

APPLYING GENERATIVE AI IN DESIGN EDUCATION: AN OVERVIEW OF CURRENT WORK AND FUTURE RESEARCH DIRECTIONS

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ABSTRACT

Generative artificial intelligence (GenAI) is gradually being introduced into academic design courses. Naturally, its introduction poses many challenges for learners and instructors in any design domain. Alongside these, GenAI hold a promise for design learners, by allowing learners to quickly generate relevant visual materials for inspiration, translating simple design representations into detailed ones (e.g. sketches to renderings) and more. To further integrate GenAI effectively into design curricula, it is important to learn about the possibilities for its implementation in pedagogical scenarios, their benefits and limitations. To this end, we are reviewing the proceedings of a past international conference which highlighted the usage of GenAI in educational contexts (E&PDE 2024; Design Education in the Generative AI Era). Key findings include: (1) GenAI skills which demand instruction need to be identified and mapped, e.g. prompt engineering, selection of tools and integration of multiple tools into pipelines; (2) researchers are encouraged to report the educational framework employed in teaching GenAI; (3) suggested areas for future research include the impact of GenAI on engagement in the classroom, and on facilitating effective communication and collaboration in design pedagogy.

Keywords: Generative artificial intelligence, design education, higher learning, systematic review

1 INTRODUCTION

Developing and applying digital tools for supporting design pedagogy is among the main goals of research in design computing [1], [2]. Technological developments continue to offer new possibilities for design instructors and learners, such as virtual teleportation [3], real-time support by avatars [4], sharing of attention information [5], and more. Among these, GenAI technology emerges as a powerful force, enabling us to process large amounts of data and automate various parts of design processes. GenAI accelerates various aspects of designing, e.g. prototyping [6], and can support conceptual design [7], analysis of the artifact's environment [8], and more. The recognition that generative techniques are an important facet of design education is not new [9]. As these technologies open new possibilities for instructors and learners, it is crucial to map these and direct the course of applying GenAI in design education. A systematic literature review presented in E&PDE 2024 concerning AI in design pedagogy has found GenAI tools to be the most used type of AI tools in design education [10]. Considering this, we are investigating the impact of GenAI on pedagogy, by organizing insights from past studies. Our primary objectives were to identify opportunities for (1) curricula development and implementation, and (2) inquiry into GenAI in design pedagogy that can inform (1). Our overarching research question is - *how have GenAI tools been applied in design education?* The three sub-questions addressed in this study are: (RQ1) *in what academic scenarios have GenAI tools been applied?* (RQ2) *how have GenAI tools been applied in design pedagogy?* (RQ3) *what is the benefits/challenge of integrating GenAI into design pedagogy?* Unlike broader evidence-mapping reviews [11], this study interprets its findings through an existing theoretical framework, which highlights three critical components for studying AI in design education: learner competency, curricular content, and assessment [12].

2 METHOD

To answer our research question, we executed a PRISMA-style survey of E&PDE 2024 proceedings (N=118). The conference was selected due to its focus on design education, as well as to the topic of the specific year which was surveyed - “Rise of the Machines – Design Education in the *Generative AI* Era”, which directly aligns with the focus of our work. A PRISMA-style review was executed, to organize insights concerning the application of GenAI in design education. PRISMA is a widely used protocol for conducting systematic reviews that increases coherency and replicability [13]. The details of paper selection (2.1) and classification and synthesis (2.2) are now provided.

2.1 Paper Selection

In PRISMA, paper selection is conducted in two stages of screening, and determination of eligibility. An overview of the outcome of this process is provided in Figure 1. We first screened the papers based on their titles and keywords using the following criterion - was there any mention of AI? In this, we regarded any of the following as a mention of AI: (1) explicit mention, e.g. “AI”/“Artificial Intelligence”; (2) phrases related with AI, including both tools and techniques, e.g. “ChatGPT”, “generative fill” etc.); (3) keywords implying on consideration of AI, such as “next-gen technology”, etc. During screening, 65 records were removed from consideration. To determine the eligibility of the remaining records, we read their abstracts and examined whether they reported on empirical findings from a pedagogical activity (any design-related educational activity in higher learning) in which GenAI tools were used. GenAI tools refer to tools drawing on AI for generating content to users [14], including specialized tools (e.g. image generators) and general-purpose tools (e.g. ChatGPT [15]), etc. When a record was deemed as potentially ineligible, we examined its full text prior to making our final decision.

