Design and Technology Education: An International Journal

28.1

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Design and Technology Education: An International Journal
(formerly The Journal of Design and Technology Education) is published three times a year

Contributions
All contributions and materials for review should be made through the Journal website at:
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Volume 28
Number 1
ISSN 2040-8633
(online)
May 2023

Issue 28.1

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Editorial: A New Home

Lyndon Buck, Aston University, UK
Kay Stables, Goldsmiths, University of London, UK

Regular readers will recall that the previous issue of the DATE journal was updated with the new branding of the Design and Technology Association, sponsors of *Design and Technology Education: An International Journal*, and we have now moved to a new home to go along with our new look. After many years of being hosted by Loughborough University we have moved to Liverpool John Moores University and over the next few months you will see our webpages being updated with new features from Open Journal System (OJS) 3.3. This change of host has taken a great deal of work in the background and has caused some delays to the publication of this issue, but we hope that you will enjoy the benefits of the updated OJS interface and that you will notice the visual improvement to the webpages too. The move does require that journal users re-register with the new site but once this has been done the interface should feel familiar, but with added features and improved workflows. We hope that you enjoy the new site and we would very much like to thank the open journals team at Liverpool John Moores University for their help in this transition, and also of course the library team at Loughborough University for their hosting of the journal and the archives of its antecedents for many years.

In this issue of the journal we present eight research articles, the first three are from Turkey, two focusing on delivering core skills in electronics and the pedagogic and technical challenges of encouraging an open innovation approach in schools and universities, the third exploring the value of play through game-based learning in supporting design processes with interior design students. The subsequent four articles from USA, Japan and Australia highlight issues and challenges surrounding online and blended design education. The final article is a scholarly review of research on user-centred design practises in design and technology education. We end this issue with a book review.

In *How Electronics Knowledge Relates to Industrial Design Education* H. Güçlü Yavuzcan and Barış Gür of Gazi University, Turkey discuss the issues surrounding teaching electronics knowledge in industrial design degree programmes. The authors note that as design frequently focuses more on the digital interface of products, there is often less emphasis on physical interactions and electronic interfaces in current design education. While industrial design is widely regarded as multi or inter-disciplinary there is often little electronic engineering content in courses. With the current trend towards digitalisation of most products there is a growing need for a more thorough and practised understanding of electronics for designers. Through a literature review and survey of junior and senior industrial designers it was clearly shown that their reasoned problem solving of electronic issues was dependent on their undergraduate studies, and the inclusion of sufficient electronic content. 13 common products were chosen to highlight the gaps in understanding or application of electronic engineering components and theory. Their recommendations include a focus on hands-on terminology and the basics of electronics, although they do question the reliance on using systems such as Arduino which can limit the options available to solve a given problem, which may mask a lack of fundamental knowledge and understanding of the underlying theories.

In *A Study on Designers' Attitude for Open Innovation* in Turkey, Ilgım Eroğlu of Mimar Sinan Fine Arts University, Turkey, and Deniz Ekmekçioğlu of Ondokuz Mayıs University, Turkey explore the rich and diverse information resources that students encounter on their courses, and how these help to develop innovation habits among the designers' behaviours. Through interviews with 20 designers the authors show that the informational resources that students receive as part of their problem-solution-oriented approaches in their studies are crucial to researching problems in their later professions, and the way that they utilise these resources may be linked to their open innovation tendencies and their attitudes towards open innovation, co-design and co-development practises. The structure of design education can therefore be shown to shape not only shape design professionals' behaviours and functional design performance but also their potential in the wider business and professional environment. The use of problem-based models in project courses with often ill-defined, real-world problems encourage students to adopt trial-and-error structures and the use of outside data to test ideas, both of which help to encourage open-innovation and collaborative practises. By comparing students, in-house, and freelance designers, the authors discuss how information is openly shared and communicated between colleagues, and they suggest ways for this to be encouraged on design courses in order for it to develop quality of open resources and the culture of sharing resources in the commercial design environment.

In *Game-Based Learning in Interior Architecture Education* Tuğçe Babacan Çörekci of Istanbul University, Turkey explores the impact of using game-based learning methods within design processes. The research was undertaken with second year interior architecture students who engaged in a workshop that was structured to reveal how students managed design processes when games based learning was employed. Data was collected via a pre-test in which students evaluated their studio experience of designing, highlighting challenges faced, observations during the workshop and then a post-test and in-depth interviews. The research highlighted students' beliefs that design processes were linear, which resulted in them not going back to correct problems. The workshop structure required students to take a more iterative approach and this resulted in students gaining a more developed understanding of designing and, through the game-based learning, increased aspects such as time management, self-confidence and social dynamics with colleagues. The research was small scale and the author highlights the potential value of a longer study. Despite this, the workshop and data that emerged adds to existing understandings of the value of play in design education.

Echoing the importance of play in the previous article, *Building relationships with remote participants through playful technology interactions in online codesign*, by Jeni Paay, Simone Taffe, and Sonja Pedell of Swinburne University of Technology, Australia discusses how students can learn to co-design in online environments by engaging remote participants in online participatory experiences. Covid-19 had necessitated going online to both teach and practice codesign, and as educators, the authors were left with no alternative but to explore online alternatives to the traditional methods of teaching co-design. They describe codesign activities of postgraduate design teams who created a series of unique online activities to explore designs and trial them in virtual workshops with the local community. The unexpected finding is that online co-design activities need to remain tactile and include multisensory qualities. The authors argue that online codesign needs to focus on building relationships, engaging the senses, keeping it simple and allowing flexible timing. They identify the benefits, challenges and implications for online codesign and provide a checklist for designers wanting to

prepare for a hybrid co-design future. Overall, they argue that online co-design needs to focus on building relationships, engaging the senses, keeping it simple and allowing flexible timing, through the novel use of technologies to support the future of hybrid co-design education.

In *3D Virtual Site Visit as an Alternative to On-Site Experience in Interior Design Education*, Ye Ji Yi and Suchismita Bhattacharjee of University of Oklahoma, USA discuss the use of a 360-degree panorama-based Virtual Reality (360VR) tool to simulate real-world site visit experiences in interior design education. Second year undergraduate interior design students were given multiple project briefs with interactive 3D virtual tours. They were then surveyed on their 360 VR experiences on their engagement in learning, special layout, visualisation, and educational effectiveness. While the result of the student learning outcome evaluation showed no significant difference between 360 VR method compared to no site visit, there was a significant improvement in students' spatial planning, finish selection, and total scores when using the 360 VR method compared to an on-site visit. The students could engage with the 360VR technology in this study through computers and mobile devices, but further studies using more immersive emerging tools such as wearable devices, VR glasses, and Oculus Quest are suggested as future work. While the study underlines the need for a physical site visit to help develop a visual understanding of the space, the 360VR technology has been a crucial part of these design projects as it promotes students' imagination, provides sensory experiences, and allows accurate measurement, while providing a more controlled, flexible and accessible learning environment.

In "*How am I supposed to tell my mother what happened in today's class?": at the intersection between blended learning and design (thinking) education*, Miikka J. Lehtonen of Rikkyo University, Japan explores how the hands-on, experiential and collaborative learning that is so fundamental to most design education and design studio teaching can be replicated in blended learning environments. Visual learning diaries of postgraduate students from Aalto University, Finland, were analysed and showed that there is a perception that blended learning can influence how students approach designing for societal issues, and how they explore ambiguity. Triggers for personal development are discussed, and the results challenge the assumption that face-to-face learning is always the most effective way to deliver design education across disciplines. How technology can provide a structure to learning is discussed, as well as the potential shortcomings of many widely used online collaborative tools. The need for a learning frame to help develop and scaffold student learning and design briefs that specifically nudge students to use more first-hand experiences outside the classroom, especially important with post-pandemic students, is highlighted.

In *German Design Educators' Post-Covid Challenges: Online, Artificial Intelligence (AI) and Government Data Restrictions*, Dr Katja Fleischmann of Griffith University, Queensland College of Art, Australia explores the experiences of design students from a variety of disciplines during the Covid-19 pandemic and the subsequent move to online studios and digital communication. The author shows how this has profoundly altered the practises of design educators in Germany due to restrictive legislation which is limiting the integration of online educational technology, and there is comparison with international colleagues' experiences to provide a wider context. Design educators were surveyed during and after the pandemic to gauge the effects on student behaviour and learning and the results show the importance of encouraging a back-to-campus policy in order to benefit from the physical design studio pedagogy.

Furthermore German data protection laws make open-source collaboration platforms that were developed and used successfully in many countries over the lockdown period very difficult to implement without strict control of the data. There is however an emerging consensus that some of the online tools and platforms that were introduced in the pandemic could be utilised in a blended design studio moving forwards, although there remain concerns regarding how to maintain the social cohesion encouraged by physical design studios, with the associated opportunities for informal learning.

We have always encouraged contributions to the DATE journal in a number of different formats, so that in addition to the regular research articles we often include book reviews and opinion pieces, but we have also in the past published scholarly reviews which are relevant to our readership. Our final research paper is such a scholarly review which, given that this is the first issue from the journal's new home, we are delighted is by an author from Liverpool John Moores University.

In *Interaction with end-users in design and technology education: a systematic review* Philip A. Jones of Liverpool John Moores University, UK presents a systematic literature review of user-centred design practises and their potential application in design and technology education. Literature from *International Journal of Technology and Design Education* and *Design and Technology Education: an International Journal* highlighted the advantages to students from engaging in user-centred practises, improving both their design outcomes and their social and emotional skills. The exposure to real world problems and problem-solving contexts helped to develop reflection and empathy, and disability or so called 'extreme users' emerged as a focus of many of the studies. It is clear that participatory practises lead to more relevant design outcomes, and yet many students are not introduced to these until higher education. The author suggests that user-centred design methodologies should be further explored in schools alongside 21st-century skills development to ensure that design and technology education becomes remains human-focused and based on 'real', authentic interactions with 'real' people.

Finally, in addition to the research articles we present a book review by Alice Hellard of Goldsmiths, University of London, UK of the recently published *Debates in Design and technology Education (2nd Edition)* edited by Alison Hardy and published by Routledge. This book and the review are of particular importance as, at this moment in time, Design and Technology Education in England is under threat as a subject in schools.

We hope that you enjoy this issue and welcome any comments readers may wish to make.

Design and Technology Education: An International Journal

28.1

How Electronics Knowledge Relates to Industrial Design Education

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Abstract

This study has two purposes: To clarify how industrial design relates to electronics knowledge and to determine whether industrial design education is sufficient for teaching it. As digital product design is frequently focused on the design of virtual interfaces until recently, less attention was paid to the design of physical interactions and electronic interfaces. There is increasing interest in electronics education in industrial design, yet electronics is still a bottleneck for many industrial designers. What electronics knowledge industrial designers should have and whether they know it is debatable. Therefore, the study presents a literature review and thematically analyzed interviews to determine its scope. Then, a survey is planned based on the concepts which interviewees remark on. The survey aims to determine whether senior-grade and fresh-graduate industrial designers use correct reasoning in design cases based on electronics. Findings remark that two-thirds of the participants failed in the critical electronics domains and their reasoning scores are distributed equally depending on whether they took electronics courses. Therefore, it is discussed that there is a need for developing a common understanding of the role of electronics in design education. And it is recommended that the approach may focus more on a hands-on terminology education.

Keywords

Industrial design education, product design education, design engineering, design curriculum.

Introduction

The consensus in the literature is that the education and practice of industrial design are multidisciplinary or interdisciplinary (Li-Jun et al., 2016). However, the diversity and extensity of these disciplines, particularly engineering, are debatable. Although the connection between industrial design and engineering is widely acknowledged, it is debatable whether branches other than mechanical engineering are related to traditional industrial design education. This research focuses on one of the *other* branches: electronics engineering. Considering that digitalization is the new *megatrend* of the economy (Stein, 2015), the research discusses that, whether knowledge about electronics should be one of the major focuses of industrial design education.

Semantic Approach

Industrial design is often explained as a discipline closely related to mechanical engineering (Tavrou, et al., 2011; Akbulut, 2015). Because *industry* often implies mass production and manufacturing machines (Kemp, 2013), being *industrial* semantically refers to automated manufacturing. However, numerous industrial designers work as user experience or interface designers nowadays, and fewer designers are employed in physical product design (World Design Organization, 2020; Gill, 2003; Howell, et al., 2016; Vial, 2015; Trathen & Varadarjan, 2017). Therefore, entitling the profession industrial design was reasonable when manufacturing

industries were emerging (Vial, 2015). However, arguably the industrial design title is inadequate to clarify the present scope of the profession.

Industrial design and *product design* are often used interchangeably. Confusingly, both titles deal with producible design (Nazarenko & Kazachkova, 2019; Kim & Lee, 2016). Therefore, the term *product* also affects what industrial design means. Whether it has a mass, any object, environment, or activity produced by humans is a *product* (Junginger, 2008; Margolin, 1995). However, semantically, *product* in economics and colloquial speech often refers to physical goods produced by the manufacturing industries (Durmaz, 2009; Lager, 2000). Accordingly, *industrial* designers may be responsible for designing *non-industrial* things.

On the other hand, as discussed below, there is a gap between *industrial* and *virtual.* Due to the growing popularity of e-service design (Funk, 2007), interface design is overgeneralized to design an internet or application-based medium (Benyon, 2019). *Digital* is often mistaken for what is graphical and intangible, and for software (Rask, 2005; Hui & Chau, 2002). Yet, hardware is digitalized as well (Page, 2016). Some researchers argue that *digital product design* is designing an object that includes a display and/or its software interface (Oygür İlhan & Karapars, 2019). However, technically, what distinguishes digitalized products is the binary logic (Stein, 2015; Ligthart, Porokuokka, & Keränen, 2016). Plenty of digital components exist other than displays. However, *digital product* in industrial design does not imply a technical basis. Therefore some studies criticize the usability literature for often focusing on software and underline that any physical part of a product that users interact with is a user interface (Dumas & Redish, 1999; Norman, 2013).

Being digital and being technological are interconnected phenomena. Although *technology* refers to the knowledge of any type of production (Fomunyam, 2019), being technological is about the complexity and novelty of the problem solved (Soltanzadeh, 2015). Therefore, society perceives technology as synonymous with the Internet and computers (Lachapelle, Cunningham, & Oh, 2018). However, plenty of other objects also benefit from complex digital technologies. Many simple devices, a remote controller, for instance, compute many choice axioms. Nevertheless, many would probably not regard it as digital. The discussion above points out that if a product does not contain a display and/or resolve a complex problem, it is often regarded as non-digital. However, designing digital hardware interactions and experiences is still essential (King & Chang, 2016).

Pedagogical Approach

The perceived quality of any sensory experience is aesthetics (Shusterman, 2011). Aesthetics is a branch of philosophy that deals with beauty (Walton, 2007). Industrial designers focus on the aesthetics of everyday objects (Akner-Koler, 2007). They design satisfactory experiences (Norman, 2013). Unlike the society considers, neither design nor aesthetics is focused only on visual beauty (Borja de Mozota, 2006; Faste, 1995). Therefore, if a design interacts with humans, but is designed to satisfy all sensory perceptions, it is a *good design*. And it is the expertise of an industrial designer (Moody, 1980; Vial, 2015). Contrarily, there is a concept titled *silent design.* It refers to the designs of someone who is not formally educated to design a product considering aesthetics (Gorb & Dumas, 1987). However, it is controversial whether formal education of industrial designers provides them with enough skills to design aesthetic elements other than visuals.

In early industrial design education, schools implemented specialized workshops, where students experientially learned tactile, auditory, and olfactory experiences of materials and finishing while designing (Lee, 2006; Birringer, 2013; Moholy-Nagy, 1939). However, the emphasis on experiential learning did not last long. Schools reduced the variety of workshops due to economic and political reasons (Weingarden, 1985; Betts, 1998; Findeli & Benton, 1991). Later in the 1950s and 1960s, a theoretical approach towards materials, production, and aesthetics emerged (Rhi, 2019), which forms the basis of the common approach in the present industrial design education. Since then, it is arguable that students lack in prototyping real materials or components. Therefore, they learn less about designing tactile, auditory, and olfactory features of an object and some visual aspects such as the brightness of an indicator. Consequently, industrial designers paid less attention to user experience than visual aesthetics until the previous decade (Norman, 2013). Therefore, the reason why industrial design is often considered as designing visual aesthetics (Borja de Mozota, 2006) may be the lack of experiencing in education. Ironically, industrial designers who fail to design all experiences of the objects, are the cause of *silent design* (Gorb & Dumas, 1987).

Epistemological Approach

Experiential learning is one of the most efficient learning styles. One learns more when one gets involved in the activity rather than listening or observing only (Wood, 2004). Moreover, some knowledge cannot be learned without experiencing. One cannot learn driving until one experiences driving, despite one is told what pedals are used for. Therefore, experiencing is often hands-on, sensorial, subjective, implicit, and sometimes unconscious (Groth & Mäkelä, 2014). Vice versa, theoretical knowledge is objective, explicit, common, taught verbally or written, and learned consciously.

Except for being theoretical or experiential, part of the knowledge in industrial design is also often mentioned as *technical*. *Technical* and *technological* terms are used interchangeably. Therefore, part of an industrial designer's knowledge is based on engineering, as engineering is the source of technological knowledge by applying scientific theories into practice (Günay, 2018). And presently, engineering education is focused on learning and experiencing through *Conceive, Design, Implement and Operate* (CDIO) approach (Mauryo & Ammoun, 2018). Therefore, technical knowledge is not necessarily theoretical in engineering education. Instead, it becomes more experiential. Nevertheless, technical knowledge in industrial design education is criticized for being overly theoretical and focusing on the manufacturing economy and mechanical domain (Yenilmez & Bağlı, 2020; Varekamp, Keller, & Geraedts, 2014).

On the other hand, experiential learning is relearning previously met knowledge (Yavuzcan & Gür, 2020). One must be told what the pedals are used for, before or during one experiences driving for the first time. Accordingly, theoretical knowledge is still essential and beneficial, as long as it is not too intense and learned to provide a basis for experiencing. There are a few studies that emphasize that teaching electronics over-theoretical does not fit the perception of industrial designers (Molwane, Sheikh, & Ruele, 2017). Instead, it is suggested that they would learn better by tearing objects down and prototyping electronics which is a typical CDIO approach (Romero et al., 2012). And it is argued that if a prototype of a design is to be made, it is necessary to prototype electronics as well (Seetsen et al., 2019). For now, prototyping is the only common option for designers to experience the sensorial features of what they are designing. Therefore, theoretical knowledge of electronics is argued as necessary for industrial

designers, yet necessitated knowledge is not that extensive (Seetsen et al., 2019). Industrial designers do not design or prototype printed circuit boards. Instead, they build simple circuits often through physical programming with ready-made kits, Arduino in particular (Page, 2016). However, theoretical knowledge is not only beneficial while prototyping. Industrial designers may never design circuits themselves, yet fundamental electronics knowledge will still be beneficial in practice for transdisciplinary communication (Romero et al., 2012).

Although formerly graduated industrial designers are often not trained in electronics, many of them designed electronic appliances (Varekamp et al., 2014). They experienced situations where electronics knowledge is necessary. And they usually consulted experts. However, researchers point out that industrial designers communicated in *designerly* ways. They benefited only a little from technical terminology. And what they designed is often unfeasible. Researchers underline that courses on electronics were marginal in the early 2010s (de Vere et al., 2010; Pedgley, 2010; Moalosi & Molokwane, 2008; Varekamp et al., 2014). Therefore, nearly a decade ago, lacking these courses resulted in industrial designers suffering from deficient terminology.

Electronics in the Curriculum

Presently, interest in electronics-based technology education increased. Numerous design departments and polytechnics offer courses on electronics or mechatronics. TU Delft in the Netherlands, Loughborough and Brunel in the United Kingdom, University of Aegean in Greece, MSFAU and METU in Turkey, Monash in Australia, and NUS in Singapore are some of the many. Nevertheless, in Turkey, such courses are still few in number. However, some lecturers state that they initiatively modify the contents of courses such as *materials, manufacturing,* or *ergonomics* to include electronics. Arguably, a common ground has not yet been reached due to the types of design programs being diversified worldwide. The programs are classified into these types except for the unique ones:

1. Design
2. Industrial design
3. Product design
4. Industrial design engineering
5. Product design engineering

A typical example of the classification above, Loughborough (2023) offers 4 types of design-related undergraduate programs: design, industrial design, product design & technology and product design engineering. The programs contain technical courses, from less to more, in the above-mentioned order. And their emphasis on prototyping and designing for manufacturing increases in the same order. The engineering program offers numerous technical courses on various technical domains, including electronics. However, programs other than engineering benefit more from common social sciences based courses. Nevertheless, product design and technology program still gives more credit to designing for manufacture. And the program includes a compulsory course titled Electronics, Programming, and Interfacing.

On the other hand, some of the engineering programs have more in common with the design programs. TU Delft (2023) offers *industrial design engineering* as the only undergraduate program. It includes numerous compulsory and elective courses based on both social sciences

and technical knowledge. The program emphasizes producible design, yet it still includes typical design courses. These electives directly focus on electronics: *Electronics for Product Designers* (TU Delft, 2022) and *Interaction and Electronics* (TU Delft, 2022). During these courses, by designing, analyzing, and prototyping via Arduino and programming tools, students are taught the fundamental concepts and components: circuits, energy sources, what sensors, actuators, and controllers are, and differences in analog and digital electronics. For further research, readers may visit the course browser of TU Delft: studiegids.tudelft.nl.

Furthermore, some industrial design programs differ from others in their approach to electronics. MSFAU (2022) offers two electives, despite it originally is a fine arts university. *Product Electromechanics* focuses on basic principles of electrics, circuits, micro components and elements of digital electronics, Arduino and coding. *Smart Industrial Products* is based on graphics based programming. METU offers two electives. One is *Interactive Prototyping for Designers* (METU, 2022). As a former lecturer mentioned, the course emphasizes teaching a basic understanding of electricity, circuitry, sensors, and actuators through hands-on experiential learning through building circuits and coding.

Except for the specific courses on electronics, electronics knowledge is often an element of systems thinking. It is often included implicitly or explicitly in education. Systems thinking is a holistic approach which prefers to examine elements in the context of their relationships (Ghim, 2022). It regards the complete product experience as the coherent integration of a set of experiences. Since the product-service systems emerged, in which the objects and the services are integrated, it necessitates a systematic approach to product design (Greene, 2019). Following a systems-thinking approach, students design flow charts and schemes as well as the physical aspects. In this way, they develop a better understanding of complex interactive things. NUS Division of Industrial Design (2022) offers a specific course titled *systems-thinking*. And many others, the University of Cincinnati, for instance, integrate the approach into studio courses (Ghim, 2022).

As researched through the Turkish Higher Education Institution (2023) website, the majority of the undergraduate design programs in Turkey are titled *industrial design.* The few engineering programs offer courses on various technical domains, including electronics, fluid dynamics, thermodynamics, etcetera (Erciyes University, 2021). Therefore, it is argued that design engineering departments should not be considered as a version of industrial design due to their cross-discipline basis (Akbulut, 2015). The following question can be answered based on the above section. Do design programs include electronics, apart from design engineering? Yes, many do. Yet, many do not. Besides, any design program may offer electronics unless it puts too little emphasis on producible design.

Methodology: Rationale and Scope of Electronics Knowledge

Considering the conceptual framework given above, this study, which is based on an ongoing doctoral thesis, argues that, despite the increasing interest in electronics worldwide, there is no common approach. Except for a few, courses are often elective. Many programs still do not offer any, particularly in Turkey.

The study presents the recently completed phases of the research: Interviews and the survey. A conference proceeding has been published in Turkish (Gür & Yavuzcan, 2021). It presents the

interview findings. The survey, published hereby for the first time, is designed based on the interviews. Therefore, the methodology and findings of the interviews are given in detail. Interviews and the survey together have two purposes and three research questions:

P1. To determine the details of electronics knowledge required in industrial design,
RQ1. What electronics knowledge do industrial designers need and why?
RQ2. What benefits and harms does electronics knowledge bring to industrial designers?
P2. To find out whether industrial designers have the necessary knowledge,
RQ3. What electronics knowledge do industrial designers currently have?

What these questions search for is implicit. Implicit knowledge is subjective and varies based on the experience of each subject (Leonard & Sensiper, 1998). Answers may depend on what problems participants face, what they need, and what is expected of them. Subjective opinions and beliefs are typical data in qualitative research (Creswell, 2007). Therefore, the research is qualitative. Moreover, because what participants may argue cannot be predicted in detail, closed-ended questionnaires are not reasonable. Consequently, interviewing is preferred in the first stage, as the non-response rate to the open-ended questions is much lower in interviews than in surveys (Reja et al., 2003; Manfreda et al., 2002). Semi-structured interviewing is the most appropriate, considering that structured interviewing is based on closed-ended questionnaires, and unstructured interviews could fail to stay focused on the subject (Stuckey, 2013; Carruthers, 1990). Semi-structured interviews are often based on open-ended questionnaires. They provide both unrestricted answering and comparability (While & Barriball, 1994).

Based on the recommendation that Varekamp, Keller, and Geraedts made for further studies (2014), it is considered valuable to get insights from electronic experts as well. Accordingly, six industrial designers and four electronics engineers attended interviews. The participants represent different backgrounds regarding their level of experience and expertise. Two of the industrial designers are lecturers in industrial design departments, two are employees, one is a student, and one is both a lecturer and a manager in a design studio. While employees have only two years of work experience each, those who are business owners have 19 and 12 years. The lecturers have 8 and 14 years of experience in studio courses. One of them used to give an elective on prototyping electronics and physical programming. Two of the attending electronics engineers are employees. One is a manager in an IoT start-up, and one is both a lecturer and manager of a research and development agency.

Industrial designers are asked during interviews:

- How often and what electronic appliances they design,
- Which components they often benefit from and what for,
- Whether these components significantly affect the design,
- Whether they ever faced situations that they need electronics knowledge,
- Whether could they learn it and how,
- What components or concepts they had to learn,
- Whether they benefit from the knowledge in further projects,
- Whether they make recommendations regarding electronics,
- Whether what they recommend is considered feasible,

- Whether they feel more competent as they learn electronics more,
- How much should industrial designers know about electronics,
- Should it be taught during undergraduate education,

Electronic engineers are asked:

- Whether industrial designers which they cooperated make decisions regarding electronics,
- Whether they ever encounter situations that they need electronics knowledge,
- Whether and how they acquire the necessary information,
- What problems arise when they have incomplete or incorrect knowledge,
- Whether a list of topics on electronics concepts and theories concerns industrial design,

Analysis of semi-structured interview records can be carried out inductively or deductively (Marks & Yardley, 2004; Vaismoradi et al., 2013). The deductive approach requires predetermined keywords or themes. Although it is efficient, the rich content of the raw data obtained cannot be analyzed in-depth (Braun & Clarke, 2006). Besides, considering there are limited studies regarding the phenomenon, keywords and themes are undetermined. It is necessary to derive the keywords or themes from the interviews. That is an inductive method (Hsieh & Shannon, 2005).

Interviews are converted into raw texts. The texts are analyzed either through content analysis or thematic analysis (Vaismoradi et al., 2013). The content analysis measures the number of repetitions of an explicit keyword. Therefore, the data obtained is quantitative. The thematic analysis concerns the implicit meanings of the themes rather than repetition (Hsieh & Shannon, 2005; Marks & Yardley, 2004). As the phenomenon is not yet specific enough to generate explicit keywords, inductive thematic analysis is preferred. Exceptionally, theories and components are generated as keywords. Because the purpose of interviews is to explore the phenomenon and provide a basis for the survey by expert opinion, repetition of the codes or keywords is not a concern. No statistical analyses are conducted. Therefore, the first stage is a case study.

Interview Findings

Through the thematic analysis of the interviews, 15 thematic codes and 15 keywords are determined. Thematic codes are combined under seven themes and content keywords under two. Derived codes and themes are presented in Table 1. The common attitudes of the participants and their significant statements are given below the table.

Table 1. Thematic analysis findings based on thematic codes

Themes	Codes
T1. Industrial designers design many electronic objects during their education and in practice,	C1. To frequently design electronic objects
	C2. To design many electronic objects in studio courses
	C3. Relevance of the amount of data inputs and outputs to the number of components

T2. The more an object interacts with users and the environment, the more electronic components the industrial designer deals with.	C4. Relevance of intensity of user interactions to the number of components
T3. Both internal and external components that affect the volume, mass, structure, materials, and manufacturing methods interest industrial designers.	C5. Relevance of volume and mass of an object to the components
	C6. Relevance of materials and manufacturing to the requirements of components
	C7. Relevance of form and structure to the properties of components
	C8. Relevance of form and structure to the internal components
T4. Utilizing the electronics knowledge in creative thinking stages can lead to more creative ideas or block creativity.	C9. Likelihood of leading an industrial designer to design more creative user experiences
	C10. Likelihood of leading an industrial designer to develop ideas less creatively
T5. The more industrial designers have electronics knowledge, the more their ability to manage interdisciplinary projects increases.	C11. Being able to criticize the electronic components which engineers decided
	C12. Relevance of the amount of electronics knowledge to feeling competent
T6. The amount of electronics knowledge given in education should at least be adequate for datasheet reading.	C13. Datasheets and distributors as the sources of electronics knowledge
	C14. Need for electronics knowledge in education
T7. The electronics knowledge of industrial designers might be measured by evaluating their reasoning skills while solving case problems.	C15. Irrelevance of theoretical computational skills to the expected industrial designer competencies

Predictably, all industrial designers mentioned that the increasing necessity of electronics in education and practice is related to the amount of data inputs and outputs in the technological objects. However, it is noteworthy that the participants associate the *data* phenomenon with even the most basic interaction.

> *P6 (industrial design student): Even the most basic lighting, or the charge indicator, requires electronic components. The objects that interact with the user include many electronic components because there is an input or a data reception.*

One of the lecturers assumed that nearly half of the projects given in the studio courses include basic or complex electronics. Considering that the program does not offer any courses on electronics, the assumption is notable for discussion. Remarkably, one of the electronics engineers acknowledged that interacting components concern industrial designers rather than engineers.

> *P9 (electronics engineer business owner): Deciding on a component that interacts with the user directly concerns industrial designers. Moreover, it has almost nothing to do with electronic engineers.*

Predictably, participants often mentioned interfaces and interactions. However, all industrial designers frequently marked that components affect the structure, volume, and mass. Thus, they affect the form and ergonomics. Moreover, engineers underlined that electronics affect the choice of materials and production methods. Based on the statements, electronics affect many non-electrical physical aspects of a product.

> *P5 (industrial design lecturer): Benefiting from the electronics knowledge, one might not decide to use a motor. One may prefer another approach. Then, the ergonomics and aesthetics of the object would drastically change.*

> *P8 (electronics engineer business employee): The volume and mass of the components matter. As some components overheat, they shall not be placed near plastics.*

> *P9 (electronics engineer business owner): Concepts such as electrical insulation are critical. Therefore, industrial designers severely need to know the electrical properties of materials.*

The participants shared their opinions on both benefits and harms of electronics knowledge on creativity. No generalizable consensus has emerged. Yet, their perspectives are noteworthy. What was agreed upon by all six industrial designers is that electronic knowledge is beneficial in interdisciplinary collaboration, time and cost saving, and feeling more competent.

> *P2 (industrial design employee): Industrial designers should be able to argue what is unsuitable and suggest alternatives. The electronics engineer should consider that the designer is competent in electronics at a basic level. However, electronics knowledge is not required in the early steps of design. The brainstorming phase should be free of any technical limitations. Yet, while shaping the outputs of brainstorming, the knowledge of electronics comes in.*

> *P3 (design studio owner): Once, my studio designed a medical device. The client requested to add a button that wakes the device up. Instead, we suggested placing a gyroscope inside to detect movement and wake the device up as the voltage increases. What we have suggested resulted in a more advanced experience, and it became much easier to design a waterproof body.*

> *P4 (industrial design lecturer): Students sometimes think ahead, yet other times behind the present technology. They are not aware of the existence of some types of sensors. Learning innovative technologies help them to design better products. Therefore, they get rid of unnecessary components and design smaller objects. They may benefit from sensors that suit the purpose better. However, comprehending that sensors work within certain limits may block them. Learning a lot may cause one's expertise to shift. Students may lack in thinking free if they get bogged down in the technical details.*

Remarkably, four industrial designers stated that the primary source of electronics knowledge is datasheets and websites or salespersons of distributors. They argue that industrial designers should at least be trained to read datasheets and to research and compare components. Moreover, participants criticize that their design decisions regarding electronics are often not a matter of evaluation during education.

