Design and Technology Education: An International Journal

30.2

Outputs of a Cross-Cultural Virtual Design Studio: EINSTUDIO – A Design Journey Across Countries

Barış GÜR, Gazi University, Turkey
N. Hande KUTBAY, Gazi University, Turkey
H. Güçlü YAVUZCAN, Gazi University, Turkey

Abstract

Following the COVID-19 pandemic, research on Virtual Design Studios (VDS) increased significantly, revealing mixed opinions about their limitations. This paper aims to present these contrasting views on VDS education, with a particular focus on peer-learning. While many studies argue that peer-learning diminishes significantly, or even disappears in VDS, others claim the opposite. The conceptual framework of this study explores the possible limitations of peer-learning in VDS and critically highlights how COVID-19-related anxiety may have influenced many of these opinions. The empirical study discussed in this paper is based on an Erasmus+ project titled *European Strategic Partnership Project: European Interactive Industrial Design Studio (EINSTUDIO*). Students and instructors from three different countries participated in EINSTUDIO. The project aimed to leverage recent developments in online and web-based communication to address the challenges of teamwork in cross-national teams. Accordingly, this paper investigates whether current virtual technologies support the implementation of cross-national design studios. Variables such as motivation, collaboration, cultural diversity, and the contribution of the e-learning infrastructure are examined through participants' self-evaluations. The findings indicate that although virtual peer-learning presents certain limitations and cross-national collaboration poses even greater challenges, a more structured methodology, syllabus and close supervision, such as EINSTUDIO's semi-hybrid studio model, syllabus, and platform can help mitigate issues related to peer-to-peer communication and collaboration issues.

Keywords

design pedagogy, virtual design education, virtual design studio, cross-cultural studio,

Introduction

The studio course is widely regarded as the core and most intensive component - the backbone - of undergraduate design curricula, including architecture (Özorhon & Sarman, 2023), urban design and planning (Peimani & Kamalipour, 2022), interior design (Kurt Çavuş & Kaptan, 2022), product and industrial design (Toprak & Hacıhasanoğlu, 2019; Fleischmann, 2020), graphic design, and fashion design (Fleischmann, 2020). Studio work applies theoretical knowledge from lectures to practice-oriented, real-world projects (Kumar et. al., 2021), and is characterised by hands-on learning, individualised instruction, and frequent feedback exchanges (Fleischmann, 2020). It relies heavily on face-to-face interaction and iterative processes, which led many educators to be sceptical of online studios even before the pandemic (Fleischmann, 2021). However, Fleischmann (2021) describes the COVID-19 shift as a "sink-or-swim" moment, noting that both educators and students adapted more effectively than expected.

Although VDS dates back to the early 1990s, they became essential during the pandemic as programmes had to rapidly transition to remote or hybrid models (Iranmanesh & Onur, 2021). This abrupt change spurred increased research interest in VDS, yielding mixed perspectives on its strengths and weaknesses. A Google Scholar search for "Virtual Design Studio" returns an average of 71 results annually between 2000 and 2019, but this number surged to 197 in 2021, with continued growth in subsequent years (see Figure 1). While VDS initially gained traction in the late 1990s, it remained a relevant topic through the 2000s and 2010s before experiencing renewed prominence in the early 2020s.

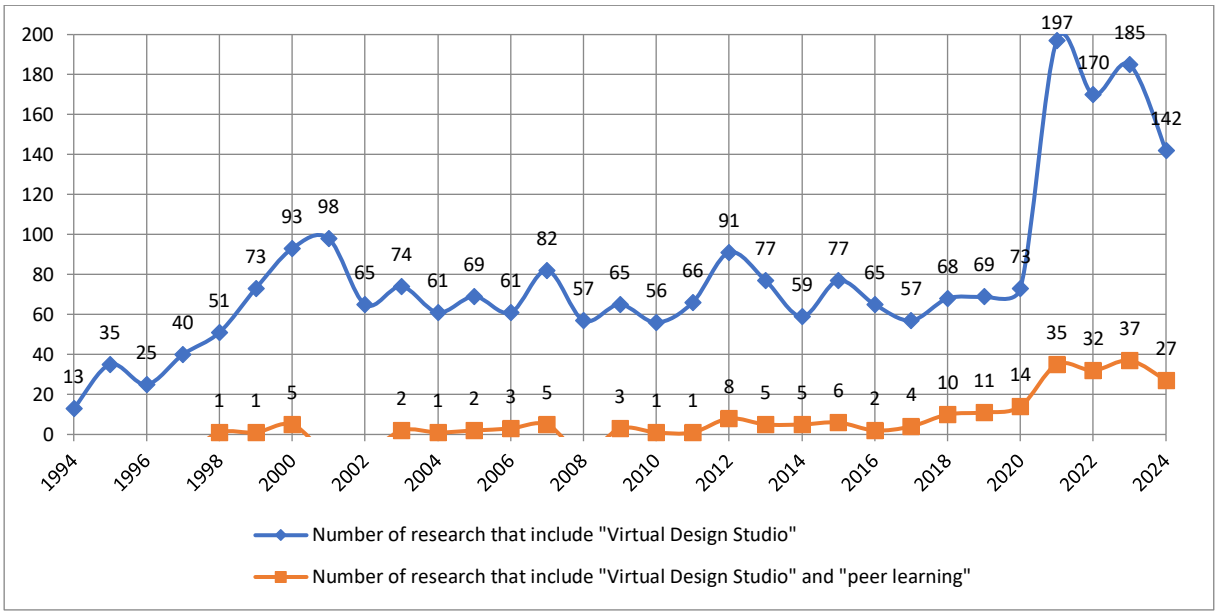


Figure 1. Google Scholar search results per year that include VDS and peer-learning

A key issue in recent VDS studies is peer-learning. As shown in Figure 1, peer-learning has become a prominent topic in VDS pedagogy since 2018, with 19–20% of publications between 2021 and 2024 addressing it. Although earlier results retrieved through these keywords include some extra-pedagogical articles and conference papers, most are relevant to design education literature. Traditional studios were seen as physical environments where students interacted, inspired one another, and informally exchanged knowledge and practices (Perolini, 2019). Consequently, peer-learning remains a significant and debated theme in VDS literature, with mixed views on its effectiveness.

Jones (2022) highlights that the complexities of studio-based learning have only recently gained scholarly attention, particularly regarding social dynamics, informal learning, and hidden curricula. As such, peer-learning in VDS remains an emerging research field. The following chapter reviews key findings from existing studies and presents a conceptual framework defining the studio and VDS. Given this paper's specific focus on cross-national collaboration and peer-learning via VDS, subsequent sections describe the implementation of the Erasmus+ project EINSTUDIO as a case study. Students' reflections and perceptions are presented as the study's primary findings.

Conceptual Framework and Literature Review: Studio

The studio course, rooted in craft-based disciplines, is considered the core of the curriculum. Typically held once or twice a week for half a day or longer, it requires a shared physical space and emphasises experiential, collaborative learning. It is usually delivered to small groups and refers not only to the course itself but also to the physical, social, and cultural environment where real-world design problems are addressed under the guidance of expert practitioners (Jones et al., 2021; Crowther, 2013; Taşlı Pektaş, 2012; Johns & Shaw, 2006). Contemporary studio pedagogy in design schools follows a Bauhaus-inspired model, itself rooted in the École des Beaux-Arts tradition of the 19th century. Students engage in realistic design problems (Taşlı Pektaş, 2012), with an emphasis on craftsmanship and apprenticeship through direct tutor-student interaction (Thoring et al., 2020).

Studios are tutor-centred (Cao, 2019), and tutors are often practitioners with little formal pedagogical training (Fleischmann, 2020). This distinctive interaction makes the studio the hallmark of design education—rich, complex, experiential, contingent, often messy, and difficult for newcomers and non-designers to grasp (Jones, 2022). Project briefs are typically open-ended, with no single correct answer (Fleischmann, 2020). As such, the studio learning model is problem-based, constructivist, explorative, and creative, often shaped by productive ambiguity (Jones et al,. 2021).

Studios involve critical feedback loops, commonly known as "crits," which support iterative design processes (Fleischmann, 2020; Goldschmidt et al., 2010). A crit is feedback from a tutor, helping students generate and evaluate concepts through dialogue, gestures, and other forms of interaction. However, studio learning is not limited to crits. Students also engage in self-learning and peer-learning (Lotfabadi & Iranmanesh, 2024), creating knowledge both independently and collaboratively (Corazzo et al., 2023). Peer-learning in studios is often described as having a “beehive effect,” where the collective energy of students—whether working individually or in groups—stimulates shared learning (Blevis et al., 2007).

This unique pedagogy depends on people, identities, networks, interactions, material surroundings, atmospheres, and moments of serendipity (Corazzo et al., 2023). Donald Schön’s concept of design as a reflective practice is frequently cited to capture the complexity of studio learning (Kaya Pazarbaşı, 2019). Students learn by reflecting on the behaviours of tutors and peers, as well as their prior knowledge. Although highly experiential and context-dependent—making it difficult to objectify—the studio remains central in design education due to its adaptable, signature pedagogy (Jones, 2022).

Hapticity, Kinaesthetic and Spatial Perception in Studio

Studios in product or industrial design programmes are similar to other design studios but are distinctly oriented towards mass production (Bodur & Akbulut, 2022). They emphasise experiential prototyping using full-scale models and usability testing (Tzeng, 2011). Consequently, in addition to visual, verbal, and written communication, tactile interaction—referred to as hapticity—plays a key role (Düzenli et al., 2018). Hapticity, or the sense of touch, is supported by kinaesthetic awareness—bodily sensations related to movement and spatial orientation (Özdamar et al., 2021). Haptic perception provides feedback on qualities such as texture, hardness, elasticity, temperature, weight, shape, stickiness, wetness, and viscosity, often more effectively than visual input (Minogue & Jones, 2006).

While haptic and kinaesthetic experiences are also essential in disciplines like architecture, urban design, interior design, and fashion or textile design (Özdamar et al., 2021; Atkinson et al., 2013), their application varies across fields. For instance, fashion designers choose fabrics by touch (Atkinson et al., 2013), while kinaesthetic experiences include sensing object weight or walking along inclined paths (Özdamar et al., 2021). Some of these sensory elements—such as recommended walkway gradients or sleeve lengths—can be quantified. However, many remain subjective, like the feel of tarmac versus gravel, the coldness of steel versus plastic, or the softness of silk compared to linen.

Hands-on learning in Studio

Haptic feedback and kinaesthetics are integral not only to the designed object but also to the learning experience. While vision and sound often suffice for communication, haptic feedback enhances perceptual quality (Bruns et al., 2007; Başdoğan et al., 2000), and spatial comprehension of objects or people on a screen remains limited (Davis et al., 1994). This issue persists in remote design education, particularly in architectural studios, where it is often underemphasised (Özdamar et al., 2021). Similarly, auditory perception is influenced by spatial variables, especially vibration. For instance, touching an object or hearing its pitch when struck helps distinguish between chrome-plated plastic and polished steel.

Haptics supports hands-on learning: physical interaction with materials and tools is a powerful educational method that fosters practical skills (Minogue & Jones, 2006). Thus, being hands-on is not merely about sensing tactile qualities, but about engaging in a distinct learning mode. Minogue and Jones note that the term "hands-on" reflects the role of touch as an active, discovery-based sense, with many tactile metaphors embedded in everyday language. Learning by touch feels more real than learning by sight alone (Jones et al., 2005).

Proximities and Synchronicity in Studio

Design education has long been associated with a physical space that simulates professional practice through tools, materials, and surroundings (Wragg, 2019; Petrova, 2021). Many instructors still view physical studio spaces as essential, yet this reliance also highlights their limitations—physical and geographical constraints, limited resources, and unequal access for students (Lagier, 2003; Huang et al., 2017). COVID-19 prompted a narrow focus on physical elements—surfaces, surroundings, and tools—since these became suddenly inaccessible. However, this perspective often lacked a deeper understanding (Jones, 2022).

