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The Digitalization of Studio Practices and Its Impact on the Development of Design Literacy of First-Year Architecture Students

ABSTRACT

Digital skills are emphasized in the ongoing process of digital transformation in higher education. In this article, digital literacy is discussed within the broader perspective of design literacy and the acceleration of the digitalization process of first-year design education at the time of the outbreak of the COVID-19 pandemic in spring 2020 is highlighted. The article interrogates the role of digital skills in the development of design literacy of first-year architecture students through a multiple case analysis of ARCH 101 design studio practices executed in the Bachelor of Architecture programmes at the Özyeğin University, Department of Architecture and the Middle East Technical University, Department of Architecture. The digitalization processes of ARCH 101 studios increased rapidly when the COVID-19 pandemic started and resulted in the integration of digital tools into basic design education in ways that transformed (1) the communication modalities and the representation and research strategies used by students, and (2) the understanding and methodologies of the design process when used as generative design tools.

Keywords:

design literacy, digital literacy, design thinking, first-year design students, basic design studio.

1. INTRODUCTION

The ongoing digitalization process in the field of higher education started with the introduction of digital technology tools and platforms at the end of the 1990s. This process gained momentum in the 2000s and a transformative threshold was created through the advent of the COVID-19 pandemic in 2019. This process is defined as a *digital turn* and is associated with the concept of digital literacy. While Lanham (1995) defined digital literacy as a technical skill associated with being able to read and understand information in a digital format, Gilster (1997, p. 8) related this concept to the ability to critically restructure different types of information in digital format. Gilster's (1997) definition of digital literacy covers *knowledge assembly, evaluating information content, searching the Internet, and navigating hypertext*. Martin (2006, p. 155) highlighted a more inclusive framework that involves "acquiring and

using knowledge, techniques, attitudes and personal qualities,” including “the ability to plan, execute and evaluate digital actions in the solution of life tasks, and the ability to reflect on one’s own digital literacy development”.

The digitalization process in higher education manifests in diverse practices, such as the design of curriculum and course content, the use of teaching and learning tools/platforms and the planning of evaluation/feedback strategies. The ability to use adaptive technology for teaching and learning practices is as essential as the ability to access course resources, and digital literacy covers both. Using new digital technologies to enable purposeful and effective learning and teaching experiences requires “a new set of skills and competences” (Reddy et al., 2022). The existence of a gap between the higher education system and the digital tools used in pedagogical practices has been criticized, and it is argued that digital literacy can help close this (Reddy et al., 2022).

The concept of digital literacy has been examined within the framework of not only education policies, curriculum design and pedagogical approaches, but also initiatives on national and global scales to define the quality standards required to equip individuals with digital literacy knowledge and skills. Founded in 2003, the Global Digital Literacy Council (gdlcouncil.org) works to establish worldwide standards in digital literacy and to define and constantly update relevant skills and knowledge in line with changing needs. The main objectives of the “Life Skills Survey: National Needs and Impact Survey on Literacy, Mathematics and ICT Skills” conducted by the UK government in 2003 were to define and measure information technology skills (ICT) as well as the traditional literacy and numeracy skills of the population. Through these initiatives, it has become evident that digital literacy is considered a technical/technological skill rather than a mindset. However, this approach can hardly meet the demands of today's world, where individuals are faced with multi-layered complex problems and are expected to produce creative solutions to these problems. In the view of Buckingham (2015, p. 24), it is problematic to associate digital literacy merely with the skill of understanding and processing information; he mentioned that existing studies mostly “tend to focus on technical ‘know-how’ that is relatively easy to acquire, and on skills that are likely to become obsolete fairly rapidly”. Similarly, Eshet-Alkalai (2004, p. 93) emphasized that digital literacy includes “a large variety of complex cognitive, motor, sociological, and emotional skills” that are needed to use digital environments effectively, and digital literacy is thus beyond the ability to use digital software or devices.

The ongoing digital transformation process in the 21st century and during the COVID-19 pandemic, which represented a breaking point, has underscored the necessity of using digital tools effectively in people’s individual, social and professional lives. The concept of digital literacy, if it is not reduced to a mere technical skill, constitutes fertile ground in contemporary society. This point has manifested within the framework of the 21st century skills envisioned across all levels of formal education. Binkley et al. (2010, p. 15), categorized 21st century skills through the framework of “ways of thinking” (creativity and innovation, critical thinking, problem-solving and decision-making, learning to learn), “ways of working” (communication and collaboration), “tools for working” (information literacy, ICT literacy) and “living in the world” (citizenship, life and career, individual and social responsibilities). Bekker et al. (2015, p. 29) emphasizes that digital literacy within the framework of 21st century skills includes “the ability to use, understand and evaluate technology, and also to understand technological principles and strategies required to develop solutions and realize specific goals”. The present study based the relationship between digital literacy and design thinking skills on this understanding. Digital literacy based on design thinking, together as a skill, a foundation of knowledge and a mindset, has the potential to support the development of individuals’ collaborative, problem-solving, creativity and critical thinking skills.