> *P1 (industrial design employee): I often ask an expert when I need to learn something about electronics. However, I also frequently search for datasheets in Digikey. I watch YouTube videos. What I search for rarely requires advanced technical knowledge. I often compare the specifications of the existing components with the alternatives.*

> *P6 (industrial design student): Students often prefer to take the easy way out in the studio courses. They pick components only on whether they fit in the remaining space. Although I am often aware that a component is not applicable, I would argue that it is.*

Table 2. Thematic analysis findings based on contents

Themes	Keywords
T8. Designers should have the knowledge of components and theories which; Provide energy and movement to an object, Interact with users, objects, and the environment, Control, ventilate, heat, and cool those above, Organize, plug or assemble those above,	K1. Printed circuit boards K2. Switches K3. Displays K4. Batteries, chargers, transformers K5. Controllers, processors and memory units K6. Cables, sockets, connectors K7. LEDs, lighting K8. Electromechanics K9. Sensors K10. Ventilating, heating, cooling K11. Wireless communication
T9. Theories should be classified considering the experience of the industrial designer and the extent of the necessary knowledge.	K12. Beginner level experience K13. Expert level experience K14. Basic level knowledge K15. Superficial level knowledge

Participants often preferred to classify knowledge by its extent and the required experience (Table 2). According to the engineers, the theories based on below domains are the basic level of knowledge which beginner-level industrial designers should have.

Th1. Electrical properties of materials
Th2. Energy and power
Th3. Current and voltage
Th4. Differences between direct and alternating current (DC and AC)
Th5. Transducers and actuators
Th6. User interaction elements

And the basic principles of the concepts below are the superficial level of knowledge which experienced industrial designers should have. The participants remark that the concepts affect materials and manufacturing or the volume and mass of an object.

Th7. Printed circuit board elements
Th8. Communication systems
Th9. Electromagnetism
Th10. Antennas

Methodology: Whether Industrial Designers Have the Knowledge

The classification above clarified what theories concern industrial designers during practice. And the contents in Table 2 remarked on what components affect design projects. Therefore, each question is designed to assess the knowledge regarding one or more of these theories and components. However, how to measure the electronics knowledge of industrial designers in a field study is a matter of debate. Therefore, concluding the interviews, electronics engineers are asked for their expert opinion. All participants argued that calculative and theoretical skills of industrial designers are less beneficial than their reasoning abilities. They suggested designing short questions which represent hypothetical real-life cases.

Reasoning is the ability to draw conclusions from known facts (Cantürk Günhan, 2014). Although closed-ended multiple-choice questions are not optimal for measuring reasoning skills since they fail to assess partial reasoning, they are still reliable and efficient if only the questions and distractors are well-defined (Al Muhaissena et al., 2019; Mullen & Schultz, 2012). Accordingly, 13 cases and closed-ended reasoning questions are prepared in collaboration with two electronics engineers.

A total of 74 people participated in the internet survey, of which 18 reside in countries other than Turkey. Participants are students or graduates of 16 schools, 11 in Turkey and five in other countries. Three of them are in the majority (88%): Singapore, Australia and Greece. While 49 participants are senior-grade, the rest graduated in less than a year. The survey aims to represent the population of Turkey. And it compares the average scores of Turkey and the other countries through Chi-square, Anova, and Tukey's post-hoc tests and descriptives.

Survey Findings: Proficiency in Electronics Knowledge

The findings for each question are presented in the order of the theories. The order is listed in the final part of the interview findings section. Each case represents a theory and component sets mentioned by the interviewees. How designers are expected to approach the case is presented below for each question.

Case 1: Kettle

Theory: Electrical properties of materials (Th1)
Components: Heating (K10)

The participants are asked what type of material is better for the electrical insulation of a kettle. They are expected to understand that boiling consumes large amount of energy. Therefore they should reason that resistors of kettles often operate in AC. Since AC may cause shock in case of malfunction or misuse, designers should reason that insulation is critical in this

case. Therefore, “plastics” is correct, as others are conductive. As presented in Figure 1, notable number of the participants answered correctly.

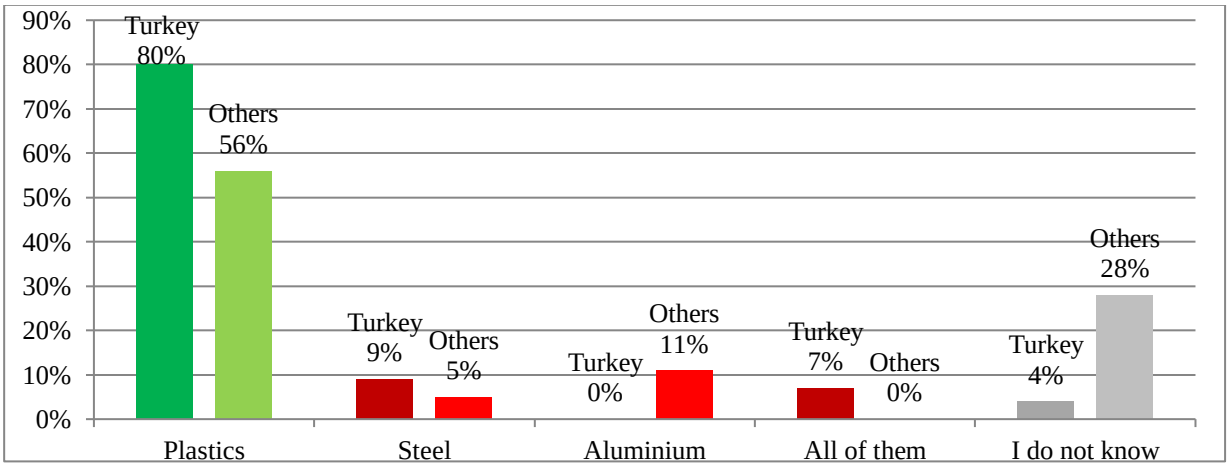

Figure 1. The material of which a kettle body is made to provide better electrical insulation

Case 2: Heating unit

Theory: Energy and power (Th2)
Components: Heating (K10)

The second case is a heating unit that is required to heat a room as quickly as possible. The participants are asked to decide what current type is the most preferable to provide the energy. The designer should reason that heating larger spaces requires a large amount of energy. Therefore, the optimal answer is AC, as AC resistors that operate on mains electricity draw much more power than DC resistors. Figure 2 presents the distribution of answers given. Remarkably, correct answers are less than half.

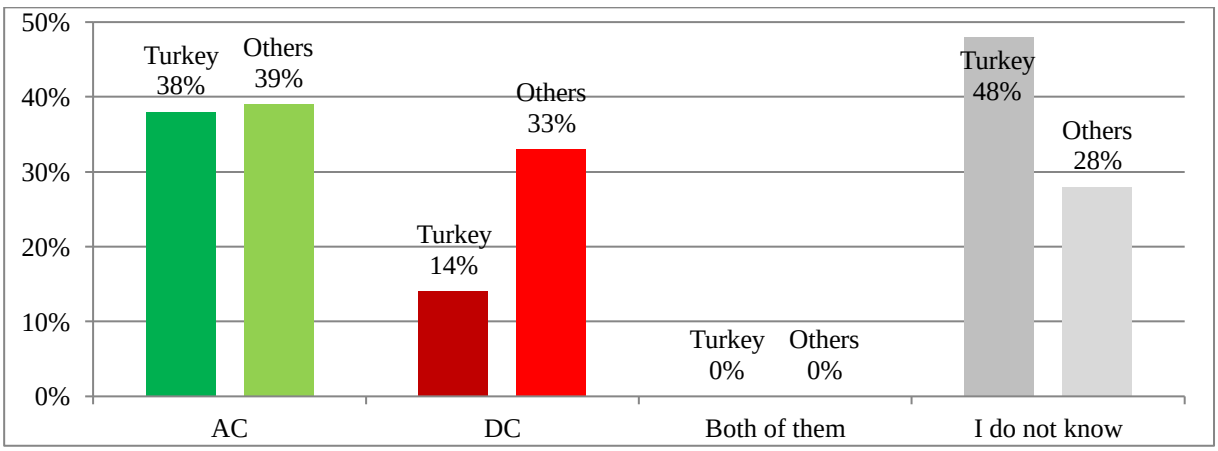

Figure 2. The preferable type of current to provide a large amount of energy for a heating unit

Case 3: Credit card reader

Theory: Current and voltage (Th3)
Components: Connectors (K5)

The third is a malfunctioning rechargeable credit card reader. The participants are asked to predict the probable cause for the overheating charging connector. Although the case is not exactly a design problem, it aims to determine whether designers understand that heat is caused by resistance against the current. Regarding the options connector resistance and

overcurrent, participants are expected to comprehend that both are similar concepts and decide to answer both of them. Yet, the distractors represent partial reasoning. Distribution of the answers are given in Figure 3.

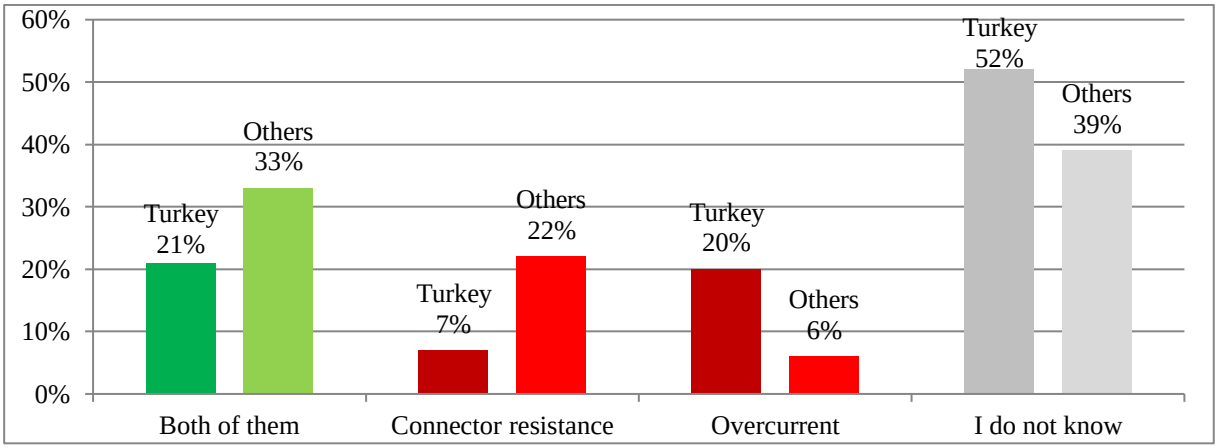

Figure 3. The probable reason for the heating of a malfunctioning charging connector

Case 4: Electric shaver

Theory: Differences between DC and AC (Th4)
Components: Batteries and transformers (K4)

The fourth is an electric shaver that is required to be washable as whole. The participants are asked to decide what type of current is safer for the user. Designers are expected to know that mains electricity is high voltage AC which may fatally shock the user. And they should decide that a battery or an adapter is preferable. The optimal answer is DC in both cases. The participants could have been asked to choose the optimal component or scenario instead. However, they might decide on the battery option as cords limit the usability, or many shavers already operate on battery. Then the reasoning would depend less on the electronics knowledge and more on scenarios and experiences.

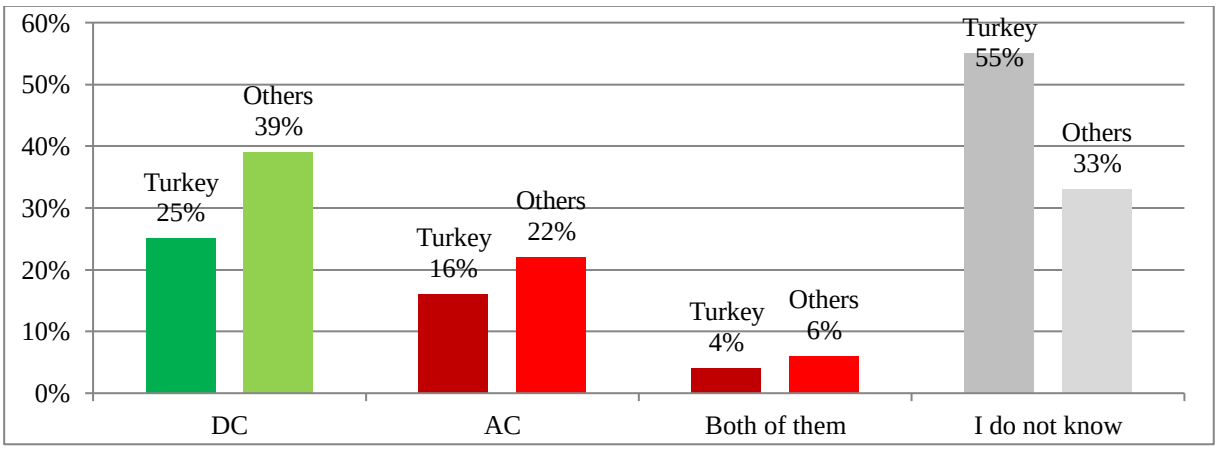

Figure 4. The safer type of current in which a washable electric shaver operates

Case 5: Desktop computer

Theory: Differences between DC and AC (Th4)
Components: Transformers (K4)

The participants are asked the reason why a power supply unit is placed inside a PC. One who knows the differences between DC and AC should be aware that computer-like objects often operate in low voltage DC. And mains electricity is high voltage AC. Therefore, one should know that the power supply is both a transformer and a regulator. However, as both of them are correct, distractors present partial reasoning in this case (Figure 5).

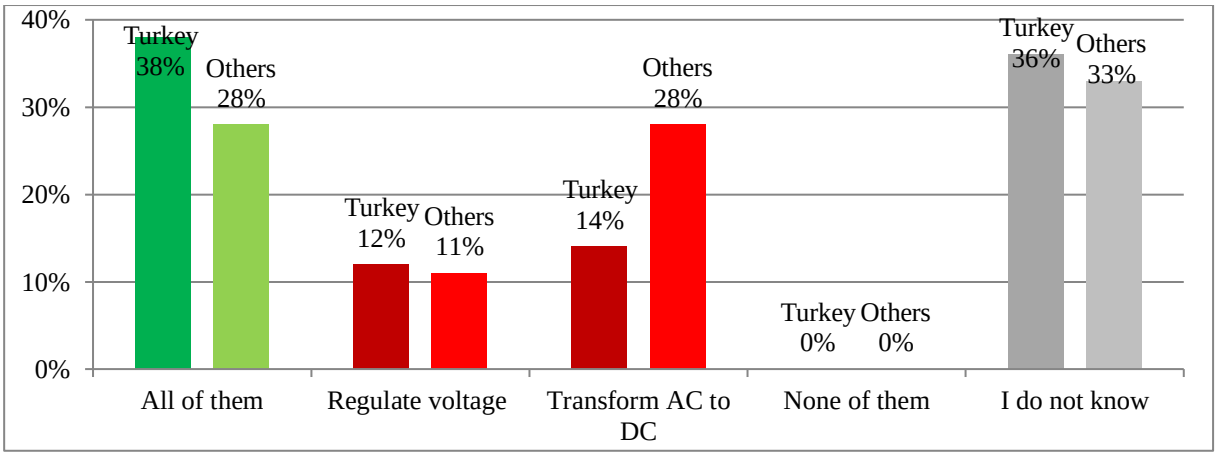

Figure 5. What a power supply is used for inside a desktop PC

Case 6: Robotic vacuum cleaner

Theory: Transducers and actuators (Th5)
Components: Electromechanics (K5) and sensors (K9)
The participants are asked what type of sensor is unsuitable for a robotic vacuum cleaner to detect obstacles without contact. Designers should know that limit switch is typical for detecting contacts. And one, who reasoned that infrared is an invisible frequency of light and ultrasonic is a term related to sound, might conclude that these two options do not require contact. As presented in Figure 6, participants in Turkey answered remarkably less correctly than the total of other countries.

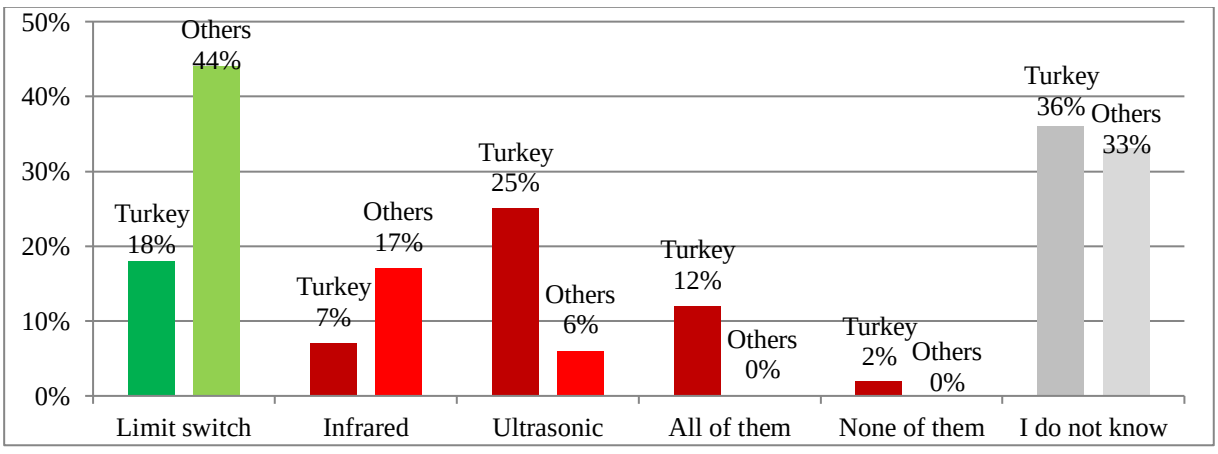

Figure 6. The type of sensor which is not suitable for detecting obstacles without contact

Case 7: Electric oven

Theory: Transducers and actuators (Th5)
Components: Sensors (K9)

The participants are asked to decide on the component that measures the inner temperature of an electric oven. And a display digitally shows the value. As resistor is a heating element, it is a distractor choice. Almost all of the participants reasoned that a resistor is not suitable. On the other hand, one-third of the participants from countries other than Turkey, decided that a bimetal thermostat is preferable (Figure 7). A bimetal thermostat may be considered a sensor. Yet, it is more of a switch which activates when a specific temperature is reached. Therefore, designers are expected to reason that bimetal thermostats cannot make measurements.

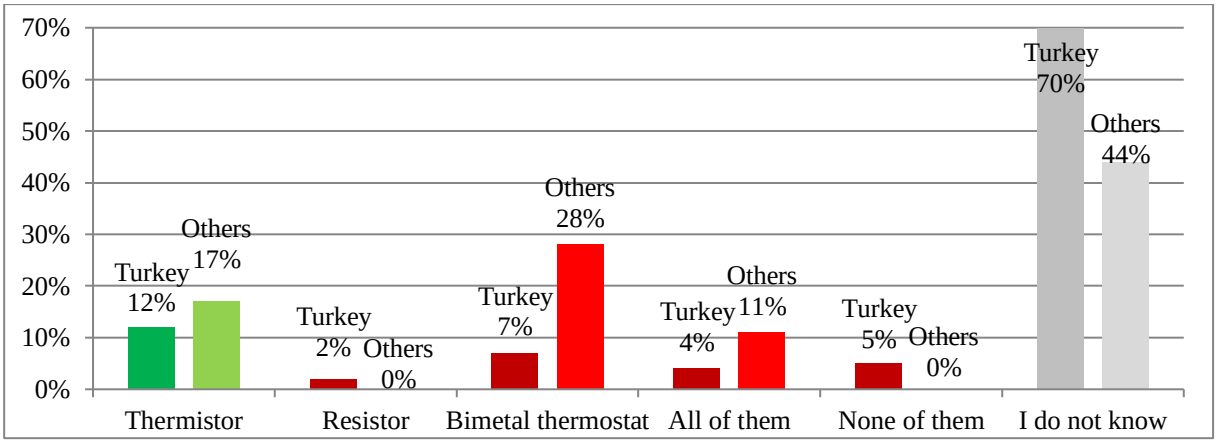

Figure 7. The type of component which is suitable for measuring the temperature of an oven

Case 8: Medical device

Theory: Transducers and actuators (Th5)
Components: Electromechanics (K5) and sensors (K9)

The next case is a device that injects medicine precisely into a patient's vascular access. The participants are asked to determine components that may serve the purpose. They are expected to know that injecting fluids can be done by pumps. And the pumps are driven by motors. Designers, who learned the terminology of transducers and actuators, should reason that stepper motors and encoders offer precision control. And feedback from a flowmeter may help control the speed of a pump. Although that "all of them" is the correct answer, distractors present partial reasoning in the case (Figure 8).

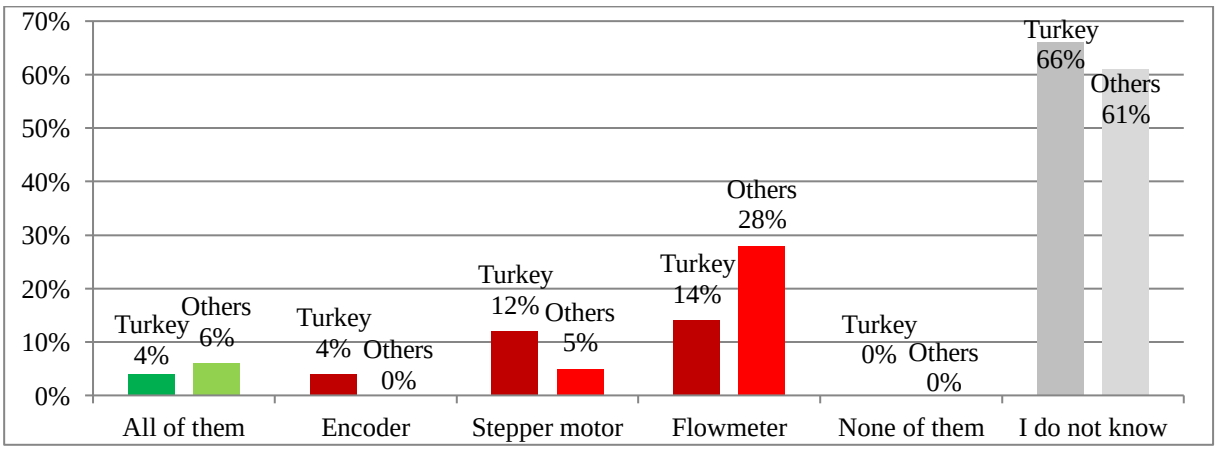

Figure 8. The suitable component for controlling the amount of medicine injection

Case 9: Digital watch

Theory: User interaction elements (Th6)
Components: Displays (K3)
The ninth case is a watch, of which the display only shows the time digitally and is always on. Participants are asked to decide what display type is the most efficient to achieve a longer battery life. The always-on requirement prevents the case from getting complex depending on various scenarios. E-inks are well-known for low energy consumption compared to all other display types. Therefore, designers should reason that it is the most efficient. Nearly half of the participants from the countries other than Turkey answered correctly (Figure 9). However, it appears that the types of displays are less known among the participants in Turkey.

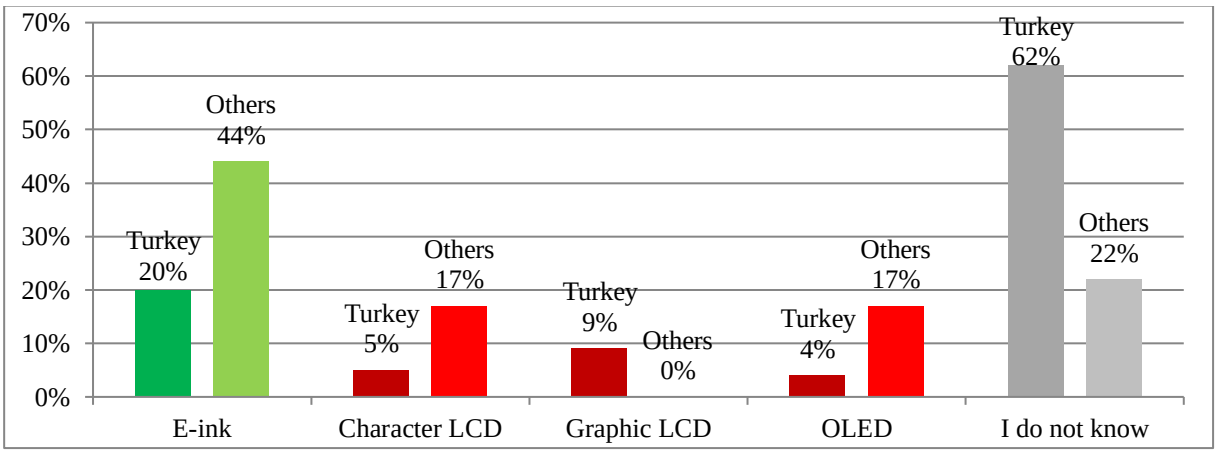

Figure 9. The type of display that is the most efficient to achieve a longer battery life

Case 10: Hair dryer

Theory: User interaction elements (Th6)
Components: Switches (K2)
The participants are asked to choose what component is suitable for adjusting the fan speed of a hair dryer. Capacitors and transistors are decided as distractors. As they are critical circuit board elements, designers may experience these often getting mentioned in transdisciplinary practice. However, they are irrelevant to the task. Therefore, designers are expected to know that these are not user interaction elements and conclude that the potentiometer is the only switch type among choices. The distribution of answers is presented in Figure 10.

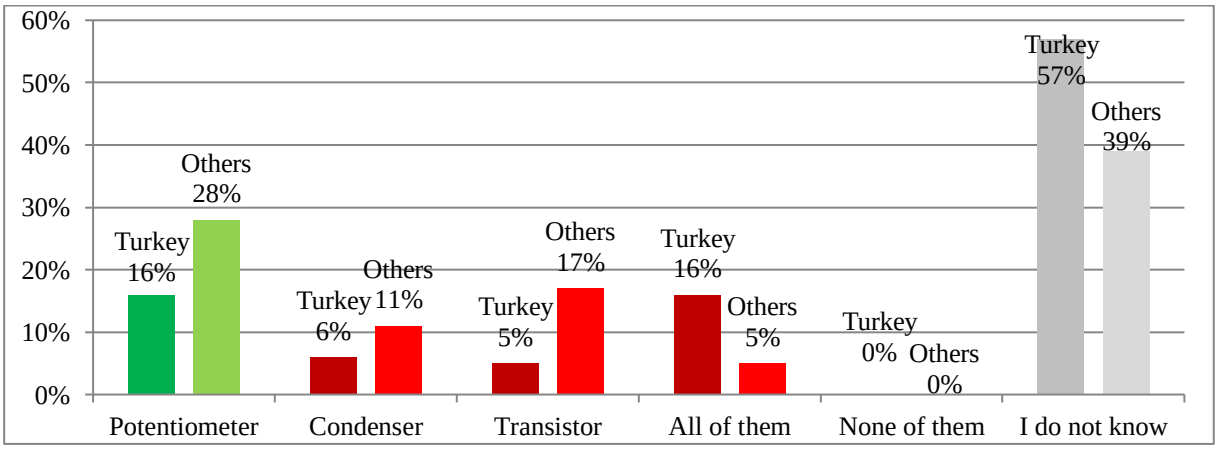

Figure 10. The type of switch that is suitable for adjusting the fan speed of a hair dryer

Case 11: Video camera

Theory: Electromagnetism (Th9)
Components: Wireless communication (K11)
The eleventh case is a video camera that transmits live footage to a cellphone. The participants are asked to decide on the material of the camera body that makes establishing wireless communication easier. Conductive materials are likely to form a Faraday cage that blocks wireless signals. Therefore, aluminum and steel bodies may limit the antenna design. Consequently, designers should reason that preferring plastics is optimal. Although the theory of electromagnetism is regarded as expert-level knowledge by interview participants, it is answered more correctly (Figure 11) than many beginner-level questions.

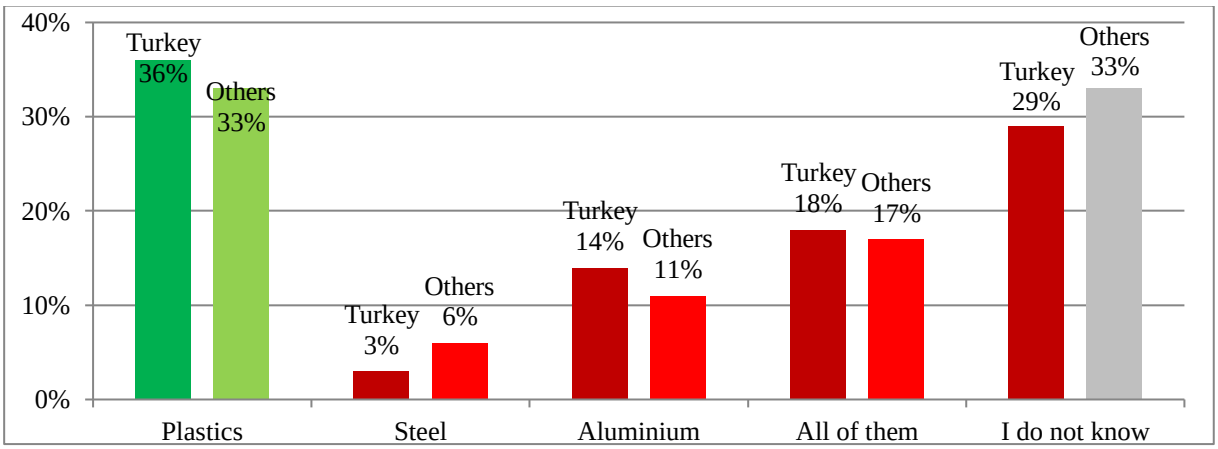

Figure 11. The material of which a camera is made to provide wireless communication easier

Case 12: Jungle fire detector

Theory: Communication systems (Th8)
Components: Wireless communication (K11)
The participants are asked to decide on a wireless communication protocol that does not necessitate another device nearby. An object that detects jungle fires by measuring temperature and transmitting the data to a fire station will benefit from the decided protocol. One who learned the theories of wireless communication systems should conclude that Bluetooth and Wi-Fi communications require receivers nearby. However, GSM is a mobile network that communicates through base stations. Although interviewed engineers decided that knowledge of communication systems is expert-level, more than one-third of the participants answered correctly (Figure 12). The participants may have reasoned the correct answer based on their everyday experiences, as connected devices are common.

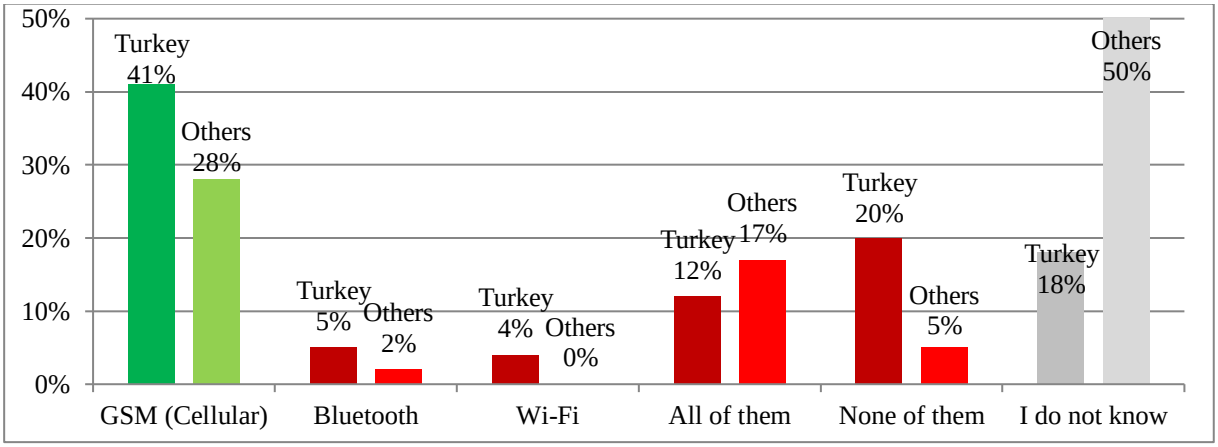

Figure 12. The communication system which does not necessitate another device nearby

Case 13: Flashlight

Theory: Printed circuit board elements (Th7)
Components: Controllers, processors and memory units (K5)
The last case is a flashlight, which operates with only one button. Yet the combinations of pushing the button should dim and change the color of the light. The participants are asked to decide on the component that is required. The Peltier is a cooling element. And the buzzer is a sound generator. Yet, a microprocessor serves the purpose, as it is a computing component where the data processing logic and control are included. Although it is classified as expert-level knowledge, more than one-third of the participants reasoned correctly (Figure 13).