Jones proposes that studio is defined by three dimensions: time, space, and being. Simply translating traditional studio to VDS by addressing time and space superficially overlooks deeper forms of engagement. He argues that *time* refers to the level of synchronicity, *space* involves more than physical proximity, and *being* concerns readiness to learn, connect, and contribute. Physical proximity is frequently conflated with social or temporal closeness—an assumption challenged during the pandemic when many participated online via limited tools. Yet studio has never been fully synchronous or socially cohesive; students may share a space yet remain disconnected, or contribute meaningfully even when absent. As Jones summarises, social proximity is not strictly tied to physical or synchronous presence.

Peer-learning in Studio

In studio, students interact with both instructors and peers, learning to express ideas verbally and visually while considering others' perspectives, which deepens their understanding (Petrova, 2021). Studio is a semi-public, social space where critique is shared, and peer support fosters a sense of community (Lotz et al., 2018). This signature pedagogy exposes students to multiple viewpoints (Kemp & Grieve, 2014). While critique traditionally flows from tutor to student, peer-to-peer critique is increasingly recognised as a key mode of knowledge-building, socially constructed through interaction and collaboration (Gray, 2013). Students learn from and with each other in both formal and informal ways (Coorey, 2016).

Sidawi's findings, cited by Lotz et al. (2015), highlight that peers often have a more positive influence than tutors, whose feedback can inhibit creativity. Peer-learning is broadly defined as the exchange of knowledge, ideas, and experiences among students (Zamberlan & Wilson, 2015), and many feel more comfortable seeking or offering help to peers (Coorey, 2016). Coorey argues that growing student numbers and increasing curricular demands make peer-learning increasingly important, helping alleviate the challenges educators face in balancing theory and technology instruction. Peer-learning can be informal or more structured, such as peer tutoring or monitoring (Zamberlan & Wilson, 2015), and also includes collaborative or team-based learning (Coorey, 2016). This paper adopts an informal understanding of peer-learning, encompassing unstructured, horizontal interactions, often occurring in small groups. Teamwork, in this context, is a concentrated form of peer-learning. Referring to Johnson & Johnson's earlier research, Coorey noted that peer-learning is traditionally believed to require face-to-face interaction. This paper critically examines whether physical proximity is truly essential for effective peer-learning, and whether such arguments remain valid in the context of VDS.

Teamwork in Studio

Collaboration, negotiation, and teamwork across disciplines are now essential elements of design practice (Tessier & Carbonneau-Loiselle, 2023), reflecting the shift from solitary design to team-based approaches (Tessier, 2021). Teamwork, whether face-to-face or virtual, is widely used in design education to simulate professional practice (Demir, 2016; Britton et al., 2017; Itkonen, 2009; Ünal et al., 2022). According to Tessier & Carbonneau-Loiselle (2023), teamwork involves activities that could be done alone, those requiring peer input, and those only achievable collaboratively. These foster skill development in communication, self-expression, adaptability, organisation, and problem-solving. Teamwork encourages creativity (Igbinenikaro et al., 2024), facilitates idea exchange (Demir, 2016; Patel, 2024), and enhances output quality through diversity (McLeod et al., 1996). Patel argues that collaboration fosters deeper engagement than peer-learning in individual settings.

Despite its benefits, teamwork presents challenges, including differing work ethics, conflicts, and unequal participation (Friis, 2015; Meseguer-Dueñas et al., 2016). Effective communication is essential but often underdeveloped in students (Salas et al., 2008). In VDS, the lack of informal interaction heightens the need for structured peer engagement (Lotz et al., 2015). Tools like Miro support connection and task coordination (Petrova, 2021).

International studios introduce further complexities. Ethnic diversity may cause distrust, communication barriers, or social division (Friis, 2015; McLeod et al., 1996; Cooper, 2009). Language and time zone differences complicate collaboration (Marchman, 2002; Sadecka, 2014). While diverse teams can enrich learning, students often feel more comfortable in homogeneous groups (Friis, 2015). Some institutions now implement intentionally global, virtual studios. For example, Northumbria's Global Studio connected students from the UK, USA, Australia, and Korea via video conferencing, with logistical issues like differing academic calendars (Bohemia, 2010). Similarly, the UNSW–Waseda studio (2020–2022) operated fully online using Miro and Concept Board (Pernice et al., 2023). Though these tools supported critique, analysis, and international collaboration, they also limited contextual understanding and peer-learning due to technical constraints.

Teamwork in Virtual Studio

Cochrane et al. (2008) define a virtual team as one with shared goals, interdependent work, and geographically dispersed members. Earlier research highlights that VDS enables students to work across time and place, and combining synchronous and asynchronous tools enhances satisfaction by improving decision-making, participation equity, and analytical depth compared to face-to-face teamwork (Resta & Laferrière, 2007). While instructor leadership is necessary in VDS, this mirrors face-to-face studios. Gül et al. (2008) found that over half of students struggled with remote teamwork, citing the lack of in-person interaction. They stressed the need for systems that manage tasks, schedules, file sharing, and communication in VDS, along with encouraging peer-to-peer critiques. Though virtual tools have significantly advanced since their study, some criticisms still apply, likely due to insufficient hierarchy, leadership, and organisational skills among student teams. As Friis (2015) noted, whether in-person or virtual, lack of hierarchy can lead to discomfort and conflict. Effective teamwork in VDS requires utilising multiple tools (Taşlı Pektaş, 2015).

Mixed views on peer-learning and teamwork are prevalent. Some argue fully virtual studios hinder informal interaction, peer-learning, active engagement, and collaboration (Süner Pla Cerdà et al., 2025). Peer collaboration is often seen as ineffective (Alnusairat et al., 2020), lost (Grover & Wright, 2023), declined (Iranmanesh & Onur, 2021), or disrupted (Hepburn & Borthwick, 2021). Wang (2025) suggests mutual engagement in design education—particularly in architecture—is rooted in physical presence, while virtual tools merely support basic idea exchange. Many researchers favour blended models. However, some findings are heavily shaped by the psychological effects of COVID-19, with newer studies often building on pandemic-era observations. Since students reported disengagement during forced VDS periods (Gümüş Çiftçi et al., 2021), overgeneralising its limitations without accounting for COVID-related anxiety risks misrepresenting how virtual proximity affects peer-learning. It remains unclear whether VDS inherently limits peer-learning and teamwork, or whether sudden, unprepared transitions caused perceived losses.

While many experienced VDS during the pandemic, others studied it beforehand. The Open University in the UK offers key pre-COVID insights. Lotz et al. (2018) noted the lack of a clear definition for quality learner-generated content via peer-learning. Referencing Kutay Güler's 2015 work, they observed that online social-network-supported design studios fostered more active communication, and peer critiques were especially valuable. The same study of Lotz et al. presents the Open Design Studio; an online portfolio and communication space that allows

sharing and viewing posts, making discussions on each other's work. Their study presents the Open Design Studio, a platform for sharing work and facilitating discussions, in which numerous peer critiques occurred, enabling informal peer-learning. Lotz et al. argued that while other researchers criticise peer-feedback in such virtual networks with not fostering learning-oriented communication, others find such conversation community-building. Though not fully remote, the Open Design Studio demonstrated how online social tools can foster virtual peer-learning. Lehto et al. (2014) also emphasised that both in-class and extracurricular discussions enhance intercultural competence. Similarly, Salman et al., (2017) argued that structured discussion prompts in VDS simulate face-to-face engagement by maintaining connections with tutors and peers. In a prior study, Lotz et al. (2015) claimed that meaningful social interaction and peer-learning in online studios are not only possible but are actively pursued by students. Cuthbertson & Falcone (2014), however, contended that simply posting on a platform doesn't ensure commitment. Jones's (2022) model is explanatory to lack of commitment issues; the studio presence in terms of being there and ready to contribute is central to engagement. While commitment levels may vary, disengagement occurs both in virtual and face-to-face.

Hepburn & Borthwick (2021) contrasted synchronous learning—rich in real-time interaction—with asynchronous models where students engage independently. They compared two VDS setups: one offering live feedback to the whole class and another with individual responses. Nearly a third of students felt neither model fostered cohort engagement. While most found tutor support sufficient, synchronicity was found slightly favorable, yet notable number of students felt otherwise. One student mentioned that they felt disconnected and they struggled to collaborate and have sense of ambition, communication or accountability without physically proximite interactions. One argued that working in student-teams is more favorable in VDS because even in teamwork it has been rather *lonely*. Another felt difficult to stay motivated in asynchronicity. These views suggest that commitment isn't solely tied to synchronicity or physical presence, yet they still have an impact. Hepburn & Borthwick warned that asynchronicity can reduce creativity. Conversely, Neubauer & Wecht (2021) argued that mandatory synchrony restricts flexibility, making VDS less adaptable. They concluded that learning improves when presence is distributed across time and platforms. Across many studies, a recurring question persists, as exemplified in Petrova's (2021) findings: 83% of students disagreed that VDS could replace in-person studios. One explanation cited was that in-person communication feels more effective than "talking to a camera." Yet "better" remains undefined. Is virtuality truly synonymous with distance? Despite students being able to see and hear tutors closely, virtual settings are often equated with detachment—raising critical questions about how students perceive presence

Dependency of Peer-learning to Kinaesthetics, Spatial Perception, Proximities and Synchronicity

Two concepts are key to understanding how social proximity relates to virtuality: kinaesthetic empathy—knowledge gained by placing oneself within another's movement experience (Artpradid, 2023) - and spatial perception - the ability to comprehend shape, distance, position, motion, and spatial relations in three dimensions, even with limited sensory input (Kaya, 2021; Gérard, 2020). Although underexplored in design research (Kwon & Iedema, 2022), both are well discussed in acting and dance literature. Kinaesthetic empathy refers to sensing movement while observing it—perceiving speed, effort, and bodily changes as if performing the action,

without physical motion (Artpradid, 2023). This capacity relies on spatial perception, as understanding movement extends beyond vision to include spatial awareness.

The complexity of proximity issues in VDS is not merely about being physically apart but rather about the limitations of spatial perception imposed by current technologies—namely, two-dimensional displays and the assumption that audio alone can simulate spatial sound perception. Moreover, spatial perception in VDS affects not only object awareness but also how tutors and peers are perceived. Since social interaction is shaped by observable behaviour (Shao et al., 2020), reduced spatial perception diminishes the quality of observation. While the link between social interaction and proximity is well researched, fMRI studies show the brain processes physical and social distance similarly, both influencing how people conceptualise events, individuals, or ideas (Shao et al., 2020). As Shao et al. summarise: whether distance is social or physical, what is farther feels more abstract, and what is nearer, more concrete. Exploring whether social proximity is similarly constrained by interface-based spatial perception as by physical distance is beyond this paper's scope but presents a promising avenue for future research. Nonetheless, the discussion aligns with Jones's view: proximity is not solely a matter of physical space.

Educational Equality of Virtual Design Studio

From a practical perspective, regardless of how advanced social media and virtual platforms become, students and instructors remain physically social beings, with campuses providing rich social infrastructure. Viewing VDS as the sole pedagogy creates drawbacks that are irrational now considering the COVID-19 crisis educational limits have passed. However, VDS offers unique benefits. Since this paper focuses on peer-learning, these advantages are briefly noted: VDS promotes individualism and independent learning (Saghafi et al., 2012). It equips students with crucial technical skills increasingly essential in professional design (Mariotti & Niblock, 2023). With digital design tools used more in VDS than in face-to-face education, students gain skills better suited for a digital-first world (Rodriguez et al., 2016). Another benefit, noted in literature, is the collaboration of multiple universities rather than replacing traditional studios. Cross-university studios, not necessarily international, expose students to diverse perspectives (Rodriguez et al., 2016) and cultural and geographical diversity, enhancing productivity (Tucker & Abbasi, 2012). Beyond financially limited students mentioned by Kvan (2001), those with reduced mobility, illnesses, social anxieties, or facing force majeure can participate in VDS with less difficulty. Thus, despite challenges, two facts remain: VDS expands educational access, and some collaborations—such as cross-national projects—are only feasible via VDS.

