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Towards an integrative model of blended design studios: a multiple case study across architecture, design and planning education

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Abstract
Design education embodies distinctive pedagogical practices rooted in experiential learning, frequent interactions between students and instructors, reflective dialogues through project deliverables, and enculturation through activities and encounters facilitated by a physical studio setting. Contrasting the traditional lecture-based format, the design studio fosters a dynamic, participatory environment, making technology-mediated instructional delivery methods more rare and experimental than widely adopted. However, the COVID-19 pandemic forced a sudden shift to emergency remote teaching, which prompted a critical re-evaluation of both conventional and unconventional teaching methods, thereby leading to a reconsideration of traditional pedagogical approaches. This paper outlines common technology-enhanced approaches in design studios and advocates for blended learning as an effective mode of delivery. Multiple case study methodology was employed to elicit collective experiences, practices and future expectations of studio instructor teams from 12 architecture, design and planning departments across six universities. Findings of the thematic analysis are presented utilising Khan's octagonal framework. The themes are synthesised in an integrative model to aid instructors in planning and implementing blended design studios, and recommendations are made for delivering blended learning experiences. The distinctive contribution of this study is its effort to develop an inclusive, comprehensive, and overarching model that resonates across various studio-based fields.

Keywords Design studio · Blended learning · Studio pedagogy · Blended design studio · Technology-enhanced learning

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1 Introduction

Blended learning is commonly defined as learning that integrates both traditional and distance learning environments, online learning methods or asynchronous online learning practices (Bonk & Reynolds, 1997; Means, et. al, 2013; Osguthorpe et al., 2003; Valiathan, 2002). In a blended learning type of instruction, students participate in a mix of in-class and online environments, allowing for flexibility, personalisation, and interactive learning opportunities providing access to resources, collaboration tools, and interactive multimedia content. By blending the best of both worlds, blended learning offers a dynamic and adaptive approach to education that caters to diverse learning styles and preferences in all fields, including design studio education (Peimani & Kamalipour, 2022).

In design fields, the blended learning approach takes on a unique form. Blended design studio education integrates the principles of blended learning into the traditional studio culture, where students immerse themselves in hands-on design projects under the guidance of instructors (Fleischmann, 2021). Similar to blended learning, blended design studio education benefits from technology to enhance the educational experience. It integrates online platforms, digital tools, and multimedia resources to supplement in-class instruction, providing students with anytime, anywhere access to course materials, collaborative spaces, and feedback mechanisms. This approach expands the boundaries of the traditional studio environment, allowing for greater flexibility and collaboration in the design process. Ultimately, it underscores the importance of integrating technology seamlessly into the essence of design education.

The essence of design education lies in the studio culture, a distinctive teaching format specific to art and design education. Within this setting, students deal with design problems of varying levels of complexity under the guidance of educators and professionals. Design knowledge is embodied through a dynamic exchange between students and instructors in regular consultations to provide formative feedback on students' evolving design projects (Crowther, 2013). The feedback on design works takes the form of an open dialogue known as 'critique' or 'the design crit', which Schön (1984) describes as a 'reflective conversation', and the design process as 'reflection-in-action'. Consequently, the project is framed as unique design problems by students, for which they propose solutions. Their works are discussed in a reflective dialogue with the instructor by utilising an authentic disciplinary language that combines speech with simultaneous sketching. This interaction ensures that the design problem is continuously redefined and reframed (Schön, 1984).

In contrast to conventional lecture-based classes, the design studio prioritises learning by doing and active student participation. Student–student and student-instructor interactions serve as the primary means of exchanging ideas. This informal learning environment is supported by an open, omnidirectional, non-hierarchical spatial structure, namely 'the studio' (Shulman, 2005). Beyond its formal setup, the studio promotes casual encounters, natural interaction, and peer learning. A concrete indicator of achieving learning outcomes is the presentation

of design works in oral, written, and two/three-dimensional design formats. Consequently, studio education incorporates 'jury evaluation', a method differing from conventional approaches to assessing learning outcomes (Broadfoot & Bennett, 2003) during which students present and defend their design solutions before a panel comprising instructors and professionals.

The distinctive features of studio education have posed challenges in adopting technology-mediated practices due to concerns about the effectiveness of learning in online environments (Fleischmann, 2020a). Prominent technology-enhanced practices in design education began emerging in the 1990s, initially focusing on design communication and remote collaboration in the form of virtual design studios (Broadfoot & Bennett, 2003; Budd et al., 1999; Kvan, 2001). Moreover, scholars tested various blended studio models combining face-to-face and online environments with synchronous and asynchronous methods and reported numerous benefits for learners (e.g. Afacan, 2018; Ioannou, 2018; Miralles et al., 2012; Pak & Verbeke, 2013; Pektaş & Demirkan, 2011). Despite the growing recognition of the potential to transform or enhance traditional design studio practices in digital environments, instructors predominantly preferred face-to-face mode, therefore online and distance education had not gained widespread popularity.

Naturally, the COVID-19 pandemic significantly disrupted studio education, necessitating an urgent shift to compulsory distance learning due to the global implementation of social distancing measures and lockdowns. The comfort of the design studio, which was taken for granted to maintain necessary interactions and hands-on activities, was no longer available (Jones, 2021). Despite challenges, the experiences during the 'new normal' provided a context for evaluating the advantages and disadvantages of both conventional and unconventional approaches to the design studio (Bamoallem & Altarteer, 2022; Ceylan et al., 2021; Varma & Jafri, 2021). The exploration of traditional and novel methods during the pandemic prompted instructors to reconsider their existing approaches to studio instruction. Recognising the limitations of a solely online format, educators are increasingly considering the benefits of blended learning in design studio education. Furthermore, increasing student numbers in higher education poses challenges to maintaining traditional methods (Ni et al., 2023).

Building upon these efforts, this study is part of a research project that aims to aid design educators in planning and executing blended learning practices, specifically focusing on design studios. The paper presents a conceptual model, which was developed through a rigorous process of multiple case studies conducted with 12 design studios. The research seeks to answer this question: *How might we blend face-to-face and remote contexts, synchronous and asynchronous methods, physical/offline and digital/online tools and environments to cater to the distinct requirements of design education and educators while ensuring the learners' benefits?* Throughout the paper, we provide a brief overview of technology-enhanced practices in design education, followed by the introduction of the methodology and findings of our original research. Subsequently, we present the integrative conceptual model for blended studio education and offer concrete suggestions for practice.

2 Overview of technology-enhanced approaches in design studios

2.1 Virtual design environments

Technology-mediated learning in higher education has gained popularity in recent decades, guiding instructional practices to enhance delivery methods, materials, and classroom interaction through computers and virtual environments. Alavi and Leidner (2001) defined technology-mediated learning as "an environment in which the learner's interactions with learning materials, peers, and/or instructors are mediated through information technologies" (p. 2). The purposes of technology use vary and are often broadly defined. In their critical literature review, Kirkwood and Price (2014) discovered that the anticipated 'enhancement' of learning through technology encompasses increased flexibility, engagement or performance, fostering of positive attitudes and perceptions towards technology, development of deeper learning or intellectual skills, and improved student interactions in online discussions and collaborative activities.

In design education, technology-enhanced practices trace back to the early 1990s, notably to the applications named 'virtual design studios' (VDS). Exploring the potential of computer-supported collaborative work, VDS applications used web-based technologies to conduct project activities in virtual, networked environments (Broadfoot & Bennett, 2003; Kvan, 2001). Remote design collaboration among stakeholders and higher education institutions has been a significant character of VDS applications, also known as 'networked design studio' (Al-Qawasmi, 2006), 'distributed design studio' (Lauche et al., 2008), or 'global design studio' (Bohemia, 2010). International collaboration remains a prevalent practice in studio education, whether in fully online or blended modes (e.g. Adiloğlu et al., 2021; Bohemia & Ghassan, 2012; Chen & You, 2010; Pektaş, 2012; Polaine & Bennett, 2010).

Various digital design tools and virtual environments have been experimented with to improve design performance, learning, and collaboration in studios. Multiple studies have explored the impact of these tools on design creativity, three-dimensional comprehension, improving design deliverables, and overall learning experiences. These technologies encompass equipment (e.g. tablets) and software (e.g. computer-aided design, CAD) for digital design and communication, contrasting traditional manual methods such as hand sketching and physical modelling (e.g. Al-Matarneh & Fethi, 2017; Eren & Yılmaz, 2022; Griesel & Price, 2017; Ranscombe & Bissett-Johnson, 2017; Şenyapili & Basa, 2006; Speranza, 2016; Zuo & MaloneBeach, 2010). Additionally, immersive environments like virtual, augmented or mixed reality have been utilised or discussed (e.g. Abdelhameed, 2017; Abu Alatta & Freewan, 2017; Aydin & Aktaş, 2020; Cindioglu et al., 2022; Jiawei & Mokmin, 2023; Lee et al., 2021; Mohamed & Sicklinger, 2022; Obeid & Demirkan, 2020; Özgen et al., 2021; Sinfield & Cochrane, 2020; Zhao et al., 2022). Some scholars have even employed virtual games as virtual environments to foster design collaboration among students (Johns & Shaw, 2006; Reffat, 2006), and enhance student motivation and learning (Goli et al., 2022).