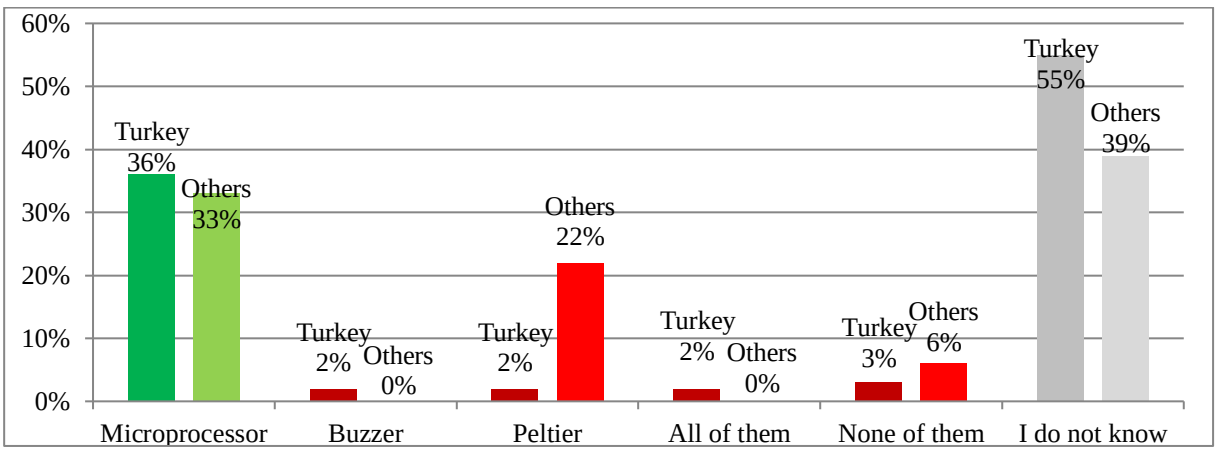

Figure 13. Survey question 13

Remarkably, correct answers given to the beginner-level questions (Cases 1-9, $\bar{x}1$=31%) are noticeably close to the experienced-level ones (Cases 10-13, $\bar{x}2$=29%). Notably, questions based on the electrical properties of materials and concepts of energy, power, current, voltage, and differences in DC and AC are given more correct answers in total average (Cases 1-5, $\bar{x}1$=41%) compared to ones based on user interaction elements (Cases 6-13, $\bar{x}2$=25%).

Although 95% of the students in Turkey have never taken any courses related to electronics or physical programming, 61% of the participants in other countries have attended at least once. However, there is no significant difference between the scores of the participants in Turkey

($\bar{x}^1$=30%) and the average of the other countries ($\bar{x}^2$=33%) despite they are trained differently in electronics (Anova, $\Delta\bar{x}$=3%, n=74, p=0.183).

The scores of the participants in Turkey are not equally distributed dependent on the program they study or graduated from (Anova, n=46, p=0,033). The post-hoc tests indicate, participants of the highest-scoring program (49%) and the lowest-scoring one (19%) are significantly different in their scores (p=0,022). Yet, there is no significant difference between the others.

86% of those who participated from Turkey and 61% of those from other countries failed to reason correctly. The highest score in Turkey is 77%. In other countries, it is 62%. Scores of graduated participants in Turkey ($\bar{x}$=29%) are significantly higher (n=47, p=0,013) than the senior year students ($\bar{x}$=23%).

Although the majority of the participants strongly agreed (42%) or agreed (32%) that they have found answering the questions difficult, the majority of them strongly agreed (31%) or agreed (31%) that an industrial designer should be capable of giving correct answers to the questions. Participants who strongly agree and disagree are more in other countries (39% and 28%) compared to Turkey (29% and 12%). However, there is no statistically significant difference in their opinions, depending on whether they have participated from Turkey or other countries (n=74, p=0,603 and n=74, p=0,429).

Senior-year students who attended or are attending the electronics-specific courses scored higher in 8 of the 13 questions. However, they scored at least 10% higher only in 4 of them, and at least 20% in only 1. Statistically, there is no significant difference between the scores of those who did and did not attend courses on electronics, except for a question. The question is about deciding on an appropriate sensor (Case 7, n=50, p=0,036). Although it is significant, those who attended electronics courses scored only 4% higher ($\bar{x}^1$=28%, $\bar{x}^2$=24%).

Discussion

The conceptual framework clarifies that the interest in electronics increased compared to a decade ago. Many programs offer electives. Some of these courses are experiential. It appears that these courses approach electronics through CDIO and systems thinking approaches. Even a few of these courses are compulsory. Considering the curricula, there is a similar trend in Turkey. However, those who attended these electives are still less than 5%. Unlike Europe, Turkey does not offer diversified design programs, except for a few engineering-titled ones. These few programs include many compulsory courses in a variety of technical domains. Therefore, arguably they should not be referred to as a version of industrial design (Akbulut, 2015).

It is noteworthy that the participants, who did not receive electronics training in Turkey or other countries, and those who did, all achieved similar scores. Arguably, designers implicitly learn a little electronics in the studio courses. And interestingly, attending a specific course had little effect on the scores. Moreover, the participants lack electronics terminology more than electrical theories. Industrial designers lacking terminology is a decade-long argument (Varekamp et al., 2014).

Designers may benefit from the knowledge they gained through courses in pre-higher education. In fact, some of the theories determined through this research concern physics

courses in pre-higher education. Moreover, many countries, including Turkey, offer compulsory courses based on electronics, robotics, coding, and technology during pre-higher education (Kılıçkaya Boğ, 2019). Besides, these courses are often hands-on. Nevertheless, teachers in Turkey criticize that they lack the necessary competencies, and are not educated to teach electronics, Arduino, and sensors (Akbaşlı & Akyüz, 2021).

Conclusions and Recommendations

Benefitting from complex electronics in everyday objects has become widespread. Therefore, the interactions between humans and machines have become more intense (Prisecaru, 2016). It is clear that many products which concern a designer presently include electronics. However, design education has not developed a common ground yet, regarding the approach to electronics knowledge. Design programs around the world have diversified. Design, industrial design, product design, and design engineering are the most common. Those which are titled engineering have already covered electronics. However, they offer curricula that consist of many technical domains. Therefore, the approach of design engineering programs to aesthetics differs from a traditional design program. They often put more emphasis on technical courses and producible designing. However, many design programs offer electives on electronics as well. Yet, many others still do not. The findings mark that these electives are less common and rarely taken in Turkey.

The motive to the study is the prediction that traditional design programs regard electronics knowledge often as out-of-field, theoretical and calculative. And it is predicted that, similar to materials and manufacturing, electronics is essential for designing better experiences more than making producible designs. Contrary to what this study suggests, digital product design is often regarded as the design of things that include displays and/or what the displays show (Oygür İlhan & Karapars, 2019). A few studies argue that interface elements, such as LEDs, switches, displays, speakers, and microphones, concern designers (Frens, 2018). However, a compact list of components and theories is missing in the literature. Therefore, this study aimed to clarify why and what knowledge is necessary by generating a list through interviews, and then to measure whether industrial designers have the listed knowledge.

The conceptual framework presents that approach to electronics in design education is not generalizable as theoretical. Multiple studies acknowledge that electronics necessitate hands-on learning. It is remarked that Arduino and physical programming are beneficial. Besides, numerous programs appear to focus on experiential teaching of electronics. And teaching via Arduino became common, both in higher and pre-higher education. Arduino is a popular programmable electronics kit that offers a plug-and-play circuit board and mountable accessories such as sensors or LEDs. Therefore, building with Arduino is hands-on. And it naturally focuses on systems thinking. However, only a few real-world objects are produced benefiting from Arduino or its plugins. While acknowledging that Arduino is paradigm-shifting in electronics education, it is debatable that it simulates the structure of an end product. The debate is rarely discussed in the papers and it may be the reason why electronics is still a bottleneck for designers (Seetsen et al., 2019).

The survey findings remark that even the terminology of interface elements and sensors is less known than the knowledge of electrical theories. Besides, the overall score in the survey is barely 30% and being trained in electronics courses had only little effect. Thus, the theories and

the terminology that interview participants mentioned as essential are not commonly known. The study recommends the below approaches to the programs which do and do not include electronics, in order to train industrial designers more in electronics:

- Electronics courses interest more design programs.
- It is argued that making decisions on which electrical theories and components concern and communicating in the electronics terminology while collaborating with engineers is an industrial designers task, as well as product designers and design engineers.
- Electronics courses might be given compulsory in more programs.
- Components and theories affect fundamental aspects of an object. Therefore, it is argued that electronics knowledge should be emphasized as much as materials and manufacturing.
- Electronics should be trained using other hands-on methods in addition to Arduino.
- Courses often focus on building circuits via Arduino. Whether over-emphasizing Arduino limits the learning of real-world design problems is a debate. Yet, the discussion is beyond the purpose of this study. However, another approach is worth further researching: Tearing down objects (Romero et al., 2012). It is hands-on. And it may fit the CDIO approach because the C stands for conceiving.
- Electronics education should focus more on the terminology and the basics of electrics.
- Terminology and theories knowledge in electronics education should be in balance with experiential learning. The study argues that an interactive learning kit may be beneficial to achieve this balance. The learning kit should issue terminological and practical real-world design problems via teardowns, comparisons, and reviews. The authors plan to design and test the learning kit as a further study.

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Design and Technology Education: An International Journal

28.1

A Study on Designers' Attitude for Open Innovation in Turkey

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Abstract

In design education, students benefit not only from their project courses' content but also from the information resources they contain. When it comes to the repetition of unique problems and solution-oriented approaches in the design professions, the resources used to research solutions for the problems encountered in design education are also specific to that problem. This situation highlights resource diversity, and especially resource sharing, at various stages and thus opens a view into innovation habits among designers' behaviors. This empirical study explores whether or not designers' behaviors can be related to their practices in design project courses, regarding their open innovation tendencies. Semi-structured interviews with 20 designers are used to form a case study. Interviewees had experience with both in-house designers and freelancers, therefore purposive sampling was used. The results were analyzed thematically and discussed under open innovation practices.

Keywords

Industrial Design, Industrial Design Education, Open Innovation

Background

Design has recently been recognized as a trigger of innovation, as opposed to being considered only one stage of a larger process. Its relevance in managerial processes has been discussed in the literature. As open innovation may be considered both an innovation strategy and a management style, its relationship with design is also discussed in the literature.

Open innovation mainly refers to opening the innovation process to cooperation with others, as opposed to the formerly closed practices where the ideas are solely built within companies (Huizingh, 2011). Open innovation requires interaction and information sharing with others; Enkel et. al. summarize possible information transfers in three groups. Where the outside-in process refers to bringing information from other companies, the inside-out process refers to sharing ideas with others and the coupled process is a combination of both through alliances and cooperation (Enkel et. al, 2009).

Many studies that explore design's assistance with innovation and management focus on its potential to facilitate the abilities needed to solve so-called "wicked problems" and to create a basis for novelty (Cooper et al., 2009; Johansson-Sköldberg et al., 2013; Lockwood, 2009; Verganti, 2009). Design education has the potential to facilitate individuals' managerial capabilities, therefore some have argued that a more holistic understanding of the application of designers' capabilities can be applied to the topic (Boyarski, 1998; Buchanan, 2004; Owen, 1990). Buchanan (2001) stresses that the skills and knowledge bases of designers originate from various disciplines, so that they may act as supporters and implementers of managerial

activities and innovation strategies. Studies that evaluate design as a source of innovation have suggested that design is a factor that should be considered as an element of its own when creating novel ideas, as it is just as effective as technology for facilitating innovation (Norman & Verganti, 2014; Verganti, 2009).

When observing the evolution of innovation processes, Rothwell (1994) argues that innovation becomes increasingly integrated into industrial environments and potential buyers through networks. By developing information technologies, buyers and users become more integrated into the process, addressing innovation strategies that are suggested in design thinking (Brown, 2008). The tendency in innovation practices to be more open through networks and the inclusion of customers in the process may also address the tendency of using design and design-related practices in the same, as discussed in the literature (Acha, 2008; Christiansen et al., 2013).

Education is known to enhance and facilitate professionals' functional capabilities; therefore, an examination of design education provides clues about the main competencies of designers, making it possible to understand their potential value in innovation processes. Ozkan and Dogan (2013) assert that the operation and functioning styles of senior design students are similar to those of design professionals; therefore, the structure of design education can shape design professionals' behaviors. Its investigation may also suggest designers' potential in a business environment.

The projects completed by design students typically include draft and brief professional design practices; students aim to finish a design project within a given timeframe by themselves or while working with a group. The design research that designers conduct through design education plays a major role in their professional design practices (Buchanan, 2001).

Since the behaviors and preferences used in a school design project may shape students' future professional tendencies, an exploration of their design activities and research choices may shed light on their future professional capabilities and propensities. However, the differences between real-world situations and students' assumptions make it important to explore whether a major change happens in the students' research tendencies after graduation.

This study seeks to build upon a prior investigation where a survey was conducted with industrial design students to determine whether a link existed between the habits of students and the open innovation concept. As a possible correlation was found, the study has been extended to explore whether the behavior of design students is reflected in their professional practices (Eroğlu & Ekmekçioğlu, 2018). To gain a more comprehensive understanding of the subject matter and to determine if there have been any changes in preferences, this study aims to compare the tendencies of design students and professional designers concerning information-sharing. To make this comparison, 20 designers were interviewed to determine if their actions in their design project courses are reflected in their current professional practices. To provide a more complete evaluation, designers with both in-house and freelance experiences were chosen for these interviews, to investigate if corporate restrictions affect designers' research preferences. Moreover, their research preferences as freelancers may provide hints concerning the effects of design education and design project courses on their innovation behaviors. Finally, the study evaluates whether design education and design project courses affect designers' potential for open innovation practices.

Open Innovation and Information Sharing

Sharing knowledge is mentioned to be one of the crucial aspects of open innovation (Enkel et. al, 2009; Costa et. al, 2021). In the literature, both "information" and "knowledge" are used to describe intellectual inputs that are shared between co-workers and organizations (Bogers et. al, 2019; Oh & Choi, 2020). In this article "information sharing" term will be used to describe sharing of any kind of data with an intellectual value that may be vital for the development of ideas and projects.

Sharing intellectual property that is developed inside the company is one of the ways of seeking collaboration and commercial potential. Enkel et. al (2009) refer to the "inside-out process" to speed up the process of commercialization of ideas; through sharing intellectual property with other companies, organizations may broaden their market scope through tools such as licensing, joint ventures, etc. While this view focuses on gaining revenues faster than the internal development processes; Chesbrough (2004) stresses the exploring potentials of projects that are no longer continued by firms as they are thought to lack commercial value for the organization. By sharing these intellectual properties, companies can see if there is an interest in the market, which will lead to reconsideration of the intellectual property from different viewpoints (Chesbrough, 2004). Regarding the risks of knowledge sharing, Borgers et. al (2019) mention the necessity of careful management of information transfer among firms to avoid unwanted knowledge leakage.

Singh et. al (2021) address another aspect of knowledge-sharing and open innovation; suggesting that sharing behaviors among co-workers enhance intellectual productivity and pointing out that knowledge-sharing behaviors directly support open innovation. Another study that points out the individuals' role in the success of open innovation suggests that the willingness of team members to share information is an effective element for project success (Oh & Choi, 2020).

Since knowledge sharing between companies and co-workers seems to be an important element of open innovation and the individual behavior of the employees affects overall open innovation success, evaluating industrial designers through their natural knowledge-sharing habits in project courses could hint at their potential for open innovation success.

Project Courses and Their Relevance to Open Innovation

Project courses are a core element of design education (Wang, 2010), as they are considered the venues in which other relevant design-related knowledge should be implemented (Findeli, 2001; Schön, 1988). When the behaviors of design students working on design projects are evaluated, these evaluations are often somewhat in line with open innovation concepts. In this study, the term "behaviors" is used to describe actions that are more unstructured and instinctual, while the term "practices" is used to describe actions that are structured and outcomes of educational and work environments.

Many scholars have underlined the vagueness of the process. The structures of design education programs, and design projects, are complex (Wang, 2010). The problems tackled are, by nature, ill-defined and they involve real-world problems that are solved at different paces by employing varying sets of knowledge (Easterday et al., 2018). This reflective learning and improvised nature of design education and design projects are found in many designers’

professional practices (Waks, 1999). Along with a trial-and-error structure and the habit of testing ideas by gathering data from outside (Wang, 2010), these qualities may reinforce designers' open-innovation practices.

Another aspect of design education and management to consider is that project courses are collaborations. Students are integrated into a design firm's daily environment during project courses, and they are critiqued along with their fellow students. In the process, students find themselves in other students' worlds (Uluoğlu, 2000). Sometimes, they study in groups, but otherwise, they work on their own to build both a sense of fairness and teamwork (Soliman, 2017). Many studies address the practice of group work and the dynamics of knowledge-sharing (Schön, 1988; Shih et al., 2006). During group discussions, students build their visions and manage data, though they may not always be engaged in interdisciplinary work Research and case studies are also vital for project courses (Soliman, 2017), as they force students to work together to collect data and learn from one another (Kuhn, 2001; Shih et al, 2006). Their research media can vary from basic internet sources to online feedback, former practices of well-known professionals, and social networks (Ham & Schnabel, 2011; Soliman, 2017), all of which somewhat reflect the sources that may be applied in an open innovation environment. During the design phase, students sometimes assume different roles (Schön, 1998) and can then give each other feedback on their projects, a form of peer learning (Kuhn, 2001). They also help each other to solve design problems and come up with solutions, though this undermines the fact that their designs are their intellectual property (Shih et al., 2006).

Even though students are encouraged to act as if intellectual property is not something to be protected, they still act as if they are in a competitive environment and often face the dilemmas between sharing and hiding, or cooperation and competition (Shih et al., 2006). These situations resemble the balancing act of being open and closed in open innovation settings (Odriozola-Fernández et al., 2019).

Open Innovation and Design

Today, design is considered both a source of innovation in general and a supporter of open innovation (Acha, 2008; Verganti, 2009). Although innovation features prominently in the literature, design is often ignored (Hobday et al., 2011). This is mostly due to the perspective in earlier studies that saw innovation because of scientific improvements (Cooper & Press, 1995). The development of innovation was regarded as a transformation process that began with research, led to technology, and then to the emergence of an innovation (Trott, 2005). Recently, new approaches have appeared in innovation studies.

Verganti (2009) studies innovation through the aspects of technology and meaning, where the former refers to novelties that can be related to technical improvements and the latter refers to the changes in a product's meaning created through its design. Both aspects display radical and incremental improvements, as design-driven radical innovations are the result of research into the meaning, and incremental innovations are generally formed by the tenets of human-centered design (Norman & Verganti, 2014).

Designers can support open innovation practices, and user involvement is a critical aspect of them (Gassmann et. al., 2010). Working with users is the core aspect of human-centered design and is frequently used to improve existing products. This is discussed in the concepts of design

thinking (Brown, 2008; Cooper et al., 2009). Designers can include lead users in their design processes to help develop novel ideas (Urban & Von Hippel, 1988).

Another aspect that is stressed in design thinking studies is the ability to cope with uncertainty. Cross (1990, 2001, 2004) underlines these aspects in his work. This ability of designers is also referred to as dealing with "wicked problems," which are, by nature, hard to describe (Buchanan, 1992; Dorst, 2011; Rittel & Weber, 1973). Cross (1990) also draws attention to designers' ability to work with incomplete data and to apply their imaginations in defining and solving uncertain problems in novel ways. These abilities may support companies' open innovation potential, as open innovation may result from the company's design practices, given that design can enforce more open strategies (Acha, 2008). Design is also considered a tool for strategic problem-solving (Hobday et al., 2012), considering that its tendency to openness may affect workers' overall approach to open innovation.

In addition to the above, design enhances innovation activities by supporting knowledge mobility. Researchers who promote radical design-driven innovation bring together designers from various disciplines and other professionals to create a multidisciplinary working environment (Dell'Era & Verganti, 2010). In creative industries, workforce mobility is higher than is common in other fields, as designers are often willing to work in many areas; this may facilitate their knowledge transfer through their mobility and the natural habits of their business practices (Chesbrough, 2012). Designers and design offices can also transfer knowledge, information, and trends among organizations (Verganti, 2003).

Case Study

Research Context: Industrial Design Education in Turkey

Industrial design education in Turkey was first considered through the U.S.-sponsored Marshall Aid Program in the early 1960s; however, the first department in Turkey was not formed until 1971 — at the Istanbul State Academy of Fine Arts (Asatekin, 2006; Küçükerman, 2006). In the early days, industrial design education was not considered necessary (Er, 1993; Özcan, 2009). In the 1960s, architectural and interior design academies mainly supported the formation of these curricula (Celbiş, 2006). Since educational systems that stemmed from other disciplines were adapted, rather than having their language, industrial design education was a derivation of other disciplines and countries' education systems (Bayazıt, 2006; Er & Er, 2006; Er et al., 2003; Flores, 2000; Günal Ertaş, 2011). The early academicians in some industrial design departments were mostly interior architects who held graduate degrees from schools located in Britain, Japan, Germany, Canada, and Italy (Celbiş, 2006). For these reasons, design education in Turkey shares elements with other design disciplines, such as architecture and interior design.

As a result of adaptations, Turkish design education programs historically developed around two main disciplines, the LYS (undergraduate placement examination) and aptitude tests. Through the LYS, students' abilities to solve basic scientific problems related to math and physics are evaluated. In aptitude examinations, students are required to make hand drawings that address the requirements defined by the judging instructors. After 2017, the aptitude tests were abandoned, and today all design departments accept their students based on LYS scores.

Industrial design education recently found its tone after being shaped through the lenses of architecture and interior design education. Industrial design education, mainly via project-

based courses, aims to reinforce students' own identities, styles, and design ideas (Balcıoğlu, 2009). Today's design students are evaluated in terms of the design process, in which their responses to various aspects are questioned alongside the development stages of their designs, rather than being judged solely on technical and aesthetic elements. Design project courses are regarded as the core element of design education, as these are where knowledge gathered from other courses is applied; this design project-centered view of education is in line with the approaches used in other design disciplines (Wang, 2010).

In the present study, graduates from a variety of disciplines in Turkey are included; all of them are, or hope to be, employed under the title "industrial product designer." This sampling provides a more holistic "designer" profile for our study, as it is common to choose students for programs based on a variety of criteria. At the same time, it should be noted that these selection criteria may also affect students' preferences for conducting research. Different types of problem-solving approaches are defined in the literature (Dorst, 2003), and they may lead to different profiles among designers, based on their educational backgrounds (Resnick, 1999).

Research Design

The empirical study is based on semi-structured interviews with 20 industrial designers to form a case study (McGregor, 2017). 12 designers are undergraduate graduates, 6 of them are graduates and 2 of them are doctoral graduates. All designers' undergraduate degrees are in industrial design and they are all actively working in the industrial design professions. In addition, all participants have 10 to 20 years of professional experience. While selecting the sample of designers, it was considered that they were familiar with both current and past methods and tools of information sharing. The reason for this preference is that while the instruments that are available in design education may differ between the past and present, the instruments used in design processes in today's business world are independent of the designers' graduation years.

The interviewees had experience both as in-house designers and freelancers, therefore purposive sampling was used (Gray, 2004). The designers had experience in the yacht, automotive, furniture, ceramics, wearable products, packaging, household appliances, lighting, and exhibition industries. The research was conducted in the form of open-ended interviews with the participants. The following questions were asked to understand the information sharing of the participants both while working as students, in-house, and freelance:

- What were the sources you used to get information about your design activities when you were a student?
- When you were a student, did you share information in your design activities? What would you pay attention to while sharing?
- What were your sources of information gathering in your design activities while working in the company?
- Would you share information with those outside of the company while you are in the company? (Unfinished, abandoned project, found technologies, etc.) ... What would you pay attention to while sharing?
- What are your research/information sources in your design activities while working as a freelancer?

- As a freelancer, do you/would you share information in your design activities? What would you pay attention to while sharing?
- What do you think a designer should prioritize while exchanging information? Why is that?

Due to the Covid-19 pandemic, interviews were conducted online. Each interview was recorded and transcribed. The transcriptions were read for thematic coding to identify repetitive tendencies within three different practices (Flick, 2018). The results of the thematic analysis for each case are seen in the tables (Appendix A, Appendix B).

Designer Behavior in Education Phase

Sources that Students Use

The interviewees declared that they utilized global and local sources along with expert opinions.

Global sources that can be reached by everyone globally were mainly online sources such as the internet and design blogs. Surely, the utilization of these sources depended on the era and some of the older designers declared that they were not able to reach them at the time of their studentship. However, younger designers mentioned these as their main research media.

> *"... blogs were very popular back then, Blogspot was popular, now that I think of it, it's something else. We made working speaker models with the help of Blogspot while we were doing a speaker project. I remember there were such blogs of people who were very interested in sound systems. I remember finding and reading something there."*

Local sources which were within the physical reach of the students were libraries, printed media, events, sources of other disciplines, and potential users. Some designers declared that they couldn't utilize the Internet at the time, and they were mainly dependent on libraries and bookstores. Arts exhibitions and design events along with industrial exhibitions were also attended by designers while they were students to get inspiration and information. Attendees mentioned that they were used to talking with companies in industrial exhibitions to gather information about certain products and technologies. Also, some of the designers mentioned that they took advantage of being in a campus environment and got information and printed resources from instructors and students of other departments. Finally, gathering information about user tendencies from salespersons and users was also applied to get more information about the design context.

> *"Other than that, we made a lot of observations, especially for user research. We used to record them and analyze them later."*

Instructors and professionals were also present as information sources during design education. The interaction with these people were mostly knowledge transfers, where the refined knowledge from experience was passed to students.

> *"...I decided to do a graduation project without even knowing what sanitaryware means, and there, of course, there are companies with some departments. They directed us to the relevant departments; this is produced like this, that is produced like that..."*

Information and Knowledge Sharing Among Students

Designers declared that when they were students, they shared both information and knowledge and also, and they naturally shared these as a result of the daily networks.

Many of the designers mentioned that they were part of real-life networks with both their classmates and students from other disciplines in faculty buildings or dormitories. Therefore, information was shared in physical spaces like classrooms or working spaces in dormitories. Also, it was easier for them to show their peers how they work with a certain design program or technique. They mentioned that they brought materials and books to their networks to share with their friends in the faculty.

> *"... I think we nurtured each other more as a class. I mean, I hope it's not unfair to my professors when I say I've learned more from my classmates than I've learned from them."*

Regarding information sharing, designers declared that sharing information and not hiding it from peers were common behaviors in university. They also declared that they frequently worked together and brainstormed together. Some designers mentioned that because of the juries, sooner or later they had to share their ideas. They stated that as everyone followed a different path even though they worked on a similar concept, sharing information was not a concern for them in terms of originality.

> *"Because everyone develops their problem and their solutions, the solution that they bring to a problem... I think that the solution that others bring, even if it is the same problem, will be different. Because of this, we didn't hide information from each other, at least it was the tendency around me."*

Designers mentioned that they also shared knowledge through teaching each other and providing criticisms about projects among peers. They declared they taught each other to learn computer programs and more specific knowledge about different courses such as technical drawing. They pointed out that it was usual for them to get criticisms from their peers to improve each other's projects.

> *"When you're telling the person in front of you about your project and when you make a presentation, you present your arguments, so that your friend can provide an answer and the work can get better. We didn't have such a restriction you know, like anything to hide and keep some parts myself, we didn't act like that."*

Although many of the comments reflected an open behavior, some of the designers also defined preferences that can be considered as hesitations, such as closeness and concern about keeping originality.

> *"But I had an idea like this, and if I wanted to keep it, I wouldn't have done it (sharing) until the first presentation, but when I say, "I wouldn't have done it", it's not in the sense of keeping information, you know, I had concerns about copying, etc."*

In-House Designer Behavior

Sources that In-House Designers Use

Attendees specified global sources and local sources as their main tools for research. Designers declared that while working as in-house designers they frequently employed global sources. These are the sources that can be reached globally and are mainly internet sources and expositions. The Internet was mentioned more frequently here as this section is not mainly about past experiences and many of the designers could use the Internet with more efficiency after their graduation. Also, they mentioned dedicated websites and apps such as Pinterest, designer blogs, and design competition websites. Also, as the organizations they worked for provided the opportunities they frequently mentioned expositions and exhibitions among their primary sources. They mentioned they visited both sectoral and non-sectoral expositions.

> *"I was working in the furniture sector, and I was attending fairs in the ceramic sector."*

> *"And of course, the WGSN fair is very useful for me as I have access."*

Local sources were mainly printed documents, local networks, and local events. Among printed documents, the archive of the organization was frequently mentioned and design magazines, dedicated industrial magazines, product catalogues, trend books, and exhibition books were mentioned. Local networks included sources from other disciplines and user participation. Sources from other disciplines were suppliers, craftspeople, and other designers such as architects. They mentioned working with lead users during the concept phase and the participation of regular users in the market research and concept testing phases. Finally, events such as lead user briefings, education programs, and seminars organized by the companies were mentioned among the sources.

> *"If there is information to be gained, there may be courses specific to that project, certificate programs of competence, or technical tours. These may be related to the new material or the production method."*

> *"Besides that, we were bringing consultants within the scope of the project, for example, from abroad, the racers, sailing racers for example."*

Information and Knowledge Sharing as In-house Designer

The information-sharing tendencies are evaluated under four sections real-life networks, information sharing, knowledge sharing, and hesitations about openness.

As real-life networks, both networks within and outside of the companies are mentioned. Networks within the firm include both natural interactions during work along with the help provided by colleagues. But designers also mentioned that they share information with the people outside, such as design offices they work with, universities, suppliers, the design community (through research reports and even some of the competitors.

> *"But when our friend working for the competitor asks where you have the packaging for cookware produced, I would share the information of the packaging companies we work with. I mean, why worry if they work with them?"*

Information sharing mostly refers to information sharing among colleagues outside the business context. The main motive is to help the careers of designers.

> *"There was Coroflot and even an advertisement on it like 'send your designs for our book'. The designs were to be published in a book or something. I have sent it to my close designer friends."*

When talking about knowledge sharing, designers stressed sharing their professional experience and personal knowledge. Sharing professional experience means transferring the knowledge gained through career to peers and students, while personal knowledge sharing refers to knowledge that originated from designers' interests or personal capabilities.

> *"We had colleagues who said, 'Those who want to learn Maya, raise your hands!', and they stayed after hours to teach without getting paid for it."*

Again, there were hesitations about openness which could be grouped under closeness and concerns about intellectual property rights. Closeness is more about designers' concerns about a project getting copied (even within the organization), while intellectual property rights concerns were mostly enforced by companies.

> *"When I turned around, I saw him looking at my screen and he stood up and developed my product without asking me. The situation was he was trying to develop and imitate my project visually."*

> *"We already had a contract, and that contract was protecting the client. A general innovation privacy contract."*

Freelance Designer Behavior

Sources that Freelance Designers Use

Designers mainly referred to global and local sources when they talked about their main research tools as freelancers.

They referred to internet and trend reports as global sources. In this section, as there is a lack of organizational financial support, answers are closer to the tendencies of students.

> *"As I said, as a freelancer, I need to research trends more. I also get support from YouTube or Google, or trend reports from large companies while researching trends."*

Local sources that are mentioned are more varied; printed sources, sources from other disciplines, expert opinions, user participation, and events are the sub-themes of this section. Printed sources that were referred to are magazines, libraries, and catalogues that are provided by clients. Sources from other disciplines include people such as architects and animators through personal networks. Expert opinions refer to both professional links with organizations such as suppliers and producers along with experts that are reached with the help of other colleagues. User participation includes surveys and product comments on various websites, while events refer to expositions.

> *"Our friends we work with, those I work with, are industrial design graduates. Because my friends are also involved in different industries, for example, when it is necessary, you know, I get help from them about other areas where I'm not a professional."*

Information and Knowledge Sharing as Freelance Designer

Information sharing as a freelance designer is evaluated in three categories: real-life networks, information transfer, knowledge transfer, and closeness.

Real-life networks are mostly shared data with other designers. Designers share data they got from certain databases, photos, expertise about a certain industry, design ideas, and such.

> *"I try to share all I know in terms of exchanging ideas with those around me. It further enhances the exchange of ideas so there is no such thing as keeping information. That's how I proceed."*

Information transfer is mostly among designers and other professionals or students. Designers share information with others to enhance information networks and pass the information to other generations. They also believe it nourishes the suppliers and improves their work.

> *"It should not be overemphasized, it turns into paranoia at some point, I think knowledge is not that valuable. It is when you do something with it, that it turns into something."*

Sharing knowledge includes sharing work experience and personal acquisition. Sharing work experience is mostly with interns, companies, and sometimes with colleagues. Sharing personal acquisition is sharing networks and information about how to utilize programs and such.

> *"(Sometimes I say to my colleagues) 'Look, I have such products'. You know, maybe there are designs that you can show your customer."*

Closeness is mostly about ethical concerns and forced intellectual property rights. Even without a written contract, some designers find it unethical to share information or designs. When they sign a contract, they are obliged to keep the data closed and they do so.

> *"Again, it's based on personal trust, but as I find it ethically wrong, we have never done this (sharing data) before.*

Designers' Thoughts on Sharing Information

Designers' tendencies about sharing information are evaluated under two sections: openness and closeness.

When it was asked how information sharing among designers should be, designers emphasized that there should be communication between colleagues. It is stated that connections between designers enhance both the business and design itself. Another aspect is turning information into an open source for all designers. Designers declared common knowledge such as trend reports, materials, and such can be reached through open sources, and they appreciated online platforms such as Pinterest. According to interviewees another benefit of openness is avoiding

information pollution; as today there is too much information on the internet, designers may help each other to avoid wasting time in a struggle to find useful information.

> *"I pay attention to… for example, you know now when we receive information from the internet, yes, sometimes we share it, but now there can be information pollution."*

When they talk about keeping information from others, their concerns are mostly commercial. Intellectual property rights are one of the main concerns for designers. They strongly believe that any information that is specific to a company should be kept secret. They also mention commercial concerns; they mention that they don't want to lose their competitive advantage to other designers. Finally, among ethical concerns, they mentioned they find it unethical to share any data about a company with anyone outside the business (not only colleagues) even if there is no written contract.