1.1. Design Literacy as an Overarching Framework for Digital Literacy

Digital literacy has essential implications for the notion of design literacy, which is emerging as a new research area. Although digital and design literacy are based on a common philosophy, the definitions differ in terms of focus, scale and scope. Nielsen and Brænne (2013) related design literacy with acts of empowering individuals to use multiple modes of knowledge. For Bolinas (2022, p. 94), design literacy

covers “the competency to develop skills in making *things* (concretizing mode) and making *meanings* (iconic mode) using designerly ways of knowing, thinking, and inquiring”. Lutnæs (2020) placed the attempts to raise awareness of “socio-ecological sustainability” primarily at the core of design literacy and considered design education as a productive tool for this purpose. The design literacy literature also addresses perspectives covering all age groups and education levels. The underlying philosophy is an understanding of “design as a literacy for all” (Pacione, 2010, 2017). It has been emphasized that design literacy can provide a basis for thinking and doing for designers and non-designers, including users, decision-makers and consumers to act jointly within the framework of “a participatory and bottom-up process” to find solutions to the global challenges of the 21st century (Nielsen et al., 2014, p. 3). The issue of how to design buildings and cities after the devastating earthquakes that occurred on the southern Anatolian fault-line on 6 February 2023, in Turkey revealed the importance of design literacy for all stakeholders in the decision-making, design and implementation processes.

The literature gives prominence to the notion that design literacy should be considered together with critical thinking skills to ensure the maintenance of cultural values and diversity from the perspective of personal, social, and environmental sustainability. In today’s world, it is vital for individuals to be able to adapt to changing conditions in the face of global crises (e.g., climatic, environmental) and unexpected situations (e.g., COVID-19 pandemic, earthquakes). Design literacy is also considered a fundamental topic in the strategic planning of education at all levels. In the directive document by the European Design Leadership Board, in 2014, it is mentioned that due to the “revolutionary impact” of “today’s rapid development of digital networks and communications technologies” on society, educational policies should consider “[raising] the level of design literacy for all the citizens of Europe by fostering a culture of design learning for all at every level of the education system” and to “encourage Member States to support the development of design competencies for the 21st century by embedding the strategic role of design across disciplines in higher education” (EDLB, 2014, p. 11).

While the development of design literacy covers skills development, the foundation of knowledge and critical reflection, the “design thinking” skill comes to the fore as an essential component of 21st century teaching and learning approaches that promote awareness of real-life problems and the development of alternative solutions for them (Koh et al., 2015; Razzouk & Shute, 2012). Design thinking and designerly ways of knowing have been the topic of numerous studies on the nature of the design process and the cognitive strategies used by designers (Cross, 1982, 2001). The design process is initiated with the exploration of ill-defined, ill-structured or “wicked” problems mostly deployed in real-world contexts and continues in a problem-solving mode using cognitive approaches such as framing (Donaldson & Smith, 2017), divergent and convergent thinking (Choi & Kim, 2017), abductive reasoning (Dreamson & Khine, 2022) and reflection-in-action (Schön, 1983). Design is based on an iterative process in which the analysis, evaluation and synthesis phases are intertwined, and new strategies that could lead to the development of alternative solutions to the design problem are employed. Wrigley and Straker (2017, p. 2) indicated that design thinking is not only a cognitive process used by designers, but also an intellectual strategy and methodological approach in which non-designers use design methods. Cross (2023, p. 1) critically pointed to a new conception of design thinking in the literature that addresses “the use of design or design-oriented approaches in business, management, and even social innovation”. The design thinking approach is also used to solve pedagogical problems in the field of education as an agent to foster the development of active, reflective, and engaging students (Bravo et al., 2022).

As the multi-layered complex problems of the 21st century necessitate empowering individuals with problem-solving skills, design thinking triggers awareness of, critically enquire into and the production of creative solutions for real-life problems. Design literacy offers a generative basis (for designers and non-designers) to initiate design thinking processes in problematic situations. At this point, design thinking acts as a bridge to connect design and digital literacy (see Figure 1). Design literacy and design thinking skills lay the foundation for using digital technologies in critical and creative ways, thus sustaining “the students’ learning dispositions that support their engagement inside the digital environment” (Bolinás et al., p. 94). Digital platforms can turn into environments where different types

of information (e.g., visual, auditory, written,) can be processed, and where both instructors and students can reconstruct knowledge interactively. This point of view is apparent in the discussions on “digital design literacy” as a new research area in the literature (Pangrazio, 2016).

