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Artificial Intelligence as a Pedagogical Tool for Architectural Design Education

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Abstract: Artificial intelligence (AI) is increasingly influencing art and design, with tools like ChatGPT, DALL.E, and Midjourney transforming the way designers create visual content from written descriptions. Since its launch, AI-powered systems have sparked widespread interest and expanded production practices in design and artistic creativity. This transition has ushered in a new era of co-authorship, in which human designers and AI systems collaborate to reshape the boundaries of design. The introduction of language-based diffusion models has enabled a harmonic integration of language and visual elements, resulting in creative design paradigms. However, this incorporation of AI raises serious concerns about the cultural and social relevance of AI-generated designs, which may become estranged from human contexts if heavily dependent on algorithms. The representation of architectural knowledge is also evolving, as AI allows for a return to textual and mathematical tools, rather than traditional visual representation methods. This transition creates substantial challenges and possibilities for architectural education, particularly in design studios. The integration of AI into design curricula has the potential to reshape architectural education, necessitating that educators adapt to technology advances. This study investigates these developments, providing insights into the evolving landscape of design pedagogy in the age of AI and contributing to the continuing debate about the role of AI in design and architecture.

Keywords: Architectural education, Artificial intelligence, Design learning, Design studio.

Introduction

Machine Learning (ML) has become more prevalent in our daily lives, leading to a growing interest in art and design, as well as Artificial Intelligence (AI). These applications, which make communication between ML and humans possible by eliminating the prerequisite for software knowledge, are pushing the boundaries of creativity and technological interactions by transforming textual descriptions from users and/or images that indicate contextual situations into customized visual content. While the language-based pre-trained models ChatGPT-3 will be publicly accessible by the end of 2022, to anyone with literacy and access to technology; the AI-powered systems DALL.E and MidJourney—which both provide customized visual content—have sparked interest in the fields of art and design and have begun the process of

transforming design from a human monopoly into a joint product of artificial and human beings.

In this new approach, which emerged as a result of language-based diffusion models, designers are exploring a new design process in which language and visuals contribute together, while architects and architecture students want to learn what these new systems can offer them. In this perspective, it is clear that the interaction between architectural design processes and artificial intelligence is becoming a topic for discussion among practitioners and academics (Leach, 2022; Ploennigs & Berger, 2023). While artificial intelligence (AI) provides architects with new conceptual frameworks and performance-enhancing tools (Zhang et al., 2023), it also highlights the relationships that architecture students currently have and will have with AI. Considering the integration of this new link between architecture students and AI into traditional pedagogies, a problematic and complicated scenario is given in the context of architectural design pedagogies.

The foundation of architectural design education is the dissemination of architectural knowledge, which is primarily developed within the boundaries of the design studio, through hands-on activities emphasizing the experience of design-making within relationships established with peers and master-apprentices, and through oral discussions that primarily use visual aids. The traditional educational environment is undergoing changes due to the rapid changes brought about by digitalization in design processes. As a result, a major concern is how to effectively implement established pedagogical paradigms that prioritize the transmission of architectural knowledge in the design studio (Yıldırım, 2023a). This study aims to critically examine the transformative impact of innovative digital design tools, which are envisioned to be indispensable for today's architectural practices, on the culture of architectural representation, and to focus on the various openings of the use of artificial intelligence, which has begun to be encountered as a new tool while examining contemporary architectural design studios, as a pedagogical tool that affects architectural design education.

While the architectural profession can swiftly adjust to current technological breakthroughs and incorporate digital tools into its practice, the gap between the skills taught in the classroom and the competencies necessary in professional practice is rapidly widening. This mismatch is not only a technical flaw or an isolated case that may be avoided by adding a skill set to the curriculum that can be completed by falling behind, but it also results in inconsistency between the skills taught in academics and the skills required in practice (Abdullah & Hassnpour, 2021; Hariri et al., 2020), it also undermines the primary goals of architectural education. This paper argues that integrating digital literacy into architectural education is not a practical necessity, but rather a pedagogical imperative that enriches teaching and learning experiences and suggests ways in which architecture can combine methods used by other design disciplines with its own.