> *"I think the ethical part should be prioritized. If you made something original and you go and use it somewhere else, it doesn't seem very ethical to me."*

Discussion

General Description of Practices

The interviews indicated that designers understood open innovation, both during their time as students and in their professional practices as in-house and freelance designers.

As students, the education environment enforced the sharing of ideas, even at the concept stage, which led to the inevitable exchange of ideas. As students, the designers learned that a single design problem can be resolved by a variety of solutions. They also reported their tendency to share information about techniques and materials, as they were more focused on the differentiation of their final solutions. They also noted that they tended to keep their final solutions to themselves until a certain point. Also, due to the nature of the education environment, most of their information sources were open ones, and they were used to interacting with their peers to get information.

As in-house designers, naturally, the designers reported some closed resources, such as archives, that only the employees of a company may access. However, the open sources they used during their education are still in frequent use. When sharing information, professional designers are more careful since their works are directly related to the intellectual property rights of an organization. Nonetheless, they continue to share information both within and outside their companies. Sometimes, they mentioned keeping a distance from their colleagues, as if there is a competitive environment within the company, but generally, they are eager to teach skills and knowledge to other designers within the company. Outside of their company settings, they share information with others for educational purposes, they inform their networks about beneficial information, and they even tend to bend company restrictions to enhance others' capabilities.

As freelancers, designers seem to have more control over their design ideas, and they share them more freely with their friends. They also share knowledge and information with younger designers and peers. However, they are still bound to agreements they make with their clients, and some designers tend to keep their intellectual property to themselves, to preserve their competitive edge. Their information sources are the same as the sources they used throughout

their education, though supplemented with the addition of clients, suppliers, and their more advanced personal networks.

When designers talk about their thoughts on sharing information, they refer to the natural processes of design actions and typically separate information and certain knowledge from seeking a competitive edge. They are in favor of sharing and open-source use, as they believe data itself does not solely create intellectual property, whereas the unique synthesis and interpretation of the data, which leads to a design, does. Although they are often restricted by contracts and agreements, they tend to share information but are certainly hesitant when it comes to sharing material that creates a competitive edge.

Comparison of Practices

It can be understood that within each different practice, designers gather and share informatively. However, not surprisingly, there are differences between actions, as practices occur in various environments and under differing restrictions.

While gathering information, ease of reach is an important factor for preference of the source (Table 1). Internet and design events are equally preferred among the three different practices as they are open for designers from all levels. However, some of the sources are accessible for certain practices; libraries and academic staff are more accessible for students while exhibitions are financed by companies and therefore are more accessible for in-house designers. Freelancers are not backed up by corporate structures such as universities or companies, therefore they rely more on their network and highly depend on experts and share information with colleagues. Printed sources are accessible to students and in-house designers, as they are financed by organizations such as firms and universities. Sources from different disciplines are easy to reach on campus and in office environments and therefore are mostly used by students and in-house designers.

Trend reports are more utile for freelancers as they provide intense insight that freelance designers cannot obtain on their own. User participation is valuable at every stage; however, the type of participation may change from snowball sampling at the student level to organized focus groups at the corporate level. Event participation may be seen at each level but can be more frequent if backed up by a corporation.

Table 1. Information gathering motivations according to the designer's stages

Information Gathering		Designer's Stage		
Codes	Motivations	Student	In-House	Freelance
Global Sources	Internet	+	+	+
	Design Blogs	+		
	Sources From Different Disciplines	+	+	+
	Exhibitions		+	
	Trend Reports			+
Local Sources	Libraries	+		
	Printed Sources	+	+	+
	Events	+	+	+
	User Participation	+	+	+
	Instructors	+		
	Experts	+		+

Regarding information sharing, it is defined by abilities and restrictions (Table 2). Most freelancers sign binding contracts so they are careful not to share any business-related context with those outside of the company. This tendency is only seen in in-house designers, probably because they have a better understanding of the limits they are required to obey. However, as freelancers, designers support openness more. This may be related to the perception that as in-house employees; designers feel that their expertise should serve the company that they work for. While they as in-house they share knowledge, and they frequently mention cooperation practices, such as the projects they conduct with universities. They also do not share information with colleagues, while as freelancers and students, they frequently do. Designers refer to openness more when talking about their practices as freelancers and students, as they mostly depend on open sources. They mention closeness within every practice in a sense to protect intellectual property that they expect to benefit from. Also, naturally, intellectual property concern on a legal basis is mentioned while working with companies and students do not mention this aspect.

Table 2. Information sharing motivations according to the designer's stages

Information Sharing		Designer's Stage		
Codes	Motivations	Student	In-House	Freelance
Real-Life Network	Sharing in Physical Space	+		
	Working Together	+		
Information Sharing	Personal Information Sharing		+	
	Sharing Information Among Students /Colleagues	+		+
	Inhouse Information Sharing		+	
	Information Sharing With Outside the Firm		+	
Knowledge Sharing	Openness	+		+
	Closeness	+	+	+
	Experince Sharing		+	+
	Personal Knowledge Sharing	+	+	+
	Intellectual Property Concern		+	+

To summarize, it can be said that designers have an understanding of open innovation as students, in-house designers, and freelancers based on our field study in Turkey. However, they feel obliged to be more sensitive about information sharing when they work with companies and they tend to keep the knowledge and intellectual property that differentiates them from others at every level. This tendency is also in line with the basics of open innovation, it may hamper innovation capability through being more restricted than required.

Conclusion

The results of the study suggest that industrial design students' information-sharing tendencies reflect their professional practices; as individuals' willingness to share information enhances project success in open innovation (Oh & Choi, 2022), industrial designers may be valuable assets for companies that depend on open innovation for product development.

Industrial design education enables design students to adapt their design methodology and problem-solving skills to different problem-solving areas, instead of teaching them in-depth knowledge in a particular field. This situation reveals the need to create a new information framework for every project encountered, both in a designer's school and professional life. Designers also try to use every available resource effectively for every new project. This trend, which begins during student life and is predominantly open source, is also reflected in designers' professional lives. The generally open environment of design education programs can also be related to the discipline's need for up-to-date information on various subjects and the responsibility placed on students to provide necessary information for every design

problem. Therefore, industrial designers may act as sources for various information in design practice, as they tend to scan and apply information that comes from various sources.

Due to the nature of design courses, knowledge sharing among students is quite common, and design can often be considered a case of open innovation, in terms of using design and design-related practices from a design education perspective. This study has observed that open innovation habits formed during one's design education continue in professional work, both as in-house and freelance designers. This approach may enhance information networks between designers in professional practices, which may lead to formal and/or informal networks between designers and companies to enhance open innovation practices.

The interviews with designers reveal that they have an in-built understanding of open innovation as they favor nourishing their peers while keeping their original solutions and points of view for design. One of the most striking points uncovered in this study is that designers generally want to share information mutually. The student's belief in the variety of possible solutions that can arise from the same data set encourages them to share information, and this is later reflected in real-world situations of working with mutual sources to come up with different solutions. The idea is one of the core strengths of open innovation, as it is thought that sharing information may favor companies on the way to bringing better solutions for innovation tasks along with keeping the core competitive advantage to itself. The generation of differentiated solutions through novel combinations also favors radical innovations, which is vital for the development of any industry. Therefore, design practice may also lead to radical innovations by favoring open innovation with industrial designers' information behaviors, without hampering companies' competitive advantage.

While practicing open innovation in project courses comes naturally to designers, they seem to feel restricted in corporate environments. This is an important issue because their natural habits can enhance a company's innovation capabilities in the modern industrial environment. Furthermore, designers' interpretations of open information sources and their definitions of sharing vary based on the generation in which they were educated. This study observed that the means of accessing resources, both in education and professional design life, the prevalence of digitalization in education, and changes in communication opportunities facilitated by technology can affect the quality of resources and the culture of sharing. Encouraging interactions among designers can help design practice nurture open innovation further.

To summarize, it can be said that an awareness of designers' natural habits regarding project research behavior and an understanding of their information-sharing habits may benefit companies in establishing better open innovation capabilities. As designers have a core understanding of what to share and what to keep, they may have more freedom to develop networks and manage information flow to build an effective and agile innovation practice.

The limitations of this study mainly arise from the variety of interviewees that were included. Designers from various age groups were added to the study to understand if their tendencies regarding information sharing arise from actual popular information sources or design practices. As a result of this choice, this study does not provide an up-to-date picture of current design students. The results were derived from Turkish design education, which is briefly explained and may differ from other countries with different educational practices. Finally,

while designers with experience in various industrial areas were included, the results may be industry-dependent in some cases. To obtain a more holistic understanding of a single industry, an exclusive study may be necessary.

In future studies, researchers can identify the factors that nurture designers' open innovation tendencies and evaluate design education using the latest communication and information media. This can lead to the development of more supportive design education programs.

Ethics Declarations

Data availability statement

The datasets generated during and/or analysed during the current study are not publicly available due to the fact that the data of the study was collected through interviews and there was interview confidentiality but are available from the corresponding author on reasonable request.

Conflict of interest

The authors declare that they have no conflict of interest.

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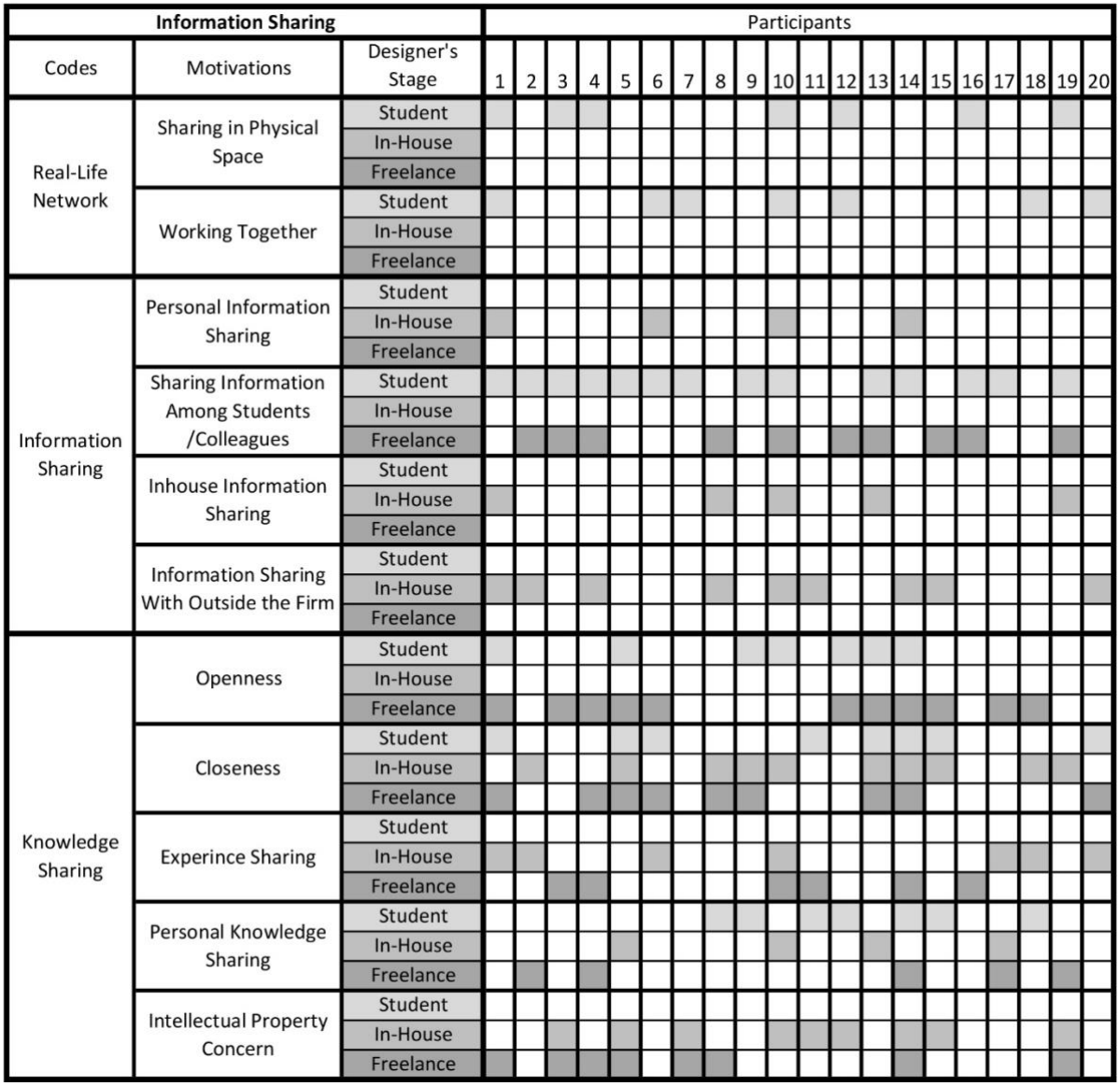
Appendix A. Designer's Information Gathering Codes and Motivations

Information Gathering			Participants																			
Codes	Motivations	Designer's Stage	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Global Sources	Internet	Student																				
		In-House																				
		Freelance																				
	Design Blogs	Student																				
		In-House																				
		Freelance																				
	Sources From Different Disciplines	Student																				
		In-House																				
		Freelance																				
	Exhibitions	Student																				
		In-House																				
		Freelance																				
	Trend Reports	Student																				
		In-House																				
		Freelance																				
Local Sources	Libraries	Student																				
		In-House																				
		Freelance																				
	Printed Sources	Student																				
		In-House																				
		Freelance																				
	Events	Student																				
		In-House																				
		Freelance																				
	User Participation	Student																				
		In-House																				
		Freelance																				
	Instructors	Student																				
		In-House																				
		Freelance																				
	Experts	Student																				
		In-House																				
		Freelance																				

Appendix B. Designer's Information Sharing Codes and Motivations



Information Sharing			Participants																			
Codes	Motivations	Designer's Stage	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Real-Life Network	Sharing in Physical Space	Student																				
		In-House																				
		Freelance																				
	Working Together	Student																				
		In-House																				
		Freelance																				
Information Sharing	Personal Information Sharing	Student																				
		In-House																				
		Freelance																				
	Sharing Information Among Students /Colleagues	Student																				
		In-House																				
		Freelance																				
	Inhouse Information Sharing	Student																				
		In-House																				
		Freelance																				
	Information Sharing With Outside the Firm	Student																				
		In-House																				
		Freelance																				
Knowledge Sharing	Openness	Student																				
		In-House																				
		Freelance																				
	Closeness	Student																				
		In-House																				
		Freelance																				
	Experince Sharing	Student																				
		In-House																				
		Freelance																				
	Personal Knowledge Sharing	Student																				
		In-House																				
		Freelance																				
	Intellectual Property Concern	Student																				
		In-House																				
		Freelance																				

Design and Technology Education: An International Journal

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Game-Based Learning in Interior Architecture Education

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Abstract

The concept of play supports the experiential and creative aspects of the design field because it is a familiar and fun phenomenon and involves interaction. The use of game-based learning in design processes will increase participation by supporting the regulation of these processes and the problematic aspects of the design studio course, which is at the heart of design education. For this reason, this study investigates the use of game-based learning methods in the design studio processes, one of the most important courses in interior architecture education. The study, which preferred the embedded theory method to develop hypotheses, one of the qualitative research methods, investigated the effects of game-based learning on the understanding of design processes and time management in a voluntary workshop with second-year students of interior architecture faculty. The study preferred a pre-test-post-test design for a single group as the data collection instrument and was supported by observations. Consistent with this preference, data collected with participants prior to the workshop were analysed and the workshop structure was created, and an attempt was made to compare the results of the game-based learning method with the post-workshop observations and survey results.

Keywords

Game based learning, design processes, design education, interior architecture education, workshops, master-apprentice learning style

Introduction

Game based learning is an informal education style for students to comprehend certain processes through experience. When using games for educational purposes according to Pivec et al., (2003) several aspects of the learning process are supported. Learners are encouraged to combine knowledge from various subject areas to choose a solution or to decide at a certain point, they can test how the game's outcome changes based on their decisions and actions, and they are encouraged to get in touch with other team members to discuss and negotiate next steps, which among other things helps them develop their social skills. In past and recent literature learning is conceptualized as a multidimensional construct which includes learning skills, cognitive learning outcomes and attitudes. Learning occurs when the learner is mentally engaged and actively participates in the game, which provides a balance of difficulty and potential future actions. We must develop an adequate education mapping to facilitate learning.

Game Based Learning

Games themselves are not new, but Kapp (2012) argues that we have reached a point when they appear to be all around us and have the special capacity to engage when we need them most. Game mechanics can be very useful for learning and growth, as well as for altering health

habits and inspiring work habits, among other things (Kapp, 2012). Most definitions of game-based learning focus on the fact that it is a kind of game play with clear learning objectives (Shaffer et al., 2005). Although it is frequently assumed that a game is digital, this is not necessarily the case. This definition has the implication that while designing games for learning, it's important to strike a balance between the desire to prioritize game play and the need to cover the subject matter (Plass, et al., 2010). This argument, according to Plass, et al. (2015), highlights the difference between gamification and game-based learning. The definition of gamification varies greatly, but one of its key characteristics is the use of game components, including incentive systems, to encourage players to participate in activities they might not otherwise find enjoyable. Like this, there is continuous discussion among academics about the precise definition of a game, particularly what does not qualify as a game (Salen & Zimmerman, 2004). A game is a system in which players engage in an artificial conflict that is governed by rules and has a quantifiable outcome, according to Salen & Zimmerman (2004). Good games, according to Plass, et al. (2015), aim for the sweet spot where players can succeed but only after some difficulty, creating what has been called a "state of flow." Good games for learning should be played in the player's zone of proximal development.

Plass et al. (2015) also suggest that there are four main functions of games that are used for learning: motivation, player engagement, adaptivity and graceful failure. All these functions are linked together. The motivational function of the games is that they contain motivating features to ensure long-term interaction of the participants. These features can be used as incentives such as stars, points, leader boards, badges, and trophies. The player engagement function is linked to motivation. When a game is used in training, what kind of participation it will involve depends on the learning outcomes of the training, the setting, and the characters of the participants. Adaptivity function can be achieved by making the game adaptive which means the participants can customize or personalize their experience. Adaptability is the ability of the game to engage each participant in a way that reflects their situation. As a function of the game-based learning processes graceful failure is an expected and necessary step in the learning process (Kapur, 2008; Kapur & Bielaczyc, 2012; Kapur & Kinzer, 2009; Plass, et al., 2010). Kapp (2012) suggests that games encourage improved learning attitudes, boost student motivation, stimulate higher order thinking, alter real-life perceptions, influence decision-making processes, and help students achieve better learning outcomes.

Interior Architecture Education

Kaptan (1998) defines interior architecture as the activity of designing and arranging interior spaces with colour, texture, material, light, furniture, and accessories according to the needs of the user and the function of the spaces within the architectural structure. Formal interior architecture education is a design-oriented discipline. The only way for students in design education to learn to design is to experience design on their own (Tuğlu Karslı & Özker, 2014). According to Demirbaş and Demirkan (2003) curriculum in architectural design education should be created in a way that facilitates and advances students' learning and program through the educational steps should provide interrelated and reinforced lessons throughout the curriculum. The architecture curriculum consists of core courses that enhance design knowledge, technological courses that enhance the scientific formation of architecture, and art-based courses that strengthen architectural expression. And design studios, which are the most fundamental part of design education, are the courses that are the combination of all three and constitute the most important part of design education (Demirbaş and Demirkan, 2003).

Demirbaş (2001) suggests that since the design studio process forms the core of the curriculum, all the courses taught in design education support the design studio processes. The design studio serves as the main teaching tool for giving aspiring architects the creative abilities to create three-dimensional spaces that are suitable for socio-cultural interactions (Salama 1995; Yurtkuran and Taneli, 2013). Design thinking typically involves a collaborative mindset, problem-solving, and an individual-centric approach (Aflatoony et al., 2018). According to Rauf, Gunce and Ozersay (2020) students that have a collaborative mindset are more able to voice their needs, goals, and address the issues that can be resolved in their assignments. Students' ability to advocate for themselves and communicate their answers to teachers is enhanced as a result. Therefore, the capacity to stand up for one's demands while being aware of one's obligations and rights is known as self-advocacy (Rauf et al., 2020).

Although design studio teaching techniques are described as participatory, this is not necessarily the case. According to Alaswad (2017), the focus on the studio in design education has been criticised for several reasons, including: (1) the distribution of student workload, (2) the reliance on the master-apprentice structure; and (3) the lack of clarity of evaluation methods.

Design Processes

The design process is not linear; repetitive models of the design process can be helpful in examining what happens during design (Oygur, 2012). For every different design area there are different design approaches and design processes. Different designers use different approaches. Throughout the literature, design processes are divided into a different number of stages and each stage was labelled with a different name. Cross (2008) determines design processes as clarifying objectives, establishing functions, setting requirements, determining characteristics, generating alternatives, evaluating alternatives, and improving details which is consistent with the interior architecture design studio curriculum. Ching and Binggeli (2012) defined the stages in the design process as Define Problem, Formulate Program, Develop Concept, Assess Alternatives, Make Design Decisions, Develop and Refine Design, Implement Design and Re-evaluate Completed Design. Oygur (2012) states that as the user is not a stable factor in an interior architecture processes there is continual interaction with the client, the information from users is constantly changing within the various stages of the design process. The designer reconstructs the user image in their mind based on the feedback from the client. Each design process and solution in architecture and interior architecture is situation specific. A project's primary occupant population and client are both predetermined. It is impossible to provide generalizable answers from the research phases because each situation is defined according to the needs and desires of these parties (Oygur, 2012).

Research Design

After the literature review, 3 main topics were selected that can work in conjunction with each other and support design education. These topics were determined as Design Education, Design Processes and Game Based Learning approach. Based on the features under these topics, a research design was created. Relationships between the research method and research topics were established with the 4 guiding research questions. The research questions are listed below.

R.Q.1. How is design education evaluated by students?

R.Q.2. How is the act of designing performed by students?
R.Q.3. How does the use of game-based learning methods in design education affect students' design processes?
R.Q.4. What are the effects of Game-Based Learning in design education? How can Game-Based Learning be effective in students' understanding and maintenance of design education?

To get the evaluations of the students for the design education, a pre-test was carried out in which the students evaluated their experiences in design studio. The problems that identified through the pre-test led to the formation of the workshop structure. The workshop structure was created to better understand how students manage the processes of the design, also by using game-based learning method to seek a solution associating the problems they currently experience during the design process. In addition to the observations made by the coordinator during the workshop, data were collected for the analysis of the students' approaches to the game-based learning method, the benefits they gained, and the problematic aspects of game-based learning with the post-test and in-depth interview method. In line with these data, the benefits and harms of using the game-based learning method in interior architecture education have been revealed in terms of students and educational structure (Figure 1).

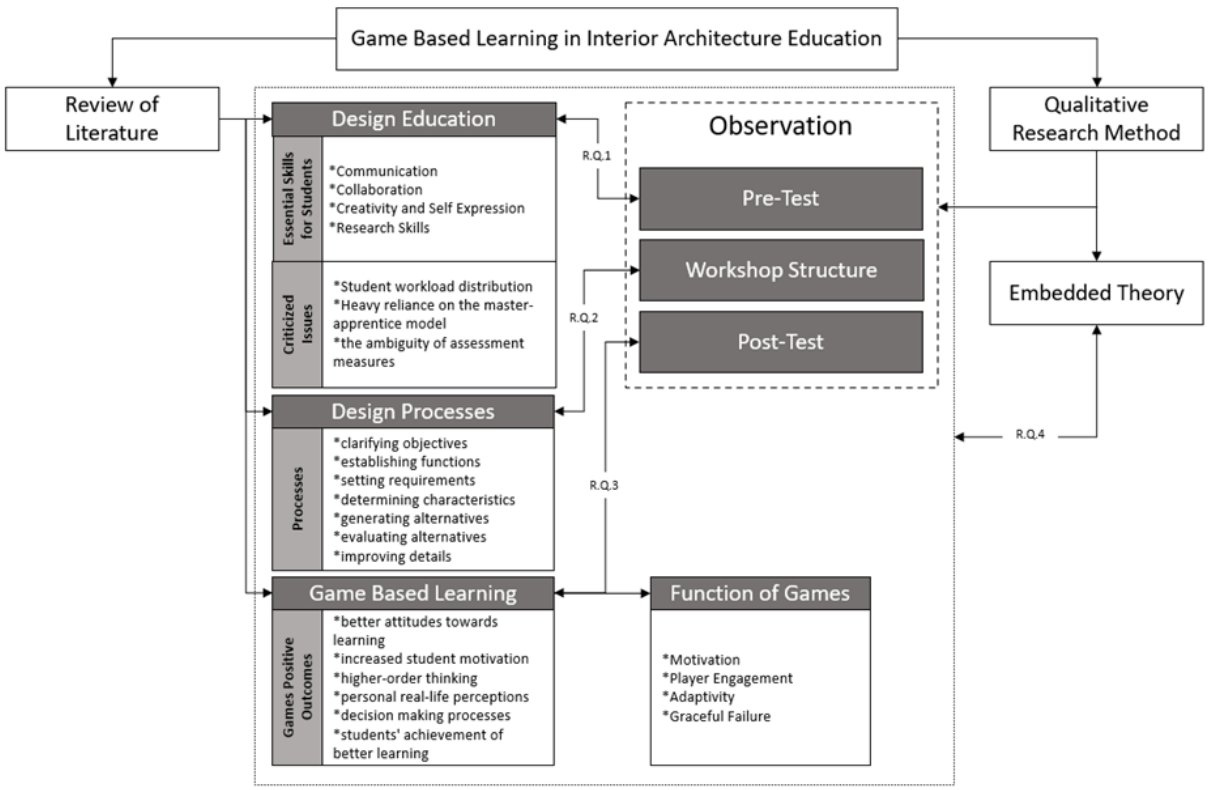


Figure 1. Research Design

After the establishing the research design, a workshop structure was created with the game-based learning method to solve the problematic aspects of the traditional design studio. As the sample, 2nd year students of the Department of Interior Architecture at Istanbul University were selected because they had previously carried out 3 projects and were at a level to evaluate these projects and evaluate new information with their current achievements. Participation in the workshop was voluntary. The participants of the study were asked to fill out

a questionnaire considering the weekly duties of the traditional design studio. In line with the data obtained from this survey, the areas that the participants had difficulty in the design process were determined and the structure of the workshop was prepared in a way to focus on these areas. While creating the workshop structure, Alaswad's (2017) skills that students should have in the design studio, the problems experienced in the design studio and the positive outputs of the learning by game method were used. The definitions of design processes were created by benefiting from the research of Oygur (2012) and Cross (2008), and the functions that a game should have by using the studies of Plass et al. (2015).

Defining the Problem: Pre-test

A questionnaire was presented prior to the workshop for participants to evaluate traditional design studio processes to complete the pre-testing process of the research. This questionnaire was delivered to the students at the end of the Design studio course they took before the workshop, and they were asked to evaluate the processes from their own perspective. Since the syllabuses of the Design Studio courses of the Istanbul University Interior Architecture Department are in accordance with the design processes stated by Cross (2008), the design process evaluations of the students were carried out through these processes. This questionnaire was created by giving Likert-type statements about their evaluation of weekly tasks in their current curriculum (Table 1).

Table 1. Current Curriculum in Istanbul University, second year first term Design Studio in relation to Cross' (2008) design processes

Week	Topic – Design Processes	Design Processes (Cross,2008)
1	Introduction: Informing about the aim and the scope of the course	Clarifying objectives
2	Research, observation, creating scenario	Establishing functions
3	Preliminary design research, concept development	Setting requirements
4	Creating alternatives for spatial organization	Determining characteristics
5	Design development studies: plans, sections, 3 dimensional models	
6	Design development studies: plans, sections, 3 dimensional models	
7	Midterm project submission-Jury evaluation	Generating alternatives
8	Design development studies: plans, sections, 3 dimensional models	Evaluating alternatives
9	Design development studies: plans, sections, 3 dimensional models	
10	Detail resolution studies	Improving Details
11	Detail resolution studies	
12	Expression and presentation studies	
13	Expression and presentation studies	
14	Preparation for project submission- critics	

The statements given were evaluated based on the "1- Strongly Disagree., 2- Disagree., 3- Neither agree nor disagree., 4- Agree., 5- Strongly Agree." Scale in a 5-point Likert type. After

the statement evaluations were completed, the participants were asked 2 open-ended questions to better understand their design process experiences and to try and create solutions to the problems during the workshop (Table 2).

Table 2. Pre-Test Statements and their evaluation criteria in relation to design processes

Design Processes	No	Statement	Evaluation
Clarifying objectives	1	When starting a project, I find it difficult to do research.	5 -point Likert Scale
	2	When starting the project, I have difficulties in the concept development phase.	
Establishing functions	3	When starting the project, I have difficulty in determining my user identity.	
	4	When starting the project, I have difficulty in determining the needs of the user.	
Setting requirements	5	I find it difficult to sketch when starting the project.	
	6	I find it difficult to define the concepts when starting the project.	
Generating alternatives	7	I find it difficult to work with abstract concepts when starting a project.	
	8	I have a hard time creating a mood board for the project.	
Evaluating alternatives	9	I have difficulty in determining the functions of the space given in the project.	
	10	I find it difficult to express the functions that I set for the project.	
	11	I find it difficult to develop different options for the project.	
	12	I have difficulty in making 1/50 scale furnishing drawings of the project.	
Improving Details	13	I have difficulty in drawing 1/20 detail scale of the project.	
	14	I have difficulty in drawing 1/10 detail scale of the project (furniture and structure).	
	15	I have difficulty in choosing materials for the project.	
	16	I have a hard time creating the presentation layouts to present the project.	
	17	I have a hard time preparing the 3D visualization of the project.	
	18	I have a hard time rendering the 3D visualization of the project.	
	19	What are the reasons for your difficulties in the areas you think you have difficulty in during the project process?	Open-Ended
	20	In your project process, what kind of changes do you think would be beneficial as a learning method?	Open-Ended

The pre-test results were evaluated according to the design processes. In this way, it was started with the idea that the evaluations of the participants about the design processes could

be understood more clearly. Since the given statements are negative, evaluations were made according to the idea that the average values between 1-3 were not problematic design processes, and the design processes with an average value between 3-5 were troublesome processes for students.

Clarifying objectives design process statements contain statements about research and concept development processes. While the statement about doing research was included in the design processes that were not problematic in terms of getting a value below the average (2,64), the statement given about the concept development was accepted as one of the design processes where the students had problems with an above average value (3.71) and took part in the workshop (Table 3).

Table 3. Clarifying Objectives design process evaluation statements

Design Process	Statement	Mean	Count
Clarifying objectives	When starting a project, I find it difficult to do research.	2,64	14
	When starting the project, I have difficulties in the concept development phase.	3,71	14

Establishing functions design process statements contain statements about user identity and user needs determination processes. The statements given for the processes of user identity (2,5) and determination of user needs (2,35) took sub-average values and included in the design processes that were not problematic (Table 4). The result is meaningful since this process is related to the research processes of the project.

Table 4. Establishing functions design process evaluation statements

Design Process	Statement	Mean	Count
Establishing functions	When starting the project, I have difficulty in determining my user identity.	2,5	14
	When starting the project, I have difficulty in determining the needs of the user.	2,35	14

Setting requirements design process statements contain statements about the processes of sketching and associating the determined concept with the project. The statements given for the processes of sketching (3,35) and the implementation of the concept in the project (3) were included in the workshop by taking the above-average and average values and taking part in the design processes where the students had problems (Table 5).

Table 5. Setting requirements design process evaluation statements

Design Process	Statement	Mean	Count
	I find it difficult to sketch when starting the project.	3,35	14

Setting requirements	I find it difficult to define the concepts when starting the project.	3	14

Generating alternatives design process statements include statements about working with abstract concepts and creating a mood board and applying it to the project. The statement about working with abstract concepts was included in the workshop by taking part in the design processes where the students had problems with an above-average value (3.28). The statements given for the implementation of the concept in the project with the mood board method (2,7) took a value below the average and took part in the design processes where the students did not have any problems (Table 6).

Table 6. Generating alternatives design process evaluation statements

Design Process	Statement	Mean	Count
Generating alternatives	I find it difficult to work with abstract concepts when starting a project.	3,28	14
	I have a hard time creating a mood board for the project.	2,7	14

Evaluating alternatives design process includes statements about processing the determined functions in the space, expressing the functions in the space, developing different options, and making 1/50 scale furnishing solutions. All the statements were given below the average and were not among the topics that the workshop focused on. However, the statements about the determining functions (2,92) and the development of different options (2,92) were determined as the topics to be discussed during the workshop in terms of their values very close to the mean (Table 7).

Table 7. Evaluating alternatives design process evaluation statements

Design Process	Statement	Mean	Count
Evaluating alternatives	I have difficulty in determining the functions of the space given in the project.	2,92	14
	I find it difficult to express the functions that I set for the project.	2,85	14
	I find it difficult to develop different options for the project.	2,92	14
	I have difficulty in making 1/50 scale furnishing drawings of the project.	1,64	14

The Improving Details design process includes statements on 1/20 drawings, 1/10 detail scale drawings, material selection, preparation of presentation sheets, and 3D modelling processes. The statement about 1/20 drawings (2,92) was determined as one of the non-problematic processes in the design processes by taking a value below the average. The statements related to 1/10 scale detail drawings (3,92), preparation of presentation sheets (3,92), material selection (3,71), rendering of 3D models (3,64) and 3D modelling processes (3,07) were among

the design processes in which the students had problems to be included in the workshop process in terms of getting scores above the average (Table 8).