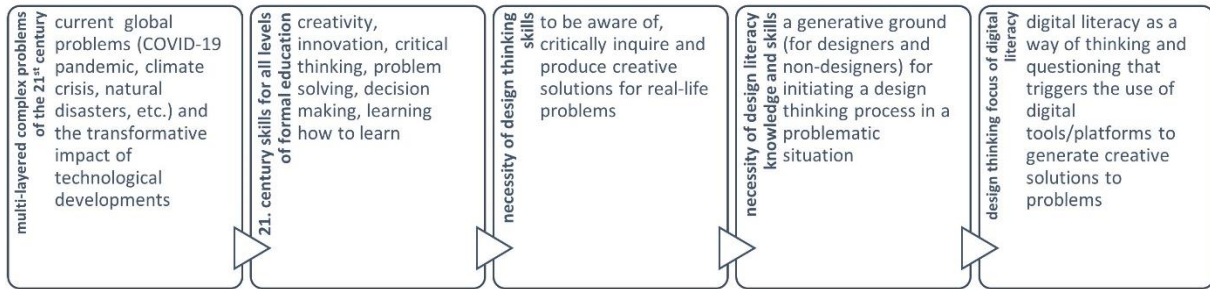


FIGURE 1. Contextual relationship between design and digital literacy.

1.2. COVID-19 pandemic as a threshold

The COVID-19 pandemic set a threshold for the ongoing digitalization process in higher education (Babaoğlu & Kulaç, 2021; Erhan & Gümüç, 2020; Tejedor et al., 2020; Vishnu et al., 2022). On the one hand, due to the obligatory quarantine conditions, classes had to be carried out online (synchronously and/or asynchronously) at every stage of education. On the other hand, some problems emerged regarding the ability of students to access, evaluate, and adapt resources using digital technologies for effective learning. During this process, it was observed that instructors and students did not have equal access to digital technologies and tools, which highlighted some inequalities in the digitalization of education (Azubuiké et al., 2021; Czerniewicz et al., 2020; Gandolfi, et al., 2021). The process experienced in education during the COVID-19 pandemic has been the subject of recent research that has addressed the integration of digital tools into education, curriculum design and the development of new education policies and pedagogies. Evidently, the effective use of digital platforms and tools will persist in the post-pandemic period, and this points to the emergence of a new learning paradigm in terms of skills and mindset in education.

The COVID-19 pandemic revealed how vital digital literacy, nourished through the design thinking skill, is for effective teaching and learning experiences in education. This has become even more apparent in the design studio, in which project-based and learning-by-doing models form the basis. The challenges and potential that emerged during the pandemic were varied. The removal of the physical studio environment resulted in the lack of embodied tutor-student and student-student encounters, and this transformed the pedagogical roles of these actors and the formal-informal interactions between them (Yorgancıoğlu, 2020). Students had to develop new strategies to express themselves and their project ideas in the absence of their and their tutors' physical presence. Accordingly, the use of digital platforms and tools caused changes in students' ways of learning design, developing design expertise and self-awareness as members of a community of designers. The new digitally assisted teaching and learning contexts have also influenced feedback and assessment mechanisms: giving feedback through digital platforms has caused some difficulties for tutors when observing students' project processes synchronously, while weakening the formative assessment potential of design studio pedagogy based on iterative feedback practices.

Over the last three years, within the framework of the conditions revealed by the COVID-19 pandemic, we experienced three different teaching/learning models at our respective design studios in the Bachelor of Architecture programmes at the Özyeğin University Department of Architecture and the Middle East Technical University (METU) Department of Architecture. First, we had to transform the face-to-face design education of the 2019 fall semester into “emergency remote teaching” (Asadpour, 2021; Green et al., 2020; Komez Daglioglu et al., 2020) for the spring term of 2020, and we continued in this way for three terms. Second, in the fall and spring semesters of 2021-2022, we physically returned to the campus: while some design studios returned to full face-to-face education, some studios con-

ducted a 'hybrid' education model (Guppy et al., 2022; Wolford et al., 2021), as the pandemic conditions were partially continuing. The last three years motivated us to explore the effective and improvable aspects of traditional design studio pedagogy as well as to develop alternative teaching/learning strategies. This process also underscored the importance of digital literacy in the development of design skills among architecture students. The contributions of digital literacy to students' adaptations to educational technology and emerging digitalized (design) learning models have become more observable. Before the pandemic, digital tools were used in design studio practices, but the accelerated digitization of design education due to the pandemic transformed the way in which students use these tools and the way they think and produce. This study aimed to reveal these aspects of this transformation.

In the pre- and post-COVID-19 pandemic literature, many studies have addressed the digitalization of design education, online or blended design studio practices, the use of different digital tools and platforms in design studios and the contribution of all these changes to the development of students' design skills and design learning experiences (Asadpour, 2021; Ceylan et al. 2020; Erkan, 2020; Fleischmann 2022; Masdéu & Fuses 2017; Mohammed 2017; Rodriguez et al. 2018; Rosa & Ferreira, 2023; Yu et al. 2021). However, the number of publications approaching the subject from the perspective of *literacy* and emphasizing *digital literacy in design education* is limited. This not only indicates an emerging field of literature, but also helps contextualize the present study.