2.2 Blended design studios

The widespread adoption of learning management systems (LMS) from the 2000s onwards, the rise of social networks in the 2010s, and the pandemic conditions in the 2020s prompted design educators to explore the potential of these platforms for enhancing asynchronous communication and content delivery. Blended studio models, combining synchronous and asynchronous methods in face-to-face and online settings, have been extensively trialled (e.g. Afacan, 2018; Bender & Vredevoogd, 2006; Chen & You, 2010; Ioannou, 2018; Miralles et al., 2012; Pak & Verbeke, 2013; Pektaş & Demirkan, 2011; Schnabel & Ham, 2012). Blended design studio education not only preserves the essence of the studio culture but also enriches it with the affordances of digital technologies. It fosters a dynamic learning environment where students can engage in hands-on design activities, receive real-time feedback, and collaborate with peers both in-person and virtually. By combining the best practices of face-to-face instruction and online learning, blended design studio education offers a holistic approach to design education that prepares students for the complexities of the digital age while preserving the traditional aspects of design studio education. In this direction, educators used popular social networking platforms like Facebook and Ning to facilitate design feedback and peer interaction beyond class hours (e.g. Ham & Schnabel, 2011; Rodrigo & Nguyen, 2013; Turan & Sahin, 2012). Recognising the limitations in common LMS platforms such as Moodle and Blackboard for accommodating studio interaction, alternatives like whiteboard applications and audio feedback were used for asynchronous communication (e.g. Endo et al., 2022; Jones & Hilton, 2022; Lawrence & Watson Zollinger, 2015; Schlickman, 2022).

Fleischmann's (2021) study stands out for its longitudinal intervention in integrating blended learning into design education. Over four years, 119 first-year undergraduate design students participated in a blended learning experience, which combined online delivery of lectures, tutorials, and readings with face-to-face studio sessions. The study adopted a flipped classroom model, where students engaged in online learning activities before attending practical tutorials for project work and dialogue with instructors. The results indicate that students and instructors found the blended learning approach effective, with online components enhancing learning by offering flexibility in pace, time, and location. Reduced travel to the university and increasing motivations of students for self-directed learning were noted. Instructors also noted that the quality of creative work produced in the blended format was comparable to that in fully face-to-face settings.

The COVID-19 pandemic profoundly impacted studio education. The physical studios, fostering casual encounters, natural interaction, and peer learning, remained necessarily inaccessible for nearly three semesters. This disruption fundamentally challenged habitual instructional practices and compelled design educators to seek alternative environments, tools, and methods. While online studios offer benefits like increased learner autonomy, integration of digital design tools and theoretical content delivery, there was an evident negative impact on interaction quality, peer learning, and manual production processes (Alnusairat et al., 2021; Charters & Murphy, 2021; Grover & Wright, 2023; Iranmesh & Onur, 2021; Marshalsey & Sclater,

2020). Investigating the implementation of blended learning in urban design studios during the pandemic, Peimani and Kamalipour (2022) focused on students' experiences and perceptions of various aspects of blended learning, including assessment methods, feedback mechanisms, field study visits, live online studios, and the use of digital platforms. The study found that students favoured both face-to-face and online methods, highlighting the importance of exploring both the affordances and challenges they present in facilitating meaningful communication and interaction within studio pedagogy.

Similarly, many scholars advocated exploring the potential of blended approaches by combining the strengths of both physical and virtual environments beyond the pandemic (Al Maani et al., 2021; Ceylan et al., 2021; Fleischmann, 2021; Hewidy et al., 2023; Varma & Jafri, 2021). Al Maani et al. (2021) investigated the transition to virtual design studios as a response to the pandemic, reporting on the perceptions and experiences of 248 students across 15 universities. The study emphasizes the importance of further exploration into blended design studios because the facilitation of design studio instruction requires the formulation of blended learning strategies that explicitly accommodate students' flexibility, diversity and individuality. The shift towards blended design studios reflects changes in professional design sectors as well (Fleischmann, 2020b; Öztürk et al., 2021), highlighting its inevitability in higher education due to the close alignment of design education with professional methods and processes.

Taking the necessity for a comprehensive educational model as our starting point, we present our systematic inquiry into blended studio education, which draws from experiences and expectations collected as diverse studio cases from various departments and institutions. In the subsequent sections, we detail the methodology and findings of the multiple case study research and introduce our model which aims to support studio instructors in designing and implementing blended learning experiences within the design studio.

3 Methodology

We applied multiple case study methodology (Stake, 2006) to elicit experiences and expectations of design instructors for a possible blended education scenario. Multiple case study is a research design where researchers investigate two or more cases, potentially leading to stronger insights than a single case by yielding similarities and contrasts between different contexts (Yin, 2017). Due to the exploratory nature of our research, we adopted a holistic design with cross-case analysis to enhance the generalisability and transferability of the findings to other contexts, therefore strengthening the theory (Miles et al., 2014). The holistic design granted an in-depth inquiry into the unique needs and requirements of each case varied across departments, institutions and course levels. The cross-case analysis enabled the identification of patterns across cases while allowing the comparison of case-specific differences.

Educational practices and instructor perspectives from 12 design studios in six Turkish universities were investigated in the study. Research ethics committee

approval was obtained from TED University, no. 2021-10/1 and from Middle East Technical University, no. 416-ODTU-2021. The data was collected across the 2021–22 Spring, 2022–23 Fall and 2022–23 Spring semesters. This was a 'normalisation' period following a year of uncertainty, distance and mixed practices due to the COVID-19 pandemic. Furthermore, twin earthquakes that jolted south-eastern Turkey in February 2023 led to a decision by the Higher Education Council which enforced hybrid education at universities throughout the 2022–23 Spring semester. Therefore, the collected data is based on experiences with various educational methods and approaches spanning five-to-seven semesters.

Data triangulation is recommended in the literature to examine the cases in every respect (Yin, 2017). For this purpose, group interviews with studio instructors, synchronous/asynchronous observation of classes and document reviews were carried out at various studio levels in different departments and institutions. During interviews, open-ended questions were posed to teaching teams to stimulate group discussions about past and current practices, and future needs and expectations.

3.1 Participants and data

A summary of the participants and collected data is presented in Table 1. Participants consist of professors, instructors and teaching assistants. The variance in the number of participants per case is due to differences in class populations, and whether or not the studio is conducted in independent sections, which means fewer students and instructors. U1, U3 and U5 are public universities, and U2, U4 and U6 are private universities. The term 'studio year' refers to the level of the undergraduate studio course (1-freshmen, 2-sophomore, 3-junior, 4-senior). By ensuring variance in course levels and departments, we aimed to collect a wide range of experiences and requirements.

3.2 Data analysis

To ensure reliability, we implemented data triangulation (Flick, 2004). Shared experiences gathered from group interviews, observations, and compiled documents were treated as complementary data sources. Interview transcriptions were merged with screenshots from other data sources for thematic analysis. The analysis process engaged multiple researchers and encompassed various stages, including open coding, axial coding, and selective coding (Williams & Moser, 2019). The analysis process is presented in Fig. 1.

Qualitative analysis began with four researchers by inductively open coding the first case in MAXQDA until initial themes emerged. Then with a deductive approach, the octagonal framework for web-based (Khan, 2000) and blended learning (Singh, 2003) was utilised to organise the emerging themes while coding the first four cases (axial coding). Three workshops were held with six researchers for collective discussions, ultimately leading to the development of a codebook. Each of the remaining cases was coded independently by two researchers using the codebook (selective coding), while a senior researcher supervised this process and

Table 1 Participants and data

Uni. & Case No	Department	Studio Year	Participants	Data
U1, C1	City and Regional Planning	1	2 prof 6 teach. ast	Interview recording, online class recording, presentation outlining studio applications and student works during distance/mixed education
U2, C2	Architecture	1	4 prof 2 teach. ast 1 p.time inst	Interview recording, hybrid class observation, websites hosting virtual galleries of student works during distance/mixed education, collective student blogs
U2, C3	Interior Arch. & Environ. Design	1	1 prof 1 teach. ast 1 p.time inst	Interview recording, online class observation, records of distance/mixed studio applications and interfaces
U1, C4	Industrial Design	1	2 prof 1 teach. ast	Interview recording, records of distance/mixed studio applications, student works, interfaces
U3, C5	Industrial Design	3	2 prof 1 teach. ast	Interview recording, a tool developed by department staff, records of distance/mixed studio applications, process flows, student works, interfaces
U2, C6	City and Regional Planning	2	1 prof 1 p.time inst	Interview recording, records of distance/mixed studio applications, process flows, student works, interfaces
U3, C7	Interior Arch. & Environ. Design	3	1 prof 1 p.time inst	Interview recording, records of distance/mixed studio applications and student works
U4, C8	Interior Arch. & Environ. Design	3	1 prof 1 inst 1 teach. ast	Interview recording, records of distance/mixed studio applications, syllabi, project briefs, student works and interfaces
U2, C9	Industrial Design	mixed (2–3)	1 prof 1 teach. ast 1 p.time inst	Interview recording, records of distance/mixed studio applications, process flows, student works, interfaces
U5, C10	Industrial Design	2	2 prof 1 inst 1 teach. ast	Interview recording, relevant publications by department staff, records of distance/mixed studio applications, student works, interfaces
U6, C11	Architecture	4	1 prof 1 teach. ast 1 p.time inst	Interview recording, records of distance/mixed studio applications, hybrid applications after the earthquake, student works, interfaces
U6, C12	Industrial Design	4	1 prof 1 inst 1 teach. ast	Interview recording, records of distance/mixed studio applications, hybrid applications after the earthquake, student works, interfaces

