts, AI-augmented critique/feedback etc. in short, the focus was on restructuring of design workflow(Doumpioti & Huang, 2024; Iranmanesh & Lotfabadi, 2024).

Assessment practices also came in discussion and papers discussed making AI-use visible in assessment methods e.g., in process artefacts, using disclosure statements, or designing rubric criteria aligned to AI-supported processes(Ning et al., 2024). Studies emphasise the use of strategy over tool choices, e.g. structured and clear prompts, maintain iteration logs, and practicing critique moments, and observe that results are more beneficial when GenAI is intentionally embedded within existing instructional models rather than appended as a one-off activity(Agkathidis et al., 2024; Cudzik et al., 2024; Doumpioti & Huang, 2024).

Only approximately 6–7% of the reported empirical studies explicitly referenced an existing formal educational theory or pedagogical framework to guide this integration. This underuse presents an opportunity to connect GenAI activities more tightly to learning theories, studio pedagogy, and assessment design(García-López & Trujillo-Liñán, 2025).

Research gaps and directions

Facilitating AI Integration in Design Tools and Workflows

Studies call for deeper integration of GenAI across the full design workflow—from ideation to prototyping and evaluation—so that assistance is timely and embedded rather than add-on (Huang et al., 2024; Wang & Wang, 2024). A recurring direction is to build co-creative systems

that position AI as a collaborator rather than a replacement for designers (Chellappa & Luximon, 2024). Research also prioritises AI-assisted novelty assessment to evaluate originality and quality consistently(Chaudhuri & Dhar, 2023), alongside better UX so tools are seamless within studio practice (Omran Zailuddin et al., 2024). Personalisation is another thread—GenAI that adapts workflows to learner needs (Liu et al., 2024)—and AI-supported grading/evaluation methods that are fair and transparent for creative work (Chaudhuri et al., 2022).

Building AI literacy and Adapting New Skillsets

Curriculum proposals emphasise baseline AI literacy, data-informed decision-making, and computational design thinking (Omran Zailuddin et al., 2024; Samad et al., 2024; Zhiqiang Yang & Shin, 2024). Future programmes should cultivate hybrid skillsets—traditional design expertise with AI fluency (Vahdat & Mansoori, 2020; Shang, 2021)—and invest in faculty capacity-building so staff can integrate AI-enabled pedagogies (Wei, 2024). Interest is also growing in adaptive learning systems that tailor content/instruction with AI (X. Liu & Yao, 2023).

Ethical AI in Design Education

Authors recommend ensuring AI remains assistive rather than autonomous in student work (Flechtner & Stankowski, 2023a; Calixto & Croffi, 2024), with attention to bias in AI-generated content, particularly around cultural representation and ethical decision-making (Huang et al., 2024). Governance directions include bias-mitigation practices, intellectual-property clarity, and authorship/disclosure norms in creative coursework (Chellappa & Luximon, 2024; Liu et al., 2024).

Reshaping Pedagogical Frameworks and Curriculum

Future work urges curriculum reforms to embed AI-driven design methodologies and rethink assessment criteria to match AI-supported processes (Huang et al., 2024). Promising pedagogies include AI-enhanced project-based learning, flipped classrooms, and real-world AI design challenges(Fleischmann, 2024b; Tang et al., 2022).

Policy Development and the Long-Term Role of AI

There is a call for institutional policy that sets responsible-use guidelines tailored to design education (Stevens et al., 2023) and for research into the long-term impact of AI on creativity—e.g., whether over-reliance alters creative intuition and originality over time (Chellappa & Luximon, 2024).

Cross-cutting methodological agenda. Across areas, the field needs validated outcome measures (especially for creativity/product quality), comparative and longitudinal designs, and clearer reporting standards (context, tasks, measures) to support future meta-synthesis and effect estimation.

Implications for Practice

Tool/workflow integration: Pilot small co-creative toolchains integrating GenAI solutions within studio practices like ideation, iteration, critique, and always capture process artefacts alongside outcomes for assessment (Huang et al., 2024; Chellappa & Luximon, 2024).

Assessment alignment: Have students disclose AI-use and show their process with evidence like iteration logs etc. Use any AI contribution only as input; the final call stays human which follows critical reflection on AI output.(Chaudhuri & Dhar, 2023; Chaudhuri et al., 2022)
Curriculum & skills: Embed a mandatory AI-literacy module (prompting, data use, limitations) and integrate computational design thinking within core studios (Omran Zailuddin et al., 2024; Samad et al., 2024; Yang & Shin, 2024).

Faculty development: Run hands-on staff workshops on AI-enabled studio workflows and assessment redesign; pair early adopters with colleagues (Wei, 2024).
Equity & governance: Provide reliable access to approved tools; implement responsible-use policies covering bias awareness, IP, and authorship/disclosure in coursework (Chellappa & Luximon, 2024; Huang et al., 2024; Stevens et al., 2023).

Limitations

This review maps reported practices and outcomes; it does not estimate effects. We did not conduct a formal risk-of-bias assessment. Heterogeneity of contexts, tasks, and measures precluded meta-analysis, so findings are descriptive. Searches were limited to Scopus and Web of Science, published in English Language and published during 2020 to 2024, so relevant studies may have been missed. Several included reports provided limited methodological detail; we therefore report outcomes as stated and interpret them cautiously. Future work should use comparative and longitudinal designs so that effects can be estimated reliably.

Conclusion

The review provides a consolidated synthesis of current research on the integration of Generative AI (GenAI) in design education, examining adoption trends, pedagogical strategies, and the barriers impeding effective implementation. While GenAI's potential to enhance creative workflows is widely recognized, its integration remains fragmented and often lacks grounding in formal educational theory. Persistent challenges such as limited GenAI literacy, inadequate faculty development, absence of institutional policies, and unresolved ethical concerns continue to constrain meaningful adoption. Although much of the current literature remains exploratory, promising efforts have begun to emerge that embed GenAI within structured educational settings grounded in sound pedagogical principles. Moving forward, design education must shift beyond tool-centric use toward pedagogically aligned, research-informed integration strategies. There is a pressing need to develop educational frameworks and learning environments that foster creativity, critical thinking, and active engagement among design students. Achieving this vision will require longitudinal research, faculty training, and institutional preparedness to support the reflective and ethical application of GenAI. Ultimately, only through such systemic alignment can design education equip learners for a future where AI functions not merely as a tool, but as an active collaborator in the design process.

Conflict of interest

The authors declare no competing interests.

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We used ChatGPT (OpenAI) to support routine editorial tasks like language polishing, concision, and alternative phrasings; to draft outlines and to consult where informed

decisions were required. The system was not used to conduct the search, select sources, extract or chart data, appraise studies, or draw conclusions, and it did not introduce uncited material. Every AI-assisted output or suggestion was double-checked against primary sources and revised by the authors, who accept full responsibility for accuracy and integrity. No personal or confidential information was provided to the tool, and use complied with institutional and publisher guidance.

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