2. THE STUDY

The objective of our study was to examine the effects of the 'digital turn' in higher education on introductory design education and the role of digital literacy in the development of design literacy among first-year architecture students. We examined the implications of the growing engagement of first-year design students with digital tools/platforms to reconceptualize the notion of design and design learning. Methodologically, this examination took the form of a multiple case study analysis of the ARCH 101 design studio practices at two different Bachelor of Architecture programmes, namely, the Özyeğin University Department of Architecture and the METU Department of Architecture following the COVID-19 outbreak during the spring 2020 semester. The sample group of first-year students consisted of 100-125 students per year for the Özyeğin and METU cases. Our article showcases the use of digital tools and platforms as *representation* and *generative design* tools; analyses the ways these tools and platforms played role in structuring *the studio organization, project submissions, and assessment practices* such as weekly design crits and juries. We, as the tutors of ARCH 101 design studios in the two cases, focus our discussion on our on-site observations and reflective evaluations, which gave us the opportunity to observe different studio environments and student experiences. The study was based on a qualitative case study methodology that investigates a particular case with the aim of producing analytical findings and draws on the researcher's first-hand interaction with a phenomenon within its real-life context (Bergin 2018; Groat & Wang 2018; Yin 2018).

2.1. Basic design education: the Özyeğin and METU cases

First-year design education plays a central role in architectural education as it lays the ground for students' development as designers and a threshold to architectural design processes. The first-term design studio, which usually comprises a basic design course, has the more critical responsibility of providing a constructive learning environment for students to encounter the design studio pedagogy. Students are encouraged to develop new ways of looking at, seeing, observing, analyzing and visualizing through the exploration and use of different design and representation media. While the first-year design studio concerns the "issues related specifically to perceptions, processes, and definitions" of design, it also lays the foundation for the formation of "habits of mind, habits of hand, habits of reflection, and habits of communication, as a basis for continued learning, exploration, and development" (Temple, 2006, p. 5). The design projects are structured in to help students develop abstract, analytical, diagrammatic, critical, and creative thinking skills, combined with the skill of doing through hands-on experience. Through 2D and 3D design exercises, students critically re-frame design problems

and develop solution alternatives (Çil and Demirel-Özer, 2021; Erkök et al., 2005; Saghafi, 2021; Yorgancioğlu & Tunalı, 2020). Critical thinking and creative problem-solving provide the core of design critiques in the first-year design studio (Çakmaklı et al., 2022; Demiri, 2021;). Notwithstanding, the digitalization process of design education that gained momentum during the COVID-19 pandemic affected the processes of structuring, implementing, and internalizing the design thinking approach in first-year design education, and especially the basic design course of the first semester.

The principles and frameworks of basic design education described above have been implemented in the basic design studios conducted at the Özyeğin University Department of Architecture and the METU Department of Architecture, which are the subject of the present multiple case study analysis. According to the curricular structure in both departments, architectural education begins with basic design education with a focus on the principles of visual thinking, visual design and designerly ways of knowing. In both basic design studios (ARCH 101) the formation of the designer identity starts with the development of the students' design and visual literacy. In the studio practices of ARCH 101 since the COVID-19 outbreak, digital tools and platforms have been used as tools not only for representation, but also to support students' awareness of each design decision they make and each action they take in line with this. Consequently, the basic design studio in the two departments have been structured to equip first-year students with design thinking skills, which act as a bridge between design literacy and digital literacy, by triggering the students to question what they do, for what purpose and how.

3. FINDINGS AND DISCUSSION

In this study, the evaluation of the ARCH 101 basic design studio cases was based on the digitalization of the studio practices and the resultant transformations in the development of design literacy of the first-year architecture students. The two main categories defined through this evaluation were: (1) the *instrumentality* perspective and (2) the *understanding and methodology* perspectives. First, we examined the ways digital tools and platforms are used for content sharing and production, feedback and discussion, design, representation, assessment and the visibility of students works. Second, we assessed the transformative impact of digitalization on the conception of design, the processes of design learning and design methods. In the following section we illustrate how these two categories were implemented in the ARCH 101 studio practices in the Özyeğin and METU departments of architecture after the COVID-19 outbreak during the spring 2020 semester.