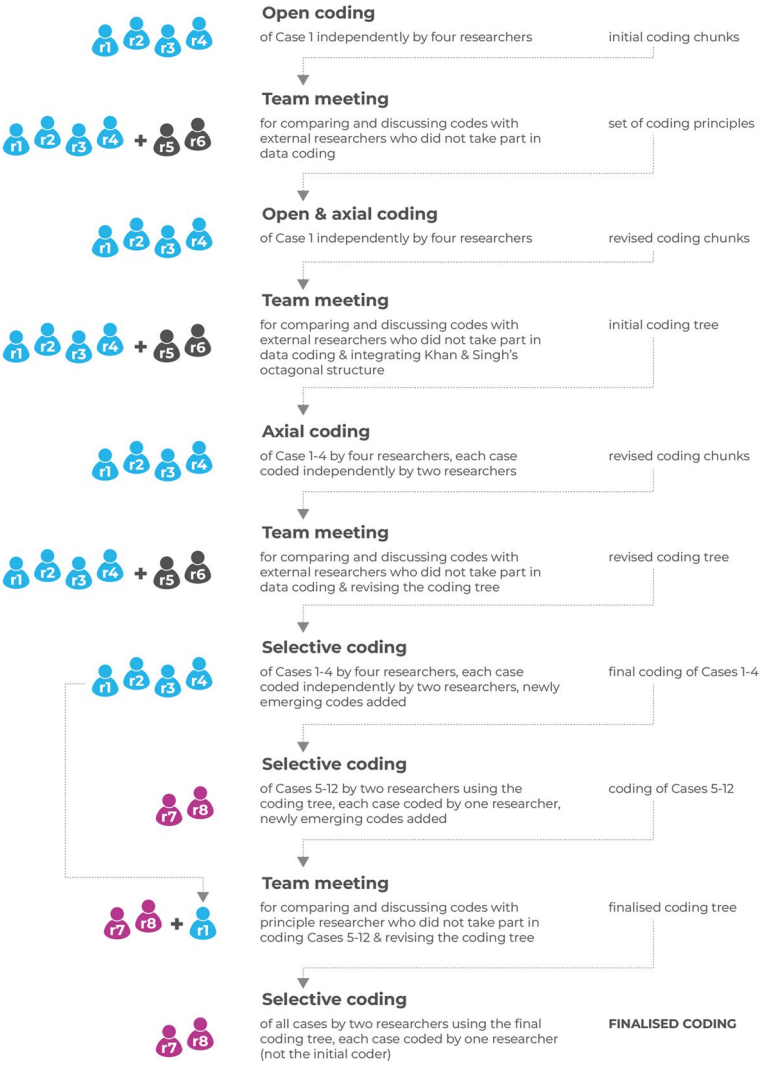

Fig. 1 Data analysis process

helped resolve disagreements. Finally, the codebook was updated with newly added sub-themes.

The octagonal framework was a useful coding frame for two reasons. First, it embraces a blend of a wide variety of instructional methods, mediums and delivery strategies (e.g. face-to-face and remote, synchronous and asynchronous, structured and unstructured learning). We expected this inclusivity to align with the flexibility required for planning and execution of various scales and contexts of design studios across departments and course levels. Second, the components of the octagonal framework present a holistic understanding of the factors affecting the blended

learning experience, including the role of the institutions, the importance of technology and user interface, and the ethical considerations brought by curriculum delivery. Such a comprehensive framework is much needed in design education, which is traditionally known to focus largely on issues related to remote collaboration and improving students' design performance through technology (see the literature review section).

3.3 Findings

Our findings are based on the reflections and experiences of studio teams as they navigated online and blended modalities and their future projections. As explained in the previous section, the emerging themes were organised based on the octagonal framework for web-based (Khan, 2000) and blended learning (Singh, 2003), which involves eight components: Pedagogical, Evaluation, Resource support, Management, Technological, Interface design, Institutional and Ethical (Table 2). Findings demonstrate how educators viewed, handled, and talked about these aspects, offering perspectives into their experiences and future projections regarding online and blended design studios. To protect the privacy of the participants, we match statements with case codes (see Table 1) when including quotes, opinions or sample practices that exemplify the emerging themes. The Supplement file presents the frequencies of each code matched with the cases.

3.3.1 Pedagogical

The Pedagogical dimension is concerned with effective teaching practices. Studio instruction has *distinctive qualities* involving experiential learning, open-endedness, reflection on student works, and learning by doing. Participants highlight their preference for synchronous learning both in in-person and remote formats due to the interactive nature of the studio. *Delivery requirements* are a largely emphasised factor impacting the choice between face-to-face or online learning environments. These requirements include understanding scale and proportion, representational expectations in 2-dimensional and 3-dimensional formats, and digital or manual tool usage. Online mediums are favoured when using digital deliveries like research presentations, feedback on 2D design boards, and CAD models for equal accessibility of students (C4, C5, C8, C9). However, instructors caution about distortions in scale and proportion in the online mediums (C3, C6, C7, C12).

> The fourth-year students in the first online semester initially started face-to-face but had to complete the year online. So we had to plan all the submissions online. Next year, the students continuing from the third to fourth year, which means from online to online, had a dimensioning problem. Some took a step back, looked at their printouts, and said, 'This is not how it looked on the screen.' We had an eleven-metre-long technical drawing of a boat. The whole class gathered behind it to take a picture with it. We said this is not a technical drawing. That's why you draw in scale; for printing. Whoever convinced them to print in real size might have had a good laugh. (C12)

Table 2 Emerging themes

Components	Themes	Descriptions
Pedagogical	Distinctive qualities of the studio pedagogy	Experiential learning, open-endedness, hands-on and interactive nature of the design work, reflection-in-action
	Delivery requirements	Expectations about scale and proportion, 2-dimensional and 3-dimensional design and delivery formats, making and use of models/mockups and printouts, digital and manual tool usage
	Course operation	Delivery of theoretical content, managing practical applications and hands-on work, contributions of guest participants, fostering student participation, interaction and communication
	Project presentation and documentation	Methods and platforms for documentation of the student project process, conduct of design juries, disseminating student works, documenting and archiving student works
Evaluation	Assessment of student works	Formative assessment (e.g. submission and feedback process, design critiques, assessment of project phases), and summative assessment (e.g. organising submission processes and delivery formats, presentation methods, participation of external evaluators)
	Evaluation of student participation	Evaluating student attendance, participation and presence in online classes
	Evaluation of studio operations	Gathering student feedback about course conduct
Resource support	Resources categorised by content	Project brief, design templates, image galleries, content for materials and model-making methods, software tutorials, theoretical sources, video recordings of design critiques or course sessions
	Resources categorised by type/method	Concurrently conducted supportive courses, discussion forums, custom content
Management	Multi-stakeholder governance and shared responsibilities	Transformed roles and responsibilities of faculty members, teaching assistants and students in studio management
	Management of the course	Coordination and consistency across academic years and course sections, flexibility in lesson planning and implementation, handling unexpected or urgent situations
	Workload management	Handling the increasing workload of the teaching staff
Technological	Digital tools and online environments	Tools for online in-class and out-of-class interaction, video conference and remote collaboration, software for recording and sharing classes, learning management systems (LMS), online platforms for disseminating student works, digital design communication tools, online platforms for research and design inspiration

Table 2 (continued)