Transfer of Architectural Knowledge - Architecture, Design and Artificial Intelligence

Text-based representations used by ancient Greek architects, one-to-one scale models based on geometric relationships used by medieval builders, perspective drawings developed by Brunelleschi and widely used during the Renaissance, and the introduction of Cartesian geometry with Beaux-Art in the late 18th century, have all been adopted as a more standardized common architectural language, especially in the last few centuries, and have evolved into widely used conventional (Carpo, 2003; Hewitt, 1985; Necipoğlu-Kafadar, 1986). The transition from manual to digital tools in architectural production, which adopted a Cartesian geometric approach, particularly with the introduction of Computer Aided Design (CAD) in the 1980s, is more than a simple transformation. The CAD-led digital revolution has also caused a paradigm shift in how architects approach design and engineering, necessitating a rethinking of the integration of technology, pedagogy, and content in architectural education (Burry, 2014; Carpo,

2012; Dearden, 2006; Oxman, 2006). Building Information Modeling (BIM) software, which followed CAD in the 1990s, enabled the construction and maintenance of three-dimensional, real-time design models, allowing architects to visualize, simulate, analyze, and collaborate in new ways (Aish, 2013; Karakaya & Demirkan, 2015). The wave of parametric design, which swept the world in the early 2000s with its highly stylized approaches and pushed the known limits of Cartesian geometry by allowing the exploration and manipulation of complex geometries via algorithms, emerged as a computational design method distinct from CAD and ICT (Kolarevic, 2013; Oxman, 2017; Schumacher, 2011).

Unlike its predecessors, parametric design is more than just a tool for designing complex geometries; it also opens up fresh prospects for multidisciplinary collaboration with fields such as mathematics, computer science, and biology. Parametric design also introduces a new level of complexity into architectural design education, requiring a shift from an intuitive pedagogical approach to a more analytical and computational approach, which enriches the architectural design process and has prompted a rethinking of architectural education by broadening its scope (Oxman, 2006; Radziszewski & Cudzik, 2019). Integrating these new computational pedagogies with traditional architectural pedagogies creates a program that can address the intricacies of computational design (Mark et al., 2008), and the requirement for educators to continually enhance their skills in order to stay up with fast evolving technologies (Tucker-Raymond et al., 2021). Although this trend tends to embrace, or at least not oppose, novel design approaches, it is not very favorable for architectural education, which also values the transmission of professional practices. Educators have been responsible for incorporating computational design into architectural design studios, often through elective courses and graduate education (Uncu & Çağdaş, 2022).

While discussions on the professional applications of computational design and its proliferation in design education proceed, the applications of artificial intelligence, which are now increasingly widely available, have created new opportunities in a variety of fields, including art and design. By adapting to the multidisciplinary nature of architectural practices, they can serve as an unique tool for automating design tasks, topology optimization, energy efficiency, material use, and construction processes, particularly parametric design and design tasks involving large datasets with complex operations (Gero, 2012; Yıldırım, 2023b). The interaction of artificial intelligence with architecture is transforming not just architectural design services, but also the products. It indirectly reshapes social and cultural structures by making transdisciplinary design products accessible to the general public via buildings that contain systems that learn from user experience, such as smart buildings and customizable spaces (Şapcı & Pektaş, 2021).

In light of these advancements, researchers in the field of architecture are investigating whether artificial intelligence can show competence in architecture if it is trained by introducing the problem-solving techniques used by architects during the design process (Başarır & Erol, 2021). Burry (2011) thinks that the competence and tacit knowledge that designers acquire via experience are internalized and transformed over time into transferable knowledge that can be quantified and reproduced using digital tools. He mentions that data collected utilizing digital instruments, particularly in the built environment, can provide more objective measurements/evaluations. According to Leach (2018), the subjectivity of artificial intelligence based on information obtained from the built environment allows for a more objective evaluation than subjectivity that varies according to the architect's interpretation, enabling other actors to create design impact scenarios with greater accuracy, making the use of artificial intelligence in the field of architectural engineering explorable. Artificial intelligence systems, thanks to their algorithms fed by complex data sets that are difficult for humans to address, enable architects and other building stakeholders to effortlessly create

potential impact scenarios that will be caused by design (Leach, 2018).

Opinions on Artificial Intelligence and Architecture Education

Artificial intelligence-driven discussions and transformations have a direct impact on architecture education. Design students, who have started to discover the uses of artificial intelligence in many areas of daily life, as well as the conveniences offered by emerging technology, seek to incorporate these next-generation digital tools into their creative processes. In this context, it is critical to consider how, at which stages, and under which identities artificial intelligence will be used in architectural education. Oxman (2008) investigated the extent to which architecture students incorporate innovative design approaches into their conceptual design processes and discovered that parametric formalisms, one of the current approaches, have started to be incorporated into students' conceptual approaches, but artificial intelligence tools such as machine learning are seldom used in conceptual design. It is believed that there is a link between the slow progress of incorporating AI into the architectural education curriculum and the studio instructors, who are not in short supply, who oppose the use of CAD programs in conceptual design on the grounds that it will dull skills in analog design and representation methods (Billie, 2002).