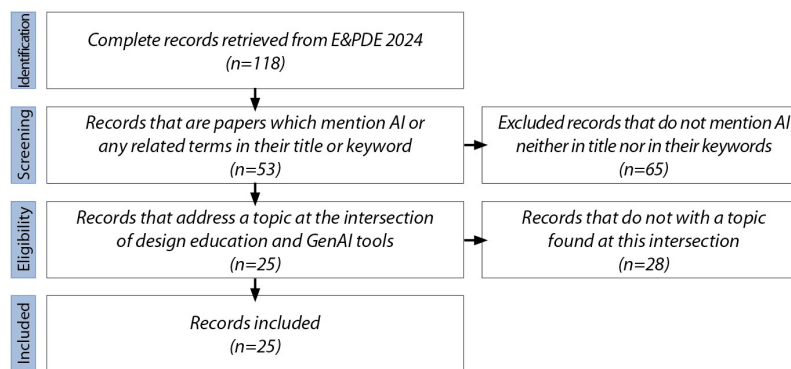


Figure 1. Information flow in paper selection

2.2 Paper Classification and Synthesis

The process of classification proceeded as follows. Two independent reviewers, who are both researchers at the intersection of design and computing, have classified all selected records independently. Then, the results concerning the classification of each paper across multiple categories were merged. This process has enabled to produce a robust classification result, as it helps to reduce bias and increase the reliability of classification [16]. In cases where differences among classifiers emerged, these were resolved via discussion and by consulting the full text of the original work. Our classification system (Table 1) was devised to answer our questions by focusing on three main aspects of each work: the pedagogical scenarios in which GenAI was used, the purpose for using it in each and the lessons learned (including positive outcomes and challenges in implementation). Finally, key findings were interpreted through the three-tiered framework proposed by Gao et al. [12] (refer to 1).

Table 1. Classification system employed in this study

Question	Aspect	Explanation
RQ1	1.1. Educational level	Undergraduate/Post-graduate/Other
	1.2 Design discipline	The discipline which the educational program focuses on
	1.3 Tool used	The GenAI software tool utilized in the educational activity
RQ2	2.1 Purpose	The pedagogical purpose of using the GenAI for
	2.2 Framework	The pedagogical framework employed (where applicable)

RQ3	3.1 Contribution	The contribution of GenAI to designing or design pedagogy
	3.2 Challenges	The challenges in using GenAI in design pedagogy

3 RESULTS

3.1 Educational Scenario, Discipline and Tools Used (RQ1)

In terms of the educational **scenario**, most studies focused on undergraduate level classes and workshops (N=14), only a few focused on postgraduate design studies (N=3), and a single study involved both undergraduate and postgraduate students. In some cases, the educational level was unspecified, or involved design professionals, or even university administrators (thus classified as “other”, N=4). As for the educational **discipline**, half of the records focused on product design (N=11) (aligning with the surveyed conference’s theme). These were followed by investigations into pedagogy in engineering design (N=5), by studies integrating multiple disciplines (N=3), and by two cases of exploring GenAI in service design and textile design (N=1 each). In a single case, the design domain was unspecified. Concerning the **usage** of GenAI tools, 12 papers employed a single tool, while 10 papers employed more than one (up to ten). ChatGPT was the most widely used tool (N=12). Several other generative tools have stood out, primarily Midjourney (N=5) and Vizcom & Bing Image Generator (N=4 each).

3.2 Manner of Employing GenAI in Design Pedagogy (RQ2)

Researchers have studied GenAI in design education with five different purposes. We introduce these from the most to the least explored. **First**, most studies focus on exploring the potential of GenAI to contribute to students’ ability to design (N=12). Examples include the attempt to enhance ideation abilities [17], [18], the understandability of student works [19]. In some cases, this potential was examined by comparing the outcome of employing GenAI with that of a traditional method [20]. Interestingly, GenAI was not only compared with traditional methods, but also used to improve upon them, by reconsidering a method (QFD) in light of current technology [21]. **Second**, several studies have explored how students use GenAI (N=3), to learn about issues which may emerge in the process and mitigate them. For example, one study has examined the ability of students to detect bias in AI-generated output [22]. **Third**, researchers have studied the potential of GenAI technology to be accepted by learners (N=4), e.g. by collecting students’ feedback [23]. **Fourth**, researchers have also explored the impact of AI on students’ design process, with the aim of describing the nature of emerging design processes in these settings. For example, Romanillos et al. [24] have examined the extent to which a learning process driven by GenAI corresponds with Bloom’s taxonomy [25]. **Finally**, one study focused on supporting instructors by helping to generate teaching materials [26]. Overall, less than half of the studies have indicated a specific framework that was employed in the educational activity (N=9).