Brief History of Virtual Design Studio

To conclude this chapter, it is important to highlight key milestones in VDS. The concept dates back to the early 1990s, initially as an experiential, collaborative tool to overcome geographical barriers in architectural education (Kvan, 2001). Early VDS initiatives emerged alongside advances in computer-aided design (CAD) and the internet, mainly enabling asynchronous collaboration, such as MIT's early distributed design studio experiments (Kolarevic et al., 2000). Some of the earliest projects include Distance Collaboration in 1992 (University of British Columbia and Harvard), Virtual Village and VDS in 1994 (Wojtowicz, 1995), and the Virtual Design Studio Project involving the University of Hong Kong, MIT, and the University of British Columbia, which used then-nascent tools like email, file transfer servers, and 2D CAD software to facilitate overseas design exchanges (Kvan, 2001). Due to hardware and software limits, real-

time collaboration was restricted, and the technology was costly and complex for large classes (Kvan, 2001). The late 1990s and early 2000s witnessed multiple VDS approaches: design teaching via email, remote TV lectures, the Design Pinup Board, MIT's innovative collaboration systems, cross-university/national projects, file uploading, chat, whiteboards, self-learning materials, and hybrid face-to-face/VDS methods (Saji et al., 2008). The Design Studio 2.0 concept then emerged, emphasizing web tools to enhance reflective design learning (Iavarone, 2021). From the mid-2000s, web tools supported studios, with social networks often serving as VDS mediums. The UK's Open University, led by Nigel Cross, exemplifies this era and its researchers are pioneers in VDS literature (Heyik & Erdoğan, 2022). The 2010s witnessed many VDS projects globally beyond the US, UK, and Far East; some failed, others evolved. Despite over two decades of existence by 2019, VDS was not widespread until the pandemic due to access barriers. Approaching the 2020s, fiber optics, 4G, cloud computing, big data (Bieringa et al., 2021; Cui et al., 2023), improved video codecs reducing bandwidth (Galteri et al., 2020), and WebRTC—an open-source browser video framework (Zeidan et al., 2014)—enabled plugin-free conferencing. Zoom, leveraging WebRTC, became emblematic during lockdowns, despite earlier tools like Skype and WebEx. These advances propelled VDS from experimental to mainstream pedagogy. In the past decade especially, video conferencing tech became cheaper, accessible, and commonplace (Iranmanesh & Onur, 2021). Today, even those with low purchasing power can access video-enabled phones.

Modern VDS combines synchronous and asynchronous tools. Platforms like Zoom, Miro, Prezi, and Teams support communication, while CAD software enables collaborative design (Komarzyńska-Świeściak et al., 2021). Social media such as YouTube, Facebook, Discord, and WhatsApp also back VDS (Schnabel & Ham, 2014; Iranmanesh & Onur, 2021; Karaca Şalgamcıoğlu & Genç, 2021). Although VDS has taken many forms since early attempts (Kvan, 2001), the core of design education—realistic project themes and crits—remains as in traditional studios. Key differences between VDS and face-to-face studios lie in Sense of Place (Kusumowidagdo & Prihatmanti, 2022), spatial perception, and lack of haptics and kinaesthetic feedback. These affect culture, community type, space flexibility, technology, learning styles, evaluation methods, and whether course content and outcomes are physical (Saghafi et al., 2012). Emerging technologies like augmented reality (AR), virtual reality (VR), and extended reality (XR) offer potential to reduce these gaps. Although first applied in VDS in the early 2000s, AR/VR/XR are not yet widespread in distance education. These technologies enable immersive interaction with 3D models, enhancing reduced spatial perception in VDS (Tan et al., 2022; Crolla et al., 2024). However, due to the high cost of necessary hardware and software, their use remains experimental. A paradigm shift is likely once these become widely accessible. Meanwhile, blending VDS with face-to-face delivery is the simplest way to minimize VDS's major drawbacks and is gaining attention (Saghafi et al., 2012; Komarzyńska-Świeściak et al., 2021). Yet, instructors often resist losing familiar face-to-face methods (Peacock & Cowan, 2016), while younger students and instructors view virtual environments as routine (Resta & Laferrière, 2007). In some respects, rushing to blended approaches is status quo; attributing VDS limitations solely to missing sensory experiences shows a technology-dependent path, while blaming physical proximity reflects a resigned acceptance of current drawbacks.

Methodology

This chapter outlines the aims, implementation, and data collection methods of EINSTUDIO, a cross-national Erasmus+ undergraduate VDS project. In the broader context of educational

transformation, projects like EINSTUDIO support the European Commission's (2020) goals of enhancing digital literacy and collaboration in higher education. Such cross-cultural design education fosters technical skills, promotes professional development in multicultural settings, encourages critical thinking, deepens diversity awareness, and advances sustainable, scalable education models for a digital-first, interconnected world (Rodriguez et al., 2016).

EINSTUDIO was launched after COVID-19 lockdowns ended and operated as a semi-hybrid VDS. It is 'semi-hybrid' rather than 'hybrid' because teams, composed of cross-national members, worked collaboratively; each member met proximate peers and tutors face-to-face but only encountered overseas participants virtually. Peer-learning occurred via five types of proximities and synchronicities: scheduled virtual class meetings, virtual private meetings, face-to-face class meetings, face-to-face private meetings, and an online discussion board. While class meetings were synchronous, others were occasional. This complex, semi-hybrid, semi-proximate, and semi-synchronous peer-learning model distinguishes EINSTUDIO from other studies and forms the focus of this research. Participants included tutors and students from Gazi University (Turkey), University of Beira Interior (Portugal), and University of Alicante (Spain).

The study's scope centres on whether EINSTUDIO's infrastructure, curriculum, and learning design effectively support cross-cultural peer-learning in VDS. Accordingly, the research primarily measured motivational outcomes. In psychology, self-reports are often preferred for assessing motivation (Touré-Tillery & Fishbach, 2014) through percieved quality (Kirchmer & Kim, 2023). Therefore, EINSTUDIO's outcomes were analysed through student self-reports, offering rich insight into motivational effects from the students' perspective, though limited to their viewpoint alone.

Infrastructure

EINSTUDIO utilised a web-based e-learning platform supporting both synchronous and asynchronous interactions, accessible via any preferred web browser. The platform features a blog for posting texts and media, replying, accessing a library of downloadable documents, and viewing various design and manufacturing YouTube videos embedded by instructors. It also includes an interactive schedule and team-based subfolders for uploading and managing tasks. Integrated with Zoom, the platform offers private video conference rooms accessible through or independently of the system. Teams held numerous private meetings for collaboration alongside general classroom sessions with all participants.

The main page links to ten sections: assessments, syllabus, schedule, studios involved, labs and libraries, applications, users, files, my homework, and group homework. Students have access to seven; applications, users, and group homework are tutor-only to manage infrastructure, accounts, and submissions.

The homepage (Figure 2) serves as a one-page, blog-like discussion board where all participants can share and comment. Instructors posted announcements, teaching materials, and community-building content, while students were expected to share progress and asynchronously communicate via texts, images, or videos. However, students rarely engaged here, resulting in an unexpected loss of peer-learning. This suggests that, given easy access to synchronous tools and popular asynchronous apps like WhatsApp, students pay less attention to public asynchronous interactions.

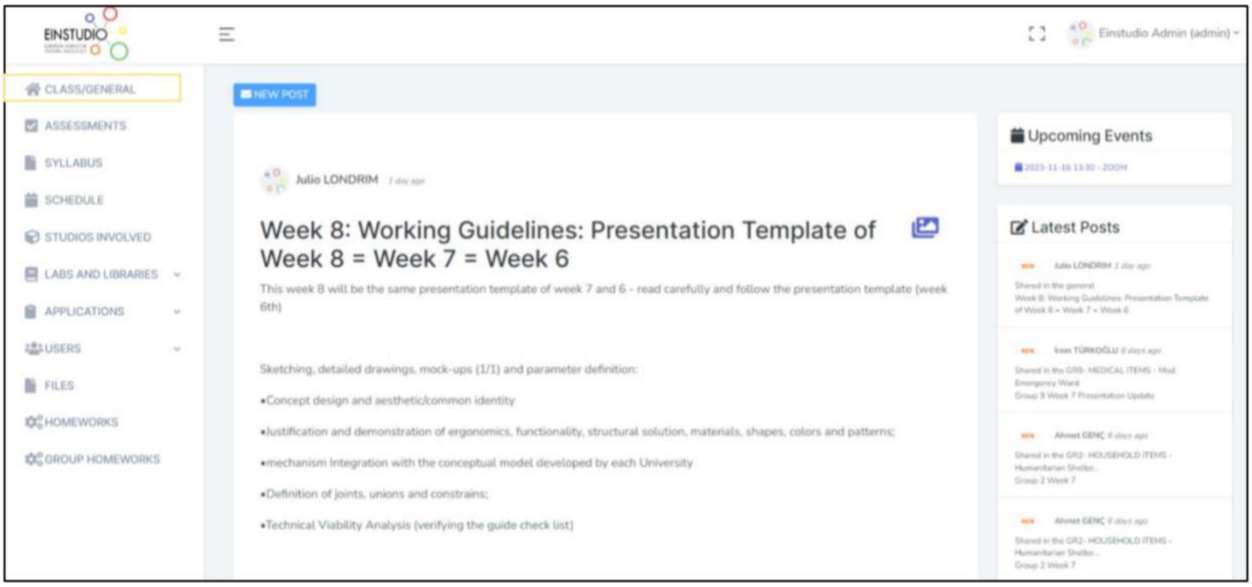


Figure 2. Main page of the EINSTUDIO platform (instructor sign-in)

The Assessments, Syllabus, and Schedule pages are simple one-page sections outlining upcoming tasks and events. As EINSTUDIO integrates Zoom and supports multiple simultaneous meetings, teams scheduled private meetings as well as the routine class meetings. While these private meetings were primarily limited to team members, tutors were occasionally invited to provide critiques or observe, with prior notice. Most meetings, however, remained closed to tutors. The remaining platform sections support scheduling or joining private or class meetings, uploading homework (Figure 3), and accessing pre-uploaded library materials.