Contrary to what is suggested by studio directors who resist the use of digital methods in conceptual processes with these ideas, the use of digital tools in conceptual design, beyond the search for alternative side paths carried out only in digital media by excluding all other tools, can be presented in a hybrid structure that allows the permeability of analog and digital, and can create a broader set of tools that the student can include at the stage he or she deems appropriate (Salman et al., 2008). Although not as conservative as architecture professors are resistant to digital culture Picon (2011) notes that using digital tools in design can lead to designs disconnected from human and context. This situation may arise, especially when students with limited architectural knowledge allocate design processes to artificial intelligence algorithms in the pursuit of innovative design without first establishing the relationship between design, user, and context in conceptual design and early design processes. However, a master architect-educator can help to bridge the gap between novice architecture students and artificial intelligence, which is still in its early stages, and prepare a base for a controlled discovery.

The number of academics researching the integration of artificial intelligence into design and design education is escalating. By instrumentalizing the design narrative, which is frequently used in the conceptual design phase in design courses by academics working in this direction, there are studies on basic conceptual productions and form finding studies on images using language-based artificial intelligence systems in students' design processes (Ploennigs & Berger, 2023; Sadek, 2023). These experiments consist of both text-based, text plus image-based, and solely image-based outputs generated with artificial intelligence.

Ploennigs and Berger (2023) investigated architecture students' creative form-finding processes utilizing texts prepared via the architectural storytelling method, as well as the effect of artificial intelligence on the form-finding processes of groups that used and did not use AI. It was discovered that the group employing artificial intelligence made partial choices from the images generated by artificial intelligence and used them in a way that had a positive impact on their form-finding processes. Although both groups prepared scenarios, it turned out that students in the group utilizing artificial intelligence encountered unusual forms in their productions. In this context, the potential for implementing artificial intelligence as a tool to promote creative design comes to the surface.

Smith et al. (2023) stated that there may be scenarios in which artificial intelligence does not always give outcomes that are suited for real-world applications as a consequence of their AI studies with textual definitions. Within the scope of the study, it has been discovered

that the images produced by artificial intelligence via keywords entered to be used in conceptual approach and form generation are either a composition in which images associated with keywords are superficially brought together, or that some keywords are selected by artificial intelligence while others are ignored. In fact, this circumstance is similar to the methods that produce speculative designs by focusing on parts used in early design processes, and in some ways, it highlights the parallels between human and artificial beings in terms of design methods. Although the designs generated via artificial intelligence in conceptual design and form finding processes do not produce results that are in line with the initial objectives, they can be seen as an intermediate step that can be interpreted by humans and incorporated into the process (Smith et al., 2023).

Yurman and Reddy (2022) used artificial intelligence to generate reproductions of the objects they painted with watercolor method in a study employing just visual material rather than text. They both created a watercolor painting of a tangible object, handed it to each other, and made reproductions. The reproduction was then returned to the original maker, and a creative transformative process was carried out by reproducing reproduction of the reproduction. In the study's continuation, a new set of reproductions was generated by repeating the initial producer-artificial intelligence-second person cycle while incorporating artificial intelligence as a creative participant. As a result of this study, it has been observed that the ambiguity brought by the watercolor technique leads to new visions for both human and artificial intelligence, but in the reproductions in the human-AI sequence, the artificial intelligence creates dramatic new visions every time, while in the reproductions in the artificial intelligence-human sequence, the human tends to imitate the artificial intelligence product at a high rate. Although the study was not conducted in the context of architecture, the processes for generating visuals from visuals, particularly in design, and humans' tendency to imitate and make sense of artificial intelligence production are similar to the speculative work done by students who want to use artificial intelligence in design studios today with sketches or models. Especially in architectural image production, visual-based artificial intelligence software frequently exhibit dramatic changes depending on the ambiguity of the given image.

Studies on the simultaneous use of visual media and text input in generative artificial intelligence systems, as opposed to text-only or visual-only inputs, are not uncommon (Gal et al., 2022; Gao et al., 2022; Zhang et al., 2023). In the study carried out by Zhang et al. (2023), the sketches produced on the digital tablet were uploaded to the artificial generative artificial intelligence system, and the artificial intelligence was made to produce visuals by making a description over the text and using the sketches, after that the designers made a layered sketch study over the visual alternatives produced by the artificial intelligence. The original sketch and new layers were re-uploaded to the artificial intelligence, and new variations were generated by describing them again. The participants in this study are professional architects. As a result, experienced architects were able to work with clarity in both the visualization and written explanation of design ideas, as well as to expertly apply the seeing-knowing-interpreting procedures to the interplay of design elements. As a result, they avoided leaving ambiguous areas that could lead to artificial intelligence producing irrelevant results, allowing them to employ it for its original purpose.