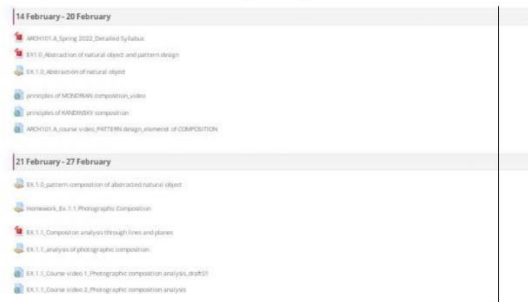
3.1. Structures of the ARCH 101 studios

The main purpose of the ARCH 101 Design studio at the Özyeğin University Department of Architecture is to introduce first-year design students to the basic elements and principles of design and to guide them in developing creative and critical thinking skills using varied design and representation strategies (manual and digital). The ARCH 101 studio comprises five modules covering short-term 2D and 3D design exercises of increasing complexity. The topics of these exercises are abstraction, composition analysis, figure-ground relationships, movement analysis, the transformation of form, kinetic structures and urban abstraction and mapping. We meet the students twice a week, and the students work individually to develop their design projects. In the pre-COVID-19 period, students were encouraged to work on their design projects, produce physical 2D sketches, compositions, collage work and 3D models and to present them in the physical studio environment to prepare the ground for one-on-one and group discussions as part of their design learning. This physical pattern of communication and production allowed the studio tutor to follow and provide timely feedback on the student's project development processes while supporting the formation of a studio culture. Nonetheless, content sharing and announcements were also made on *ozu.lms* during the pre-pandemic period.

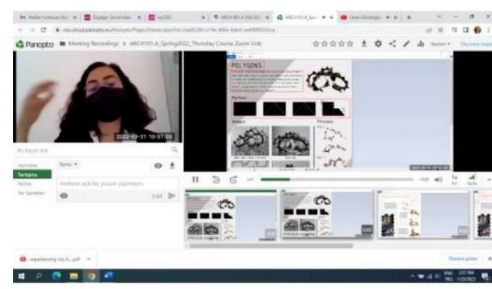
In the period after the COVID-19 outbreak, the ARCH 101 design studio was delivered using three different modes: (1) fully *online* via the Zoom platform, (2) *hybrid* as face-to-face synchronous, in which the students could interact with the studio either in-person on campus or online via the Zoom platform and (3) *face-to-face* in which all the students physically attended the design studio (Figure 2).

For all three delivery modes, we uploaded design briefs as handout documents to ozu.lms (learning management system) to inform the students of the objectives and scope of each project, the stages of the design process, the material alternatives to be used and the submission deadline details. For each project, we also uploaded supplementary readings, tutorials or related design portal links. The students were expected to upload their 2D and 3D works to ozu.lms in a digital format (as drawings, images or videos) for each exercise. In this way, they produced content to discuss in the weekly reviews that everyone could follow. These digital contents also provided an archive for students to use in the design of a digital portfolio at the end of the semester. The tutors stored all types of course-related content in a common Google Drive file, and this was accessible to all the instructors in the different studio sections. Except for the period when the studio was completely online, the interim and final evaluations were carried out by juries, where the students and jurors were physically present in the studio. The grades were announced to the students via ozu.lms.

Weekly document & information sharing through LMS



Weekly “hybrid” studio critiques via ZOOM



Submission of projects in digital format to LMS

Student Name	Submission Status	Grade	Feedback	Submission Date	Comments
Ali Kemal	Submitted	Grade	Feedback	21 April 2022, 9:18 AM	Comments
Yakup	Submitted	Grade	Feedback	21 April 2022, 12:52 AM	Comments
Yakup	Submitted	Grade	Feedback	21 April 2022, 9:52 PM	Comments
Yakup	Submitted	Grade	Feedback	21 April 2022, 9:52 PM	Comments
Yakup	Submitted	Grade	Feedback	21 April 2022, 9:52 PM	Comments
Yakup	Submitted	Grade	Feedback	21 April 2022, 9:52 PM	Comments
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Yakup	Submitted	Grade	Feedback	21 April 2022, 9:52 PM	Comments

Face-to-face mid-jury and final jury evaluations in the studio



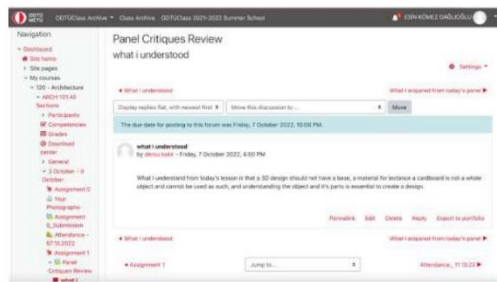
FIGURE 2. ARCH 101 studio delivery methods in the hybrid semester at the Özyeğin University Department of Architecture, fall 2021.