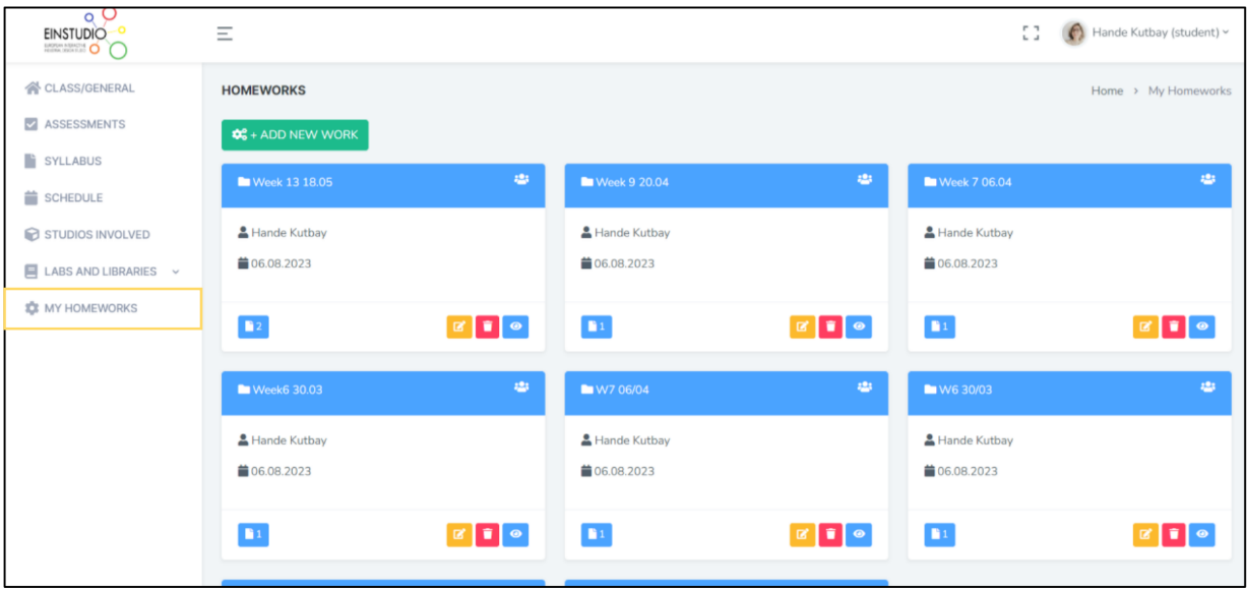


Figure 3. Homework page of the EINSTUDIO platform (student sign-in)

Syllabus

The course spanned 15 weeks and included 12 virtual crit sessions (Figure 4), up to 12 optional face-to-face crits per team, and three semi-hybrid juries (Figures 5). Attendance in virtual classes was mandatory, while face-to-face crits remained optional. All teams worked on the

same general brief: designing the interior of a predefined minimum space (a 20-foot container) and six pieces of furniture sharing a unified design language. To complete the project, students were required to collaboratively decide on forms, colours, surfaces, textures, and usability—necessitating peer-to-peer critiques and intra-team decision-making.

Figure 4. A team of students taking crits from the tutors while whole class attending

Teams were expected to meet at least weekly, though many met more frequently. However, some struggled with coordination and required tutor intervention. During the first four weeks, teams conducted varying levels of research, ideated, and developed concepts through sketches. In week five, they participated in a semi-hybrid jury—local students met tutors face-to-face while remaining connected to the broader class via Zoom. Weeks six to eight focused on refining designs through sketches and mock-ups, culminating in an interim jury presentation in week nine. From weeks ten to thirteen, teams developed CAD and large-scale models aimed at implementation. The final jury, held in week fourteen, was semi-hybrid; some tutors traveled to attend in person. Week fifteen concluded with a synchronous exhibition across all participating universities.

Figure 5. Tutors watching a prototype being tested by the presenting team in another country

Sampling

A total of 85 design students from three partner universities participated in the study: 39 from Gazi University, 35 from the University of Beira Interior, and 11 from the University of Alicante. The cohort included second- and third-year undergraduate design students. Eleven instructors from these institutions—each experienced in VDS—facilitated the course. Students applied voluntarily, were interviewed, and selected based on their English proficiency and genuine motivation, excluding those seeking participation for unrelated reasons such as language practice or course avoidance. Prior to the project's launch, instructors met face-to-face to build collaborative rapport, while students from different countries interacted only virtually. Eleven teams were formed, each composed of seven to eight students: three or four from Gazi University, three or four from the University of Beira Interior, and one from the University of Alicante, assigned randomly.

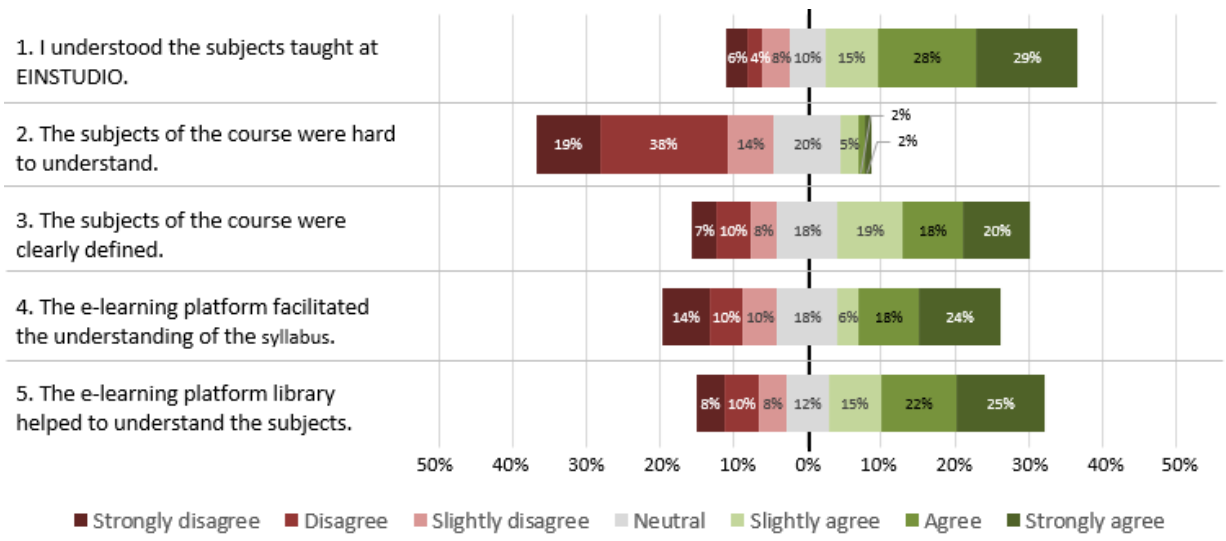
Data Collection and Analysis

At the end of the semester, students were invited to complete an online survey. Participation was voluntary, and responses were anonymous. A total of 53 students completed the survey, representing 62% of EINSTUDIO participants. The survey included 43 seven-point Likert scale items. Based on recommendations from EINSTUDIO's quality-assurance partners, most statements were positively worded, with a few negatively framed to detect response bias. An additional open-ended question asked students to reflect on their overall experience. Each closed-ended item and its response distribution is presented in diverging bar charts in the next chapter. The open-ended responses were excluded, as they did not offer significant explanatory or complementary insights. Survey outcomes are discussed in the Discussion chapter, supported by instructor observations.

Findings

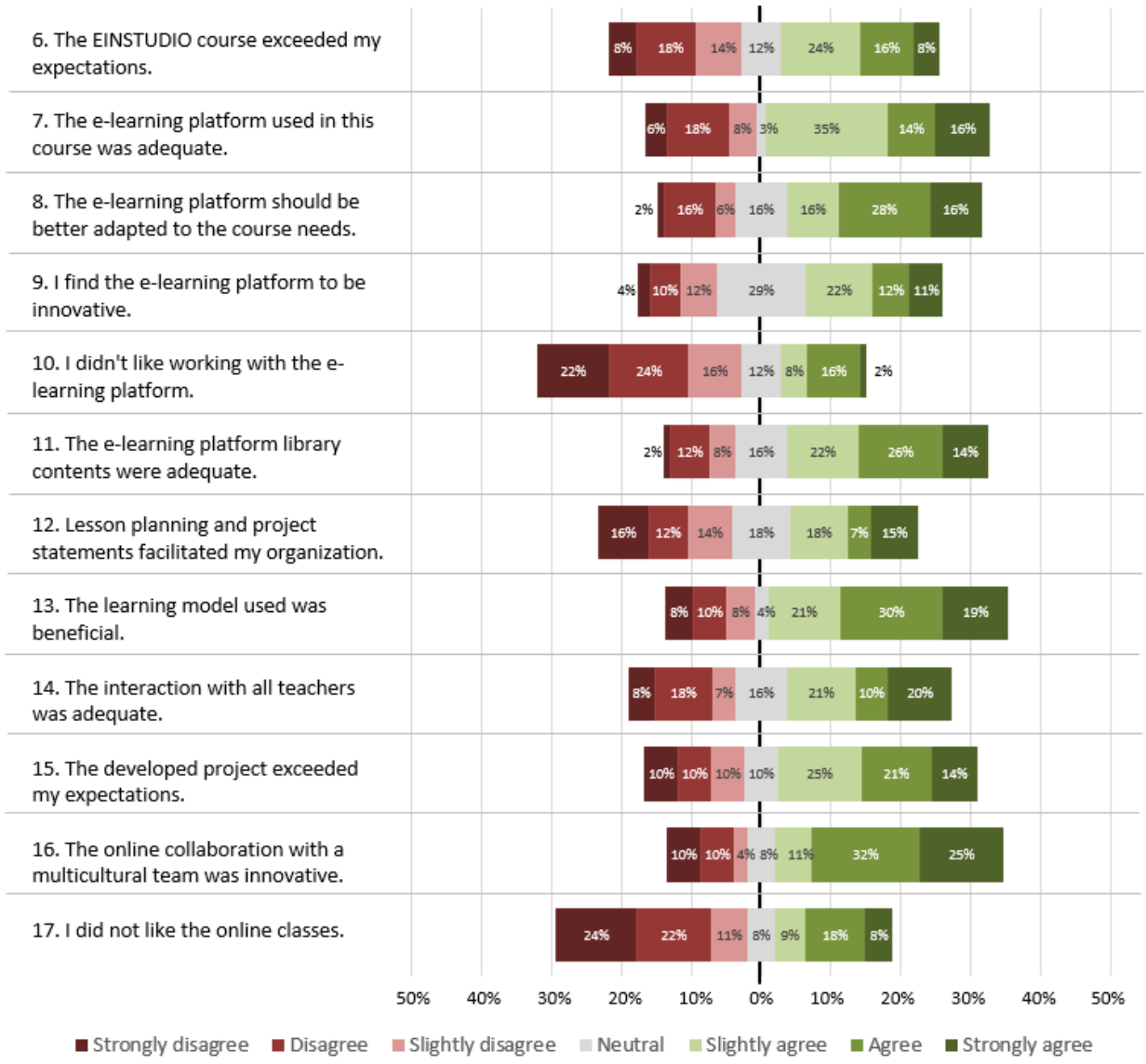
The first set of survey questions examined whether respondents had difficulty understanding the course's concepts, terminology, and theoretical content, and whether the e-learning platform supported their comprehension. While presenting the findings textually, the answers *slightly agree*, *agree* and *strongly agree* were merged, and vice-versa regarding the negative responses; detailed frequencies are given in the diverging bar charts.

Table 1. Frequency of responds to the survey questions 1-5



As illustrated in Figure 6, responses generally leaned toward agreement that the subjects were understood and the e-learning platform was supporting. However, 18% of students reported difficulties in understanding the content, and 25% indicated that the subjects were not clearly defined (questions 1 and 3) despite only 9% of the respondents found the subjects hard (question-2). Additionally, although fewer in number, a notable portion of respondents did not find the e-learning platform or its content helpful (questions 4 and 5).