However, because architect candidates at the learning stage are not mature enough in terms of seeing-as, seeing-that, and design knowledge, they can present very vague details to artificial intelligence at initial stages, when describing in written and/or visual form. In fact, trainable artificial intelligence systems that use a feedback mechanism function as rookie systems alongside these rookie designers, leaving the student with even more ambiguous outcomes. Based on the examples analyzed, we can see that the work produced by artificial intelligence using text, visual, or hybrid data inputs has parallels with the processes of seeing,

making, and designing loops, as well as the revision methods used in the design studio as described by Schön (1983).

In the design studio, students sketch design concepts based on a written or oral recipe. In these studies, students show their work to their teachers at regular intervals and solicit their feedback. Depending on the instructor's inclination, this exchange of ideas can be continued solely through verbal communication, or it can be extended both orally and by sketching on each other's drawings, which are usually layered over the sketches at the desk. Schön (1985) defines this process, which develops naturally in this design studio, as a reflective pedagogical approach. The instructor, who acquires knowledge about the design from the students' sketches and oral narratives, interprets his or her own ideas through oral narratives and visual representations; however, despite all of these interpretations, the student is expected to develop the design using the instructors' interpretations. This communication takes place in an environment where all studio participants can observe and intervene, and students' progress in their individual projects by learning from each other's design ideas as well as the revision process between other students and the instructor. Therefore, the student refines the design project by adding his or her own intellectual process and observational learning to the instructor's recommendations, developing a fresh interpretation. It is considered that learning occurs in this manner in the design studio, based on the master-apprentice relationship (Goldschmidt, 2002; Schön, 1985; Uluoğlu, 1996).

Changing pedagogical identities in the design studio over time has transformed the instructor from a coach who imposes design orientations to a coach who accompanies, supports and facilitates learning (Dutton, 1991; Ledewitz, 1985; Lee, 2014). This, in fact, has enabled cyclical interpretations in design learning processes and opened up space for new breaths that the relationships established between student-instructor, student-student and student-instrument can bring to design. In today's architectural education environment, with digitalization and especially the use of artificial intelligence technologies, there are studies that draw attention to the necessity of the current studio order to rapidly integrate artificial intelligence into studio pedagogies (Kavakoglu et al., 2022; Ogata & Ogawa, 2023; Tianran et al., 2022). Just as previous digital tools were used as tools over time and then turned into environments where the design process was carried out and became an integral part of architectural education, the researchers also mention the possibility of artificial intelligence being first a tool and then an environment in which design will be done (Schmitt, 1997). Although the use of artificial intelligence in the field of design education is discussed at the graduate level within the framework of didactic and constructivist theories, there are researchers who suggest that it should be used as a tool rather than collaborative in terms of project-based learning pedagogies at the undergraduate level (Khean et al., 2018; McCormack et al., 2020). However, Başarır (2022) underlines that if artificial intelligence is seen as a learning machine, it may be possible for it to gradually acquire profession-specific knowledge. In this case, artificial intelligence has the potential to be both a guide for design students to acquire professional knowledge and a partner to accompany their design processes. Kavakoglu et al. (2022) conducted a study with students in the early stages of design education, they examined the effect of artificial intelligence on creativity and observed that datasets created in collaboration between students and artificial intelligence encouraged creativity.

Epilogue

The applications of artificial intelligence in architectural education raise debates at different levels in terms of conceptual approaches, alternative approaches and collaborative approaches. From a conceptual perspective, although artificial intelligence offers students a new medium to open the doors of creativity, students are not equipped to use artificial intelligence in a targeted manner because they lack sufficient knowledge about the competencies and limits of artificial intelligence (Flechtner & Stankowski, 2023). In

today's architectural landscape, students use artificial intelligence in architectural concept development through visual synthesis. Thanks to visual synthesis, 2D images and 3D models can be created quickly and easily using text and images. However, it may not be easy for students to use these systems properly. They consider artificial intelligence as a joker who can do anything in almost every situation, with unclear and unsteady directions that are not intended. However, artificial intelligence provides unpredictable outputs in images based on poorly defined data. Students exposed to a series of random results search for meaning in the ambiguous contents of the image pool, but frequently fail to locate it. In this case, the series of images exposed are processed in the students' memories within the context of today's youth's media consumption habits, and they take their place among the consumed images that they look at superficially but do not see, far from examination and internalization on a scroll-and-pass basis.