Table 8. Improving Details design process evaluation statements

Design Process	Statement	Mean	Count
Improving Details	I have difficulty in drawing 1/20 detail scale of the project.	2,85	14
	I have difficulty in drawing 1/10 detail scale of the project (furniture and structure).	3,92	14
	I have difficulty in choosing materials for the project.	3,71	14
	I have a hard time creating the presentation layouts to present the project.	3,92	14
	I have a hard time preparing the 3D visualization of the project.	3,07	14
	I have a hard time rendering the 3D visualization of the project.	3,64	14

While examining the open-ended questions of the pre-test, it was determined that the situation was different in the open-ended questions, although the students' scored points on the Likert-type scale indicating that they did not have any problems with the concept. In general, there were students who stated that they had problems with the concept and that they did not know what concept means. One participant said, "Because I had difficulties in determining the concept, the other stages proceed in the form of knots that I could not solve accordingly." While another participant stated, "Creating a user ID and choosing what they do is the most critical decision in the project, in my opinion. Because all the designs, space organizations and most of the things to be done in the project are formed in line with this decision. If I can't identify a concept and user ID that I feel comfortable with at the beginning of the project, I keep thinking "should I choose another concept?", "What would it be like if I chose my user ID differently?" I can't focus on the project without thinking about the questions. " To explain what they experienced with concept creation. Another participant said, "Not knowing the design periods when creating a concept and not being able to understand exactly how it was determined makes it difficult for me." expressed their thoughts. When asked how they think it would be beneficial as a learning method to make changes in the sections they had difficulty with, one participant said, "I think we have difficulties as a class in decisions such as how to choose a user ID and what the concept of the project will be. First of all, it can be better if we may have an environment where we can discuss this more or if we have a chance to get more critiques." Concept creation and design processes were also included in the study topics of the workshop according to the answers obtained from the open-ended questions.

Pre-Test Results

When the answers given by the students to the survey are examined together with the design processes, it has been determined that they have problems with the concept development within the clarification objectives design process. It was decided to include a general lecture on concept development processes in the workshop, especially in line with the answers to open-

ended questions. Another design process that the students had problems with was determined as setting requirements, and a brainstorming session to be held as a group was included in the workshop after the user identities were determined to communicate and collaborate on the ideas in general. A side challenge was added to the workshop for the participants to better understand the abstract concepts after the abstract concepts under the Generating alternatives process were identified as a problematic issue. Another design process in which students had problems was identified as improving details. When the answers given by the students to the open-ended questions were examined, it was determined that this problem was a problem related to the perception of the detail scale, and the games in the workshop were prepared for these problems, with the suggestion that the fact that this process took place at the end of the design process might be a problem arising from the time management of the students.

As a result of the observations, it was determined that the participants perceived the design processes as a linear process and did not return to the stages at the beginning of the design processes in the later stages. Since the design processes are transformative, changing and developing processes in themselves, revisiting the processes was encouraged so that the participants could reconsider their design processes and earn points in the Bingo Board game.

Implementation of Game Based Learning in Interior Architecture Education: Game Based Learning Workshop

Workshop Structure

The workshop was prepared in the form of a 4-day design sprint during the students' semester break. These 4 days are divided by different functions. The first day is called "Idea to Sketch", the second day "Sketch to Design", the third day "Design to Presentation" and the last day "Presentation Day". Although the workshop was held in person, the game and design interfaces were run on the Miro website. Miro was used during the workshop because it is a common digital interface. Participants were able to see the changes made by other participants during the workshop and communicate with each other both face-to-face and through the digital interface. In particular, the use of digital interfaces in online education due to the pandemic of recent years has shortened distances and lengthened communication channels. The Miro interface provided a new environment for participants to express themselves and collaborate.

The group days were guided by Cross's (2008) design processes, which are most appropriate for current design studio courses. The first day of the workshop was devoted to research and sketching, the second day to supporting the designs with technical drawings, the third day to working on detailed studies and visualisations, and the final day to preparing the designs for presentation and then presenting them. First, the schedule, purpose and general rules were included in the Design Sprint Board prepared in Miro (Figure 2). There are 3 main games in the workshop process. These are called "Bingo Board", "Guess the Number" and "Look and See" and their rules and outcomes are clearly indicated on the board (Table 9).

Table 9. Educational Games and their learning aim.

Game	How to play?	Learning Aims
Bingo Board	The group that finishes the determined tasks of the day first is entitled to put the checker of their group colour on the bingo board.	*Time Management *Managing the Design Processes
Guess the Number	In the game, in which information such as construction dates, heights, and lengths of some architectural structures are tested, the groups have 1 minute to write their predictions on the first day, 30 seconds on the second and third days, and 15 seconds on the last day.	*Time Management *Multi-tasking Skill Development
Look and See	Participants are obliged to find out what and where macro shots provided by the coordinator are during the day.	*To better understand the detail scale *Learning to pay attention to details

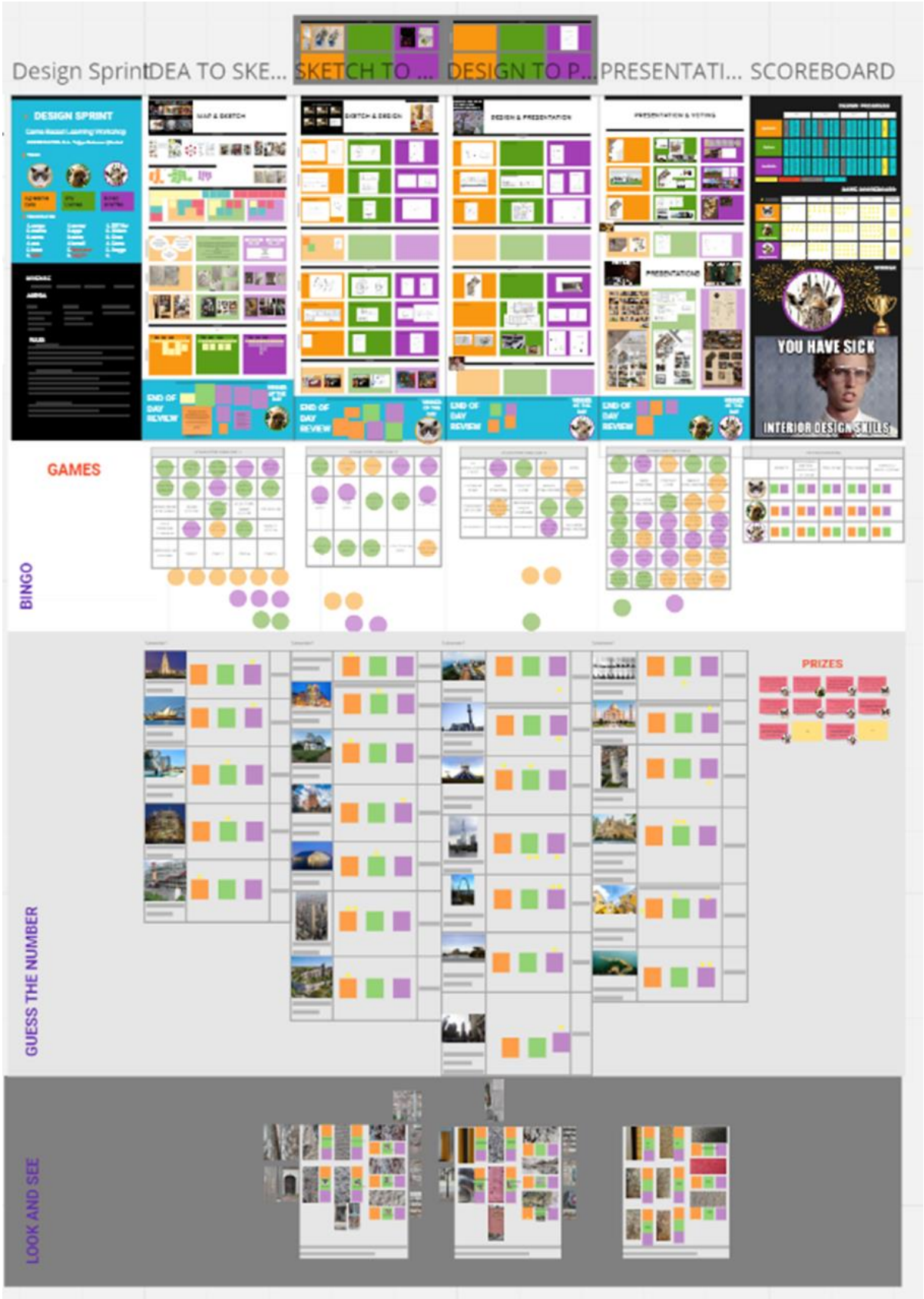


Figure 2. Miro Board for the Game Based Learning Workshop

A design process chart and scoreboard were created so that the groups could follow their progress during the workshop. The design process chart was prepared for each group to determine their point during the day or at the end of the day (Figure 3). Groups marked their location according to the colours determined as " under construction", " to be continued", " revisited" or " finished". This has always been created so that the groups can follow each other, and the groups can make their own business plans. On the other hand, the Scoreboard was created so that they could follow the stars their own groups earned and the progress of other groups throughout the workshop.

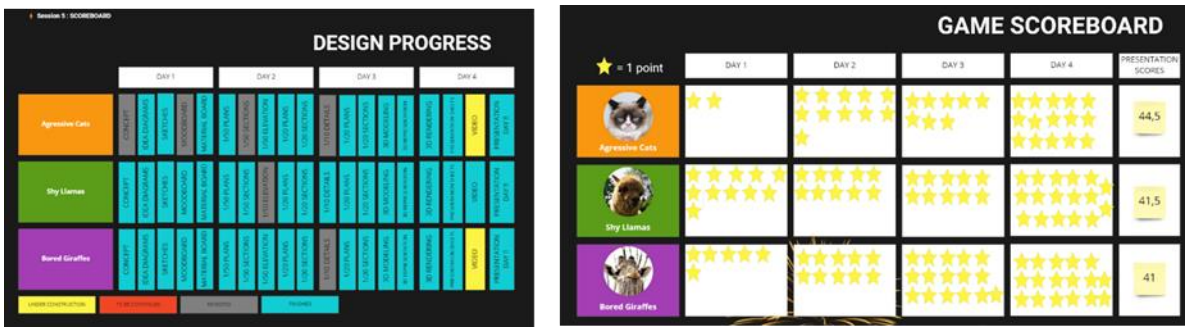


Figure 3. Design Process Chart and Game Scoreboard

Participants first determined their groups by drawing one of 3 different colours. After the formation of the groups, two people from each group formed the group names by drawing an adjective and an animal name to determine the group names. The creation of group names in this way is to ensure unity in a fun way, to define their own groups during the game and to create a sense of belonging in their groups.

After the groups were determined, a short lecture was given about the concept and user identification processes, which emerged from the results of the surveys conducted to analyse the process management in the final design studio lessons before the workshop, and then 2 minutes were given to think about different user identities. User IDs determined by different groups were opened for voting by all groups and the rule that groups should not vote for their own ideas was clearly stated. The 3 user IDs that received the most votes were assigned to the groups by drawing lots (Figure 4).

Figure 4. User Identification via voting

After determining the user identities that the groups will design, a 15-minute research period was given, then they were asked to choose one design problem from the first group and two

from the other two design problems collected under 3 main headings, and 2 minutes were given to make this choice. After the design problems of the groups were determined, these selected problems were locked by the workshop coordinator and the participants went to the 15-minute sketching process with their groups (Figure 5).

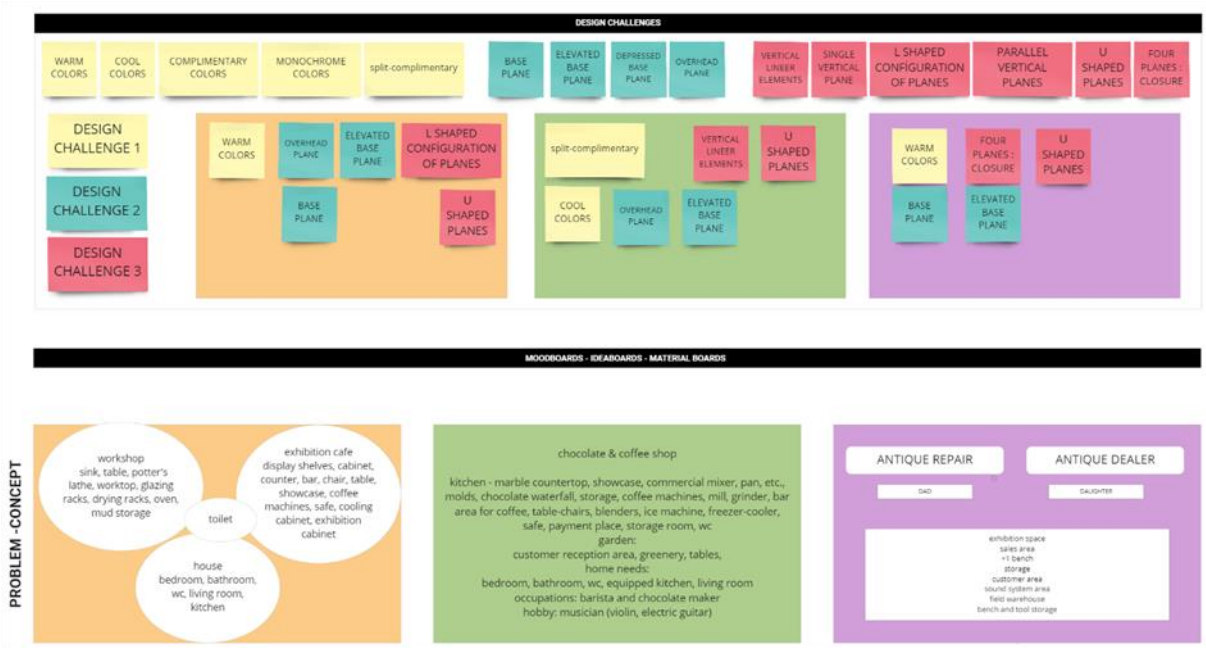


Figure 5. Selected Design Challenges and problem-solving research process for the user identity

At the end of the sketching process, they were asked to choose one of these sketches to work on in 5 minutes. A more in-depth design process was initiated on this sketch. To solve the problems related to material selection, a table with material samples was prepared and the groups were given 1 minute to find and select the materials suitable for their concepts and created their mood boards and material boards (Figure 6).

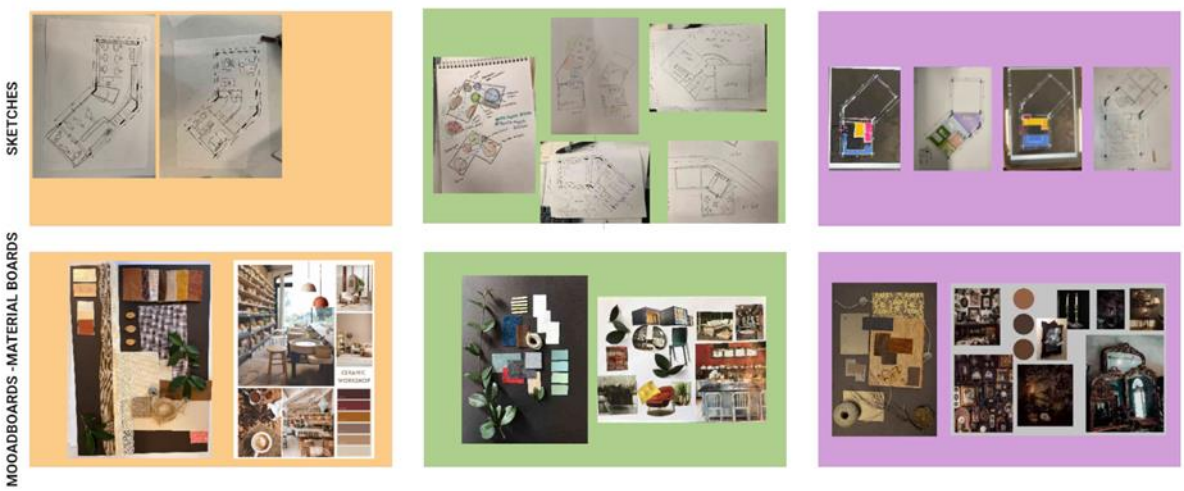


Figure 6. Sketches and related conceptual material boards- mood boards

The second day of the workshop was the day of the technical drawings of the areas whose sketches and functions were determined. While the technical drawings continued, the side challenge was given. On the third day of the workshop, detailed drawings and models were made. And on the last day, while the modelling continued, layouts were made to prepare for the presentation. At the end of the workshop, the groups presented their projects and scored each other according to the criteria determined by the coordinator. The winning group of the workshop was determined according to the stars they won from the games during the week and the points they collected from the last project evaluations, and the prizes of the winning group were given.

Design Challenges

The design problem given to the groups is the design of the sales office, which will work in a residential structure with a minimum of 2 people. During the workshop, 3 main design challenge and one side challenge were given to the participants. The first of the three main design challenges are about colour theory and requires them to work with different colour families. The groups were asked to choose a minimum of 1 from this challenge. The other two main design challenges consist of Ching's (2007) horizontal and vertical elements that define the space. They were asked to choose at least 2 of these two design challenges. After these challenges were determined, the selections were locked by the workshop coordinator and the sketch phase started. On the second day of the workshop, the groups were given a side challenge. Side challenge is an abstraction problem in which they are obliged to express a famous painting in an abstract way in their spaces (Figure 7).

Figure 7. Side challenge outcomes

Educational Games

The "Bingo Board" game is a game that allows groups to compete and is also prepared to shorten the completion times. Each day is mapped according to what is requested on that day, and as of the first day of the workshop, all the boards have been prepared in a way that can be seen by the participants. The group that finishes the determined tasks of the day first is entitled to put the checker of their group colour on the bingo board. Here, it is up to the workshop coordinator to control the completion of the required task. As it is clearly stated in the rules of the game, if the team that placed its colour on the board has not fulfilled the task completely, the coordinator has the right to withdraw the checker, and this allows the other teams to place their checkers (Figure 8).

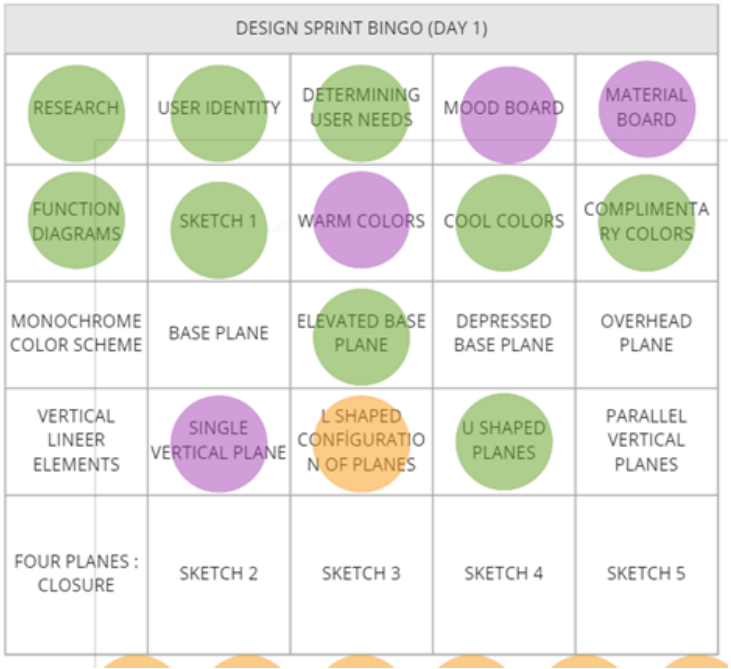


Figure 8. Bingo Board Example (Day 1)

The game "Guess the number" is designed as a game in which the participants can use their professional general knowledge acquired in the theoretical courses they took in the previous semester and in their daily lives. In the game, in which information such as construction dates, heights, and lengths of some architectural structures are tested, the groups have 1 minute to write their predictions on the first day, 30 seconds on the second and third days, and 15 seconds on the last day. The group with the closest number to the answer wins the star. If a group gives a perfectly correct answer, that group gets two stars. While the questions were all opened to give the participants a 5-minute break on the first day, they continued to be opened one by one in the later days of the workshop when the participants did not expect it. This was done to improve the time management method and multi-tasking skills.

Figure 9. Guess the Number Example (Day 1)

The game "Look and See" is a game designed to make the participants pay attention to the details in their environment and to become familiar with the detail scale. On the day of the opening of the questions, the coordinator takes macro photos on the routes of the participants and keeps them open from the beginning of the workshop to the end of the day. Participants are obliged to find out what and where these macro shots are, whether among them or during the workshop. The group that correctly knows the place and what is entitled to 2 stars, the group that knows only one correctly has the right to receive one star (Figure 10).

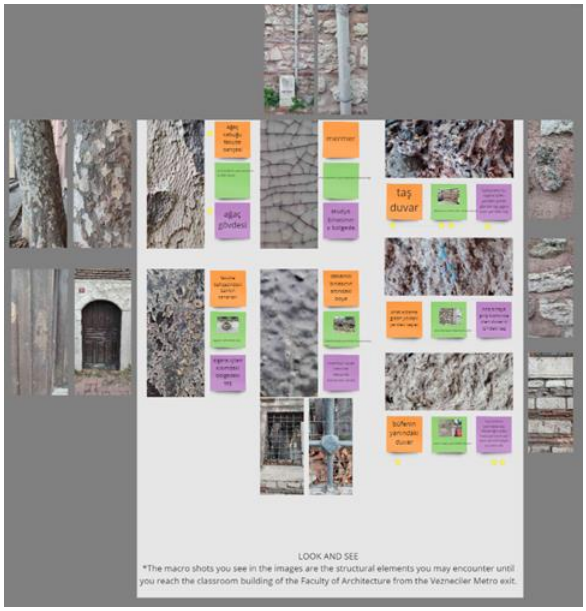


Figure 10. Look and See Example (Day 1)

In each game, the winning groups had the right to choose one of the 12 prizes or penalties under a number they chose from the prize list. The winning groups could choose when they wanted to use their rewards and punishments. At the end of the day, the winner group of the day was determined according to their success in the games and the last prize of the day was chosen, and the day was closed in the list to continue the games and the design process the next day (Figure 11).

Figure 11. Prizes for the game winners

Final Peer Review

The groups could add the problems they experienced on the discussion boards during the workshop to be solved by the coordinator or their peers. The notes they placed in this area were being removed after its resolution. While these discussion boards were used on the first day (Figure 12), the participants preferred to solve these problems by talking face to face on the other days. During the process, the groups supported each other in solving their problems, and the coordinator provided support for solving problems that could not be solved among peers.

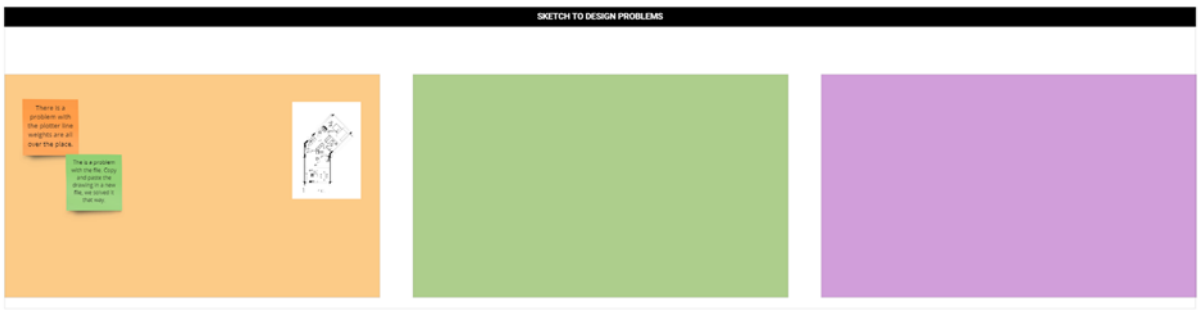


Figure 12. Discussion Board (Day 1)

On the day of the presentation, the coordinator did not participate in the evaluations except listening to the presentations after explaining the project evaluation scale to the groups. Peers evaluated each other according to the criteria given by the coordinator and gave their scores as a group (Figure 13).

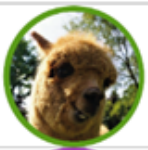
PRESENTATION VOTING					
	CONCEPT	MOODBOARD - MATERIAL BOARD AND THEIR RELEVANCE TO THE PROJECT	DETAILS (1/20,1/10)	PROJECT DESIGN (CHALLENGESİ SIDE CHALLENGE, SPATIAL ORGANIZATION)	3D VISUALIZATION AND PRESENTATION LAYOUTS
	5 4	3 4,5	5 4	5 5	5 4
	4 4	5 4,5	4 3	3,5 4,5	5 3
	4 4	4 4	5 3	4 3	5 5

Figure 13. Evaluation criteria (Presentation Day)

Results

At the conclusion of the workshop, the post-test was distributed to the participants. The questionnaire consisted of a repetition of the statements given as a pre-test to evaluate the workshop process (Table 2). In addition, during the workshop, participants were asked to provide an evaluation of the game-based learning method and the design processes conducted that day at the end of the day.

Comparing the points given for the statements in the Clarifying Objectives design process between the pre-test and the post-test, it is observed that there is a decrease in both subjects. Since the statements given are negative, the decrease in the mean value is that the participants' experience of the processes in these areas has improved as a result of the game-based learning method (Table 10).

Table 10. Clarifying Objectives evaluation statements Pre-test & Post-test comparison

Design Process	**Statement**	**Pre-test**		**Post-test**	
		Mean	Count	Mean	Count
Clarifying objectives	When starting a project, I find it difficult to do research.	2,64	14	2,42	14
	When starting the project, I have difficulties in the concept development phase.	3,71	14	3,57	14

When looking comparatively at the scoring on the statements in the Establishing functions design process, there is a decline in both subjects. In particular, the significant decrease in the average score in the process of determining user needs shows that although this subject was not a focus during the workshop, the participants' experience of the processes in these areas improved as a result of the game-based learning method (Table 11).

Table 11. Establishing functions evaluation statements Pre-test & Post-test comparison

Design Process	**Statement**	**Pre-test**		**Post-test**	
		Mean	Count	Mean	Count
Establishing functions	When starting the project, I have difficulty in determining my user identity.	2,5	14	2,21	14
	When starting the project, I have difficulty in determining the needs of the user.	2,35	14	1,85	14

Comparing the ratings of the statements in the setting requirements design process are compared, there is a decrease in both subjects when looking at the pretest and the posttest. Specifically, in the sketching process, the significant decrease in the mean score is an indication that the participants' experience in these areas improved in the sketching process with the game method through the game-based learning method during the workshop process (Table 12).

Table 12. Setting requirements evaluation statements Pre-test & Post-test comparison

Design Process	Statement	Pre-test		Post-test	
		Mean	Count	Mean	Count
Setting requirements	I find it difficult to sketch when starting the project.	3,35	14	2,71	14
	I find it difficult to define the concepts when starting the project.	3	14	2,64	14

When the points given to the statements in the generating alternatives design process are examined comparatively, it is observed that there is a decrease in both subjects. Although the decline in the statement regarding the use of abstract concepts in design continues to be one of the problematic issues with the side challenge they carried out in the game-based learning method during the workshop, it can be said that the attitude of the students in this area has improved (Table 13).

Table 13. Generating alternatives evaluation statements Pre-test & Post-test comparison

Design Process	Statement	Pre-test		Post-test	
		Mean	Count	Mean	Count
Generating alternatives	I find it difficult to work with abstract concepts when starting a project.	3,28	14	3,14	14
	I have a hard time creating a mood board for the project.	2,7	14	2,5	14

When the scores given to the statements in the Evaluating alternatives design process are compared, when the pre-test and post-test are examined comparatively, a decrease is observed in the average value in the fields of function creation and option generation, while an increase is observed in making 1/50 scaled drawings. Although it is still not considered among the problematic subjects in terms of its sub-average value, it can be said that this increase is because the participants continued a group work and there was a time constraint (Table 14).

Table 14. Evaluating alternatives evaluation statements Pre-test & Post-test comparison

Design Process	Statement	Pre-test		Post-test	
		Mean	Count	Mean	Count
Evaluating alternatives	I have difficulty in determining the functions of the space given in the project.	2,92	14	2,14	14
	I find it difficult to express the functions that I set for the project.	2,85	14	2,5	14
	I find it difficult to develop different options for the project.	2,92	14	2,71	14
	I have difficulty in making 1/50 scale furnishing drawings of the project.	1,64	14	1,78	14

When the scores given by the participants in the pre-test and post-test in the Improving Details design processes were compared, it was observed that there was a decrease in every subject. Especially in the creation of project presentation sheets and rendering in 3D visualizations, the values fell below the average and were no longer considered as problematic issues experienced by the participants in the design processes (Table 15).

Table 15. Improving Details evaluation statements Pre-test & Post-test comparison

Design Process	Statement	Pre-test		Post-test	
		Mean	Count	Mean	Count
Improving Details	I have difficulty in drawing 1/20 detail scale of the project.	2,85	14	2,64	14
	I have difficulty in drawing 1/10 detail scale of the project (furniture and structure).	3,92	14	3,42	14
	I have difficulty in choosing materials for the project.	3,71	14	3,35	14
	I have a hard time creating the presentation layouts to present the project.	3,92	14	3,5	14
	I have a hard time preparing the 3D visualization of the project.	3,07	14	2,57	14
	I have a hard time rendering the 3D visualization of the project.	3,64	14	2,92	14

At the end of the workshop, participants' daily assessments were examined, and the concepts of time management, self-confidence, and confidence in professional relationships emerged as embedded outcomes. In terms of time management, several participants wrote that they planned their personal times and the group's times together and thus knew when and where to work and take their breaks. One participant wrote, "I find it helps with time management and group work and keeping up with distractions." Another participant wrote, "Before this course, I did not know how to spread the project over time, and I was wasting a lot of time on unnecessary things. At the same time, when competition was involved, I realized that I focused on the project much more and worked faster." Mentioned as such. Another participant also mentioned time management in relation to project management processes, "This course taught me how to manage time and project management. I realized that in a shorter period I can get a lot of things done for the project." In this context, the participants also mentioned that with the help of this workshop, they managed to design a project from start to finish in just 4 days, which made them believe in themselves. One of the participants wrote, "We fit our project process, which normally takes weeks, into 4 days. This allowed me to look at the picture from a wider perspective, frankly. We concluded the decision-making phase, which was my biggest problem, in a shorter time with the ideas of my friends. I have also experienced the division of labour. I saw the importance of this once again, as reconciling with people of different characters on the same point affects team spirit. I think that we used our time efficiently in this process and managed it very well. "And another participant said, "In the project design process, we did not need the critique process with our coordinator without realizing it. It was something we normally do a lot in design studio classes, but we didn't need it except in very difficult moments."

Conclusion

Game-based learning is a fun method that incorporates the concept of play and engages participants in the process. Design studios are heavily dependent on the master-apprentice method for their handling and provide little opportunity for the rotation processes of design processes in relation to curriculum structures.

As the number of students in interior architecture departments increases each year, the time in which instructors and students can interact in the master-apprentice model becomes increasingly limited. For this reason, it is important that peers have discussions with each other, listen to the instructor's comments during the critique process, and be able to do so with each other.

To obtain answers to students' evaluation of design education processes, which was the first of the research questions during the research process, participants were asked to complete a pre-test to evaluate their experiences in traditional design studios. As a result of this survey, it was found that participants had issues with the design processes of clarifying goals, establishing requirements, developing alternatives, and improving details. These issues were included in the workshop.

During the workshop, participants' project processes were observed to find answers to the question of how students approach the design process, which is another research question. In terms of its design, the workshop was designed in line with traditional design studios. The design processes are compatible with traditional design studio education processes. In accordance with the answers given by the participants during the pre-test, it was found that they considered these design processes to be linear and therefore did not go back and make corrections after passing a phase. For this reason, games were built into the workshop structure that required participants to go back and repeat the processes. Participants were able to better understand that design processes are transformative processes and were observed repeating these processes during the workshop. It was also observed that they preferred the method of specific to general instead of a method of general to specific, so they had difficulty understanding the design processes in the early stages of the workshop. During the workshop, they had the opportunity to experience working from the general to the specific.

The benefits of using the game-based learning method in design education and in the design process were evident from the end-of-day evaluations collected from the participants during the workshop and from the post-test completed by the participants at the end of the workshop. After the workshop, all design processes were found to have improved in general. Despite the design challenges and time constraints given during the research process, participants improved in the design processes.