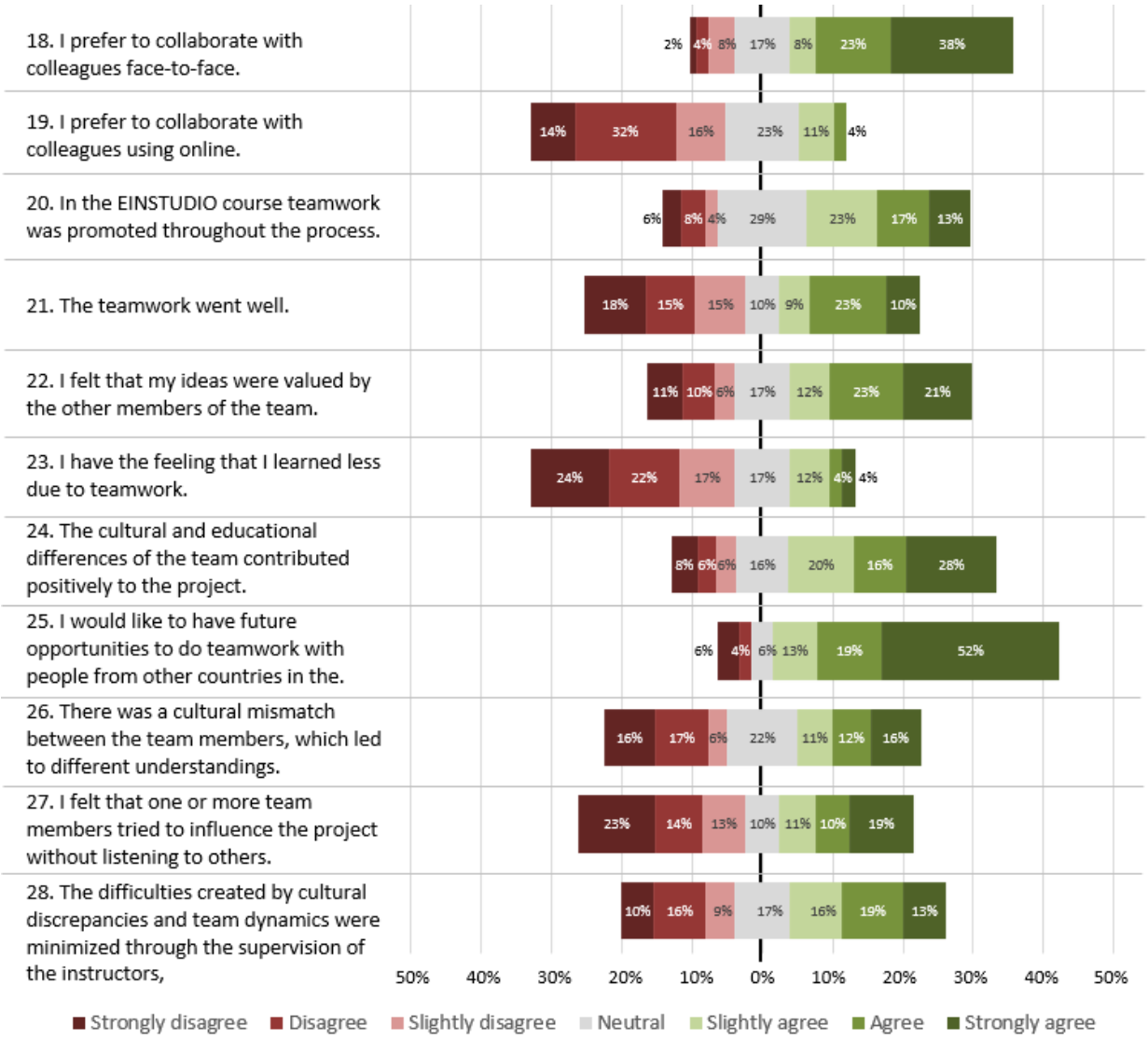
Table 2. Frequency of responds to the survey questions 6-17



The next set of questions (Figure 7) further explored the perceived effectiveness of the e-learning platform and the overall learning model. In overall, respondents were positive about the e-learning platform in various means. While 65% agreed the e-learning platform was adequate (question 7), 60% also saw room for improvement (question 8). Additionally, 62% reported enjoying working with it (question 10), and 62% found the library function of the e-learning platform and uploaded content sufficient (question 11). Notably, 70% found the EINSTUDIO learning model beneficial (question 13), and 68% viewed cross-national collaboration via VDS as innovative (question 16). Despite these positive assessments, 35% still expressed dislike for attending virtual classes (question 17), and only 14% disagreed with a

preference for face-to-face collaboration (question 18, Figure 8). In contrast, 62% disagreed with a preference for online collaboration (question 19, Figure 8), indicating a general tendency to favor in-person interaction despite the model's perceived benefits.

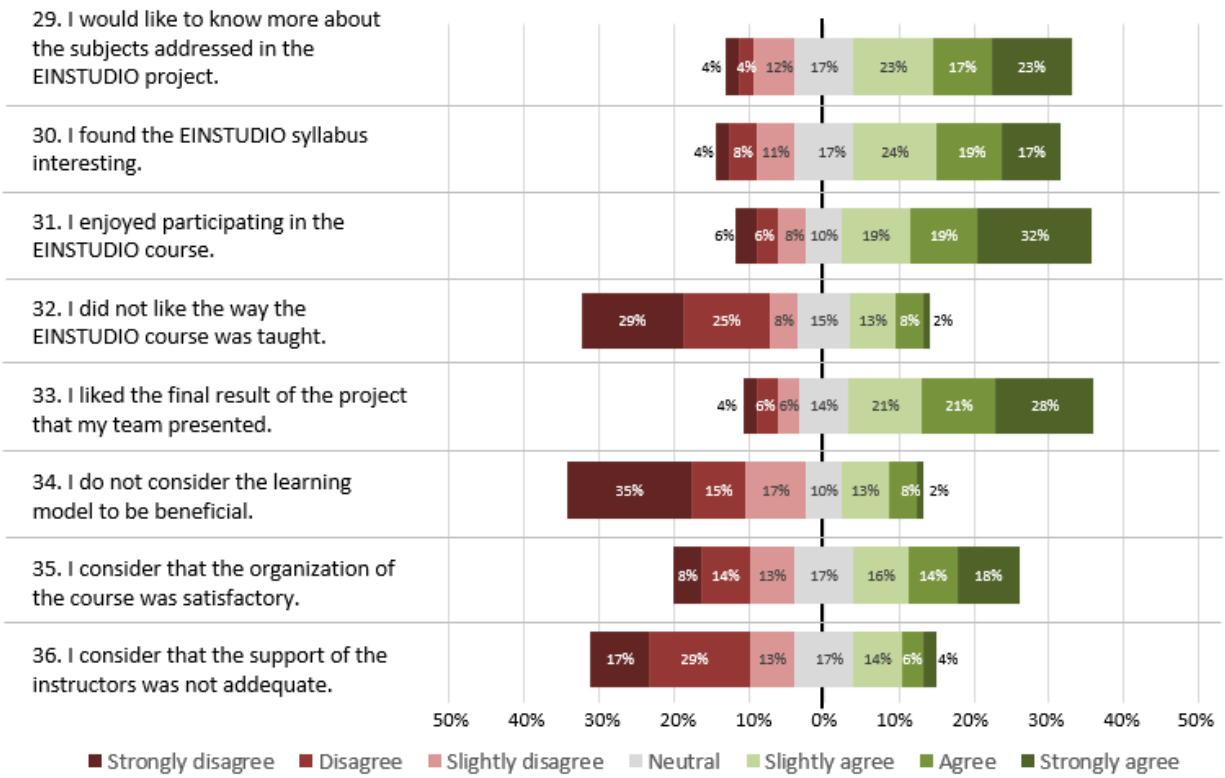
Table 3. Frequency of responds to the survey questions 18-28



The next set of questions (Figure 8) examined teamwork and cross-national collaboration. Overall, respondents were mixed or slightly negative regarding teamwork effectiveness: 48% responded negatively and 42% positively (question 21). Responses were equally split on whether cultural misunderstandings occurred (39% positive; 39% negative, question 26), and 50% disagreed that some members tried to dominate others, while 40% agreed (question 27). 48% felt instructors supported them in resolving team issues, compared to 35% who disagreed (question 28). Although a majority felt their opinions were valued, 27% disagreed and 17% remained neutral (question 22). Notably, 63% disagreed that teamwork hindered their learning (question 23), and 64% agreed that cultural and educational diversity was beneficial (question 24). A strong majority (84%) expressed interest in future cross-national studios, with 52%

strongly agreeing (question 25). Additionally, 53% agreed that EINSTUDIO's model supported teamwork, while 18% disagreed (question 20).

Table 4. Frequency of responds to the survey questions 29-36

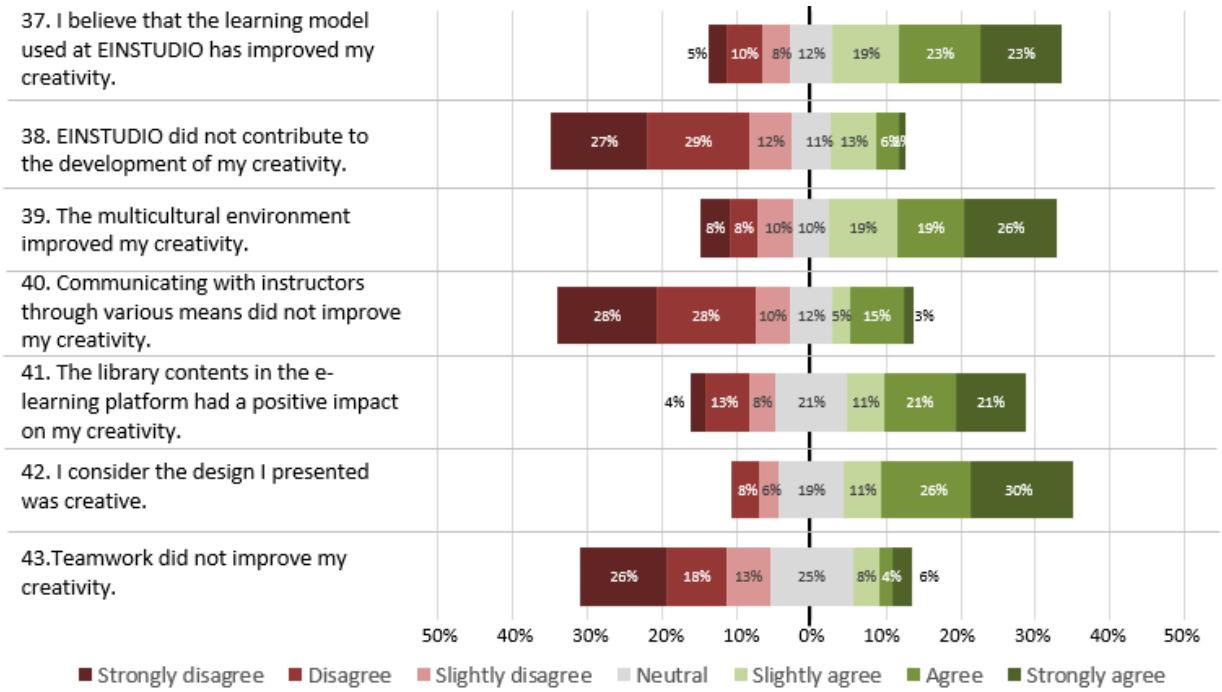


The questions in Figure 9 evaluated participants' enjoyment of the course in terms of its content, syllabus, learning model, final designs, and instructor support. Overall, responses indicated a positive experience: 63% expressed curiosity to learn more about the EINSTUDIO Erasmus+ project (question 29), 60% found the syllabus interesting (question 30), and 70% enjoyed participating (question 31). Only 14% reported dissatisfaction with their team's final work (question 33). Additionally, 62% and 67% disagreed with negatively worded statements in questions 32 and 34, indicating they found the learning model both enjoyable and beneficial. However, 35% disagreed that the course was well-organized (question 35), representing the highest level of criticism across questions 29–36.

The final set of closed-ended questions examined how EINSTUDIO's semi-hybrid model, cross-cultural team structure, and e-learning platform influenced creativity (Figure 10). A majority of respondents found the cross-cultural and semi-hybrid aspects beneficial, with 64–67% agreeing with positively stated items (questions 37 and 39). Although fewer participants found the platform's library and content supportive of creativity, 53% still responded positively (question 42). Only 23% agreed that the semi-hybrid crit system failed to enhance creativity (question 40), suggesting that most viewed the model as beneficial. While 18% believed teamwork did not foster creativity (question 43), this is slightly lower than the 23–26% who disagreed that the cross-national setting and overall model supported creativity (questions 37 and 39), indicating that the team structure may have posed minor creative challenges. Notably, 66% disagreed with the negatively phrased question 38, the inverse of question 37, suggesting a low rate of

careless or contradictory responses. As no significant inconsistencies emerged in other reversed items, the overall reliability of the responses is considered high.