Components	Themes	Descriptions
	Design studio hardware and infrastructure	Improvement of the studio space with hardware and infrastructure such as video camera, projector, screen and backdrop, internet infrastructure
	Design equipment	Equipment to support the integration of digital and online design environments, such as tablet PC, drawing tablet and VR sets
Interface design	Usability and accessibility	Ease of learning and use, ease of data storage, licence access, providing documentation, continuity and evolving with the changing needs
	Needs and attributes addressing design education	Compiling external resources in various formats, easy access to projects, establishing diverse classes/channels, 'hanging' and 'annotating' student works, horizontal interaction, opening whiteboards
Institutional	Administrative regulations	Coordinating class locations and schedules, providing regulations regarding the storage of course materials
	Technology support	Technical infrastructure and support, purchasing and maintaining hardware and software, ensuring equity for disadvantaged students
	Employment	Opportunities for remote teaching, employment of supporting teaching staff and professional content producer
	Training	Organising trainings for students and staff, easing communication and peer support among educators
Ethical	Sharing projects on online/social platforms	Protection of intellectual property rights, concerns about cheating/plagiarism, altering project files, cyberbullying, fear of failure
	Online visibility/recording	Performance anxiety, ambiguity of discussions, privacy concerns, personal data protection (GDPR)

Most instructors stress the early integration of digital design tools as a benefit of online classes. The pandemic enforced a digital-first approach, improving competence with these tools (C2, C3, C9, C10, C12). This allowed hybrid approaches, shifting between manual and digital methods to enhance learning (C1, C2). However, face-to-face studios are preferred for manual activities:

> We didn't have computers in the classroom with us. We had modelling materials and we made collages and then when we went to digital, we would make different digital colleges, etc. So in our minds, we were leaning into the hybridity of the situation, which was interesting. (C11)

Course operation is a pedagogical aspect which manages the logistics of content delivery, assignments, and assessments, influencing overall course structure and flow. Key elements are sharing project-related theoretical content, organising field trips, design critiques, hands-on demonstrations for skill development like model-making and CAD modelling, planning seminars and workshops with guest participants, and maintaining student participation and interaction. Almost all participants value the practicality of inviting professionals and project stakeholders for online seminars, feedback sessions and juries. Parallel with the literature, fully online studios are found to be damaging to informal interaction, peer learning, active participation and teamwork, which are seen as vital for the development of a shared culture. Students returning from fully online mode seemed to struggle with this:

> They didn't know how to behave in the studio. They didn't understand how much effort they needed to put in, what kind of work they needed to bring to get feedback from the instructors, or that the more you bring, the more quality feedback you get. Because they couldn't learn this, they considered project work as 'homework'. (C9)

The *presentation and documentation* methods of student projects are significant, especially considering the demands of diverse learning modes. Participants highlight that digital tools and virtual environments facilitate organised documentation, and accentuate the role of students in the documentation process. Moreover, sharing student works in virtual environments is found practical, supporting design juries and dissemination of student projects through online exhibitions and blogs (C1, C2).

3.3.2 Evaluation

The Evaluation dimension is concerned with program effectiveness and individual learner performance in design studios, focusing on student works, participation, and course operation. *Assessment of student works* involves both formative (critiques) and summative (jury) methods. For summative assessment, participants emphasised the value of inviting external evaluators in online juries and providing clear submission format instructions to students for effective presentation. Formative assessment deals with design critiques and assessment of project phases. Online and blended studios require structured processes and careful documentation to make up for the limited real-time observation due to less face-to-face contact. Consequently, online

documentation and assessment of student progress gain importance (C1, C4, C5, C9, C11).

> We asked students to keep blogs [in Miro]. Normally, they would show us what they had done [for the project], but we couldn't see the background process. So, we asked them to maintain these online blogs every week, and we even started grading them. This turned out to be very beneficial for us. For instance, for the students who were falling behind, we could identify which stages they struggled with. And for those who had difficulty developing ideas, we explored how we could provide tutorials and additional support. (C9)

Panel/group discussions in online critique sessions are deemed efficient since they allow for uncovering issues shared in most student works (C1, C2, C3). A similar method, 'wall critique' can be simulated in virtual environments like Miro or Google Classroom, where students 'hang' their works for group discussion (C4, C9). Although asynchronous critiques are generally not favoured due to a lack of reciprocal dialogue, leaving accessible feedback records such as videos or notes/drawings on projects is found beneficial (Fig. 2). Evaluation of studio operations is a rarely addressed theme, but they all emphasised student participation and feedback for course assessment (C1, C2, C7). *Evaluation of student participation* in online studios is found problematic in terms of presence. Active participation in the studio requires engagement with peers and instructors while actively working on their projects. Many participants expressed failed efforts to motivate students to engage in discussions and use class time for hands-on project work during online studios. The stage-like, static structure of the online environment lacks the natural turn-taking and casual interactions that a physical studio affords.

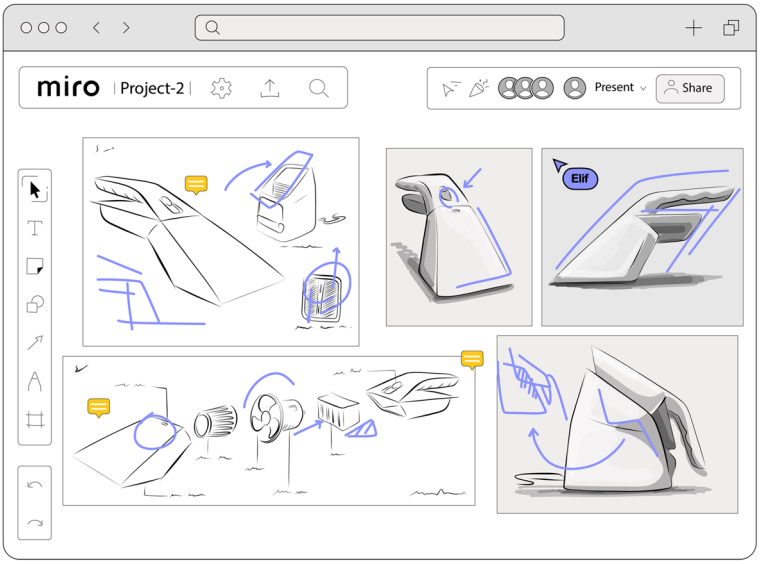

Fig. 2 Representative image of design critiques in Miro, recreated from C4 and C9

> We had concerns like whether they were there, listening, or even present. We couldn't ask everyone to turn on their cameras due to data protection regulations. To receive responses, we used the chatbox to write something, request reactions, or even create small polls. When we couldn't keep up, we divided into 'Breakout Rooms' for design critiques, and the instructors would rotate among different rooms. They worked independently, and we would suddenly enter and ask what they were doing. We tried to find our own methods. I remember asking, 'Are you there?' Send an emoji so we know you're at least present. (C10)

3.3.3 Resource support

The Resource Support dimension focuses on the delivery and organisation of various resources, mainly in digital formats for asynchronous use. The resources can be *categorised by content*, such as design briefs, theoretical sources, templates, material lists, software tutorials, image galleries and course recordings; or *categorised by type/method*, involving courses supporting design studio, discussion forums, and custom content. For instance, participants emphasised the importance of coordinating parallel courses to support the studio, especially for enhancing digital design competency (C1, C2, C3, C4, C6, C8, C12). Some mentioned recording critique or software demo sessions to share with students (C3, C10), though sometimes this was mandated by institutions (C10, C11, C12). However, instructors caution that recordings cannot replace synchronous experiences (C6); and student activity data reveals extremely low viewership of hours-long studio recordings (C12). Instructors often have to create or curate content due to the unavailability of off-the-shelf options. Resources include custom-curated Pinterest boards (C3, C8) (Fig. 3), templates for design and presentation (C3, C4, C5, C11), software tutorials (C1, C2, C3, C9, C11), theoretical sources like articles, documentaries, and project-specific lectures (C2, C3, C4, C5, C6, C8, C9).

> We share many things through Pinterest. Especially when we want to share visual images close to what we want. For example, we show different 3D allocation examples in different buildings and spaces. We ask them to review these examples. We provide an image of how we expect things to be arranged beforehand. The students can add images to these boards as well. Now, the library has become so vast that students simply follow it. We don't redo everything from scratch. We hold discussions using these examples: 'Look, they've done it like this. How might yours be?'. [...] We try to share these initial ideas with them through Pinterest. They can message us directly from there. For instance, when I find something related to their project while browsing Pinterest at night, I definitely forward it. So, we're trying to go beyond design critiques. We're also attempting to support them visually. (C8)

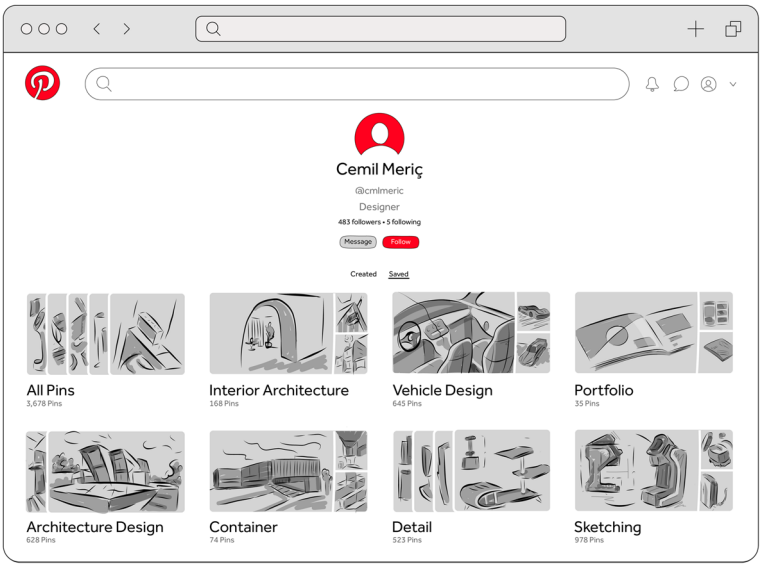

Fig. 3 Representative image of curated Pinterest boards, recreated from C3 and C8