The main objective of the ARCH 101 basic design studio at the METU Department of Architecture is to establish fundamental design thinking and exploration skills by introducing basic concepts and design principles such as order, organization, elements of design and their formal and structural relationships. Students are expected to develop 2D and 3D abstract compositions by using different materials and media (physical and digital). Exercises usually start with the visual and geometric organization of the 2D field and continue with the 3D medium to study the tectonic and spatial characteristics of abstract volumetric compositions. The abstract medium of the assignments “prevent[s] the students from settling for familiar and already known solutions” and “ensures that the design act begins with a clean slate” (Çakmaklı et al., 2022). The course is hosted for 12 hours a week, and we meet with the students twice a week for 14 weeks. The students develop their projects both individually and in some cases in small groups. During the pre-COVID-19 period, first-year students were encouraged to work in the studio and to make their submissions physically. The project presentations took place one-on-one in the physical studio environment. The projects were physically received, graded and returned to students; it was therefore not possible to see all the works digitally together and comparatively. The learning

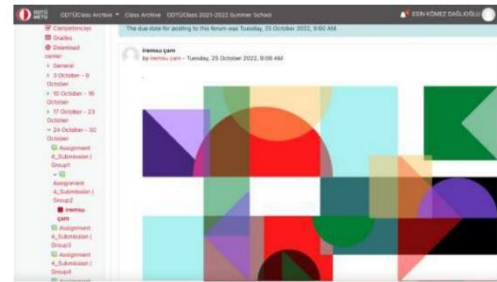
management system ODTÜClass was not actively used for homework submissions, announcements or communication for the ARCH 101 course.

After the COVID-19 outbreak and over the past three years, the ARCH 101 studio has been conducted in three different modes during the last three years: (1) fully *online* via Zoom platform in the fall 2020 semester, (2) *hybrid* in the fall 2021 semester as 40 % of the classes (seminars, juries, and some critique sessions) were held online via the Zoom platform and 60 % of the classes were face-to-face in the studio (the percentages are determined by the regulations of the Council of Higher Education in Turkey) and (3) completely *face-to-face* in the fall 2022 semester with the physical attendance of all the students in the studio (Figure 3). Like the Özyeğin University case, we used ODTÜClass in all three modes as a major communication platform for sharing the syllabus, assignment briefs, announcements and more. The students also uploaded all their submissions to ODTÜClass in a digital format and they learned their grades privately via this platform. Overall, ODTÜClass has become the digital archive of the studio conduct and content. All the seminars of invited speakers are also announced on ODTÜClass, and selected student works are exhibited online via the official Instagram page of the studio (@metuarchfirstyeardesignstudio). One of the major transformative impacts of the digitalization of the studio, which was accelerated with the emergency remote teaching after the COVID-19 outbreak, was the adaptation to digital design tools (i.e., Rhino) in the studio. This was different from the pre-pandemic period in which students were introduced to digital design tools in second-year design studios. After COVID-19 pandemic, the students became familiar with computational design in the early phase of their architectural education. Digital tools were therefore used for purposes beyond communication and representation.

Panel Critiques Review at ODTÜclass



Student project submissions to ODTÜclass



Face-to-face design critiques in the studio



Final jury evaluations via ZOOM



FIGURE 3. ARCH 101 delivery methods during hybrid semester at the METU Department of Architecture, fall 2021.

3.2. The Instrumentality Perspective

The analyses of the ARCH 101 studio structures and delivery modes in the two cases revealed the ways digital tools and platforms acted as *instruments* in the development of the design literacy of first-year architecture students (Table 1).

TABLE 1. Elements of the *instrumentality perspective* pertaining to the role of digital tools in the ARCH 101 basic design studios.

Thematic categories	Tools	Purpose of usage
Content sharing, production, discussion	ODTÜClass and ozu.lms	Project submissions and archiving
	Zoom	Synchronous studio gathering and online design feedbacks; integrated with face-to-face design critiques in a hybrid studio mode
Representation and assessment	Photoshop	Poster and portfolio design
	Miro	Poster and portfolio design, project reviews and rubric creation
Design	Rhino and SketchUp	Generative role as a design tool
Visibility	Instagram and Facebook	Public sharing of selected student project examples

ODTÜClass and ozu.lms were used as the learning management systems at METU and Özyeğin University, respectively, to share all course content with the students, to store student projects in digital formats as well as to enable communication and reflection mechanisms for both the tutors and students about design projects. Zoom was the main digital platform for synchronous weekly studio gatherings to provide design feedback and participate in discussions. Zoom was also utilized for theoretical lectures and seminars; in some cases, this allowed for invited speakers to be included in the design studio. Some of the physical disadvantages of the studio environment, such as difficulty in seeing the panels or hearing the tutors due to the large number of students, are avoided in Zoom, as students are able to access the studios via their screens equally. However, there have also been cases of inequality in online participation. For example, not all students have the same conditions at home or access to digital infrastructures.