Table 5. Frequency of responds to the survey questions 37-43



Discussion

Overall, half to two-thirds of the respondents agreed with the positively stated questions and disagreed with the negatively stated ones, evaluating their experience as either greatly or slightly satisfactory. On the other hand, findings indicated that the EINSTUDIO model negatively impacted the learning of some students—while not the majority, a notable portion of respondents, up to 18%, reported difficulties. Since it is expected that some students face more challenges than others in any type of class, it is impossible to clearly define how EINSTUDIO negatively affected their learning. However, considering that only 9% of respondents agreed that the course subjects were hard to understand, it is reasonable to infer that the other 9% of respondents, who did not find the subjects difficult but still had trouble, experienced a negative impact. Remarkably, more students disliked the VDS sessions compared to those who did not find the e-learning platform, semi-hybrid learning model, cross-national team structure, and syllabus beneficial. Furthermore, the majority preferred face-to-face collaboration over online interactions. The findings also show that cross-cultural teamwork was slightly more criticized compared to teamwork overall, indicating that issues with peer-learning in VDS were not strongly linked to cultural, educational, or social differences.

Task Sharing Versus Collaborating

Quoted directly from their statements during courses and informal dialogues, instructors provided feedback indicating that the overall quality of peer-learning in VDS could be improved by monitoring teams' communication issues more closely, transferring some members between teams when necessary, and ensuring equal contribution from all members. One instructor particularly suggested holding more virtual meetings outside of regular class hours to analyze student teams and prevent poor organization that might reduce efficiency. During the VDS

sessions and face-to-face dialogues, it was observed that students often, both privately and sometimes publicly, asked instructors for help regarding collaboration issues. They reported that some members attended private meetings significantly less frequently. Almost all teams struggled with scheduling, not only due to time zone differences but also because of extracurricular commitments such as other homework and exams. Scheduling issues were more significant during the early phases, until students got to know each other better. Additionally, some students expressed concerns about not being valued within their teams, and the workload distribution was often unequal. Although only a few in number, some students struggled with fluent English and required continuous translation support. Consequently, these students were often socially distant, regardless of their willingness to contribute. It is therefore understood that some students experienced social anxiety when speaking a foreign language during teamwork and critiques, even though they had demonstrated sufficient English proficiency during the selection process.

Considering these issues, decision-making became more difficult for some teams. Anxiety about being valued, expressing themselves fluently, and fear of disagreements led many students to mistake teamwork for mere task-sharing instead of engaging in peer-to-peer critiques. Early in the course, students rarely evaluated each other's sketches and instead divided furniture design tasks individually. They avoided comparing designs until repeatedly encouraged to critique peers. This avoidance and misunderstanding of collaborative design caused significant struggles in developing a cohesive design language. Colors, styles, shapes, materials, and purposes were mismatched for a long time; however, most teams overcame these issues by the project's end. Ultimately, nearly all teams managed to create furniture sharing a common style (Figures 11, 12, and 13). Accordingly the major driver of peer-learning in this course was the requirement to collaboratively design a cohesive product family

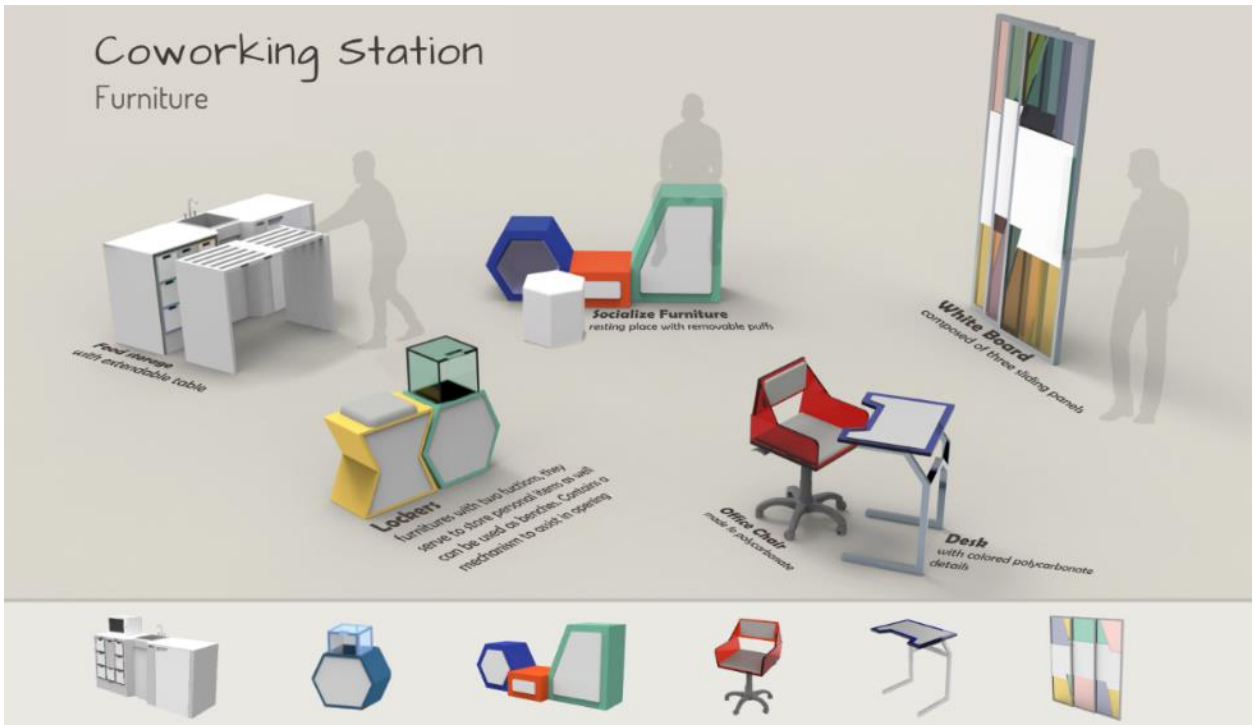


Figure 6. Co-working furniture pieces by individuals in a team

Figure 7. Medical furniture pieces by individuals in a team

Figure 8. Laboratory furniture pieces by individuals in a team

Conclusion

The post-2021 surge in VDS research created a widespread perception that physical distance undermines the quality of peer-learning. However, the anxiety stemming from the abrupt transition to online education limited a nuanced understanding of its actual challenges. Given that this unplanned shift negatively impacted student engagement (Gümüş Çiftçi et al., 2021), future research should critically reassess COVID-19-era claims that VDS inherently limits peer-learning (Alnusairat et al., 2020; Grover & Wright, 2023; Iranmanesh & Onur, 2021; Hepburn & Borthwick, 2021). While hybrid studio models have been shown to alleviate some of these issues, several studies also suggest that online-only studios can support peer-learning effectively. This paper argues that remaining limitations are more closely related to the absence of haptic and kinaesthetic feedback, and restricted spatial perception due to current display and audio technologies, rather than physical distance per se.

Although previous studies recommend teamwork or strategic student matching to enhance peer-learning in VDS, these strategies pose considerable challenges. This study finds that, without close tutor supervision and design constraints that necessitate collaboration—such as the requirement to develop a shared design language—teams tend to reduce teamwork to mere task division, foregoing collaboration, brainstorming, and decision-making via peer-crits. Multicultural teams, particularly those involving cross-national collaboration, introduce additional complexities that can hinder peer-learning. Nevertheless, engagement with culturally diverse partners remains one of the key benefits of VDS, as was evident in its earliest implementations in the 1990s. Based on student self-reports, EINSTUDIO's infrastructure and semi-hybrid model helped mitigate many challenges of virtual teamwork and cross-national collaboration. Despite its complexity, cross-culturality appeared to be a motivating and enriching element for most students.

Acknowledgements

This study was financially supported by the European Commission Erasmus+ Cooperation Partnerships in Higher Education Programme through the European Interactive Industrial Design (EINSTUDIO) Project (2021-1-TR01-KA220-HED-000030439). The authors have no financial or non-financial interests to disclose. The authors especially thank the active participation of the University of Beira Interior (Portugal) and the University of Alicante (Spain) with their students and Instructors.

References

Alnusairat, S., Al Maani, D., & Al-Jokhadar, A. (2020). Architecture students' satisfaction with and perceptions of online design studios during COVID-19 lockdown: the case of Jordan universities. *Archnet-IJAR: International Journal of Architectural Research*, 1-18. https://doi.org/10.1108/ARCH-09-2020-0195

Artpradid, V. (2023). Kinesthetic Empathic Witnessing in Relation to Embodied and Extended Cognition in Inclusive Dance Audiences. Cogent Arts & Humanities, 10(1). https://doi.org/10.1080/23311983.2023.2181486

Atkinson, D., Orzechowski, P., Petreca, B., Bianchi-Berthouze, N., Watkins, P., Baurley, S., Padilla, S., Chantler, M. (2013). Tactile Perceptions of Digital Textiles: A Design Research Approach. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 1669-1678). Paris: Association for Computing Machinery. https://doi.org/10.1145/2470654.2466221

Başdoğan, Ç., Ho, C. H., & Srinivasan, M. A. (2000). An Experimental Study on the Role of Touch in Shared Virtual Environments. *ACM Transactions on Computer-Human Interaction*, *7*(4), 443-460. https://doi.org/10.1145/365058.365082

Bieringa, R., Radhakrishnan, A., Singh, T., Vos, S., Donkervliet, J., & Iosup, A. (2021). An Empirical Evaluation of the Performance of Video Conferencing Systems. *CPE '21: Companion of the ACM/SPEC International Conference on Performance Engineering* (pp. 65-71). Virtual Event, France: Association for Computing Machinery. https://doi.org/10.1145/3447545.3451186

Blevis, E., Lim, Y.-k., Stolterman, E., Wolf, V. T., & Sato, K. (2007). Supporting design studio culture in HCI. *CHI EA '07: CHI '07 Extended Abstracts on Human Factors in Computing Systems* (pp. 2821-2824). San Jose: Association for Computing Machinery. https://doi.org/10.1145/1240866.1241086

Bodur, G., & Akbulut, D. (2022). Transferring Experience in Industrial Design Studio Education. *Journal of Design Studio*, 63-80. https://doi.org/10.46474/jds.109525

Bohemia, E. (2010). Complexities of Teaching and Learning Collaborations with International Partners: The Global Studio. In D. Durlin, R. Bousbaci, L. Chen, P. Gauthier, T. Poldma, S. Roworth-Stokes, & E. Stolterman (Eds.), *Design and Complexity - DRS International Conference*. Montreal: Design Research Society. https://dl.designresearchsociety.org/drs-conference-papers/drs2010/researchpapers/14/

Britton, E., Simper, N., Leger, A., & Stephenson, J. (2017). Assessing teamwork in undergraduate education: a measurement tool to evaluate individual teamwork skills. *Assessment & Evaluation in Higher Education*, *42*(3), 378-397. https://doi.org/10.1080/02602938.2015.1116497

Bruns, F. W., Erbe, H. H., & Müller, D. (2007). From Remote Labs to Collaborative Engineering Workspaces. *IFAC Proceedings Volumes, Cuba*. *40*(1) (pp. 108-113). https://doi.org/10.3182/20070213-3-CU-2913.00019

Cao, H. (2019). Research on Innovative Talents Training Modes of Industrial Design Major in the Era of “Internet Plus". *Proceedings of the 2019 5th International Conference on Social Science and Higher Education (ICSSHE 2019)* (pp. 796-799). Xiamen: Atlantis Press. https://doi.org/10.2991/icsshe-19.2019.194

Cochrane, S., Brodie, L., & Pendlebury, G. (2008). Successful use of a wiki to facilitate virtual team work in a problem-based learning environment. *Proceedings of the 2008 AaeE Conference: To Industry and Beyond* (pp. M2A3). Yeppoon: Australasian Association for Engineering Education. https://core.ac.uk/download/pdf/11038043.pdf

Cooper, V. A. (2009). Inter-cultural student interaction in post-graduate business and information technology programs: the potentialities of global study tours. *Higher Education Research & Development, 28*(6), 557-570. https://doi.org/10.1080/07294360903208112