3.3.4 Management

The Management dimension involves strategic coordination and consistent governance of the programme. *Multi-stakeholder governance and shared responsibilities* identify extended roles and responsibilities of faculty members, teaching assistants (TA), and students. For example, in a blended studio, the faculty acts like a curator or designer managing resources (C1, C3), designing the setting, content and interactions (C10), reviewing submitted works, and orchestrating related class discussions (C2). Various activities in the blended studio require extension of TA roles, such as managing asynchronous interactions (C2), supervising group works (C6), organising online archives (C4), and supervising process documentation (C1). The need for documentation and archiving also brings responsibilities for students. As emphasised in the literature, blended learning requires student governance over their own learning experience. Likewise, participants emphasised this as a prerequisite for the success of the blended studio and expressed scepticism at times. Reviewing course materials like videos and readings before the class (C1, C2, C6), autonomy and proactiveness in using or searching for course-related content before being told to (C3, C7, C8) are listed as major student responsibilities. Autonomy is also needed when managing their projects, including using class hours for individual work and feedback, a valuable resource thought to be lost during the pandemic (C4, C8, C11). *Management of the course* involves ensuring coordination and consistency across academic years and sections, flexibility in lesson planning and implementation, and handling unexpected situations. While the need for maintaining coordination isn't unique to blended learning, the open-ended and reflective nature of studio education may demand additional attention. Balancing consistency and standards with

flexibility is vital, especially when planning physical-remote classes and switching between mediums (C3, C4, C5, C7, C9, C12). Limited face-to-face contact presents challenges in real-time observation and detecting classroom issues, which is crucial for engagement, management of project flow, and attention to students who might have diverse needs (C2, C3, C7). Workload management becomes intricate in online and blended studios, with increased duties and responsibilities noted in most cases.

> We used the discussion forum section of Moodle quite a bit at one point. That could be considered asynchronous. Actually, Moodle has always been used very actively in this department. Of course, managing these things requires meticulous attention and timely handling by our research assistants. Everything is downloaded, opened, checked, and counted. They evaluate them, too. So, it requires continuous support, but it's manageable, I think. Last year, when we were doing things online, we used to request submissions the night before. Or maybe just an hour or two before. We'd meet first [with the instructors] to decide what to discuss. (C2)

3.3.5 Technological

The Technological aspect involves digital tools, online environments, design equipment and studio enhancements with infrastructure key to blended studio instruction. *Digital tools and online environments* constitute online learning platforms, remote collaboration and communication, and design tools. While institutions commonly provide LMS platforms like Moodle, Blackboard or custom-designed systems, their rigid structures often fall short of meeting the dynamic needs of design education due to hierarchical role definition and static interaction. Consequently, instructors seek alternatives to develop 'mashup' formulations, integrating Google Classroom (C3, C4, C5), MS Teams (C6), and remote collaboration environments like Miro (C1, C4, C5, C6, C9, C10, C11, C12), Google Workspace (C1, C5, C6), Mural (C10), and Figma (C5). Sometimes, students discover these online environments first, integrate them into their processes, and then instructors follow.

> If we were going to do that mind mapping exercise again, I would definitely use Miro rather than a drawing pad. For sure, even if we were all in the same room. So yeah, that's a really good, let's say, anecdotal representation of what I'm talking about that the tool should dictate what we're doing. Or at least we should be learning from that and trying to figure it out because it is absolute insanity that 23 people have the thing open [at the same time and collaborate]. (C11)

Given the preference for synchronous communication, video conferencing plays a central role in remote interactions. Similar to LMS, the university manages video conference tool subscriptions rather than the teaching teams. Despite initial trials of other options during the onset of mandatory distance education, all teams continued using Zoom. To record or share online sessions, they utilised software such as MS Stream (C6, C9) and Panopto (C11, C12). Engagement and observations of

student presence in online classes are maintained through tools like Slido, Mentimeter, Zoom Polls, and Zoom Chatbox (Fig. 4). Additionally, WhatsApp serves for out-of-class communications (C4, C7, C10). For project research, participants noted using Pinterest for creating visual galleries and exploring existing works (C3, C8, C9, C12), accessing open-access materials via search engines or YouTube (C9), and utilising specialised tools like ArcGIS or Google Street View (C6). Social media platforms, online galleries, and blogs serve as channels to showcase student works to interested audiences (C1, C2, C10). Digital design communication tools hold particular significance. While each design field adopts its preferred platforms following industry standards, commonly cited tools include CAD modelling software such as Rhinoceros, AutoCAD, Fusion, and graphic design software like Adobe Photoshop and Illustrator.

Enhancing *studio hardware and infrastructure*, and providing *design equipment* including graphic or PC tablets, is essential for supporting the transition between physical and digital realms. Smart video conferencing systems, cameras, and projectors facilitate seamless hybrid interactions for both in-person and remote participation in the studio. They enable activities like inviting guest lecturers, jurors, and stakeholders, which can be technically challenging in hybrid settings. These systems also aid in broadcasting critiques and software demos to remote and in-class students, eliminating inefficiencies of desk-based gatherings (Fig. 5). Tablet use affords efficient discussions on student projects through simultaneous drawing and talking, as well as asynchronous critiques via annotations (C1, C3, C8, C10, C11, C12). Therefore, proficiency in digital sketching and note-taking is found valuable. Additionally, some participants suggested VR sets for exploring cities (C6) or virtual factory visits to understand production processes (C5).

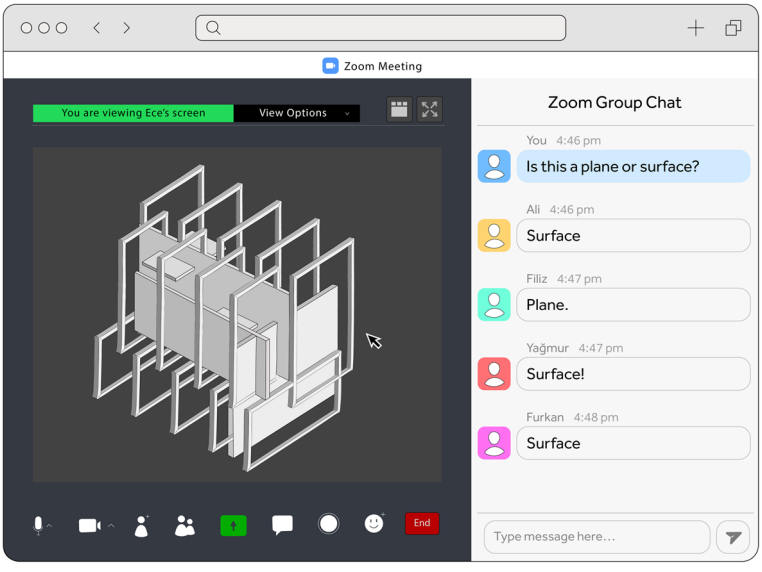

Fig. 4 Representative image of student engagement in the chatbox, recreated from C2

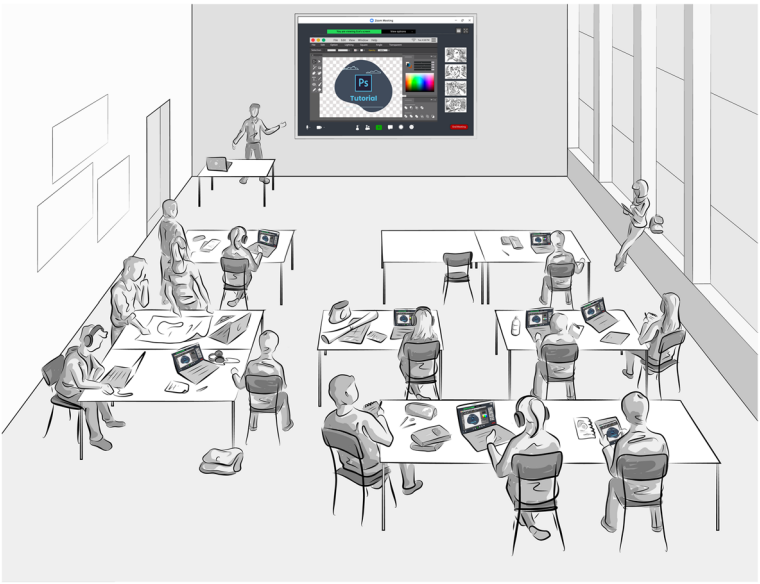

Fig. 5 Representative image of hybrid classroom setup, recreated from C2

3.3.6 Interface design

The Interface design dimension encompasses both common *usability and accessibility* issues, and requirements for design education. Learnability and ease of use are essential features, whether for design software or online environments, as one participant noted: "Moodle is not as easy to use as Google Drive. Drive is the same as our regular file-folder system [in computers]. That's why we prefer it." (C6). Ease of documentation and access, especially for student projects, is highly valued (C3, C4, C5, C6, C8, C9, C11, C12). Cloud-based systems like Google Classroom/Drive and Miro are often favoured due to their flexible and accessible nature, unlike the one-way and static submission systems in Moodle. Platforms that are flexible and continually evolve according to user needs are favoured (C5, C9). Free or affordable licence is preferred due to budget constraints. Almost all studio teams highlight 'hanging' and 'annotating' student works as crucial features *addressing design education*. Therefore, environments such as Zoom, Miro and Google Classroom/Drive receive particular emphasis for their ability to replicate desk and wall critiques, combining speech and sketching and providing visual overviews of works through images and thumbnails.