Digital representation programmes such as Photoshop and Miro also became important components of the studio practices in both the Özyeğin University and METU cases. Although these programmes had been used by students before the pandemic, they were used much more effectively when online education was required. While Photoshop was used for poster and portfolio designs, MIRO acted both as a representation tool and an interactive platform for project reviews and assessment practices, especially for the students at the METU. Tutors used MIRO to design assessment rubrics to evaluate and grade students' projects in coordination with all sections. Rhino was used as a design tool in the ARCH 101 studio at the METU. These digital tools were integrated into the design process, but when the course delivery model shifted from online to face-to-face or hybrid education after the effects of the pandemic had subsided, the design tools did not remain merely digital. The students were encouraged to re-integrate manual tools such as physical model-making into their design processes. In the Özyeğin University case, the situation was different; even in the fully online mode, the students continued to make physical models as part of their design strategies. They used these digital tools and platforms mostly to access course content in varied forms, to participate in design critiques and discussions and to create digital archives and representations.

3.3. The Understanding and Methodology Perspective

In the present study, we revealed that the use of digital tools and platforms in the ARCH 101 design studios could be revalued from the perspective of how they transformed the *understanding and methodology* of design in first-year design education. The changes in the students' spatial literacy

through the dominance of visual perception, emerging possibilities for individual and collective knowledge production, research components and the integration of digital and manual learning tools are the main thematic categories addressed in this section (Table 2).

TABLE 2. Elements of the *understanding and methodology* perspectives pertaining to the role of digital tools in the ARCH 101 basic design studios

Thematic categories	Activities the students engaged in
Dominance of visual perception	Being exposed to the design object more closely and directly through a screen
Change of spatial literacy	Better conception of the three-dimensionality of design in the absence of gravity or a base in the digital medium
Individual and collaborative knowledge production	Quick feedback given through screen sharing, and the possibility of drawing sketches or commenting on the project
Research component	Increased access and sharing of digital content that triggers research as part of the design process
Integration of digital and manual learning tools	The use of digital production strategies together with manual techniques for the development of design thinking skills

One of the main transformative effects of the digitalization of the ARCH 101 studio practices was the dominance of visual perception in the early design learning experiences of the students. In the pre-pandemic period, physical 2D compositions and 3D models acted as products that all the students could experience together, not only visually but also in a haptic way in the physical studio environment. In the online and hybrid delivery modes the students were exposed to the design object more closely and directly through a screen. Accordingly, the ways the students perceived, understood, and acquired information about design were conducted primarily on a visual basis. The digitalization of basic design education thus triggered an approach that puts vision at the core of the perception process. For example, the students could not touch the model, so this deprived them of the tactile experience of design, yet the integration of digital tools into design education increased the quality of the visual information about design. Visual content related to design also triggered the development of visual communication among designers. All the participating students were encouraged to focus on the digital content on the screen as the object of learning. The “annotation” feature of the Zoom platform enabled giving feedback to students’ projects through sketching; thus, drawing became an effective tool for the visualization of thinking. In addition, the zoom in/zoom out features made it easier to focus visually on the details of the project/object on the screen. It was also revealed that the use of digital platforms and tools altered the students’ 3D thinking strategies. In the basic design phase, where abstract 3D volumes are designed, and the inputs of physical sites or spaces are commonly not determining factors, the absence of gravity or a base in the digital medium paved the way for the better conception of the three-dimensionality of design.

Screen sharing for design critiques via the Zoom platform also helped facilitate quick feedback regarding students’ projects. Both the tutors and students were able to draw sketches and/or comment on the shared content, which was supportive for individual and collaborative knowledge production in the ARCH 101 design studios. By integrating digital tools and platforms into the design studio pedagogy, the research component of design was practised more efficiently. The students were able to access varied forms of digital content and sources of knowledge (e.g., texts, videos, tutorials, auditory and

visual resources) and to conduct research about the given design topics. During the weekly gatherings on Zoom, the tutors and students were able to conduct synchronous research on keywords and concepts related to a design brief. However, it should be noted that the design processes in the ARCH 101 studios, in both cases, have not been completely digitalized. Both in the hybrid and face-to-face delivery modes, the use of digital production strategies for 3D modelling or 2D drawing were integrated with manual production strategies such as hand drawing, sketching and physical model making. The development of design thinking and making skills for the first-year students has thus been supported through the integration of digital and manual learning tools.

Accordingly, the findings of the present study on the *instrumentality* and *understanding and methodology* perspectives of the role of digital tools in the ARCH 101 basic design studios are in parallel with numerous studies on the benefits of the digitalization of the design studio during the pandemic period. These studies addressed the elimination of constraints arising from place and time, the increasing interaction between people at different institutions and geographies, the possibilities of accessing digital contents multiple times and of co-working on and co-evaluating such content as well as creating a digital archive of course contents and student work (Dervişoğlu & Yılmaz, 2023; Fleischmann, 2022; Iranmanesh & Onur, 2021). However, research on the ways the digitalization of design education has transformed the measurement and evaluation methods specific to design education and their applications is very limited. Attention has been drawn to the factors that make a student's design learning experience challenging. These include the inability of the tutor to observe the design process directly, the difficulty of initiating peer evaluations is harder in digital environments compared to in a physical studio and the weakening of social interactions between students (Asadpour, 2021; Cho et al., 2023; Yorgancioğlu, 2020). It is also striking that the changing cognitive dimensions of design learning have not been examined in depth in studio pedagogy research conducted in pre- or post- pandemic period.