In response to another research question, secondary outcomes emerged as a result of the research. These were time management skills, self-confidence, and social dynamics with colleagues. Since the design process is constantly changing depending on the client and the end user, especially in the field of interior architecture, these results are useful for interior architecture students to manage the design process. Although there may be different time intervals for different projects, self-confidence is also an important gain in professional life, where only one's preferences are not effective in the project. Part of gaining self-confidence is

that unlike in traditional design studios, participants can make their own evaluations at each stage without the need for an instructor. Gaining confidence in their own decisions allowed them to establish appropriate communication with their group peers and strengthened the communication, collaboration, creativity, self-expression, and research skills that students should have in a design studio.

The game-based learning method also emphasizes the importance of time management by allowing participants to take a break from tasks that they describe as "boring." Gaming was also used as a distraction in this workshop. Participants also strengthened their ability to multi-task by focusing their attention on the project with questions that arose during uncertain times.

This study provides limited insight into the game-based learning approach in interior architecture education. In future studies, this approach can be used in theoretical courses and throughout the duration of a design studio to better understand the impact of the game-based learning approach in interior architecture education.

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Design and Technology Education: An International Journal

28.1

Building relationships with remote participants through playful technology interactions in online codesign

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Abstract

"Hybrid is here to stay!" If that is so, then how we educate design students and the techniques they learn need to work in a technology-driven online environment as well as face-to-face on campus. Learning codesign typically involves students being in a design studio environment where they create activities using tangible materials, for use in workshops, giving participants hands-on experiences to gather useful design insights. The question is, how does codesign need to be adapted to be effective in an online environment? To identify those elements of codesign that work effectively online, we offer lessons learned from teaching codesign online during the lockdowns and the resulting isolation of academics and students imposed by the COVID-19 pandemic. This necessitated rapidly adapting on-campus codesign techniques to online versions using available technologies to engage remote participants in online participatory experiences. We describe codesign activities of design teams who created 24 unique online activities to explore designs for *Welcoming Community onto Campus*, trialling them in virtual workshops with the local community. Case study method was used to collect and analyse weekly student reflections and educator observations using thematic analysis and basic inductive coding. The unexpected finding is that online codesign activities need to remain tactile and include multisensory qualities. We argue that online codesign needs to focus on building relationships, engaging the senses, keeping it simple and allowing flexible timing. We identify the benefits, challenges and implications for online codesign and provide a checklist for designers wanting to prepare for a hybrid codesign future.

Keywords

Online codesign, everyday technologies, community participants, creativity, design education

Introduction

In the past four decades, codesign and participatory design have gained increased use in design practice (Stappers et al., 2007, September) and increased prominence within design research (Slattery et al., 2020), with these methods finding their way into university design education programs (Stam & Boon, 2018, August). In generating codesigned solutions, student designers need to both understand the user's viewpoint and share their own design expertise and knowledge toward the generation of suitable solutions. When involving participants, it is important that information is shared in a way that a common objective and understanding of the problem is formed and maintained, creating and sustaining interest in codesign among prospective participants from the beginning (Pederson, 2016). Student created codesign activities need to be engaging for both the students and the participants to effectively help generate and consolidate innovative design ideas toward building feasible design outcomes (Taffe, 2017). Codesign flourishes when flexibility, openness and innovation is encouraged while closed structures often fail to produce meaningful and usable outcomes (Mattelmäki,

2008). This is best done with projects in real-world settings and with participants who have a stake in the issue being designed (Christiansson et al., 2018, August). Codesign requires that we not only situate our design teaching and research within the context of use, but acknowledge the role that the context plays in making design outcomes matter (MacKinnon, 2012).

Codesign is an effective process for drawing communities together and developing connections and increased levels of caring about the future of their urban environment (Freeman et al., 2019, May). As Lenihan and Briggs (2011) suggest, engaging the public is particularly relevant when designing with communities for better community services. Engaging local communities to collaborate with student designers in learning codesign gives student designers experience in understanding real user needs while finding solutions for real community problems. Practising codesign on existing problems and their complex context gives students an opportunity to reflect on the success (or not) of their tools and techniques toward gaining design insights. However, engaging communities and end-users in codesign in meaningful ways is not trivial (Bødker & Kyng, 2018).

The benefits of real-world learning and the benefits of doing codesign with real participants and live case studies are well known (Bødker & Kyng, 2018; Morley & Jamil, 2021). While educating design students, we aim to produce future-ready graduates, who have the content knowledge, the habits of success, the creative know how, and the abilities to successfully navigate life, which is reinforced by realistic contexts for their learning. In working with community, students learn about relationship-building, understanding local culture and working in real-time with immediate and visible outcomes (Cozens, 2011; Setiawan et al., 2018).

Learning codesign is usually done in a design studio, where potential users are invited to come into the studio and participate in design workshops. However, during the COVID-19 world pandemic, going online to both teach and practice codesign was a necessity, and as educators, we were left with no alternative but to explore online alternatives to our traditional teaching of codesign (see figure 1).

We found very little research on learning and conducting codesign online, exceptions being Voorend et al. (2019, April) on distributed card based codesign and Jiménez-Narváez et al. (2013, July) on remote codesign experiences between participants collaborating in different countries. We believe we are contributing to new knowledge in this area by sharing our experience of teaching codesign online.

In this research, we wanted to understand how codesign needs to be adapted to be effective in an online environment. This paper illustrates how online codesign can be achieved through sharing the processes, activities and outcomes of a project called *Welcoming Community onto Campus* conducted with a local council and a team of Master of Design students. We present our findings, based on collected student reflections of the whole cohort, our observations of their workshop sessions and educator reflections on their outcomes. Our contribution is methodological, we share insights on adapting and augmenting traditional codesign approaches to support effective student learning on conducting codesign in an online context. The result is a proposed checklist of important conditions required for the design of successful online codesign activities with focus on building relationships, engaging the senses, keeping it simple and allowing flexible timing, through the use of appropriate technologies that support remote codesign education.

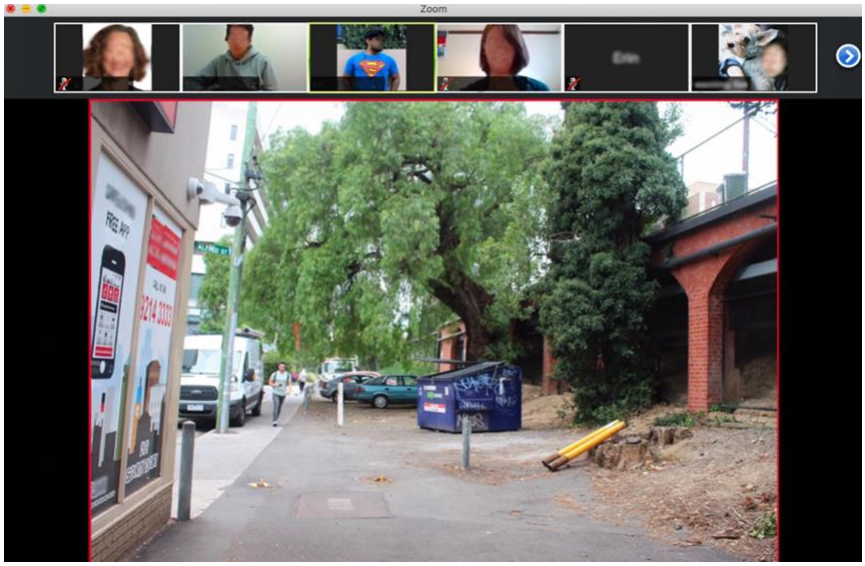


Figure 1 Sharing photos using the Zoom platform. Participants discussed the blue bin as a distraction to Welcoming Community onto Campus.

Background

For codesign to be effective, it is important that designers select tools and techniques appropriate to the project at hand so that communication is clear and open (Steen et al., 2011). Trying out different combinations to create collaborative activities helps to identify important issues with users (Sanders & Stappers, 2008, 2014). Steen (2013) also talks about a "process of joined inquiry". These are the skills that students need to learn, but there is very little research and very few examples of academic work in the participatory design and codesign literature that investigate or describe the teaching of participatory design and codesign (Christiansson et al., 2018, August; Simenson et al., 2020). As Christiansson et al. claim, "few papers actually address how we teach PD and codesign as part of an academic curriculum" (pp. 1). Christiansson et al. acknowledge the benefits of using Donald Schön's (1987) concept of reflective practicum and real-world projects. This provides students with first-hand experience of the participatory design process, teaching them how to collect and use field data, and gives them realistic expectations of a codesign process and its participants. At the same time, Simonson et al. identify the need for including participatory design methods in curriculum at university level to teach techniques and collaboration tools as well as encourage student reflection on outcomes. In this way, participatory design education is not just about the teaching methods, techniques and project context, but the education should include the development of personal and professional qualities for the student, leading to social sensitivity and responsiveness (Stam & Boon, 2018, August). As an educational approach, Simonsen et al. (2020, June) offer a checklist of important conditions required for successful participatory design for students working with external partners, including: focussing on clearly defined projects that are highly relevant to the users; commitment from the client; engaged and relevant participants; adequate project resources; potential to effect change; and understanding what can be achieved in a short time frame.

Learning and conducting online codesign with remote educators, students and participants, adds a level of complexity in trying to satisfying these conditions and educational aims. Unlike on-campus design studios and workshops, virtual classrooms and workshops make personal

interaction that bit more difficult and require creative thinking about how data will be generated, collected and shared (Fleischmann, 2022). Simple conversations online, in terms of non-verbal cues, audio clarity and turn taking are more difficult than face to face (Swezey & Vertesi, 2019, November). At the same time, online workshops allow for greater flexibility in time and space. Activities can be conducted both synchronously and asynchronously, without limits on the number of people who can participate at any one time, or over time. There are no material or refreshment budgets and no travel time or painstaking coordination required to get participants together in one room at the same time. This makes online codesign more accessible to researchers, for example, students without a budget, but also to those who may otherwise not be able to participate because of time or mobility constraints.

Our research adds new knowledge about online university education in codesign and the implications of involving students in real world projects with remote clients and participants. We discuss how this might impact a hybrid on-campus online future for codesign education and practice. Our findings are based on analysis of documented student reflections from individual students' weekly journals, reporting on tool design, stakeholder engagement, team collaboration, personal learnings and feelings about the process. Students were especially asked to reflect on how they adapted existing codesign techniques and tools to work in the online context, what they created and what they learned from this experience. This was augmented by our observations of the workshops.

Methods and Materials

The *Welcoming Community onto Campus* project was jointly undertaken between the university and its local council. The aim was to redesign the campus to create a welcoming experience encouraging the local community to enter, enjoy and linger on campus. Our university has porous boundaries, is not gated, has a public train station on campus and has good accessibility for pedestrians.

As educators, we started the semester thinking it would be business as usual. However, by the second week the university was closed to all on campus activities due to COVID-19. We soon realized that the traditional codesign methods we usually taught would need to be adapted to work online and would also need to be exclusively taught online after week one. We were interested in what qualities of on-campus codesign techniques would be transferable to an online environment looking forward to a new hybrid model of codesign. We rapidly changed from a teaching plan that was based around the students conducting a series of on-campus codesign workshops with local members of the community, to development of a student-driven set of diverse, synchronous and asynchronous activities to be delivered in online "virtual" workshops. However, it was still important for the student learning experience that they design for a real project and context, collect rich field data (as much as possible within isolation restrictions) and create shared ownership of the solutions with the local community. At the beginning, this caused heightened stress in the students with feelings of "missing out on doing the fun stuff" of codesign and lacking the personal interactions with participants that happen in face-to-face workshops.

The Participants

Three academic educators were involved in guiding the process. The students were 25 Master of Design students, some of whom were practising designers with industry experience, working

in five project teams. The students were a multicultural group coming from all over the world to study at our university. For many, the isolation was compounded by living far away from home, and not being able to visit or return to their families. The teams were tasked with finding appropriate activities and adapting them to work online to answer the research questions that they developed in response to the problem of welcoming the community on campus, as specified by the educators and the client. The client had met with the students in the first week of semester, pre-lockdown, to elaborate on their needs. All teams were required to hold two "virtual" workshops, which resulted in a total of 24 synchronous and asynchronous activities across the class (4-5 unique activities per team).

The Technologies

As educators, we helped students create their activities by giving them recommended readings on online codesign and online data collection (e.g., Friedrich, 2013; Jiménez-Narváez et al., 2013, July; Lefever et al., 2007; Nakki & Antikainen, 2008, October; Walsh et al., 2012, June, Voorend et al., 2019, April). Rather than mandate a particular technology, we allowed teams to choose their own preferred platform. The different off-the-shelf communication, productivity and software tools that the teams used as platforms to create their unique activities included: Adobe XD[1], Blackboard Collaborate[2], Facebook[3], Google Slides[4], Instagram[5], Google Jamboard[6], MIRO[7], OptimalSort[8], Sketchup[9], Skype[10], SurveyPlanet[11], Typeform[12], Twitter[13] Wordpress[14], YouTube[15], and Zoom[16].

The Activities

The activities created were inspired by findings from traditional (face-to-face) codesign studies. This included the use of visuals for communicating more effectively than words and their power in eliciting memories and experiences, including the potential of photographs to generate deep and rich stories from participants (Harper, 2002). Students used card sorting as a way to understand user preference and needs, and 'closed' card sorting as an inexpensive method that could be used with online platforms (Paul, 2008). Card sorting activities were also used as means to engage non-designers in collaborative activities of making, telling and enacting (Durl et al., 2017). Students created customer journeys around an experience to reveal customer motivations, behaviours and problems, followed by brainstorming to help ideate solutions to the problems revealed and investigate appealing campaign elements (Daems et al., 2017). Word association exercises were used to facilitate conversations where participants reacted to

[1] https://www.adobe.com
[2] https://www.blackboard.com
[3] https://www.facebook.com
[4] https://www.google.com.au/slides/about/
[5] https://www.instagram.com
[6] https://jamboard.google.com
[7] https://miro.com
[8] https://www.optimalworkshop.com
[9] https://www.sketchup.com
[10] https://www.skype.com
[11] https://surveyplanet.com
[12] https://www.typeform.com
[13] https://twitter.com
[14] https://wordpress.com
[15] https://www.youtube.com
[16] https://zoom.us

different campaign elements and revealed consumer behaviours, followed by brainstorming to ideate new campaign strategies (Kim et al., 2020). Students were also inspired by reading practitioner generated advice on how to do fieldwork in a pandemic (Lupton, 2020).

Pilot Codesign Sessions

Pilot testing codesign sessions for the students gave them the opportunity to trial their activities with their peers before conducting the virtual workshops. The short time frame and situation of students working from home, often with poor internet connections and limited access to high-end technologies or specialized software, necessitated rapid experimentation with available mainstream technologies and off-the-shelf communication products. To provide an equivalent to traditional codesign, activities needed to be adapted to work in online, virtual delivery mode.

Case Study Method

Research data were collected using case study method (Yin, 2003). A case study is particular in its methodology and suitable for this research, as it follows the logic of analytic induction. Rather than using large samples and following a rigid protocol to examine a limited number of variables, case study methods involve an in-depth analysis of a single instance or event, or a case. Case studies can be seen to satisfy the three tenets of the qualitative method: describing, understanding and explaining (Yin, 2003). Case studies provide evidence or illustrations with which some readers can readily identify (Smith, 2004). Authors of case studies have to reveal how the investigation was conducted and how collected evidence was handled and interpreted (Bartlett & Vavrus, 2017). According to Crouch and Pierce (2012) it is important in case study research, due to the complexity, that the focus of the research is identified upfront as we did in our case. Most importantly case study research allowed us to investigate design processes and specific details at the same time (e.g. Neuman, 2003).

As researchers, we did not have a lot of control over the complex design activities. Codesign is a very creative and flexible process and the relevant behaviours cannot be manipulated. The case study method allowed us to retain the holistic and meaningful characteristics of real codesign processes. Case studies are conducted in a way that incorporates the views of the "actors" – in this case, the design students and participants – and are therefore able to explain conditions from the perspective of the actors (Zonabend, 1992). According to Darke et al., "Case study research is an appropriate research strategy where a contemporary phenomenon is to be studied in its natural context" (1998, p. 278).

Educator Observations

The case study consisted of a range of methods. The three educators acted as facilitators and were conducting observation during the online workshops visiting all teams in turn in their breakout rooms and collecting data on the students' reflections which also included feedback of the participants as described below.

Student Reflections

During the process of creating and conducting online codesign activities, all 25 students were required to document individual weekly reflections, including: 1) their contributions to team processes; 2) participation and discussions in weekly online classes; and 3) reflections on their experiences and learning of codesign, with a visual summary of what they had worked on that

week. These reflections were emailed weekly to the educators, from weeks 2-12 of semester, and submitted as a final reflection report at the end of semester. At touchpoints during semester, weeks 4, 10 and 12, students were asked to respond to the following questions: 1) how they felt about running codesign activities in an online format? 2) what their experience was in participating in virtual workshops of other teams during pilot testing? 3) which activities were the most engaging? 4) which activities inspired good ideas? and 5) how activities could be improved? These reflections were collected and reviewed by the three educators to get insight into how the education process was going, and how the students and participants were responding to online codesign as a method. This gave us the opportunity to address negative comments on the process as they happened and to provide encouragement and advice.

At the end of semester, we asked students to reflect on: 1) benefits and challenges of conducting codesign online; 2) to share the most memorable participant responses; 3) to recall their most insightful moment during the process; and 4) to reflect on what they learned overall. Students were also required to submit a project report detailing the project's design outcomes and give a presentation to the client.

Analysis of Outcomes

We analysed the student reflections, the educator observations and the final design outcomes using a process of inductive coding combining Yin's five-phased analytical cycle for qualitative data (2011) with Braun and Clarke's (2019) steps for inductive and iterative reflexive thematic analysis. Combining these methods allowed us to create themes from the data.

Illustrative Case Study: Welcoming Community onto Campus

All five design teams worked on the *Welcoming Community onto Campus* project, but to exemplify the processes and outcomes, we share in this paper the practice, activities and design outcomes of just one team. This team was selected as an illustration to show what can be achieved through online codesign by sharing activities and images from their final design report.

To explore design alternatives for *Welcoming Community onto Campus*, the team held their virtual workshops over a period of six weeks. They conducted an initial pilot online survey of the context and two virtual workshops. In Virtual Workshop 1, the first activity (Visual Appeal) was completely asynchronous, the second activity (Elements) was run in both synchronous and asynchronous modes, and a third activity was synchronous (Safety & Amenity). Virtual workshop 2 included an interview (Missing Elements) and a collaborative activity refining details on popular elements suggested during the interviews (Seating & Wayfinding).

Online Pilot Survey

Pilot Activity: The initial pilot online survey was achieved in a social media campaign using a Typeform survey, Facebook polls, and Twitter feeds. These were sent out through local networks and social groups in the community. The Typeform survey was to find the most used entrance to campus, the Facebook poll asked about best access to the campus with additional comments, and the Twitter poll asked how to improve the campus environment. This was to get rapid feedback from the university and local community about entrances to the university, and how they felt about them.

Participants: In the pilot study, participant diversity was not controlled, no demographics were collected, and all responses were included in the design data. The Typeform survey had 51 responses. The Facebook poll had over 400 responses. The Twitter feed had no responses.

Participant Outcomes: Responses indicated that the area around the train station was the most used entrance, and yet most respondents regarded the space as dirty, dark and uninviting, with suggestions that food trucks, areas to linger and colourful architecture would improve the environment. The codesign activities going forward from this survey were aimed at re-designing the area around the train station.

The different rate of responses was interesting. The Typeform survey took some time to fill in, which may have discouraged responders, whereas the Facebook polls were fast to complete and easy to share amongst friends and contacts. We were surprised by the lack of response in the Twitter feed and can only assume that this platform is not popular with university students and the local community.

Virtual Workshop 1

The first workshop was designed to identify the kinds of spaces that participants (students and local community) found visually appealing and welcoming, and to understand how they regarded existing spaces in the university and surrounding precinct. It comprised three different activities which were a mixture of asynchronous and synchronous approaches and were conducted across three different digital platforms, over two weeks, with a new set of participants for each activity.

Activity 1: The *Visual Appeal* activity used a Typeform survey where participants were shown fifteen different images of urban environments and artefacts, including spaces, buildings, lane ways, textures and colours and were asked to select 3-5 images they found visually appealing. This was done to ascertain people's preferences for different urban styles (see figures 2a and 2b).

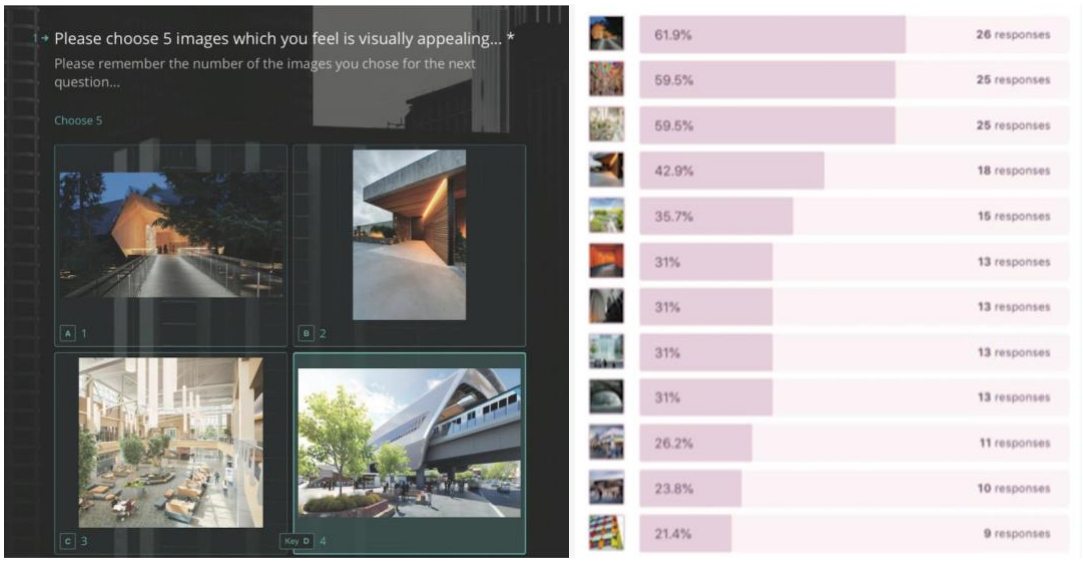
Participants: This survey was taken by 69 participants (32 males, 37 females), aged between 18 and 66 years.

Participant Outcomes: Responses indicated that the area around the train station was the most used entrance, and yet most respondents regarded the space as dirty, dark and uninviting. The participants discussed the blue rubbish bin as an off putting first thing that the community sees when transiting from the train station to the campus (see Figure 1). The codesign activities going forward from this survey were therefore aimed at re-designing this area.

The use of the Typeform survey in this case was ideal for showing sample images and getting affective responses to these urban environments and artefacts. The high response rate could be attributed to finding people who were genuinely interested in making a difference to the university's physical environment.

Case Results: In terms of benefits of using online codesign in this activity, the students were able to reach a high number of participants (69) with a wide range of ages. They were able to look at images of spaces and rate them, using the medium of a computer display showing high resolution images with the ability to zoom into an image if necessary. Another benefit was that

it was conducted over a week, in asynchronous mode, so participants could do the activity at a time that suited them, in a time frame that supported due consideration of the alternative designs.



(a) (b)

Figure 2 Activity 1, discovering places people find visually appealing: a) the Typeform form survey showing images, b) the results aligned with images

Activity 2: The *Elements* activity used a card sorting method with the OptimalSort program to drag and drop their choices. This activity invited participants to sort a set of 24 predefined elements presented on cards (e.g., bike racks, media walls, pedestrian zones, public seating, pathways, rubbish bins), into four predefined categories (ambience, diversity, accessibility and safety) to indicate important elements and associated feelings (see figure 3).

Participants: The online card sorting activity was completed by 103 participants (47 males, 56 females), aged between 18 and 98 years.

Participant Outcomes: Outcomes showed that participants regarded: state-of-the-art design and maintenance as important to ambience; festivals and food vendors as important for supporting diversity; amenities, cycle zones and relaxing areas as important aspects of accessibility; and navigation help and well-lit and open paths as important for feeling safe.

Case Results: With respect to benefits of online codesign in this activity, again as an asynchronous activity, participants could respond in their own time with as much time to consider the ranking of elements as they wanted. The high number of participants in this activity (103 people) was made possible by the ability to simply send out a link and encourage people to take the time to complete it. It would also have taken the designers a long time to do this activity with so many people in a design studio context. The spread of ages (18-98) is also impressive, as it is usually a challenge to get very old or less mobile participants to come into a physical location for face-to-face codesign.

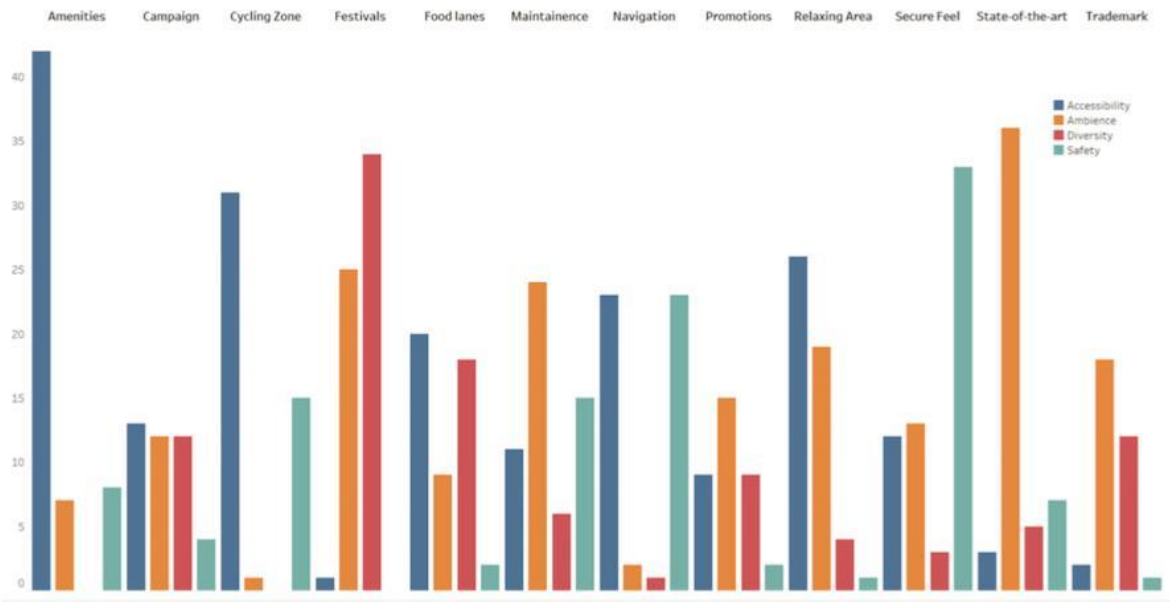


Figure 3. Activity 2, graphed results from discovering how people perceive urban elements as contributing to place.

Activity 3: The *Safety & Amenity* activity had semi-structured interviews conducted using Zoom.

Participants: 16 people from Activity 1 agreed and participated in this activity.

Participant Outcomes: Users shared that a well-lit, colourful and well-maintained environment is the first step towards a pleasant space. The participants suggested adding wayfinding as they felt lost. In summary, we discovered that consistent design, basic facilities, and good lighting can elicit a sense of safety and belonging in users.

Case Results: Doing semi-structured interviews using an online platform is not so very different in terms of time taken to run the session for the designers. In fact, they reported some frustrations about connecting with interviewees and reading their non-verbal responses, in the same way they could have with face-to-face interviews. However, from the participant point of view, although they could not leave their homes due to lockdown restrictions, they were able to save a lot of travelling time and expense, by being able to do the interview from home, as well as the ability to include any members of the community, irrespective of mobility issues. In this way, activity 1 enabled recruitment for activity 2, keeping community members involved and engaged without them having to commit to a lengthy workshop.

Virtual Workshop 2

Activities in the second virtual workshop were conducted online over a two-week period, using Zoom to interview and Google Jamboard to share design concept visualizations of an initial design idea with participants, based on outcomes from the first virtual workshop (three activities), to get their feedback and design input on creating a welcoming entrance to the university.

Activity 4: The *Missing Elements* activity was conducted as an epistolary interview (Fergusson, 2009) where the researchers conducted several interviews simultaneously, so that data from one interview was tested in and used to develop other interviews. SketchUp was used to create

3D rendered images of the space using photographs of the area, showing ideas for a new university entrance. These images were shown on Google Jamboard while conducting interviews in Zoom. Four different models showed the entrance from different viewpoints, and participants were asked to critically evaluate elements of the designs and suggest missing elements and changes using notes placed on the images (see figure 4), to share their reasons for including these elements. Participants were shown images of existing entrance spaces to prompt discussion to share their personal experiences of these spaces, with respect to safety and amenity.

Participants: A total of seven participants, (2 males, 5 females) aged between 18 and 60 years were selected from different sectors of the university community, for the interviews.

Participant Outcomes: Outcomes from the interviews showed that people felt the space was unsafe at night due to lack of lighting and being poorly maintained. They agreed that a well-lit, colourful and well-maintained environment would be more pleasant, suggesting that wayfinding, sitting areas and places to wait, coffee shops and an emergency phone are essential to making a place feel safe and welcoming.

Case Results: This activity combined both a visual platform for showing design ideas for a new entrance, with an audio channel for the interviews. Electronic sticky notes were used to record participant responses, much as the paper equivalent would have been used in a physical workshop. Like activity 3, the main benefits of doing this online were related to convenience and accessibility for participants. The students found that community members were quite comfortable with being interviewed using Zoom, so this did not form a significant barrier to information gathering for the designers' purposes. Combining this with the visual platform was an important contributor to the success of the activity.

Figure 4. Activity 4 where participants critically evaluate elements of the designs and suggest missing elements and changes using notes placed on the images.

Activity 5: The *Seating & Wayfinding* activity took findings from Activity 4 and using Google Jamboard, participants were shown 24 images, eight on ideas for public seating alternatives, nine on ideas for lighting design, and seven images of different types of wayfinding elements,

and asked to choose those they preferred and to place notes on them explaining what they liked about them and why.

Participants: Same as Activity 4.

Participant Outcomes: We found that users preferred modular benches for public seating, as both comfortable and flexible for dwelling in a place. The original design had an abundance of red in it, as this is the university logo colour, but participants found this alarming, and asked that more 'playful' colours be used in the final design. As wayfinding plays a vital part in peoples experience of spaces and in making them more welcoming, most participants added colourful and bold wayfinding elements to their selections, noting that wayfinding signage should be integrated into the new environment. Lighting was also identified as important to both wayfinding and a sense of safety.

Case Results: As a synchronous activity, it was possible for the designers to follow up on participant choices with questions about why they liked particular elements and why, giving a similar experience to face-to-face codesign. Again, the combination of visual and auditory channels was vital to getting the kind of feedback required in this activity. In particular, the participants ability to place notes on the images was important to record their feedback for later consideration by the designers.

Final Design Outcome

The workshops informed this final design proposal for a welcoming entrance to the campus. By combining vegetation with natural materials such as sustainable reclaimed timber and stone (figure 5a), the entrance becomes more welcoming. A series of thin red arches, the university branded colour, define preferred pathways into the heart of the campus (figure 5b). Large colourful wayfinding signs on walls and floors, and large situated screens and interactive media walls, provide necessary information to community and commuters. Sheltered seating pavilions encourage activity and dwelling. Bright lighting along paths both highlights the entrance and helps guide people along paths at night (figure 5c). Colour coded bins encourage recycling and give a sense of cleanliness. Overall the proposed design covers all key elements found in the online codesign process.

(a) (b) (c)

Figure 5: Design Ideas for Welcoming Community onto Campus: a) vegetation and natural materials, b) thin red arches for branding, c) lighting along paths at night.

Reflections and Observations

Although the previous section gave the example case study of activities from just one of the five design teams, the following discussion is based on our learnings from all 25 Master of Design students. The collected data in the form of the student reflections and responses and the end of semester team reports, represent the students' perspective and informed the insights and findings shared in this paper. Students reflected on how the online situation influenced conducting the activities and participant experience. They shared interesting comments made by participants during the process, and insightful moments they experienced. From our observations of the process as educators, we could see that online codesign was able to broaden the reach of the design groups in involving the community as participants, while not negatively impacting the interactions they were having with them, and the outcomes the design teams were getting. These reflective instruments were also an important part of our connection to and communication with the students, given that face-to-face interactions did not happen.

In looking at the final design outcomes of the class, we as educators could see that the students had devised a broad range of creative interactive activities that could be successfully conducted online, garnering enthusiastic participation. Their activities were well designed and achieved appropriate and meaningful input from participants, directly informing final designs, whereby the client was overwhelmingly pleased with the breadth and depth of the final solutions.

While we reported on five distinct codesign activities, examining the way they built on each other and attention to the overall process is crucial. The order of asynchronous and synchronous activities was important to work towards the outcomes, with large numbers of participants early on which built rapport and continuity with some of the codesign participants who continued through the process. In supporting the educational aspect of the process, educators continued to monitor responses and feelings of all codesign parties involved. We needed to ensure that students reflected on and understood the progress of their learning of codesign as well as teaching them to monitor their participants' feelings and engagement. Additionally, we needed to ensure that the data being collected was useful and valuable in inspiring design outcomes.