In terms of alternative approaches, artificial intelligence systems can be employed not just for visual synthesis, but also for massing decisions, form finding, and optimization. The use of parametric design tools, interactive evolutionary computation, and genetic algorithms can help architects create novel and imaginative designs (Castro Pena et al., 2021; Ekici et al., 2019). In order to prepare students for professional practice, the use of artificial intelligence starting from the early design period can create more efficient designs in terms of sustainability. In addition, topology optimizations used for structural design provide opportunities for architecture students to improve themselves and their designs in structural design, which is often a weakness of architecture students. The processing of all these possibilities, which are envisaged to contribute positively to design and design learning processes, in design studios draws attention to a different issue with deeper implications.

First and foremost, these alternative techniques can only be included in design studios on a project-by-project basis; because different projects and levels have varied requirements, it is unrealistic to expect all alternative approaches to be included within the scope of each project. Second, for students to be able to apply these other ways, they must be introduced to and given access to them, which is a problem with its own sub-expansions. Students should be exposed to artificial intelligence systems with alternative uses during their education. Furthermore, theory should be supported with practice through integrating it partially into the design studio structure. Another consideration is that students must be technologically literate in order to make use of these artificial intelligence programs (Kee et al., 2024). However, in order to achieve creative results with the appropriate method, students must first acquire a precise language for communicating with artificial intelligence. To create this language, they need to be familiar with the basic machine learning language vocabulary. Since many students lack this vocabulary, the aforementioned ambiguity arises and students do not use these alternative approaches with their existing knowledge, no matter how enthusiastic they may be. At this point, as for students to be able to use AI as a design tool that enables alternative approaches, it is necessary to have a basic education in computational systems (Hardman, 2022). Due to the already dense and loaded content of this basic education, there is no room for maneuver for its inclusion in the architectural curriculum. In this case, the actors of architectural education are expected to undertake this task in order to transfer these alternative approaches to students. However, not every design educator is expected to take on this role due to both changing areas of specialization and changing levels of digital literacy and competence. Therefore, although the use of these alternative approaches is partially left to the design studio instructors, it generally creates a situation in which the student can progress with his/her own efforts and is relatively isolated.

Finally, the ethical implications of using artificial intelligence in design and learning processes must be carefully considered. The integration of artificial intelligence into design education raises ethical concerns in multiple

areas. First and foremost, the widespread use of artificial intelligence drastically reduces data privacy (Jaime et al., 2023). Many AI tools store the data given to them in an open-ended common repository that they utilize to generate responses for all system users, not just those that share data, and there is no mechanism to access this stored information. A second ethical dilemma highlighted by these open-ended systems is the issue of ownership. The division of ownership between the designer and the artificial intelligence in a product generated with artificial intelligence poses a problem (Crawford et al., 2023). Design students should be encouraged to employ artificial intelligence with caution considering data privacy and ownership concerns. Finally, unfortunately, today, not all students have equal opportunities for education and differences in access to technology are frequently encountered. In this respect, the use of artificial intelligence and technology in terms of equality in education points to a problematic area in terms of integration into compulsory education when access concerns are considered.

As the practice of architecture has adapted to rapid digital transformations, it has directly affected the architectural design studio. This transformation in practice has the potential to lead to changes in pedagogical paradigms, learning outcomes and even the culture of architectural design education. This article draws on the gaps in the literature to provide indications that artificial intelligence is an inevitable revolution in architectural practice and education, as it was in the digital revolution and paradigm-shifting CAD and computational design that preceded it. It is also mentioned that these innovative design tools have a transformative effect on the conventional architectural representation culture, which is predominantly based on visual media production, in a way that textual representation gains weight not only in informal communication but also in formal communication, and its impact on design exercises with artificial intelligence is emphasized. In this context, it is seen that the reflections of the change in the culture of representation are also affecting design studio pedagogies. In particular, the limiting and enriching effects of design studio instructors' competencies in new digital tools, which play an important role in the field, on design pedagogy are presented and the importance of digital literacy of both students and instructors in terms of incorporating artificial intelligence into design processes is emphasized. While the dangers of the uncontrolled use of artificial intelligence as a wild card in the current order by architectural students are highlighted, it is predicted that its competent use will improve the quality of architectural education and prepare students for the equipment expected from them in the post-graduation architectural environment by stepping in at the point of closing the gaps.

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