> It might sound trivial, but we preferred [Google Classroom] for a reason. Our official [Moodle-based] LMS provides classic features. Yes, students can upload their submissions, but it doesn't give you the feeling of seeing every student's project side by side. It requires going through them one by one. Now, sometimes, we also give feedback like this. Like, 'Could you open Ali's pro-

> ject? There's something interesting there.' [Google Drive] kind of offers a wall-critique opportunity. Because when we see it in the gallery view, we see everyone's project images side by side. Of course, depending on the format, sometimes they might be cropped, so it doesn't always give a clear idea about the project. But, for instance, 'Hey, take a look at what Berk did.' (C4)

Miro is particularly found useful for compiling diverse sources like research, notes, sketches, and videos (C4, C5, C9, C10) (Fig. 6). Other than the 'annotation' feature, 'breakout rooms' are another reason to prefer Zoom, for enabling concurrent critiques or teamwork (C3, C9, C10, C12). Participants also appreciate features that foster horizontal interaction among participants and allow for collective work by opening whiteboards.

3.3.7 Institutional

The Institutional dimension addresses questions related to organisational preparedness, infrastructure availability, and managing different learning delivery modes effectively. Our findings stress the need for *administrative regulations* governing submission methods and platforms, class hours, and spatial organisation. The prevalent use of alternative online environments to compensate for the limitations of official LMS adds work and responsibilities to teaching teams, necessitating regulation by the university. Blended studio models demand flexible planning of both in-person and remote sessions, alongside asynchronous activities like research, teamwork, and independent model-making outside regular class hours. While the transition from fully online to in-person studios amidst the 'new normal' posed challenges in organising blended and hybrid sessions due to space limitations and social distancing measures, some of these challenges are no longer relevant. However, coordinating

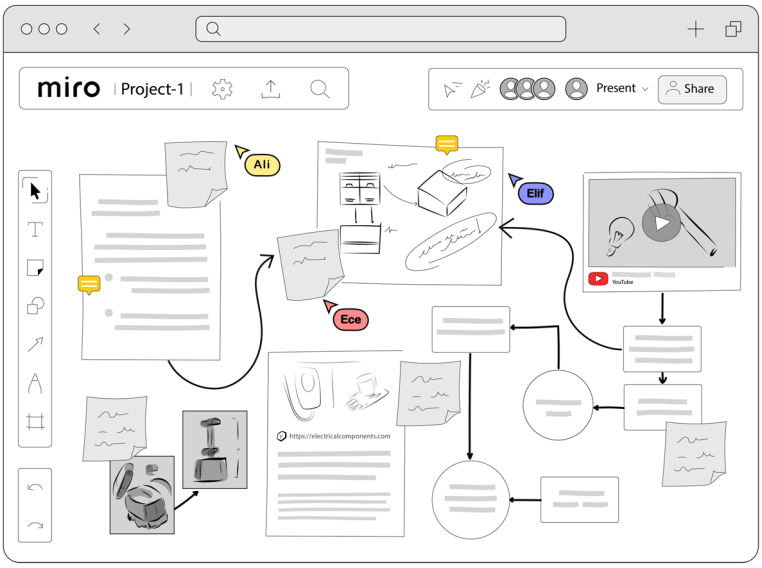

Fig. 6 Representative image of documentation in Miro, recreated from C5 and C9

class locations and schedules, including online sessions, remains a significant concern for many teams (C2, C3, C5, C6, C7, C9, C10, C11). Nevertheless, it's essential to allow flexibility considering the dynamic nature of the studio. As one participant noted: "In hybrid setups, it shouldn't be like Tuesdays are online, Fridays are face-to-face. I should decide when I do online lectures or submissions, and when it needs to be face-to-face. Strict schedules don't work well." (C4).

All teams agree that the university must invest in *technology support,* including equipment, software, and infrastructure. Some suggest effective technical support, like technical staff, to address inconveniences in classrooms (C2, C10) and ensure equity for disadvantaged students (C1, C9). Increased workload should be matched by *employing* more instructors (C7, C9) to expand remote teaching possibilities (C2), and professional content producers to aid in creating asynchronous materials. Instructors possess varying levels of technology readiness, therefore institutions should provide *training* for them (C2, C9, C11). The existing efforts may not fully meet the unique demands of studio education: "The university organises training, but I find very few of them applicable to our field. Studio isn't that type of environment, so adapting them becomes challenging" (C2). Student readiness for the blended mode of learning is also believed to be increased through institution-level efforts:

> We [instructors] have environments where we can share our experiences. Or, if we want to receive training on a specific topic, we know where to find it. But do we adequately communicate these things to students? My general expectation from the institution is to convey to students their responsibilities. Blended learning, for instance, expects students to be more active. I believe it's essential to somehow convey this to students. Perhaps we already struggle with this in design-related disciplines; we often face bigger challenges. We expect students to discover things on their own. We provide sufficient guidance, but then it becomes their responsibility. For example, we don't have an obligation to teach them how to use specific software. We're not a training course. Of course, we guide them and provide tutorials during classes, allowing them to learn through specific exercises. But even having to say this feels unnecessary. Teaching [the students their duties] falls outside the studio's responsibility, in my opinion. Perhaps seminars or other forms of communication are needed. (C2)

3.3.8 Ethical

Findings reveal ethical concerns and potential harms stemming from the increased visibility and accessibility of student works, and online presence in virtual studios. While the ease of *sharing student projects on online/social platforms* is viewed as an advantage brought about by increased digitisation and connectivity, it comes with a cost. For instance, although student projects are not commercial outputs, intellectual property rights remain a concern, particularly in industrial design departments where replication of forms is relatively simpler (C4, C9, C10). Instructors have expressed concerns about the risks of cheating, plagiarism, or unauthorised alterations to project files due to the excessive visibility and accessibility of these works (e.g., C1, C5, C12). They even shared instances of cyberbullying among students

through public sharing of a peer's work for ridicule (C1). The constant visibility leads some students to hesitate in sharing their works due to a fear of failure, a sentiment delicately expressed by one instructor as the 'student's right to be embarrassed' (C7):

> Understanding gestures and facial expressions, or wanting to speak quietly on the side — the right to be embarrassed was taken away from students [in fully online studios]. 'Well, I didn't work that hard. Maybe if I show my work in the end, everyone will go, so there won't be any comparisons made.' They didn't have this right during the pandemic. Everyone was supposed to share their work openly. And we expected them to quickly adapt to computer technologies. Because expressing themselves through other means was no longer an option. Also, it somewhat depends on being able to draw and use computer technologies well, or at least that's what they believed. So, I think many students missed out for this reason. (C7)

Studio courses are notably more intense compared to conventional classes, often requiring a minimum of eight hours of class per week. Moreover, studio sessions involve open-ended discussions on students' works rather than scripted presentations. During the pandemic, many universities mandated the recording and sharing of online classes. Even when not mandated, participants in online classes can record sessions with their own devices. This has sparked performance anxiety among instructors who may not be accustomed to public speaking, worry about their appearance in recordings, or fear that the open-ended and ambiguous nature of discussions might be misconstrued when taken out of context (C1, C2, C6, C9, C10). Additionally, privacy and personal data protection emerged as frequent concerns, closely tied to the legal responsibilities of the institution.

3.4 An integrative model for blended learning in design education

Based on the thematic findings of the multiple case analysis, we propose a conceptual model to aid in planning blended design studios. The model emerged from two expert workshops involving six researchers with backgrounds in design and education fields. In the initial workshop, researchers utilised the code tree and diverse examples of conceptual models, frameworks, and toolkit components for blended and distance education gathered via desk research. The code tree, based on primary data, formed the model's foundation. The latter, secondary data, was used to examine different synthesis approaches and to discuss the appropriate approach for the design studio. After examining the materials, and team discussions, key components and relations of the model were identified. Then, researchers individually studied a proposed model before the next meeting. In the second workshop, these models were synthesised into a single representation illustrating key components and processes for blended studio education (Fig. 7). This section introduces the components of the model and recommends corresponding sample activities for instructors.