As educators, we were interested and impressed in how well students appropriated off-the-shelf digital communication and productivity tools and adapted them to accommodate the participatory process of data gathering and design ideating. In assessing the design outcomes, we found that being online was equal if not more effective for learning about codesign processes, compared with previous years teaching on-campus, as evidenced in our assessment of the quality of final reports, design outcomes and the maturity of their weekly reflections about the value of codesign.

Benefits of Codesign Online

Benefits of Building Relationships

Being virtual did not detract from learning about the value of codesign. As one student shared with us about doing codesign online, "*I find this method excitingly chaotic because the chaos caused during the data collection … is directly proportional to the quantity and quality of the findings.*" When reflecting on what worked well online, student designers noted that production tools allowing participants to interact through drag and drop gave participants the

feeling of playing a game, which they enjoyed. The most effective tools were those that supported parallel activity and voice communication channels, so that the students could interact verbally with participants while doing audio and visual tasks, asking them what they were doing and why. This helped build the designer's understanding, their connection to the participant, as well as keep participants engaged in the activity. They also said that using a multiplicity of online platforms and tools in a rapid sequence kept the sessions lively and helped bridge the electronic chasm between student designer and participant.

From this we can see that building relationships, not only within the codesign team, but with the participants, is vital for keeping them engaged. This becomes more important when working online, because there is the natural barrier of the technology interface that sits between designer and participant, while at the same time providing a good conduit to participants. If a participant is in a physical workshop they are unlikely to walk out mid-way, be distracted by things around them, or stop paying attention to the designer. These are much more problematic when working online.

Benefits of Engaging the Senses

Students were building capacity over the workshops to communicate visually and using tangible activities in an online forum, using card sorting or interactive design boards, where their previous online experiences had been primarily video conferencing with only conversational interactions. We encouraged this as educators, running our online classes as interactive sessions, using MIRO board for presentations and class discussions, and encouraging students to trial and share different tools in pilot testing during class time. Students liked learning a range of new technological skills from each other, and learned to use technology as a way to gamify interactions with participants, adding fun to the activity, and supporting integration of different media. Students said it was important to have activities that asked participants to do something enjoyable, such as watching snippets of popular movies, listening to music, or drawing.

This indicates that people's senses play an important role in how information is shared and received in an online context. To compensate for the lack of physical tangibility in online activities it is vital that they are designed to engage multiple senses within what is technologically available, for example, the tactile effect of dragging and dropping alternative choices, typing in notes and the use of audio and video snippets to enrich communication. This adds to participant engagement, as well as eliciting more nuanced and richer responses.

Benefits of Keeping It Simple

The shift to online required the students to carefully think what they wanted to get out of the workshops and they were less distracted by the material aspects of the codesign activities, and more focussed on information gathering while still having engaging elements. In many cases the quieter students reported benefits of feeling more comfortable and confident in an online environment, saying, "*I felt quite comfortable running the co design online, as I felt less pressure to perform. Somehow it feels comforting that everyone is at home under these circumstances … I have the feeling the participants and students feel more open to discuss and talk, it's more of an open environment … it makes it a little easier to focus on our tasks and roles within the group.*"

In our experience of teaching codesign on-campus we have noted that students typically develop overly complicated activities, losing sight of the design intention and the information they needed to collect to answer their research question. They spend a lot of time and effort on creating fun and colourful physical objects and games that they want the participants to interact with, while losing sight of the specific design feedback they want to gather. In an online context, students created more simple activities using technology, while learning to be flexible, concise and to the point, to use media well, and to organise their time, all of which are important skills for codesign.

Benefits of Allowing Flexible Timing

Virtual workshops, where participants met the students online, were easy to schedule and coordinate, with participants being directed from a "virtual" waiting room, where they were greeted and gave informed consent, to a series of virtual rooms where they could participate in different activities with different groups.

The workshops were also not tied to a single time or place, because including both synchronous and asynchronous activities allowed students to take advantage of the opportunities offered by online technologies whereby activities could be done in the participant's own time, giving them time for reflection. Students also managed to attract more participants, due the flexibility in timing and synchronicity of activities.

The flexible timing and virtual workshops meant that students could run workshops at times that suited their participants, over a lengthened period of time, with some activities that participants could do on their own. This resulted in higher numbers who could participate, accessibility for those with time and movement constraints, and time for reflection by participants.

Challenges of Codesign Online

In the early student reflections, there was a belief that online was not going to be as good as on-campus. As one student reported, "*Though working and studying remotely is a better choice, subjects such as codesign need to be done with people around in order to get the relevant results for the proposed question*". Another saying, "*considering how codesign is actually done, performing the activities and working with group members narrows the availability of resources and lowers motivation to work on anything*."

Challenges of Building Relationships

It was difficult to keep participants engaged while having difficulties communicating over electronic channels. Online codesign was seen as more challenging than traditional codesign with respect to clearly and intimately communicating with participants. There were problems understanding what was being said by both the students and participants, as audio was not always clear, and depended very much on quality of home internet connections. People accidently spoke over the top of each other, unable to discern conversational non-verbal cues. This made it difficult to record and understand what participants were saying. There were also difficulties understanding participant experience and guiding them through the activities without their physical presence. Facial expressions showing confusion or difficulty were also hard to read and judging the pacing of activities without access to people's body language was

more difficult online, while being aware of the need to be sensitive to people's attention limits for being online.

To solve this, where ever possible, designers tried to use and adapt platforms that the participant was familiar with. Given the diverse ages (from 18-98 years) and different levels of computing experience of participants, this was not always possible. The challenge was to create an activity that would be interactive, engage most participants, clearly and precisely convey what the designers were asking from participants, while ensuring they felt comfortable doing the activity.

Challenges of Engaging the Senses

Interacting and working with paper, glue, pens, etc., is intuitive for most students, while having to source and learn how to use appropriate and readily available digital tools and platforms in a short time frame is challenging. Due to the lack of physical props, it became important to introduce digital visual and auditory aids into the communication, so that participants had a clearer understanding of what was required. The usefulness, features and adaptability of different tools was an ongoing conversation between students on discussion boards, resulting in a broader range of technologies and media use than otherwise would have happened had we just specified a platform.

The skills needed to guide people through an activity and the variety of digital interaction channels used is important when working remotely. This can be achieved by having both an activity channel (with different visual, tangible and auditory interactions) and a speech channel open at the same time, using different software platforms concurrently.

Challenges of Keeping It Simple

Student designers said that a lack of physical tangibility in the activities meant they had to be more creative in making them. The student designers thought that running workshops online was inspiring, in that it made them think outside the box and come up with simple and creative activities.

Challenges of Allowing Flexible Timing

Being online meant dealing with technical issues before and during the workshops. Students experienced technical difficulties in executing the workshops, due to unreliable and inconsistent home internet quality for both students and participants Even with extensive pre-testing and preparation, technical difficulties with software and connectivity during the live workshops managed to cause frustration, time delays and personal disconnection for both designers and participants.

These problems were overcome by including some asynchronous activities. They did not require an active internet connection. When activities required participants to communicate through text and image messaging, using Instagram or mobile apps, they did not have these communication issues.

Online Codesign Checklist

Effective online codesign activities should include:

- Tactile activities like simple drag and drop to give the feeling of playing a game and feeling in control and manipulating content
- Parallel activities using audio and visual tasks to keep participants engaged and connected
- Quick, rapid sequencing of activities to keep sessions lively and help bridge the electronic chasm between participants
- Diversity of media like watching snippets of popular movies, listening to music, or drawing to create a fun and lively gamified interaction with participants
- Virtual waiting rooms to allow for large numbers of participants as they are not tied to a single time or place
- Asynchronous activities to suit introverted participants as they have time to reflect, resulting in feeling confident to get involved
- Simple and flexible activities to avoid getting distracted by over complicated physical materials, focusing on the aim of the activity
- Facilitation of conversations so that participants know when to talk and feel comfortable

Implications for Hybrid Codesign

For codesign to be effective it needs to be engaging for both the students and the participants to effectively help generate and consolidate innovative design ideas toward building feasible design outcomes. This usually involves: collaboration and communication with participants; hands-on participative activities that generate useful ideas for the design space; and participants and designers gathering in a shared space.

For online codesign to be effective it needs more emphasis on the following key elements: participant-centred collaboration and teamwork, so that they feel part of the process (despite being remotely located); multi-channel communication modes which engage multiple senses to compensate for narrow online speech communication capability; simple, concise and clear activities requiring minimal instruction to produce specific outcomes; and both synchronous and asynchronous activities to give greater flexibility and circumvent connectivity issues.

The extreme situation in which we found ourselves during the pandemic provided an opportunity to discover new modes of working that gave us different and unique insights. It also facilitated a new level of accessibility and inclusion for participants. Given the benefits and opportunities of online codesign discussed in this paper, we argue that future codesign should embrace a hybrid approach, incorporating the advantages of online codesign into our traditional codesign toolkit.

In a hybrid future where online and on-campus learning is looking more prevalent, it is vital that design education, specifically the teaching of studio-based techniques, such as codesign, be better understood with respect to what works online and what does not. By understanding the responses of both the students and the community participants to online participative activities we can better design the types of tasks that are most effective and engaging for a virtual workshop. We can also see the importance of engaging students in a reflective process during the learning, which has to be primarily self-driven by the students so that they take time to record their experiences and their thinking about what they are learning. This made students more critical and intentional about the activities they created and the relationships they built with their participants.

Conclusion

At the beginning of this research, we asked the question, “how does codesign need to be adapted to be effective in an online environment?”. To answer this, we have reflected on lessons learned from teaching codesign online during the isolation imposed by the COVID-19 pandemic with Masters of Design students. Driven by the physical isolation, under academic guidance, these student designers successfully translated traditional face-to face codesign methods into online codesign activities, using everyday technologies and existing software platforms. In future, we will combine our lessons learned from online only codesign and incorporate them into our traditional teaching of on-campus codesign, to further explore the benefits and challenges of a hybrid online and face-to-face codesign process.

We showcase an exemplar student case study demonstrating five unique online activities and their outcomes. The project, *Welcoming Community on Campus*, involved local community members co-creating solutions for the local municipality around making the university campus more welcoming. The activities demonstrate working as a team with the participants, engaging multiple senses, simple activities with simple instructions aimed at a relevant solution, and a mix of synchronous and asynchronous activities for flexibility and accessibility.

Using basic inductive coding and thematic analysis on the written student reflections, educator observations and design outcomes from the whole cohort, we have identified those aspects of their experience that contribute new understandings of online codesign. Specifically, what can be gained from working online and where the challenges are. This knowledge can help inform us in a future that encompasses hybrid learning and hybrid codesign for effective design outcomes, participant engagement and increased inclusivity and accessibility.

Online codesign is about borrowing from the past and transforming it for a hybrid future. We offer a checklist of key elements that requires particular emphasis for successful online codesign. The unexpected finding was that online codesign activities need to remain tactile, and have multisensory qualities. We also found that effective online codesign activities should allow participants to engage in their own time and space. They should be multisensory, tactile, parallel, quick, simple, diverse and asynchronous. They should feel fun, playful and lively.

Understanding and knowing about the benefits and challenges of online codesign can be combined with our understanding of what works well in on-campus codesign to create new understandings for a future of hybrid codesign. Hybrid codesign is appropriate to future ways of learning and practising design, where technology supports new ways of doing things in situations where this produces new, innovative and useful results. In summary, hybrid codesign should engage participants in the online activities, while being tactile, parallel, quick, flexible and multisensory, and should feel fun and playful for all involved.

Overall, we argue that online codesign needs to focus on building relationships, engaging the senses, keeping it simple and allowing flexible timing, through the novel use of technologies to support the future of hybrid codesign education.

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28.1

3D Virtual Site Visit as an Alternative to On-Site Experience in Interior Design Education

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Abstract

This study aimed to investigate the effectiveness of 360-degree panorama-based Virtual Reality (360VR) as a tool to simulate real-world site visit experiences in interior design education. In the first stage of evaluation, the online survey was implemented to ask students about their learning experience of using 360VR. The second stage of 360 VR effectiveness evaluation focused on the objective comparison of students learning outcomes between the 360VR method and the traditional approach. The students' experience survey results indicated that 360VR and virtual walkthrough experiences benefited students' understanding of the site during the design process. Students reflected positive 360 VR experiences on their engagement in learning, special layout, visualization, and educational effectiveness. The result of the student learning outcome evaluation showed no significant difference between 360 VR compared to no site visit. However, there was a significant improvement in students' spatial planning, finish selection, and total scores when using the 360 VR method compared to an on-site visit.

Keywords

360VR, 3D scan, interior design studio, service-learning projects, learning outcome

Introduction

The on-site experience is a crucial part of learning in design education as it allows students to accurately examine the physical environment. During the site visit, students receive important information by experiencing the physical space with all senses, taking on-site measurements, photographing the space, and interacting with the users inhabiting in the space. However, site visit also involves some challenges in covering time and cost associated with long distance travelling, the uncertainty of weather, safety issues, and increase in coordination (Wolf et al., 2021). Even design education has been affected by the COVID-19 pandemic because the era of social distancing limited the students' site-visit experience.

As an alternative to a physical site visit, a 360-degree panorama-based Virtual Reality (360VR) has been implemented in a variety of sectors, not only in marketing, retail, and hospitality, but also in architecture, engineering, and construction sectors. The development of a Simultaneous Localization and Mapping (SLAM)-based mapping technology has enabled users to conveniently capture 3D indoor environments in digital format, and this technology accelerated the virtual experience spread. The 360VR also has advantages in real-world visibility different from Virtual Reality (VR) technology based on 3D modeling. In turn, the increased use of 360VR has transformed human experiences, assisting the co-existence of virtual and physical environments. However, some questions still need to be answered to implement virtual experience in educational settings regarding its effect on student performance. Thus, the goal

of the presented study is to qualitatively and quantitatively examine the use of 360 VR technology in students' learning in educational settings.

Literature Review

3D Scan Technology

The 3D scan technology captures a projection of spherical images of the surrounding environment. In this process, the camera is located at the center of the image plane realizing human-eye behaviors (Pham et al., 2018). As this technology provides real-world visibility, it has been increasingly used in a variety of industries. For instance, retail, marketing, and hospitality sectors have implemented virtual showrooms and exhibits, and such 3D experience has shown the benefits of increased traffic to the store while reducing costs and carbon emissions. When real estate development and home design services provide 3D virtual property, it boosts commissions, the number of listings, and productivity while saving time (Sulaiman et al., 2020; Vazquez et al., 2021b). Additionally, architecture, engineering, and construction sectors use an advanced feature of 3D scan building information modeling (BIM) files, they could simplify design stages by reducing modeling times and measurement errors. Overall, case studies have shown the efficiency of 3D scan technology to reduce the cost, time, and environmental contaminants (Matterport, n.d.; Sulaiman et al., 2020; Vazquez et al., 2021b).

The benefit of 3D scan technology has been reported not only in various industries but also in educational disciplines. There has been a growing interest in 3D tour technology as a potential alternative to a real-world field trip. A field trip has been a widely-used learning activity as it provides real-world experiences, engages students, and promotes student-centered learning. Virtual field trips (VFTs) tackle some challenges of physical field trips such as travel distance, time, cost, the uncertainty of the weather, safety issues, and so on (Wolf et al., 2021). As 360VR is considered as a potential tool to capture field-trip visibility, there have been a growing number of research on the effectiveness of the virtual experience in education.

Controversy has existed about whether 360VR is beneficial for students learning or not. Some researchers have argued that 360VR hardly replaces real-world experiences. Seifan et al. (2020) examined the students' perception of virtual site visits versus real-world site visits. Virtual site-visit could engage and motivate students; meanwhile, students perceived virtual experiences have limitations in fully giving an idea about the site's scale and in cultivating creative and innovative thinking and problem-solving (Seifan et al., 2020). This result concluded that 360VR could be a supplement to a real site visit but cannot be a replacement.

On the other hand, other researchers have proposed VR technology supports innovative learning activity (Pham et al., 2018; Wolf et al., 2021). Specifically, Pham et al. (2018) used 360VR in construction safety education. The result of the survey with educators, construction managers, and students suggested that the 360VR technology was effective in the comfort of using devices, ease of navigation, real-world visibility, visualization, interactivity, and motivation/engagement (Pham et al., 2018). Furthermore, the student group who used VR technology (mean = 80.33, SD = 3.46) showed significantly higher scores on acquiring construction safety knowledge, compared to the student group who learned based on the traditional method of visiting a real construction job site (mean = 77.83, SD = 5.36) ($p = 0.037$) (Pham et al., 2018). Wolf et al. (2021) also found that students in environmental engineering

and urban studies programs reported positive reflections on their motivation, emotion, usability, and site knowledge after the 360-based VFT.

Use of 360VR in Design Education

There have been limited reports that document the use of 360VR in design education and its effectiveness. Loddo (2021) implemented 360VR technology for a museum design project in architectural education. This case study supported that 360VR technology is beneficial in improving students' perception, design knowledge, recognition, awareness, design success, visualization, and interests (Loddo, 2021). This case focused on a museum design project; however, it suggested the potential of 360VR's advantages on the other types of design studio projects. Another study conducted in 2020 analyzed the use and effectiveness of VR to teach the Western History of Architecture (Ben Ghida, 2020). The author describes the importance of 360VR as a sustainable and "secure alternative to fieldtrips".

In summary, the effectiveness of 360VR technology in design education is an ongoing discussion, and limited reports of its effectiveness have been documented. It is necessary to document additional case studies to accumulate evidence. This study, therefore, reports the use of 360VR in an interior design studio project as an alternative to a real-world site visit. Based on the reflection on students' experiences, this study seeks to access its effects on learning engagement, visualization, usability, and educational effectiveness.

Conceptual Framework

This study hypothesizes that the 360 VR method is beneficial in design education based on two educational theories: Visual Learning Theory and Experiential Learning Model. Visual Learning theory explains visual format assists students' high-order thinking skills and learning (Patton, 1991). Visual learning engages visual aids. 360VR is an advanced technology to provide not only high-quality site information in a 3-dimensional visual format but also interactive features. Students can grab large chunks of information in intuitive leaps and remember the site condition easily and remind themselves by coming back to the site model whenever they need it.

The implementation of 360VR in studio courses as a tool to replace traditional project site visits also supports Kolb's Experiential Learning Model. According to Kolb's Experiential Learning model learners absorb and apply knowledge through a sequential multi-step process and it is not a one-time event. The Experiential Learning cycle of Kolb's model constitutes four primary stages of concrete experience, reflective observation, abstract conceptualization, and active experimentation (What is Kolb's Model, 2021; McCarthy 2010). The primary step is to experience and learn the new concept which is also the foundational step or *'concrete learning'*. The second step *'reflective observation'* is for the learner to reflect upon the previous knowledge and reconcile it with new information gained, followed by a successful third step of synthesizing this and introducing new concept also called *'abstract conceptualization'*. With the successful completion of the three primary steps, learner is then able to successfully apply this new knowledge in a contextual setting also referred to as *'active experimentation'.*

Figure 1 explains the theorical framework highlighting the primary differences between traditional site visit method and 360VR implementation. In a typical studio setting during a studio project, students are expected to work through the multi-step design process i.e. Pre-

Design, Schematic Design, Design Development and Post Design. In case of a traditional site visit process, students can only experience the site just once and will have to rely upon site photos and notes for the rest of the steps. However, with 360VR the exposure and access to site related information is same and learners are often able to reply on the original source of information throughout the four primary stages of learning as per Kolb's learning model.

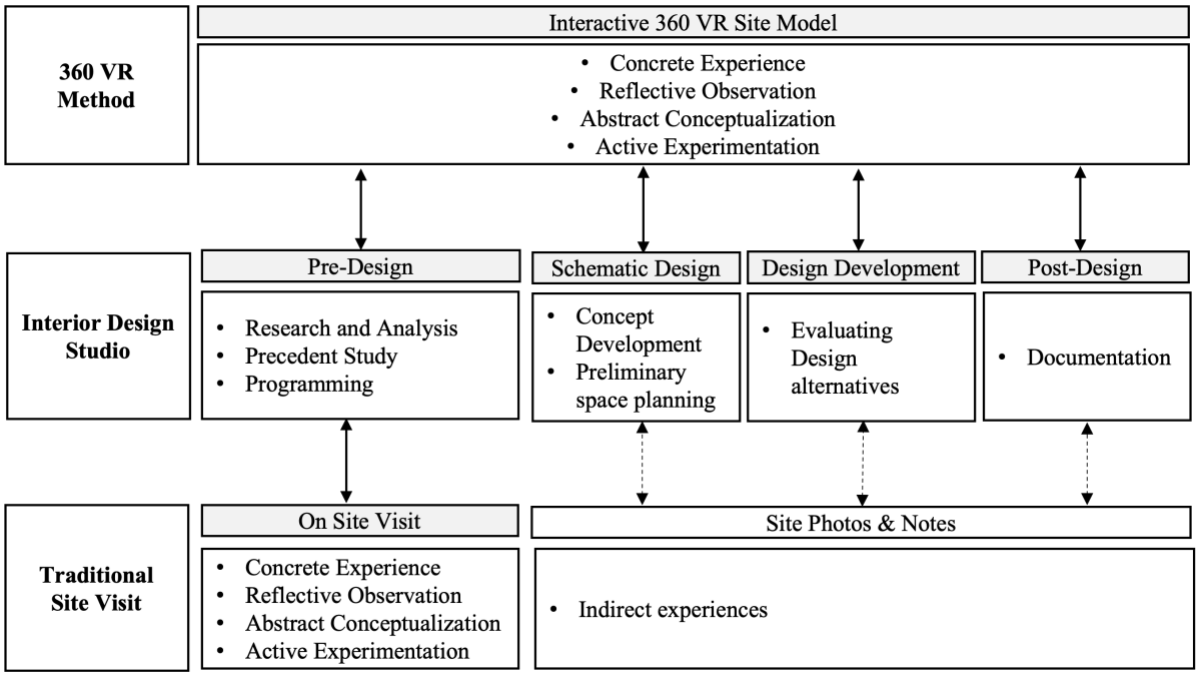


Figure 1: Theoretical Framework

Methods

The purpose of this study is to qualitatively and quantitatively examine students' virtual walkthrough experiences and identify the effectiveness of 360VR technology as an alternative to the physical on-site experience. Sub-questions include:

- Learning Engagement: How much does virtual walkthrough technology engage students in learning?
- Visualization: How does virtual technology help students understand the spatial layout of the site?
- User experience: How do students perceive current technology to be usable enough to assist their visualization of the space?
- Educational Effectiveness: How effectively does virtual technology support interior design education?
- Students Outcome:
    - Are there significant differences in students learning outcomes between 360 VR and no site visit?
    - Are there significant differences in students learning outcomes between 360 VR and an in-person site visit?

Participants

The participants recruited for this study are second-year Interior Design students from a University in South West United States, who have experienced interactive 3D virtual tours during their design studio projects. The study was conducted over a two-year period to include a larger group of participants and multiple projects with interactive 3D virtual tours.

Setting

For each year, as part of the second-year interior design studio, students worked on two projects. Each 8-week project is divided into several assignments, and the accumulated efforts is evaluated during their final presentation. This study uses the final presentation scores for student outcome comparison. As for the student group in Year 1, the student outcome was compared between 360VR and no site visit. In Year 2, the 360VR was compared with an in-person site visit.

The 360VR technology was implemented for service-learning projects with the actual site. Students were provided with a link to access the 3D scan of the project sites. The VR tour was accessible on computer monitors or mobile devices without Oculus Quest. Through the virtual space, students could view the walk-through video, move around to visualize the site, zoom in and out to see materials and measure architectural elements within the 3D model space.

The students worked through the entire pre-design and design process including research and analysis, precedent study, formulating the design program based on client needs, concept development, schematic design, design development, and final design presentation to the client (Karlen & Fleming, 2016). Throughout the design process, the 3D scan of the project site was available to students and was encouraged to use it as needed.

The two-service learning projects assigned to the second-year students in the two consecutive years were both assembly-type buildings with similar square footage. The first service-learning project given to the students in Year 1 was a Church building and the second service-learning project given to the students in Year 2 was an abandoned rail depot repurposed as a community gathering and display space.

Year 1 - Church Building: 360VR

This church building was assigned as the 1st studio project for the semester in Fall 2019. The Christian Science church building in Norman, Oklahoma was built in 1941 after the famous Mother Church in Boston, Massachusetts which was built in 1894. This 1941 church building is approximately 2868 sq ft. with an open floor plan and large fixed glass windows on the east and west wall. One of the major challenges as identified by the church users was the sun exposure in the auditorium on both east and west sides with very large windows which severely degraded the carpeting and some antique upholstery of wooden chairs in color and condition. Additionally, the main church and the Sunday school is not connected directly, so the students had to propose design ideas to connect the two spaces together. The 3D scan view of the church building is presented in Figure 2 below.

(a)

(b)

Figure 2: Christian Science Church (a) View of 3D model created by Matterport; (b) Perspective view

Year 1 – Cosmopolitan Club Project: No Site Visit

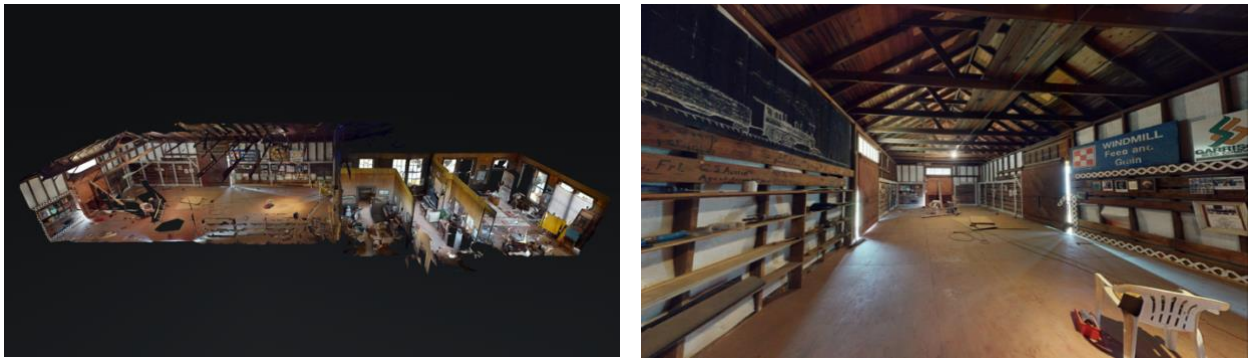
The cosmopolitan club project was assigned as the 2nd studio project for the semester in the Fall of 2019. A barn structure was provided. The building is approximately 4,000 sq ft. with one floor and then a loft area on the second floor. The program requirements included entry, lounge, main dining, private dining, manager's office, restrooms, and food service facilities. Students chose a site in a metropolitan setting in the United States, facing a heavily traveled commercial street. Students could not visit their hypothetical site in person but analyzed using photos and information available online.

Year 2 – Multisite Church Project: In-Person Site Visit

The multisite church project was assigned as the 1st studio project for the semester in the Fall of 2021. The multisite church design team selected one campus located in Norman, Oklahoma as a prototype for the upcoming lobby renovations for multiple locations. The single-story church building, built in 2017, is approximately 36,264 sq ft. and the project scope was 4,914 sq ft. A physical site was required during this project as it is beneficial for students' understanding of the site. The site visit was one time, and students used the site photos and notes for their reference for the rest period of the project.

Year 2 - Rail Depot Project: 360VR

The rail depot project was assigned as the 2nd studio project for the semester in Fall 2021. The M-K-T rail depot (also known as the Wichita Falls & Northwestern Railroad Depot) located in Vici, Oklahoma still sits on its original property by the tracks, is a one-story frame-sided building, built in 1910. The structure is one-story frame-sided with a hipped roof which now has composition shingles. This 2,112 sq ft. depot is divided into two sections: the passenger section with a waiting room and ticket booth is on the West end, with the freight section on the east. The 3D scan view of the building is presented in Figure 3.



(a) (b)

Figure 3: Vici M-K-C Depot (a) View of 3D model created by Matterport; (b) Perspective view

SLAM-based Mapping Technology

Matterport was used to capture and digitize 3D space. Matterport 3D camera consists of Simultaneous Localization and Mapping (SLAM)-based mapping sensors and a motor that revolves 360 degrees (Matterport, 2015). By scanning from multiple points at neighboring positions within 12 feet, the camera creates a 3D model exhibiting environmental data such as interior dimensions, colors, textures, etc. The mapping accuracy of Matterport is slightly lower than LiDAR-based methods; however, it is considered a reliable tool to generate centimeter-accuracy mapping results within a medium size indoor environment (Chen et al., 2018).

Measures

In the first stage of evaluation, the online survey was implemented to ask students about their learning experience of using 360VR. The survey was distributed after the design projects were completed, and administration time was approximately 10 minutes. The survey measured 4 categories using 15 questions: learning engagement, 3D spatial layout, user experience, and educational effectiveness. Each item in learning engagement was measured using a five-point Likert scale (1 = almost never, 2 = seldom, 3 = sometimes, 4 = often, and 5 = very often). For the items under 3D spatial layout, user experience, and educational effectiveness, a five-point Likert scale scored 1 = strongly disagree, 2 = somewhat disagree, 3 = neither agree nor disagree, 4 = somewhat agree, and 5 = strongly agree. For qualitative analysis which captures students' thoughts, two open-ended questions were asked: (1) please list the probable courses where similar virtual 3D spaces can be effectively used, and (2) please provide any additional comment/feedback.

The second stage of 360 VR effectiveness evaluation focused on the objective comparison of students learning outcomes between the 360VR method and the traditional method. For the first student group in Year 1, a service-learning project with 360VR methods was taught before the other hypothetical project with a traditional approach. Inversely, the second student group in Year 2 was taught using 360VR methods after being taught by traditional methods. For both groups, the same instructional pedagogy was implemented regarding the design process. Students were assigned to submit their final design solutions and evaluated by the same criteria.

Data Analysis

The data were analyzed using SPSS version 27. The students' experience survey data collected in the first stage of the evaluation was illustrated by descriptive statistics, including mean and standard deviation (SD) values. Paired *t*-test, also called a dependent t-text, was used for statistical comparisons in the second stage of the evaluation. The analysis compared mean differences on the same dependent variables when each group of students learned under two different methods, 360 VR and traditional methods. Students' outcome scores, including total score, spatial planning, and finish selection scores were measured as dependent variables. *P* value ≤0.05 was considered statistically significant.

Results

Students' Experience of 360VR Technology

The total sample of 18 students in the second year of an interior design program at a Univeristy in the southwest US. In detail, eleven responses were collected from Year 1 group and five responses from Year 2 group.

Learning engagement measured how students were motivated and engaged in the learning and site analysis through 360VR technology. For five questions, students showed, in general, positive engagement in learning. 3D spatial layout section assessed whether the 360 VR helped students visualize the space. The result revealed students' holistic understanding on the spatial information of the site. Students could develop a sense of space and visualize the space. 360 VR was also useful to identify building components and materials through 360VR. User experience asked if students could easily navigate the application during the virtual site visit using 360VR. It was noted that students highly evaluated the visual clarity of the space on 360VR. They also positively answered that the tool was user-friendly. The lowest score was reported about minimal movement lag during the use of application, however, the score still suggested an acceptable quality of user experience. Lastly, educational effectiveness considered students' satisfaction with the use of 360VR in learning design process. Students were overall satisfied with the 360VR and mostly agreed their knowledge of design and construction would improve through the 360 VR technology. Table 1 below summarizes the survey results.

Table 1: Survey Results – Students' learning experience on the use of a 360 VR

		Year 1 Church Project (n = 11)		Year 2 Rail Depot Project (n = 7)	
Construct	Measure	Mean	S.D.	Mean	S.D.
Learning Engagement	I participated actively (or attempted to)	4.7	0.5	4.6	0.5
	I saw the value in the activity	4.8	0.7	4.9	0.4
	I felt the time used for the activity was beneficial	4.6	0.7	4.9	0.4
	I enjoyed the activity	4.6	0.7	4.0	1.0
	I rushed through the activity	1.6	0.5	2.4	0.7
3D Spatial Layout	I developed a sense of space in the 3D virtual space	4.9	0.3	4.9	0.4

	I could visualize the building components through the virtual space	4.9	0.3	4.9	0.4
	The virtual space conveyed information about the materials used and components of the building	4.8	0.7	4.6	0.7
User Experience	The navigation application was user friendly	4.8	0.4	4.7	0.5
	I could easily find my way around in the application	4.7	0.5	4.7	0.5
	The visual clarity of the space was excellent	5.0	0	4.3	0.5
	There was minimal movement lag on the simulation experience	4.4	0.7	4.0	0.5
Educational Effectiveness	You are satisfied with the learning through the 3D virtual space	4.9	0.3	5.0	0
	The 3D virtual space will be favorable for tool for learning about building materials	4.7	0.7	4.5	1.1
	Your knowledge on design and construction will increase if we use similar virtual 3D spaces during instruction	4.8	0.4	4.7	0.7

Qualitative results also reflected the students' positive experience as the quantitative survey results indicated. For the question about the probable courses where similar virtual 3D virtual spaces can be effectively used, students responded *"Any interior design studio. Especially during the pandemic, physically visiting the project might not be feasible."* Students also suggested interior construction, interior materials and finishes, interior lighting, architectural history, and environment and human behavior. These responses supported that the 360VR supported students' visualization of building materials.