4. CONCLUSION

In this paper, we investigated the role of digital literacy in the development of design literacy of first-year architecture students in reference to our studio practices which provided a basis for discussing the multidimensional effects of digital transformation on design education. For the design thinking approach, which is at the heart of design studio environments, it is vital that the digital tools and platforms are integrated into the teaching/learning processes to support students' critical and creative thinking skills. Accordingly, as broadly discussed in the literature, digital literacy cannot be reduced to a purely technical skill. The digitalization process is an issue that needs to be addressed by considering its potentials and shortcomings for basic design course as the first stage of design education. These implications manifest in the elements of the *instrumentality* and *understanding and methodology* perspectives pertaining to the role of digital tools and platforms in the ARCH 101 studios (Table 3).

When the design thinking of first-year students act as a bridge to connect design literacy with digital literacy, multiple forms of communication can take place between actors through different channels and tools in the early stages of design education. This communication engages different types of knowledge (e.g., visual, auditory, tactile, digital) in the design learning processes. Learning processes, in which different types of knowledge and different forms of communication are effective, have the potential to transform the thinking and production patterns of design learners. This does not point to the replacement of physical tools and methods by those that are digital, but to the establishment of a reflective coordination between the two media (Fleischmann, 2021; Iranmanesh & Onur, 2021; Megahed & Hassan, 2021). Models of design education, which can be defined as “blended” or “hybrid”, yield positive results in the early stages of design teaching when they are based on the simultaneous use of physical and digital tools in a cyclical manner without a hierarchical relationship between them. In harmony with the cyclical nature of the design process, which cover analysis, exploration, generation and evaluation through iterative practices (Rieuf et al., 2015; van Dooren et al., 2014), the digitalization of first-year basic design studio practices allows students to develop reflective strategies regarding different media. This reflective practice does not trigger a preference of one medium over another, but

rather the use of physical and digital media iteratively at different stages of the design process, depending on the cognitive and hands-on needs of the design.

TABLE 3. Evaluations of the advantages and disadvantages of the use of digital tools and platforms in the ARCH 101 basic design studios

Advantages	Disadvantages
The three-dimensionality of the design can be better conceived as there is no gravity or a base in the digital medium.	It is difficult to develop the sense of scale; the dominance of visual perception makes it difficult for students to comprehend the part-whole and ratio/proportion relationality.
Students can revise their works easily, so they can work on multiple alternatives.	The ease of multiplying the design elements brings forth a risk of having redundant design elements and monotonous repetitions.
Students can use their time efficiently as obtaining and working with physical materials needs more time.	If not integrated into the studio requirements, physical model-making skills cannot be developed.
Representations are much more precise and visually legible.	Flattening the represented 3D object or space onto a 2D screen weakens the perception of the depth (Z) dimension.
Guest jury members can be invited and the spatial difficulties in panel critiques can be eliminated via the Zoom environment.	Students may not feel as comfortable communicating and interacting with studio stakeholders on the Zoom platform as they do in the physical studio.
Computers can be provided to those who do not have a computer via donations (technical and hardware difficulties).	Even if hardware and software are available, problems can occur with the Internet connection and interrupt design critics.
The digital delivery of design feedback supports the common concentration of the participants on the project / content shared on the screen.	In the hybrid design studio, tutors may have a limited ability to maintain the interest and involvement of students synchronously.

Although fully online design studios are rarely run in the post-pandemic period, many digital tools and platforms integrated into design education during the pandemic experience are still in use in face-to-face and/or hybrid design education models in the physical studio (Dervişoğlu & Yılmaz, 2023). This demonstrates the widespread acceptance that combining the achievements of face-to-face design education in the physical studio with the achievements of technology-assisted design education and thus utilizing the potentials of both education models is a more effective approach for the future of design studio pedagogy. We think that it would be fruitful for future studies to investigate the digitalization of studio practices, without reducing them to the technical ability using digital tools but rather re-contextualizing such digitalization within the holistic framework of design literacy, namely, a framework that integrates design knowledge and skills and critical reflection on the creative use of digital tools and platforms for design learning. The lack of feedback from the first-year design students on the effects of the digitalization of studio practices on the development of their design literacy is a limitation of the present study. However, the study will be enlarged and developed further in this direction by the authors, who are tutors in the first-year design studio.

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