Coorey, J. (2016). Learning Methods and Technology: Strategies for Design Education. International Journal of Art & Design Education, 35(3), 334-347. https://doi.org/10.1111/jade.12112

Corazzo, J., Hudson, F., & Jones, D. (2023). Unfixing the Studio. In D. Jones, N. Börekçi, V. Clemente, J. Corazzo, N. Lotz, L. M. Nielsen, & L.-A. Noel (Ed.), The 7th International Conference for Design Education Researchers (pp. 1-9). London: Design Research Society. https://doi.org/10.21606/drslxd.2024.057

Crolla, K., Song, J., Bunica, A., & Sheikh, A. T. (2024). Integrating Extended Reality in Architectural Design Studio Teaching and Reviews: Implementing a Participatory Action Research Framework. *Buildings, 14*(6), 1865. https://doi.org/10.3390/buildings14061865

Crowther, P. (2013). Understanding the signature pedagogy of the design studio and the opportunities for its technological enhancement. *Journal of Learning Design, 6*(3), 18-28. http://dx.doi.org/10.5204/jld.v6i3.155

Cui, Y., Ma, Z., Wang, L., Yang, A., Liu, Q., Kong, S., & Wang, H. (2023). A survey on big data-enabled innovative online education systems during the COVID-19 pandemic. *Journal of Innovation & Knowledge, 8*(1), 100295. https://doi.org/10.1016/j.jik.2022.100295

Cuthbertson, W., & Falcone, A. (2014). Elevating Engagement and Community in Online Courses. *Journal of Library & Information Services in Distance Learning, 8*(3-4), 216-224. https://doi.org/10.1080/1533290X.2014.945839

Davis, E. T., Corso, G. M., Barfield, W., Eggleston, R. G., Ellis, S., Ribarsky, B., & Wickens, C. D. (1994). Human Perception and Performance in 3D Virtual Environments. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (pp. 230-234). Human Factors Society. https://doi.org/10.1177/154193129403800409

Demir, Ö. (2016). *Industrial Design Students' Experiences of Interdisciplinary Teamwork*. [Unpublished doctoral dissertation]. Middle East Technical University. https://hdl.handle.net/11511/25995

Düzenli, T., Alpak, E. M., Çiğdem, A., & Tarakçı Eren, E. (2018). The Effect of Studios on Learning in Design Education. Journal of History Culture and Art Research, 7(2), 191-204. http://dx.doi.org/10.7596/taksad.v7i2.1392

European Commission. (2020). *Digital Education Action Plan 2021-2027: Resetting education and training for the digital age.* European Union. https://education.ec.europa.eu/focus-topics/digital-education/action-plan

Fleischmann, K. (2020). Hands-on versus virtual: Reshaping the design classroom with blended learning. *Arts and Humanities in Higher Education, 20*(1), 87-112. https://doi.org/10.1177/1474022220906393

Fleischmann, K. (2021). Is the Design Studio Dead? - An International Perspective on the Changing Shape of the Physical Studio across Design Domains*. Design and Technology Education: An International Journal, 26*(4), 112-129. https://eric.ed.gov/?id=EJ1352487

Friis, S. A. (2015). Including diversity in creative teamwork in design education. *International Journal of Design Creativity and Innovation, 3*(3-4), 239-255. https://doi.org/10.1080/21650349.2014.892233

Galteri, L., Bertini, M., Seidenari, L., Uricchio, T., & Del Bimbo, A. (2020). Increasing Video Perceptual Quality with GANs and Semantic Coding. *Oral Session H2: Multimedia HCI and Quality of Experience & Multimedia Search and Recommendation* (pp. 862-870). Seattle: Association for Computing Machinery. https://doi.org/10.1145/3394171.3413508

Gérard, P. F. (2020). A Virtual Architecture Framework for Immersive Learning Environments [Doctoral dissertation, Goldsmiths College, University of London]. https://research.gold.ac.uk/id/eprint/30224/1/COM_thesis_GerardP_2020.pdf

Goldschmidt, G., Hochman, H., & Dafni, I. (2010). The design studio "crit": Teacher–student communication. *Artificial Intelligence for Engineering Design, Analysis and Manufacturing, 24*(3), 285-302. https://doi.org/10.1017/S089006041000020X

Gül, L. F., Wang, X., Bülbül, T. T., Çağdaş, G., & Tong, H. (2008). Global Teamwork: A Study of Design Learning in Collaborative Virtual Environments. In Durling, D., Rust, C., Chen, L., Ashton, P., & Friedman, K., (Eds.) *Undisciplined! Design Research Society Conference.* Sheffield: Sheffield Hallam University. https://shura.shu.ac.uk/470/

Gümüş Çiftçi, H., Nickley, W., & Proulx, S. (2021). Rekindling Student Connection and Engagement: A Covid-Era Design Charrette. *14th International Conference of the European Academy of Design, Safe Harbours for Design Research* (pp. 81-89). São Paulo: Blucher. https://doi.org/10.5151/ead2021-140

Gray, C. M. (2013). Informal Peer Critique and the Negotiation of Habitus in a Design. *2nd International Conference for Design Education Researchers* (pp. 702-714). Oslo: Design Research Society. https://doi.org/10.21606/learnxdesign.2013.060

Grover, R., & Wright, A. (2023). Shutting the studio: the impact of the Covid-19 pandemic on architectural education in the United Kingdom. International Journal of Technology and Design Education, 23, 1173-1197. https://doi.org/10.1007/s10798-022-09765-y

Hepburn, L. A., & Borthwick, M. (2021). Synchronicity in the Online Design Studio: A Study of Two Cases. Design and Technology Education: An International Journal. Special Issue, 26(4), 71-85. https://openjournals.ljmu.ac.uk/DesignTechnologyEducation/article/view/1166

Heyik, M. A., & Erdoğan, M. (2022). Collective Intelligence Model for Design Studio. Journal of Computational Design, 3(2), 27-58. https://doi.org/10.53710/jcode.1138820

Huang, Y., Han, X., & Wang, Y. (2017). Learning 'B-learning' through 'B-learning': A Practice Model for Teachers' Professional Development. *The Sixth International Conference of Educational Innovation through Technology* (pp. 41-46). Osaka: IEEE. https://doi.org/10.1109/EITT.2017.18

Iavarone, A. H. (2021). An evaluation of internet-based design studios in the context of learning styles. Yıldız Journal of Art and Design, 8(1), 33-42. https://doi.org/10.47481/yjad.885703

Igbinenikaro, O. P., Adekoya, O. O., & Etukudoh, E. A. (2024). Fostering Cross-disciplinary Collaboration in Offshore Projects: Strategies and Best Practices. *International Journal of Management & Entrepreneurship Research, 6*(4), 1176-1189. https://doi.org/10.51594/ijmer.v6i4.1006

Iranmanesh, A., & Onur, Z. (2021). Mandatory Virtual Design Studio for All: Exploring the Transformations of Architectural Education amidst the Global Pandemic. *International Journal of Art & Design Education, 40*(1), 251-267. https://doi.org/10.1111/jade.12350

Itkonen, M. (2009). Murjottelu – interdisciplinary training campaign for industrial design and engineering students. *European Journal of Engineering Education, 34*(3), 263-271. https://doi.org/10.1080/03043790903038858

Johns, R., & Shaw, J. (2006). Real-time immersive design collaboration: conceptualising, prototyping and experiencing design ideas. *Journal of Design Research, 5*(2), 172-187. https://doi.org/10.1504/JDR.2006.011361

Jones, D., Lotz, N., & Holden, G. (2020). A longitudinal study of virtual design studio (VDS) use in STEM distance design education. *International Journal of Technology and Design Education, 31*(4), 839-865. https://doi.org/10.1007/s10798-020-09576-z

Jones, D. (2022). Exploring studio proximities: Space, time, being. In Lockton, D. Lockton, S. Lenzi, P. Hekkert, A. Oak, J. Sádaba, & P. Lloyd (Ed.), DRS 2022 (pp. 1-26). Bilbao: Design Research Society. https://doi.org/10.21606/drs.2022.344

Jones, D., Lotz, N., & Holden, G. (2021). A longitudinal study of virtual design studio (VDS) use in STEM distance design education. International Journal of Technology and Design Education, 31, 839-865. https://doi.org/10.1007/s10798-020-09576-z

Jones, M. G., Minogue, J., Tretter, T. R., Negishi, A., & Taylor, R. (2005). Haptic augmentation of science instruction: Does touch matter?. *Science Education, 90*(1), 111-123. https://doi.org/10.1002/sce.20086

Karaca Şalgamcıoğlu, B., & Genç, İ. (2021). The Ones Who Have Never Been Physically in a Studio: Myths and Hacks of First Year Basic Design Students in the Pandemic. *Design and Technology Education: An International Journal, 26*(4), 130-143. https://openjournals.ljmu.ac.uk/DesignTechnologyEducation/article/view/1170

Kaya Pazarbaşı, Ç. (2019). Contemporary Art for Product Design Studio: Informed Conceptualism. In N. Börekçi, D. Koçyıldırım, F. Korkut, & D. Jones (Ed.), Insider Knowledge, DRS Learn X Design Conference 2019 (pp. 1-8). Ankara: Design Research Society.

Kaya, N. A. (2021). Gender Differences in Spatial Cognition and Social Equity by Design Education. In H. G. Yavuzcan, & N. N. Öztürk, Design Research for Social Innovation (pp. 47-5). Ankara: Karadeniz Kitap.

Kemp, N., & Grieve, R. (2014). Face-to-face or face-to-screen? Undergraduates' opinions and test performance in classroom vs. online learning. *Frontiers in Psychology, 5*, 1-11. https://doi.org/10.3389/fpsyg.2014.01278

Kirchmer, K., & Kim, B. (2023). Dynamics of Disciplines: Understanding Task-Level Experiences in Interdisciplinary Collaborative Design Studio Education. *ACSA/EAAE Teachers Conference: Educating the Cosmopolitan Architect.* (pp. 166-173). Reykjavik: IEEE. https://doi.org/10.35483/ACSA.Teach.2023.24

Kolarevic, B., Schmitt, G., Hirschberg, U., Kurmann, D., & Johnson, B. (2000). An experiment in design collaboration. *Automation in Construction, 9*(1), 73-81. https://doi.org/10.1016/S0926-5805(99)00050-3

Komarzyńska-Świeściak, E., Adams, B., & Thomas, L. (2021). Transition from Physical Design Studio to Emergency Virtual Design Studio. Available Teaching and Learning Methods and Tools—A Case Study. *Buildings, 11*(7), 312. https://doi.org/10.3390/buildings11070312

Kumar, J. A., Silva, P. A., & Prelath, R. (2021). Implementing Studio-Based Learning for Design Education: A Study on the Perception and Challenges of Malaysian Undergraduates. International Journal of Technology and Design Education, 31(3), 611-631. http://dx.doi.org/10.1007/s10798-020-09566-1

Kurt Çavuş, Ö., & Kaptan, B. B. (2022). Determination of the Structure of the Project Based Studio Courses for the Education of Interior Design Bachelor. ITU A|Z - Journal of the Faculty of Architecture, 19(2), 263-275. https://doi.org/10.5505/itujfa.2022.57983

Kusumowidagdo, A., & Prihatmanti, R. (2022). 'Sense of Place' in Virtual Design Studio (VDS): A Review. *Review of Urbanism and Architectural Studies, 20*(1), 65-73. https://doi.org/10.21776/ub.ruas.2022.020.01.7

Kvan, T. (2001). The pedagogy of virtual design studios. *Automation in Construction, 10*(3), 345-353. https://doi.org/10.1016/S0926-5805(00)00051-0

Kwon, J., & Iedema, A. (2022). Body and the Senses in Spatial Experience: The Implications of Kinesthetic and Synesthetic Perceptions for Design Thinking. Frontiers in Psychology, 13(864009). https://doi.org/10.3389/fpsyg.2022.864009