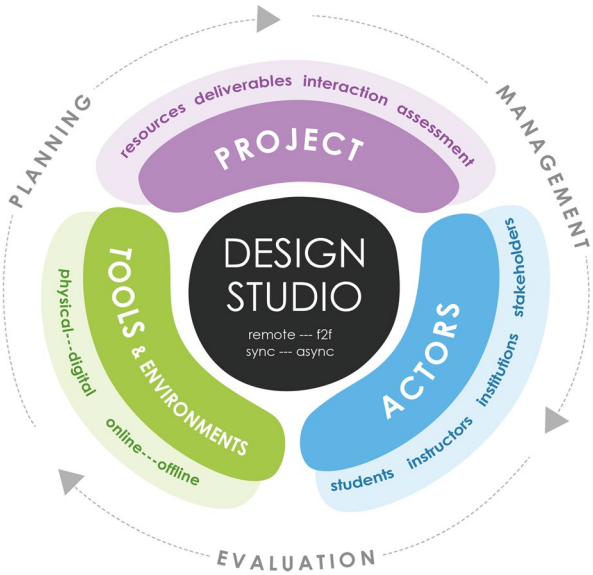

Fig. 7 Integrative model for blended design studio

3.4.1 Design studio

The design studio encompasses key project courses within design, architecture, and planning programmes. When planning a blended design studio, it is vital to consider project processes, methods, involved stakeholders, and utilised tools and environments. The blended studio should seamlessly integrate remote and in-person sessions, as well as synchronous and asynchronous methods for optimal learning. Instructors oversee three primary aspects:

Planning: Defining learning objectives is crucial when planning the studio, with projects serving as a means to achieve these goals. Planning involves providing necessary resources, outlining expected outcomes, identifying relevant stakeholders, and specifying tools and environments tailored to each project's unique requirements.

Management: The design studio operates similar to project management rather than conventional course management, embracing flexibility and openness to intervention in line with creative problem-solving. Studio management integrates diverse methods, tools, and outputs, encouraging individual differences while working toward shared objectives. It ensures regular achievement of project outcomes and course objectives, and continuity and coordination across sections and academic years.

Evaluation: It includes activities to evaluate whether the course has met its planned objectives and devising necessary measures. While it evaluates the studio as a course, assessing the project process and student works can provide evidence of achieving learning outcomes.

Sample activities:

- Listing studio/project learning outcomes, and updating if necessary, considering the blended learning goals.

- Outlining the scope and the benefits of the blended studio model in line with the learning goals for the studio course, design project, or both.
- Ensuring the students, instructors and stakeholders, ICT, technological infrastructure and physical space are ready for the transition; identifying the need for institutional roles for leadership and support in preparedness and management.
- Designing smooth transitions between physical/digital, and online/offline modes.
- Establishing flexible entry points to evaluate, intervene and reform the course or project plan in collaboration with relevant actors.

3.4.2 Project

Project-centred course structure is the prominent feature of the studio. Learning outcomes, course content, and activities are primarily shaped by the design projects. The number and scope of projects can vary based on the field and course level. While first-year studios may involve short-term exercises and assignments, planning studios may explore the same project at various scales throughout the year. Projects comprise these key elements:

Resources: Projects draw on a diverse range of resources, such as project briefs, theoretical materials like articles, documentaries, and seminars related to the project topic, custom tutorials, and desk or field research conducted by students.

Deliverables: Expected project deliverables vary in different departments and levels and as projects progress, ranging from initial sketches to plans and prototypes. Learning objectives and field norms affect the expectations of scale, ratio, 2D/3D, model/mock-up, and digital/manual; therefore how remote and face-to-face sessions can be blended with synchronous and asynchronous methods, and the selection of tools and environments.

Interaction: Studio education thrives on interaction, with one-to-one discussions and feedback sessions, known as design critiques. Teamwork is often integral to project activities. Both formal and informal interactions are essential for peer learning and nurturing the studio culture. In the blended studio, interaction should be interpreted broadly, encompassing any form of communication among various actors, including students, educators, and external stakeholders relevant to the project (public and private institutions, firms, potential users, beneficiaries, etc.).

Assessment: Assessment covers interim and final project outcomes and student participation. Individual, wall, or panel critics assess the project process, while juries provide the final assessment. Peer review and external evaluators often contribute to the assessment. In the blended studio, special attention must be given to delivery methods and formats, presentation and feedback methods, and the choice of tools and environments.

Sample activities:

- Identifying, scheduling, or creating a list of resources to support students' design process (e.g., tutorial videos and online image galleries as asynchronous activities, online seminars and workshops with guest experts).

- Aligning expected project deliverable types and formats for a seamless transition between online/offline and physical/digital tools and environments.
- Planning for both formal and informal interactions among actors (e.g. student–student, student-instructor, student-stakeholder).
- Utilising various methods and platforms to engage multiple actors in project evaluation, and coordinating blends of remote/face-to-face and synchronous/asynchronous approaches for assessment.

3.4.3 Actors

Various individuals and institutions play vital roles in planning, managing, and evaluating the studio and projects. These actors associated with the design studio are:

Students: Students are at the core of the studio and are its ultimate beneficiaries. Rather than being passive participants, they actively produce project deliverables, which are the course's most crucial resources. Thus, their active participation and interaction with all stakeholders are central. Students also play a pivotal role in presenting and documenting course outcomes and in course evaluations.

Instructors: Studio instructors take on diverse roles. Both faculty and teaching assistants actively engage in the studio activities. Part-time lecturers are often employed to infuse up-to-date professional expertise. Furthermore, guest experts may be invited to conduct workshops and seminars, imparting the knowledge and skills needed for the projects.

Institutions: Decisions made by academic and administrative units within the department, faculty, and university have an impact on studio courses. This includes rules and regulations governing course conduct, and the delivery and assessment of course outputs. External regulatory boards may be involved to provide guidelines to follow, especially for the delivery of remote or asynchronous courses. Institutions can also offer support in providing resources like spatial arrangements, software and hardware procurement, personnel recruitment, and training essential for digital transformation.

Stakeholders: External stakeholders are involved in decision-making or are directly/indirectly affected by project outcomes. For instance, in a planning studio, the related units of a municipality can be considered stakeholders. Collaborative projects between different schools also involve stakeholders. In industry-partnered studios, collaboration with companies occurs throughout project planning, execution, and evaluation. They can also serve as consultants/mentors to students. Projects following a participatory approach may involve interactions with potential users, field experts, city residents, and more.

Sample activities:

- Describing the roles of various involved actors in planning, management and evaluation of the course/project.
- Ensuring the accessibility and usability of resources, deliverables, activities and technologies for all involved parties.

- Meeting institutional requirements and standards when planning and implementing the blended course and/or design project.
- Ensuring that blended course/project design offers an enriched experience for students, instructors, and stakeholders.

3.4.4 Tools and environments

Selecting the tools and environments to carry out project activities is crucial in planning. During the pandemic, we witnessed a rapid shift toward digital tools to accommodate remote learning requirements. However, this transition aimed at maintaining traditional studio practices within a different environment, rather than being a systematically planned transformation of studio conduct. The primary distinction of the blended studio lies in its fusion of remote/in-person sessions, synchronous/asynchronous methods, and deliberate selection of environments and tools. Instead of merely transferring existing practices to different environments, successful implementation necessitates careful planning and preparation to achieve the desired outcomes for blended learning and to enhance studio education. Two key types of blending are essential:

Physical vs. Digital: Digital tools and environments, such as LMS, video conferencing, remote collaboration, and design communication tools, are essential for implementing remote and asynchronous methods. However, physical tools and manual techniques still hold significance. Therefore, physical and digital should be balanced, and aligned with learning objectives and the expected project outcomes.

Online vs. Offline: Virtual environments facilitate collaboration among participants in different locations, supporting activities like online seminars and juries via video conferencing, design collaboration in cloud-based platforms, LMS forum discussions, and virtual exhibitions. Conversely, certain activities can occur in physical settings without the mediation of communication technologies. Examples include design critiques in the studio, model-making in the workshop, field research observation and documentation, and visiting factories. Enhancing the physical studio space with digital technologies can blur the online-offline distinction, offering flexibility and a smooth transition between environments.

Sample activities:

- Specifying the tools and environments suitable for specific project activities and deliverables.
- Balancing the use of physical/digital tools, online/offline environments, and synchronous/asynchronous methods for the optimal benefit of the learner.
- Ensuring that utilised tools and environments—physical/digital or online/offline—are usable, accessible and meet the requirements of design education.
- Being mindful of ethical or legal issues that may arise from intense digital footprint and record-keeping such as personal data protection, intellectual property rights, violations of academic integrity, and cyberbullying; demanding institutional leadership if needed.