3.3 Benefits and Challenges of using GenAI in Design Pedagogy (RQ3)

A wide range of **benefits** of GenAI tools in design pedagogy were reported by researchers. These include supporting information retrieval [27], saving time in prototyping [28], lowering the requirement for acquiring skills for creating prototypes [29], facilitating ideation and expansion of the design space [30], increasing the quality of student output [24], which may be associated with a positive experience from students’ perspective [31], and more. The positive experience among students may also be associated with the alignment between students’ expectations and the tool’s output [32]. Interestingly, GenAI was also found to increase engagement among students [33], and to enhance collaboration [34]. Alongside these, GenAI was found useful for instructors as well, as it enabled to automatically generate design briefs which were roughly equivalent to ones that the instructor would write manually [26].

Contrary to the above, a diverse range of **challenges** associated with the introduction of GenAI into design pedagogy were highlighted. First, prompts occasionally require extensive refinement by learners to produce the desired result [26], which may be difficult without deep knowledge of prompt engineering [30]. Relatedly, since image/verbal prompts are not equally well-interpreted by generative systems [32], [35], questions arise regarding the best path for aiding students in achieving satisfactory results. These imply the need for a shift from informal learning of GenAI tools to formal learning, which will demand considerable effort among instructors and educational systems for integrating such tools into the curriculum [20]. Second, despite the intuitive interaction with GenAI tools, one study has found them to be less effective among novice learners [17]. Third, additional barriers concerning the output of GenAI included the lack of cultural contextualization [26], as well as challenges with producing a desired output due to unwanted visual elements which cannot be easily removed when producing

visualizations (in interior yacht design) [23]. Fourth, in one study, GenAI was found to reduce the sense of originality/uniqueness which relates with the sense of ownership, as well as the amount of mental effort required – “...you didn’t really have to do any thinking for yourself” [18] (p5). Fifth, GenAI poses issues for instructors with evaluation [36]. Finally, one study has raised critical questions regarding the development of basic design skills (e.g., understanding space in spatial/visual design), which may be hindered by overreliance on computational pipelines [37].

3.4 Opportunities for GenAI in Design Pedagogy and Research

To identify opportunities for GenAI in design pedagogy, we interpret the results using Gao et al.’s. [12] three categories: **(A)** building learner’s competency, **(B)** content, and **(C)** assessment. Concerning **(A)**, it seems important to extend our investigation beyond undergraduate level courses. Also, to support learners, formal introduction of GenAI into curricula is necessary (overlaps with **B**). For example, instructors can consider the topic of prompt engineering as a fundamental skill pertaining to GenAI usage and invest sufficient time for ensuring all learners can reach satisfactory results via LLM-based tools. Future research can map the GenAI topics to be taught, to inform curricula development. This is important since formal integration of GenAI into curricula can reduce inequities related to access to professional skills. Additionally, critical questions such as the impact of GenAI on the development of students’ cognitive capabilities (e.g., understanding of space, composition etc.), as well as the need for these in an AI-driven design era, require further investigation. Regarding **(B)**, future curricula can consider the integration of several GenAI tools into a single pipeline, when designing courses that formally introduce GenAI to students. Researchers can contribute to these efforts by studying the process of selecting GenAI tools in accordance with the task. With respect to **(C)**, we recommend that future works which employ GenAI in a pedagogical setting explicitly indicate the theoretical framework employed, as a basis for evaluating the impact of these tools beyond local effects on process/acceptance, to establish their contribution to learning itself (i.e. what new knowledge/skill have students gained as a consequence of introducing these tools into the classroom). As our survey has highlighted, the work of instructors may be under supported by current research. Therefore, it is important to inquire into the development of robust assessment methods. Beyond these three categories, researchers can consider exploring the potential of GenAI to increase engagement in the classroom, which is extremely important from a pedagogical perspective, or deepening our understanding of its contribution to design pedagogy from the instructor’s side. Finally, while GenAI tools were found to generally enhance collaboration in a pedagogical setting, no study has focused its investigation on the impact of GenAI on communication (verbal/visual) which is fundamental to collaboration, suggesting the need for further studies.

4 CONCLUSION

A systematic literature review of the proceedings of an international conference (E&PDE 2024) has highlighted promising direction for integrating GenAI into curricula.

Concerning the application of GenAI in design pedagogy:

- To integrate GenAI into design pedagogy, is important to identify the topics which demand formal instruction (e.g., prompt engineering, best practices of integrating multiple tools into pipelines)
- Curricula content can also include pipelines for integrating multiple GenAI tools

Concerning inquiry into GenAI in design pedagogy, future studies can consider the following questions:

- How can we support design instructors in scenarios where learning is facilitated by GenAI?
- How can we use GenAI to increase engagement in the classroom?
- How can we facilitate better communication and collaboration in the classroom via GenAI?

As the field of GenAI progresses rapidly, it is essential to examine the relevance of the above insights to the current landscape. Finally, when searching for ways to effectively apply GenAI in design pedagogy, future works can also consider how this can be done ethically and responsibly.

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