Lagier, J. (2003). Distance learning and the minority student: special needs. *Internet and Higher Education, 6*(2), 179-184. https://doi.org/10.1016/S1096-7516(03)00023-X

Lehto, X. Y., Cai, L. A., Fu, X., & Chen, Y. (2014). Intercultural Interactions Outside the Classroom: Narratives on a US Campus. *Journal of College Student Development, 55*(8), 837-853. https://doi.org/10.1353/csd.2014.0083

Lotfabadi, P., & Iranmanesh, A. (2024). Evaluation of learning methods in architecture design studio via analytic hierarchy process: a case study. Architectural Engineering and Design Management, 20(1), 47-64. https://doi.org/10.1080/17452007.2023.2237054

Lotz, N., Holden, G., & Jones, D. (2015). Social engagement in online design pedagogies. In R. Vande Zande, E. Bohemia, & I. Digranes (Ed.), Proceedings of the 3rd International Conference for Design Education Researchers (pp. 1-25). Chicago: Design Research Society. https://oro.open.ac.uk/43592/

Lotz, N., Jones, D., & Holden, G. (2018). Engaging Qualities: Factors Affecting Learner Attention in Online Design Studios. Design as a catalyst for change - DRS International Conference

(pp. 2745-2763). Limerick: Design Resarch Society. https://doi.org/10.21606/drs.2018.326

Marchman, J. F. (2002). Opportunities and pitfalls in international design education collaboration. *32nd Annual Frontiers in Education. Conference Proceedings* (pp. S3B-17-21). Boston: IEEE. https://doi.org/10.1109/FIE.2002.1158689

Mariotti, J., & Niblock, C. (2023). A Critical Reflection on the Impact of Virtual Design Studio on Curriculum Development and Studio Culture in First-Year Architecture Studies. *Trends in Higher Education, 2*(4), 599-610. https://doi.org/10.3390/higheredu2040036

McLeod, P. L., Lobel, S. A., & Cox, Jr., T. H. (1996). Ethnic Diversity and Creativity in Small Groups. *Small Group Research, 27*(2), 248-264. https://doi.org/10.1177/1046496496272003

Meseguer-Dueñas, J. M., Molina-Mateo, J., Gómez-Tejedor, J. A., Ardid, M., Riera, J., Giménez, M., Serrano, M. A., & Vidaurre, A. (2016). Collaborative Teamwork: Relationship Between Student's Perception and Academic Results. *ICERI2016 Proceedings* (pp. 1277-1283). Seville: IATED. https://doi.org/10.21125/iceri.2016.1286

Minogue, J., & Jones, M. G. (2006). Haptics in Education: Exploring an Untapped Sensory Modality. *Review of Educational Research, 76*(3), 317-348. https://doi.org/10.3102/00346543076003317

Neubauer, R. M., & Wecht, C. H. (2021). Materiality of Space and Time in the Virtual Design Studio. In E. Bohemia, L. M. Nielsen, L. Pan, N. Börekçi, & Y. Zhang (Ed.), Learn X Design 2021: Engaging with Challenges in Design Education (pp. 780-788). Jinan: Design Research Society. https://doi.org/10.21606/drs_lxd2021.08.214

Özdamar, E. G., Yücel Caymaz, G. F., & Yavaş, H. (2021). Hapticity in Digital Education Atmosphere. Journal of Design Studio, 3(2), 141-157. https://doi.org/10.46474/jds.982811

Özorhon, G., & Sarman, G. (2023). The Architectural Design Studio: A Case in the Intersection of the Conventional and the New. Journal of Design Studio, 5(2), 295-312. https://doi.org/10.46474/jds.1394851

Patel, R. (2024). Collaborative Learning in Engineering: Developing Teamwork and Problem-solving Skills. *Bulletin of Engineering Science, Technology and Industry, 2*(3), 100-106. https://doi.org/10.59733/besti.v2i3.50

Peacock, S., & Cowan, J. (2016). From Presences to Linked Influences Within Communities of Inquiry. *International Review of Research in Open and Distributed Learning, 17*(5), 267-283. https://doi.org/10.19173/irrodl.v17i5.2602

Peimani, N., & Kamalipour, H. (2022). The Future of Design Studio Education: Student Experience and Perception of Blended Learning and Teaching during the Global Pandemic. *Education Sciences, 12*(140), 1-13. https://doi.org/10.3390/educsci12020140

Pernice, R., Yaguchi, T., & Kobayashi, K. (2023). Blended and Transnational Higher Education in Architecture Schools: Examples and Considerations from Two International Joint-Design Studios Between Australia and Japan. In M. Gareth, & L. Li (Eds.), *Handbook of Research on Developments and Future Trends in Transnational Higher Education* (pp. 194-211). Hershey: IGI Global. https://doi.org/10.4018/978-1-6684-5226-4.ch010

Perolini, P. (2019). The Virtual Design Studio – The Development of an Online Peer Learning Studio for Spatial Design Students. In E. Lester, G. Cairns, & E. An (Ed.), AMPS Proceedings Series 17.1 Education, Design and Practice – Understanding skills in a Complex World (pp. 100-109). New Jersey: AMPS C.I.O.

Petrova, M. (2021). The connectivist design studio. Design and Technology Education: An International Journal., 26(3-2), 341-352. https://openjournals.ljmu.ac.uk/DesignTechnologyEducation/article/view/1337

Resta, P., & Laferrière, T. (2007). Technology in Support of Collaborative Learning. *Educational Psychology Review, 19*(1), 65-83. https://doi.org/10.1007/s10648-007-9042-7

Rodriguez, C., Hudson, R., & Niblock, C. (2016). Collaborative learning in architectural education: Benefits of combining conventional studio, virtual design studio and live projects. *British Journal of Educational Technology, 49*(3), 337-353. https://doi.org/10.1111/bjet.12535

Sadecka, A. (2014). Virtual team work: case study of the European commission programme Erasmus Mundus Action 2. *International Journal of Innovation in Education, 2*(2-4), 207-222. https://doi.org/10.1504/IJIIE.2014.067937

Saghafi, M. R., Franz, J., & Crowther, P. (2012). Perceptions of physical versus virtual design studio education. *International Journal of Architectural Research Archnet, 6*(1), 6-22. https://eprints.qut.edu.au/51565/

Saji, M., Matsumoto, Y., Naka, R., & Yamaguchi, S. (2008). Design Collaboration on the Web. Proceedings of the First International Conference of The Center for the Study of Architecture in the Arab Region, (pp. 143-155). Morocco.

Salas, E., Cooke, N. J., & Rosen, M. A. (2008). On teams, teamwork, and team performance: discoveries and developments. *Human Factors, 50*(3), 540-547. https://doi.org/10.1518/001872008X288457

Salman, M., Kominek, A., Melvin, E., & Sabie, S. (2017). Delivery of Design Studios for On-line Platforms and Its Impact on Teaching and Learning Outcomes. Proceedings of the joint 8th IFEE2017 and 3rd TSDIC2017 (pp. 1-11). Sharjah: IEEE.

Shao, M., Yin, J., Ji, H., Yang, Y., & Song, F. (2020). Distance Perception Warped by Social Relations: Social Interaction Information Compresses Distance. Acta Psychologica. https://doi.org/10.1016/j.actpsy.2019.102948

Schnabel, M. A., & Ham, J. (2014). The Social Network Learning Cloud: Architectural Education for the 21st Century. *International Journal of Architectural Computing, 12*(3), 225-241. https://doi.org/10.1260/1478-0771.12.3.225

Süner Pla Cerdà, S., Öztürk, E., & Ünlü, C. E. (2025). Towards an integrative model of blended design studios: a multiple case study across architecture, design and planning education. Education and Information Technologies, 2005-2038. https://doi.org/10.1007/s10639-024-12873-y

Tan, Y., Xu, W., Li, S., & Chen, K. (2022). Augmented and Virtual Reality (AR/VR) for Education and Training in the AEC Industry: A Systematic Review of Research and Applications. *Buildings, 12*(10), 1529. https://doi.org/10.3390/buildings12101529

Taşlı Pektaş, Ş. (2012). The Blended Design Studio: An Appraisal of New Delivery Modes in Design Education. *Procedia - Social and Behavioral Sciences, 51*(1), 692-697. https://doi.org/10.1016/j.sbspro.2012.08.226

Taşlı Pektaş, Ş. (2015). The virtual design studio on the cloud: a blended. Architectural Science Review, 58(3), 255-265. http://dx.doi.org/10.1080/00038628.2015.1034085

Tessier, V. (2021). A Model for Learning Teamwork Skills. In H. Grierson, E. Bohemia, & L. Buck (Eds.), *DS 110: Proceedings of the 23rd International Conference on Engineering and Product Design Education.* Herning: The Design Society. https://doi.org/10.35199/EPDE.2021.5

Tessier, V., & Carbonneau-Loiselle, M. (2023). Assessment for Learning of Design Teamwork Skills. *International Journal of Art & Design Education, 42*(3), 420-438. https://doi.org/10.1111/jade.12461

Thoring, K., Mueller, R. M., Giegler, S., & Badke-Schaub, P. (2020). From Bauhaus to Design Thinking and Beyond: *A Comparison of Two Design Educational Schools. Proceedings of the Design Society: DESIGN Conference* (pp. 1815-1824). Cavtat: Cambridge University Press. https://doi.org/10.1017/dsd.2020.19

Toprak, İ., & Hacıhasanoğlu, O. (2019). Terms and Concepts on Design Studio in the Research Articles of 2010's. Journal of Design Studio, 1(2), 13-22. https://dergipark.org.tr/tr/pub/journalofdesignstudio/issue/51053/667160

Touré-Tillery, M., & Fischbach, A. (2014). How to Measure Motivation: A Guide for the Experimental Social Psychologist. *Social and Personality Psychology Compass, 8*(7), 328-341. https://doi.org/10.1111/spc3.12110

Tucker, R., & Abbasi, N. (2012). Conceptualizing teamwork and group-work in architecture and related design disciplines. *46TH ANZAScA Conference of the Architectural Science Association: Building on knowledge: Theory and practice.* Brisbane: Griffith University, Department of Architecture. https://api.semanticscholar.org/CorpusID:106524712

Tzeng, S. W. (2011). Teach Only When Understanding: The Strategies of Teaching Industrial Design to the Net Generation. TOJNED: The Online Journal of New Horizons in Education, 1(2), 38-44. https://tojqih.net/journals/tojned/articles/v01i02/v01i02-05.pdf

Ünal, B., Deniz, G., Demirci, H. M., & Bodur, G. (2022). A Research on Remote Teamwork in Computer Oriented Internship for Industrial Design Education. *Journal of Science Part B: Art, Humanities, Design and Planning, 10*(1), 31-41. https://dergipark.org.tr/en/pub/gujsb/issue/69238/1083397

Wang, J. (2025). Architecture students' peer learning in informal situations by lens of the community of practice – one case study. Interactive Learning Environments, 1-25. https://doi.org/10.1080/10494820.2025.2462152

Wojtowicz, J. (1995). Introduction to the Virtual Village. In J. Wojtowicz, Virtual Design Studio (pp. 1-3). Hong Kong: Hong Kong University Press.

Wragg, N. (2019). Online communication design education: the importance of the social environment. *Studies in Higher Education, 45*(11), 1-11. https://doi.org/10.1080/03075079.2019.1605501

Zamberlan, L., & Wilson, S. (2015). Developing an Embedded Peer Tutor Program in Design Studio to Support First Year Design Students. Journal of Peer Learning (1), 5-17. https://files.eric.ed.gov/fulltext/EJ1076439.pdf

Zeidan, A., Lehmann, A., & Trick, U. (2014). WebRTC enabled multimedia conferencing and collaboration solution. *WTC 2014: World Telecommunications Congress,* (pp. 1-6). Berlin. https://ieeexplore.ieee.org/document/6840017