4 Discussions

4.1 Challenges of blended delivery in design education

Open-ended, dynamic, and interactive qualities of the studio pedagogy have posed challenges in widely adopting alternative instructional delivery methods. However, instructors are actively embracing technology-enhanced practices by integrating digital tools, establishing virtual design studios, and exploring blended approaches. Adoption of asynchronous methods and online environments was limited before the pandemic, mostly seen in departments dealing with 2D media (e.g. Dreamson, 2017; Fleischmann, 2019; Park, 2008) or practices with additional agendas like collaborating with remote stakeholders. While there has been an increase in blended practices across various departments, the pandemic prompted widespread experience, and a reevaluation of traditional methods, unlocking the potential for a more extensive transformation.

Our findings show that design studios inherently adopt a blended approach due to their reliance on student works as course material. Completing all project work during class hours is unlikely, so students engage in diverse project activities in their personal time and be prepared. Online platforms offer potential for panel/group discussions, and lectures, involving guest participants and stakeholders, providing feedback on 2D deliverables, and making software demonstrations. However, achieving 'presence' in online classes poses challenges. While the equal visibility of course materials and discussions in virtual environments is found beneficial, assessing genuine engagement proves more labour-intensive compared to in-person studios. Furthermore, students lacking robust infrastructure, design software, and digital proficiency, tend to have disadvantages as highlighted by Iranmanesh and Onur (2022).

Bias towards synchronous methods among instructors is evident, primarily driven by the necessity for reflective dialogues to co-construct knowledge rather than one-way delivery of scripted content. While asynchronous methods are found valuable in the form of virtual galleries, tutorials, theoretical content, and so on, they entail a significant workload due to the lack of standardised, reusable course materials. Resources need to be custom-created or curated according to the project goals, and the dynamic nature of the studio necessitates spontaneous, organic interventions based on observed classroom dynamics. These factors make conventional LMS structures often fall short of catering to the unique demands of the design work, which appears as a potential area for improvement for the successful implementation of blended studios.

Designing a blended studio demands substantial effort, as replicating conventional practices through new tools and mediums proves inefficient. It calls for a shift in mindset and an openness to unconventional methods that elevate the benefits for the learners. Hence, a shared belief in the advantages of blended studios among instructors and institutions is essential. Our findings reveal significant concerns regarding the potential loss of studio culture and informal interactions, and the voluntary autonomy students should exercise over their creative processes rather than adhering strictly to predefined tasks (i.e. 'homework'). While uncertainty is

favoured in the design studio as it fosters creativity, it also poses challenges for planning due to its unpredictable nature. Balancing these aspects represents one of the biggest challenges facing blended studio practices.

Although the willingness and preparedness of instructors are crucial, institutions should play a pivotal, transformative role for systemic change, and nurturing a shift in culture and understanding. However, the present scenario is far from this ideal, with instructors struggling with budget constraints and lacking technology support. They often find themselves frustrated having to persuade the institutions themselves, rather than the other way around.

4.2 Significance of the integrative model for blended studios

Our conceptual model proposed for blended design studios is the conclusion of a thorough thematic analysis derived from multiple cases. The model serves as a comprehensive guide for planning and implementing blended design studios, involving various components and processes essential for effective learning experiences. In light of the emerging themes organised based on the octagonal framework for web-based (Khan, 2000) and blended learning (Singh, 2003), our model comprises four main components: Design studio, Project, Actors, and Tools and environments. Each component is complicatedly linked, contributing to the overall success of the blended design studio environment. The discussion of these components sheds light on the critical factors that instructors should consider when designing and managing blended design studios.

While our study is unique in the realm of design studio education, numerous other models have been developed in the education field. For example, by utilising the octagonal framework, the components of our model are deeply rooted in the components of Khan's (2000) and Singh's (2003) works. There are other comprehensive models, such as the Blended Learning Framework for higher education developed by Mirriahi et al. (2015) or the Conceptual Framework for Evaluating Blended Learning developed by Bowyer and Chambers (2017). These frameworks also incorporate similar components like resources, activities, support, technology, institution and assessment. The major difference in our model, however, lies in the prioritisation, relationships and implications of these components. For example, 'Pedagogy' in our model is organised in line with the characteristics of studio pedagogy, by giving a central role to the design project and its intricate relationship with the related activities, resources and delivery methods. While Singh frames the 'Ethical' aspects with inclusiveness (2003, p. 54), we propose being mindful of intense digital footprint and record-keeping such as personal data protection, intellectual property rights, violations of academic integrity, and cyberbullying. These issues notably arise from the fact that in the design studios, students actively produce mediums that potentially require intellectual property protection. Furthermore, online presence makes design activities and unstructured interactions a 'public performance', bringing additional risks. Dealing with '3.3.4', 'Technology', 'Interface' and 'Infrastructure' can be more complicated in blended design studios due to the unique challenges proposed by

the characteristics of each project, an extended view of project 'Stakeholders', the need for decentralised interactions and constant observation and intervention.

Other influential models in the literature present comprehensive frameworks for evaluating distinct educational domains. For example, the Hexagonal E-learning Assessment Model in Higher Education (HELAM) (Ozkan et al., 2009) assesses the factors affecting the success of Learning Management Systems as supporting blended learning environments in higher education. Another highly influential work by Garrison and Vaughan (2008) proposes the Community of Inquiry framework as the theoretical basis for developing principles and guidelines for blended learning in higher education. Taking reference from the core elements of the framework, namely social, cognitive and teaching presence, they aim to provide a roadmap for integrating face-to-face and online learning activities. The framework developed by Graham et al. (2013) focuses on the institutional adoption and implementation of blended learning in higher education. They identify the institutional roles in developing strategies, structuring curriculum and support in creating awareness, adoption and implementation of blended learning programs. The strength of these models stems from their in-depth and comprehensive approach to certain aspects of blended learning in higher education. While our integrative model for blended design studio may have limited applicability outside the field of design education due to its tailored nature, it not only contributes to the expansion of the theory on issues such as the learner requirements of virtual environments, the community of practice in higher education and the leading role of the institutions, it can also potentially be expanded by the theoretical background informed by these frameworks.

The conceptual model proposed for blended design studios can provide numerous advantages for the quality of design education. By seamlessly integrating remote and in-person sessions, as well as synchronous and asynchronous methods, the model provides diverse learning experiences for design students. This flexibility may also allow instructors to provide personalised learning experiences, addressing the individual needs of students. Moreover, the blended approach encourages interdisciplinary collaboration and real-world application of design principles, enriching the educational experience. Regarding student development, the blended design studio model facilitates holistic growth. Students benefit from exposure to a variety of learning modalities, enhancing their adaptability and digital literacy skills. The model's emphasis on continuous feedback and assessment promotes self-reflection and continuous improvement among students. The model also contributes to instructor development by fostering pedagogical innovation and adaptability. Instructors are encouraged to explore new teaching strategies and technological tools to enhance instructional delivery. The model encourages collaboration among faculty members, sharing best practices and resources to improve teaching effectiveness. Overall, the proposed conceptual model can serve as a valuable resource for instructors and educational researchers seeking to integrate blended learning to transform design education and prepare students for success in a rapidly evolving world.

5 Conclusions and future directions

In conclusion, the conceptual model proposed for blended design studios offers a comprehensive framework for planning and implementing effective learning experiences in design studio education. Drawing insights from the experiences and expectations of design studio instructors, the model offers practical guidance for instructors navigating the complexities of blended learning environments in a design studio context. Our model contributes to the literature on technology-enhanced design studios by proposing an integrative model aiming at aiding design instructors from various fields in planning blended studio models. To our knowledge, this is the first comprehensive study to synthesise learnings from multiple cases across disciplines, course levels and institutions. Future studies will include the development and evaluation of an inclusive toolkit for studio instructors providing step-by-step guidance in course planning and management.

There are several research implications of the proposed integrative model for blended design studios. First, the model should be introduced to design studio instructors across different design disciplines and grade levels to identify how they engage with the model and whether they find it useful for applying their blended learning practice and identifying strengths and weaknesses. While we intend to pilot the model at our institution for further research, we hope that by introducing it as a proposed integrative model supported by both theory and practice, we provide an opportunity for other researchers to test the model with their own design studios. Second, as the participants were composed of instructors, future work should include scrutinising the experience and expectations of both instructors and students to further enhance the model. The views of design studio students would help recognise whether the key components of the proposed integrative model associated with the students' engagement in blended design studio environments would support their learning as well. Finally, future research can focus on enhancing the quality of design education, supporting student development through blended design studios, and providing professional development resources for design instructors associated with the proposed model's standards.

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Data availability Data sharing is not applicable to this article as no quantitative datasets were generated during the current study.

Declarations

Ethics approval Research ethics committee approval was obtained from TED University, no. 2021–10/01 and from Middle East Technical University, no. 416-ODTU-2021.

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