Students made additional. positive comments that imply the advantages of 360VR in design learning: *"I absolutely loved it. Could not speak higher of it. I always found it difficult to recall exactly how the space looked so having a reference was a big asset."* and *"It was great for setting up final perspectives as well."*

Another student comment further emphasized the importance and the effectiveness of the 360 VR as an effective visualization tool *"This was very helpful as we were not able to visit the project in person. It helped me visualize the space and how users moved through it which wasn't as easy to visualize in the photos alone."*. Students also indicated that the 360VR was also

"great for setting up final perspectives as well". It is also important to note that every student who student who commented on the effectiveness of 360VR only provided positive comments.

The Effect of VR on Students' Learning Outcomes

The objective evaluation of 360 VR effectiveness was accessed based on students' learning outcomes, including their final projects' total, spatial planning, and finish selection scores. Table 2, Figure 4, and 5 show the differences in students' outcome scores between 360VR and no site visit and on-site visit.

For the students' group in Year 1 where 360VR was used before the hypothetical project with no site visit, a paired sample t-test did not report a significant difference between outcome scores. There was no significant difference in total scores between no site visit and 360VR methods (t (26) = -0.755, p = .457, d = 2.37, 95% CI [-1.28, 0.592]). Spatial planning score of no site visit was not significantly different from 360VR methods (t (26) = -1.968, p =0 .060), although a strong effect size was found (d = 2.94, 95% CI [-2.27, 0.049]). Finish selection scores were also not significantly different between the two methods (t (26) = -0.647, p = 0.523, d = 3.42, 95% CI [-0.926, 1.778]).

In the Year 2 group where 360VR was used after the project with on-site visit methods, there has been a significant improvement in students' total scores from 15.72±1.77 (on-site visit) to 17.62±1.63 (360VR method) (t(33) = -7.869, p < .001), with a large effect size (d = 1.41, 95% CI [-1.77, -.857]). Spatial planning scores increased from 15.75 ±.1.88 (on-site visit) to 17.43 ± 2.12 (360VR method) (t (33) = -5.648, p < .001), with large effect size (d = 1.74, 95% CI [-1.37, -.56]). For the finish selection scores, students' scores went up from 15.69 ± 1.77 (on-site visit) to 17.81 ± 1.57 (360VR method) (t (33) = -7.335, p < .001), showing a large effect size (d = 1.69, 95% CI [-1.71, -.80]).

Table 2: Differences in Students' Outcome between Traditional and 360VR Methods: Paired Sample t-test

Group	Students' Outcomes	360VR*		No Site Visit		t	Cohen's d	*p*
		Mean	S.D.	Mean	S.D.			
Year 1 (n=27)	Spatial Planning	15.69	2.46	16.80	1.38	-1.968	2.94	.060
	Millwork & Finishes	16.63	3.94	16.20	1.88	0.647	3.42	.523
	Total	16.16	2.71	16.50	1.17	-0.755	2.37	.457
	Students' Outcomes	On Site Visit		360VR**		t	Cohen's d	*p*
		Mean	S.D.	Mean	S.D.			
Year 2 (n=34)	Spatial Planning	15.75	1.88	17.43	2.12	-5.648	1.74	<.001
	Millwork & Finishes	15.69	1.77	17.81	1.57	-7.335	1.69	<.001
	Total	15.72	1.77	17.62	1.63	-7.869	1.41	<.001

Note. The scores are out of 20.* The project using 360VR method was implemented before the no site visit experience in Year 1; ** The project with 360VR was used after on-site visit method in Year 2.

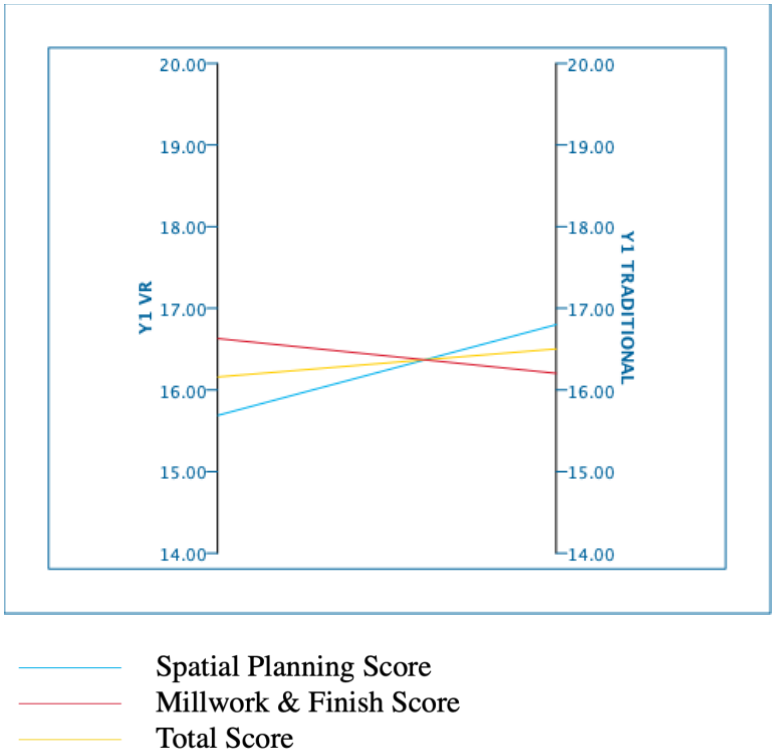


Figure 4: Mean Differences Between 360VR and No Site Visit

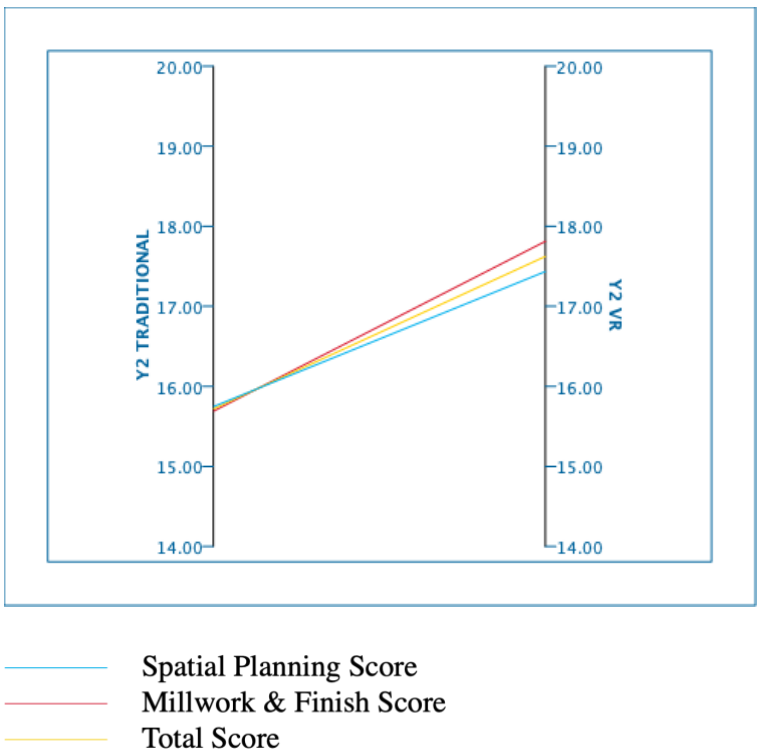


Figure 5: Mean Differences Between On Site Visit and 360VR

Discussion

This study aimed to investigate if the 360-degree panorama-based Virtual Reality (360VR) could be an effective tool to simulate real-world site visit experiences in interior design education. The students' experience survey results indicated that 360VR and virtual walkthrough experiences benefited students' understanding of the site during the design process. Students reflected positive experiences on their engagement in learning, spatial layout, visualization, and educational effectiveness. The result of the student outcome evaluation showed a significant improvement in students' spatial planning, finish selection, and total scores when the 360VR method was used after the traditional approach.

In the Year 2 group, students' learning outcome scores increased when using the 360 VR method compared to on-site visit experiences. Not only did the total score on their final presentation, but the increased scores also included spatial planning and material selections. This data support Loddo's (2021) assertion that 360VR is a useful tool for visualizing environments, design elements, and materials, as well as understanding circulation. Specifically, clear visualization of building materials and distance-measuring features enhanced the virtual experience. These features also support other pedagogical interventions such as lectures, charrettes, discussions, and analysis since it is accessible anytime for students throughout the design process.

Meanwhile, there were no significant differences between the 360VR method and the hypothetical project with no site visit. It is also important to note that the practice effect could influence the students' outcome comparison. Practice effect refers to the change or improvement in performance resulting from repeated practices in a within-subject design (American Psychological Association, 2022). In the Year 1 group in which 360VR was implemented first followed by traditional methods, no significant difference was found in students' outcomes. Meanwhile, the Year 2 group where the two methods were inversely implemented showed significant improvements in learning outcomes. When considering the difference rate in outcome scores, the data suggests that 360VR could positively influence both groups; however, further investigation is necessary.

Lastly, this study conducted a post-experience survey. Comparison studies between pre and post-experiences, or between virtual and real-world experiences will broaden the current study's findings. Also, the 360VR technology used in this study was available to students by computer monitors or mobile devices. Future studies can investigate 360VR technology with emerging tools such as wearable devices, VR glasses, and Oculus Quest. With technological development, the immersive experience is expected to be high-quality and seamless with the lighter weight of devices and lower costs. The different 360VR effectiveness in educational outcomes can be further discussed according to the device types.

Conclusion

Students' understanding of the existing site condition is crucial in their design process. According to visual learning theory, students grasp knowledge when information is provided in a visual format (Patton, 1991). Aligning with the theory, a site visit has been a crucial part of the design project as it promotes students' imagination, provides sensory experiences, and allows accurate measurement. 360 VR technology has the potential to support such pedagogical needs. This study only involved a small sample and particularly focused on two case projects,

the church renovation, and the rail depot project for the 360VR method. However, this case study could suggest a basis of explaining how other types of design projects can use 360VR in the visualization of the space. Further studies with various design project types will expand the understanding of the students' virtual experiences.

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Design and Technology Education: An International Journal

28.1

“How am I supposed to tell my mother what happened in today's class?”: at the intersection between blended learning and design (thinking) education

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Abstract

Since the beginning of the 21st century, design education has been gaining momentum across disciplines as a means to equip students with skills relevant in the job market as well as to tackle wicked problems. One of the core assumptions behind integrating design education to other disciplines focuses on the need for hands-on and experiential opportunity exploration and collaborative learning, often prevalent in studio-based settings. However, as the Covid-19 pandemic has shown, physically accessing the campus or the studio is not always feasible, so how might this impact multidisciplinary design education? Acknowledging the notion that we no longer can take face-to-face learning for granted, this paper ask what aspects of design (thinking) education could be delivered in blended environments. I contribute to this body of knowledge by investigating students’ perceptions of their learning about design methods and processes in a problem-based blended learning course focusing on design and multidisciplinary teamwork. Visual learning diaries of forty-seven students were analyzed to better understand how blended learning can support or hinder learning about applying design to societal issues. Data analysis revealed three aspects – triggers for personal development, exploring ambiguity, and technology as providing structure – that form the concept learning frame. This concept sheds light on how the students perceived blended learning elements influencing their learning about how design could be applied to societal issues. Findings contribute to further dissolving the physical-digital dichotomy in design studio and education. Pedagogical implications focus on how blended learning can promote student agency in design education across disciplines.

Keywords:

blended learning, design education, design thinking, problem-based learning, student agency

Introduction

Since the beginning of the 21st century, design education has been gaining momentum across disciplines as a means to equip students with skills relevant in the job market as well as to tackle wicked problems (e.g. Çeviker-Çınar et al., 2017; Garbuio et al., 2018). Furthermore, the concept of design thinking has popularised designerly ways of thinking and crafting (Dunne & Martin, 2006; Garbuio et al., 2018; Rowe, 1987), often compressing the material and cognitive complexities into a set of tools and methods (e.g. empathy map and customer journey) utilised in a linear fashion.

Building on the above, one of the core assumptions behind integrating design education to other disciplines focuses on the need for hands-on and experiential opportunity exploration and collaborative learning, often prevalent in studio-based settings (e.g. Barry & Meisiek, 2015; Brandt et al., 2013; Garbuio et al., 2018). In their review on design thinking courses across 28

universities, Wrigley and Straker (2017, p. 383) highlight how teaching design thinking "should take a problem-based and studio-based approach". However, as the Covid-19 pandemic has shown, physically accessing the campus or the studio is not always feasible, so how might this impact multidisciplinary design education?

Indeed, it can be argued that design thinking's signature pedagogies (Shulman, 2005) have been understood to rely, to a large extent, on face-to-face learning in studio-based environments, and similarly Jones and Lotz (2021, p. 4) argue in their editorial "that moving studio-based curricula online is a non-trivial exercise", yet "being able to make informed and effective change is important, as well as being able to articulate and support such change in education settings that might not fully understand the modes of learning and teaching required for design education" (Jones & Lotz, 2021, p. 6). In other words, acknowledging the notion that we no longer can take face-to-face learning for granted, what aspects of design (thinking) education could be delivered in online / blended environments?

Given that prior studies have suggested blended learning to hold potential in creating engaging learning experiences (Arbaugh et al., 2009; Perera et al., 2020; Proserpio & Gioia, 2007; Redpath 2012) by promoting active learning (Shieh, 2012), in this article I ask the following question:

> *How can blended learning support or hinder learning about applying design to societal issues and with what kind of implications for students?*

With this research question, I aim to contribute to discussions on how design thinking education could be delivered in a blended learning format (e.g. O'Toole & Kelestyn, 2021). Fully acknowledging the baggage that comes with "design thinking" (for a review, see O'Toole & Kelestyn, 2021, p. 241-242), in this paper I am utilising the concept to discuss design education outside design's domain. Further, problem-based learning, echoing Dewey's (1938) traditions on experiential learning, is understood as focusing on tackling real world problems and reflecting on the learning process (Albanese & Mitchell, 1993; Hmelo-Silver, 2004), thus emphasising the student's active participation in the course instead of following a boilerplate template. Building on previous literature on designing frameworks for blended learning (Kim et al., 2014; Lee & Hannafin, 2016), in this paper I propose learning frame in the form of real-life problems as a pedagogical concept to anchor the learning outcomes concerning design as a social catalyst.

In line with prior studies, blended learning is defined as an intentionally designed combination of online and face-to-face pedagogical activities with between 30 and 70% of the course's components and activities delivered online (as per Allen & Seaman, 2010; Bernard et al., 2014). The course studied here entails 135 hours of studying, out of which thirty hours were classroom hours and the remaining hundred and five hours was devoted to classroom preparations and independent teamwork. All in all, thirty-five to forty hours were devoted to online activities and interaction.

Literature review: on blended learning and teaching design

Design education across disciplines

Perhaps due to design's strong anchors in the real world, teaching design outside its own domain has been gaining currency not only in business schools (Dong et al., 2016; Lynch et al. 2021; Schumacher & Mayer, 2018), but also in engineering (Coleman et al., 2020; Dym et al., 2005) and medical sciences (van der Westhuizen et al., 2020), for instance.

As Garbuio et al. (2018, p. 55) and Gaiardo (2019, p. 213) point out, teaching design for students outside the design discipline should focus on the cognitive aspect; that is, learning to understand the complexities and competencies related to design instead of solely focusing on the tools and methods (e.g. customer journey maps, empathy mapping, and user personas) often regarded as archetypal for design. In a similar vein, Sarooghi et al. (2019) highlight design's role as providing crucial clarity for opportunity creation that is one of the cornerstones of entrepreneurial thinking and value creation. However, while most studies investigating design education in business schools seem to focus on entrepreneurship education, design's importance goes beyond new venture creation, as more established organisations are also regarding design as a strategic resource (Fixson & Rao, 2014; Fixson & Read, 2012; Knight et al., 2020).

Thus, we now know teaching design involves not only tools and methods, but also the cognitive aspect (Garbuio et al., 2018; Goel & Pirolli, 1992) as well as a more refined understanding of the theoretical underpinnings (Dell'Era et al., 2020). As Lynch et al. (2021, p. 9) note, students can go beyond superficial learning in problem-based settings. Investigating how students develop their design competencies beyond tools and methods has received relatively little attention, which is why we ought to explore pedagogical structures that support or hinder this development (in line with Nae, 2017).

Blended learning supporting the emerge of active learning

Blended learning has broadened our understanding on how we can reach our students in ways that increase their engagement and enables them to claim ownership of their learning (Arbaugh et al., 2009; Daspit & D'Souza, 2012; Owston & York, 2018). Recent reviews on blended learning in the business disciplines have highlighted the activating benefits of blended learning environments (e.g. Arbaugh et al., 2009; Arbaugh et al., 2010). Similarly, Fathallah et al.'s (2022) study on remote learning in architecture found that online learning has certain benefits (e.g. reduction in commuting) yet at the same time it is imperative that the course infrastructure supports learning.

More specifically, one potential model to encourage students' active role in the learning process is anchored instruction that "is designed to help students develop useful knowledge rather than inert knowledge" (Bransford et al., 1990, p. 123). Similarly, Eriksen and Cooper (2017, p. 389) discuss Community of Becoming as a concept "to emphasise the continuously emergent and relational nature of students as humans". Thus, while blended learning has the potential to grant more agency to the students in the form of organising activities as they see fit, at the same time there is a need to create structures that enable them to do so (see also Lehtonen et al., 2022).

Notions concerning students' agency are connected to broader discussions on teaching in higher education institutions that have advocated a departure from top-down teaching towards more collaborative inquiry (Bacon & Stewart, 2016; Davidson, 2017; Eriksen & Cooper, 2017; O'Flaherty & Phillips, 2015). Yet, in this context of transforming teaching and learning in higher education, debates have often mistakenly focused predominantly on the technological aspects (Cavanaugh et al., 2016; Kitchen & McDougall, 1999). On the contrary, and in line with extant research on new pedagogies (Redpath, 2012; Sezer & Abay, 2019), we should not only be looking at how technology improves or hinders learning, but instead what kind of pedagogical approaches and structures enable us to support active and collaborative learning in blended learning contexts (Arbaugh et al., 2010; Daspit & D'Souza, 2012; Kim et al., 2014).

Studies looking into blended learning have tremendously increased our understanding of what kind of content can be taught online and how (e.g. Cavanaugh et al., 2016; Kim et al., 2014; Owston & York, 2018; So & Brush, 2008). Despite some of the criticism geared towards blended learning (see Redpath, 2012 for a review), this pedagogical transformation is not about technology, but it first and foremost concerns improving the students' learning experiences (Daspit & D'Souza, 2012; Kim et al., 2014). As such, creating structures for learning experiences that are situated in real life (Christopher et al., 2017), or what Bransford et al. (1990) refer to as anchored instruction and Jonassen (2000) as a better understanding of problem-solving processes, is potentially a fruitful way to introduce design education across disciplines.

Synthesising literature on design education and blended learning

Acknowledging the importance of studio-based learning, more attention is required to exploring how sustainable this form of teaching design really is. As the Covid-19 pandemic has shown, relying on face-to-face learning is not always an option, thus raising concerns about the future of design education if we do not have access to the physical premises (e.g. Jones & Lotz, 2021; Lehtonen et al., 2021). To move forward, this paper explores blended learning as a potential way forward to diversify the approaches we mobilize to teach design outside its disciplinary domain. Given that blended learning places primacy on student engagement and agency (Daspit & D'Souza, 2012; Kim et al., 2014), it is worthwhile to combine design education and blended learning to explore what kind of pedagogical structures support and hinder students' learning about design as a catalyst for societal change.

Research context: Designing IDBM Challenge

This paper focuses on students who took IDBM Challenge, Aalto University's multidisciplinary graduate program International Design Business Management's (IDBM) introductory course on multidisciplinary and design-driven teamwork that was taught in 2017 by drawing on blended learning and problem-based (Helle et al., 2006) methodologies. Forty-seven students took the course (between twenty-one and thirty-nine years of age): forty-one students from the IDBM program (both major and minor students) and six students from Station (https://www.station.dk/), a student-driven organisation bringing together students from universities in Denmark. For the latter, this course was optional and the first two weeks they joined remotely with two of our local colleagues serving as additional facilitators during the workshop sessions.

IDBM Challenge was a three-week long intensive graduate-level course that weaved together studio or workshop-based learning (Barry & Meisiek, 2015) and blended learning content

(podcasts, videos, collaboration software) within a broader framework of collaborative and problem-based learning. To further illustrate the components created and utilised to support the students' learning outcomes, Figure 1 visualises the course in a temporal fashion.

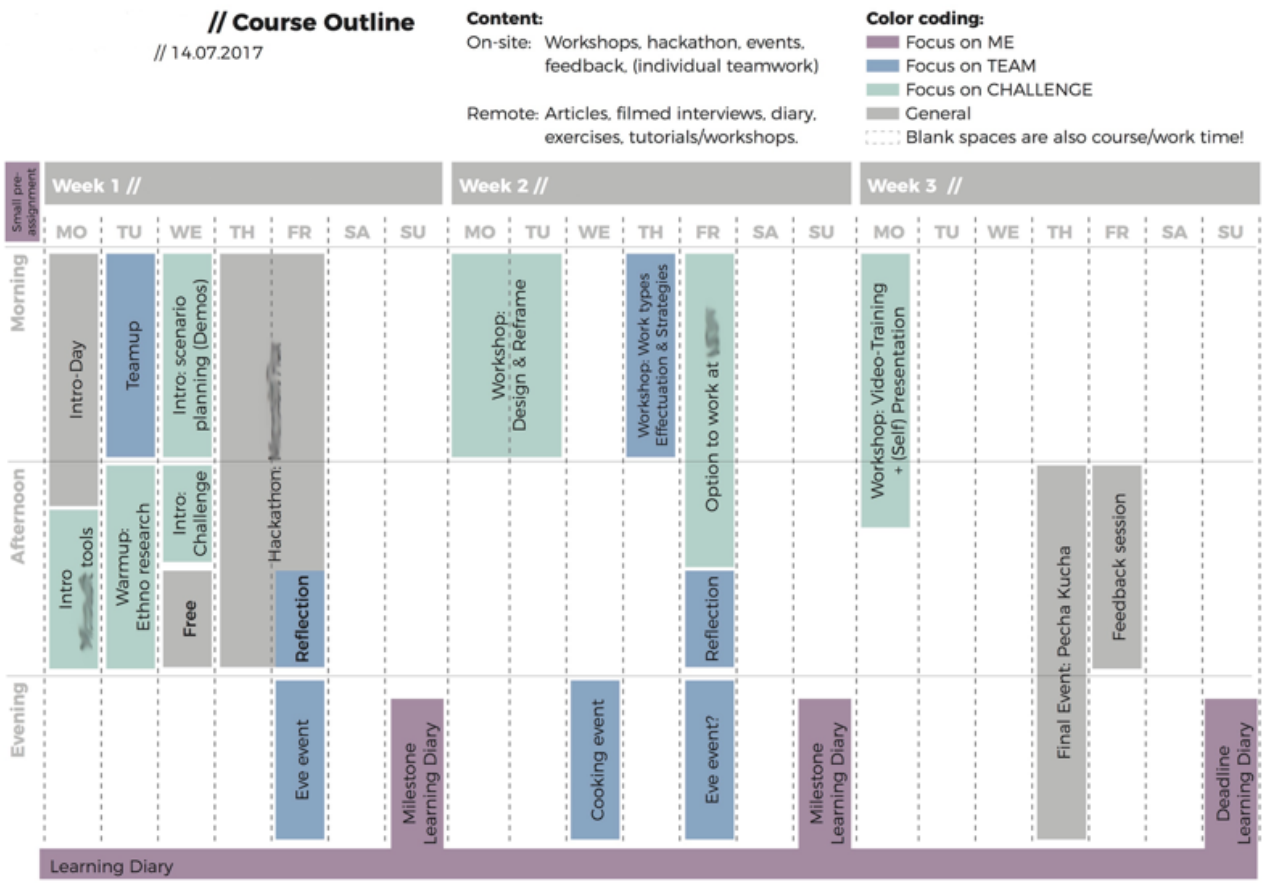

Figure 1. Visualised outline of the course components

During the contact hours, the students practiced methods and approaches related to teamwork and design-driven projects: for instance, Cooking Slam activity for translating effectuation theory (Sarasvathy, 2001) into practice, visual failure curriculum vitae (Seelig, 2016) to share learnings from failures with the team, and the team analysis tools focused on team roles (as per Belbin, 2010). More specifically, the course consisted of 135 hours of work, out of which thirty-five hours were contact hours and the remaining hundred hours were intended for individual teamwork and blended learning. Furthermore, blended learning content (e.g. podcasts and videos specifically created for the course) was organised so as to support the teams' projects while contact hours were structured so that instructions for each day were provided in the beginning and during the day the teams were progressing at their own pace. Thus, the purpose behind the course design was to provide structures "so students are the center of the story and are able to gain unique and individualized learning insights from each learning activity" (Lund Dean et al., 2022, p. 8).

To facilitate learning about teamwork and design, the students were divided into twelve teams that were formed by the teaching team based on gender, discipline, and nationality. In line with the intended learning outcomes, the teams had two tasks: the team-level task focused on

creating a future scenario focusing on outer space, while the community-level assignment was related to the final event the whole cohort was expected to organise (see Kim et al., 2014; Lee & Hannafin, 2016). More specifically, the final event was organised as a multisensory PechaKucha – a presentation format consisting of twenty slides, each shown for twenty seconds – event that was open for everyone to attend.

Each team was randomly given one of the four design briefs dealing with outer space that we co-designed with a Finnish start-up specialised in astronaut training (see Table 1). More specifically, the instructors were responsible for the pedagogical aspects in the briefs, while the start-up provided us with insights on what kind of developments were considered as more or less likely in each year (e.g. by 2037, it is possible – not certain – that space tourism will become available for broader audiences).

Table 1. Design briefs for the teams

Year	Scenario briefing – what kind of societal, political, and economic implications each scenario might have on societies back on Earth?
2027	The International Space Station (ISS) is expected to be decommissioned by 2028 – as such, commercial stations might be set up as alternatives providing hotels and manufacturing capabilities.
2037	Space tourism will become available for broader audiences – to what extent will this impact life on Earth? Will it dissolve or reinforce class divisions?
2047	Asteroid mining financially feasible – how will this influence firms and their competitive advantages and, ultimately, distribution of wealth across societies?
2057	Mars will be colonized – whilst this is the most distant scenario, what kind of ethical and moral issues might this development in the history of humankind bring about?

The problem framing invited the students to focus on two aspects in their final concepts: first, how does life on Earth look like in the future (i.e. creating future scenarios), and what kind of design-driven solutions could they devise to solve societal problems or challenges within this context. Thus, one of the main objectives of framing the design briefs this way was to draw the students' attention to two things: first, technological developments do not necessarily advance welfare in societies in a linear fashion, and second, if certain development trajectories might lead future societies into mayhem, how could design serve as a catalyst to draw our attention to potential perils.

Methodology: visual learning diaries

In line with qualitatively informed studies looking at blended learning (Daspit & D'Souza, 2012; Pachego et al., 2018) and design education (Gaiardo, 2019; Garbuio et al., 2018; Lynch et al., 2021), students' visual learning diaries were utilised as the data set to understand how the students reflected on their learning experiences and outcomes throughout the course. Especially during the last few years, visual research has been gaining momentum (Boxenbaum

et al., 2018) and visual data is well suited for exploring meanings that are not easy to express in a textual format (Höllerer et al., 2018).

The visual learning diaries were submitted digitally through the online collaboration software utilised during the course, and the students were instructed to cover reflections on the following aspects for each day of the course: course readings, workshops, video episodes and podcasts, teamwork, and digital tools. Students' permission was obtained to use the anonymised learning diaries for research purposes. In addition, the students were invited to reflect on the style and format they chose for their visual learning diary since they are both important when it comes to sensemaking.

Data was analysed by mobilising the Gioia methodology (Gioia & Chittipeddi, 1991; Gioia & Pitre, 1990; Gioia et al., 2013) that is well suited for exploring emerging phenomena with the aim of generating theoretical insights (Figure 2). Furthermore, due to the methodology's emphasis on a systematic approach (Magnani & Gioia, 2022), it can transparently communicate how theoretical insights were derived from data.

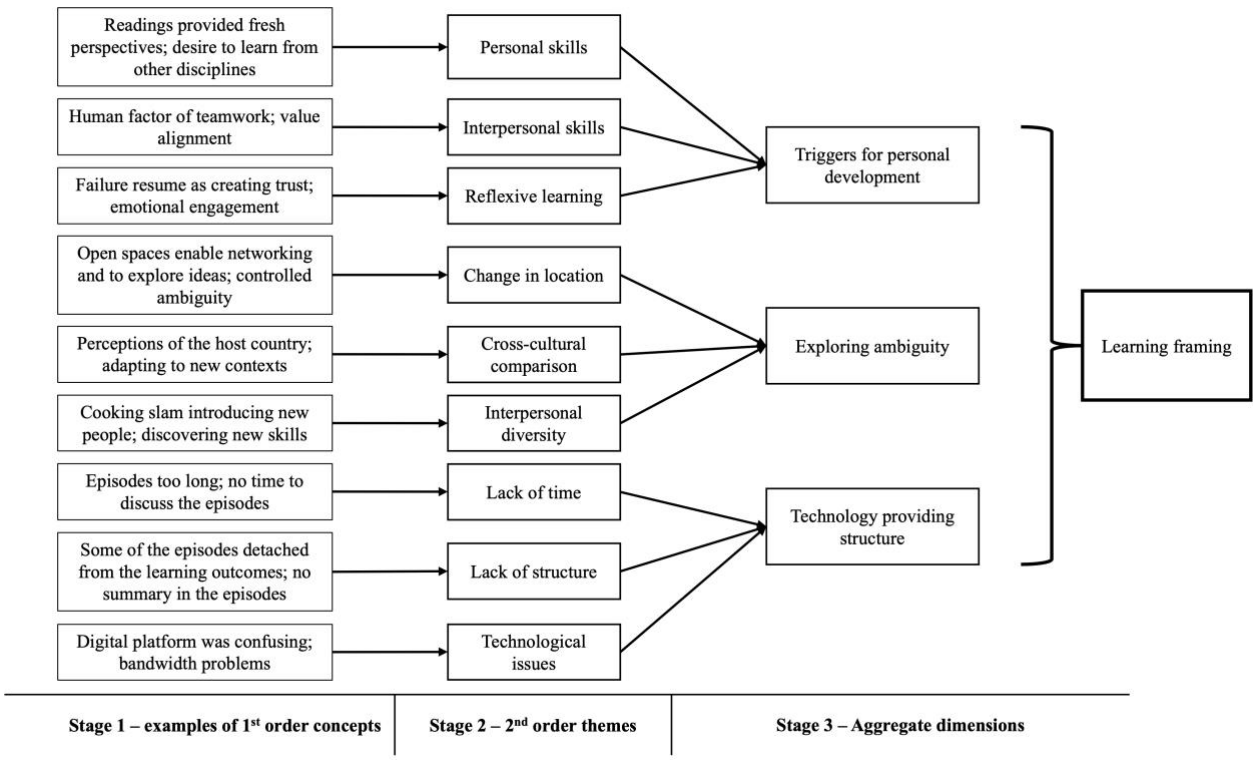

Figure 2. Data analysis process visualised according to the three phases

The first-order concepts on the left side are words, images, and symbols used by the participants – visual learning diaries were first read and reread to look for relevant codes. At this stage, codes are generated to look for emerging patterns, after which codes are grouped together so the data is easier to analyse. Once I felt no new concepts were emerging from the data, I started categorising the concepts into second-level themes. The purpose here is to raise the abstraction level from the first-order concepts by exploring connections and interdependencies between the concepts: moreover, categories emerging from this phase are traditionally researcher generated. Further, 2nd order themes emphasise "nascent concepts that don't seem to have adequate theoretical referents in the existing literature" (Gioia et al.,

2013, p. 20). Finally, the two phases were combined by forming aggregate dimensions that provide a conceptual framework for theorising on students' experiences during this blended learning course. This last stage is what Gioia et al. (ibid., p. 22) refer to as building a theoretical model that "is grounded in the data (as exemplified by the data structure), one that captures the informants' experience in theoretical terms". More specifically, the concept of learning frame is thus a theoretical explanation of how the students perceived blended learning elements influencing their learning about how design could be applied to societal issues.

Findings: three aspects of learning frame

Data analysis described above resulted in three aggregate dimensions that shed light on how blended and problem-based methodologies can support learning about design in a way that integrates the university context with the surrounding society. Taken together, I conceptualise their interdependence as learning frame; a framework for designing blended learning environments that can facilitate learning about applying design to societal issues. More specifically, the learning frame concept should be understood as a building block for design (thinking) education that goes beyond the traditional physical studio (e.g. Jones & Lotz, 2021). The three dimensions comprising the learning frame will be discussed separately in the section below, after which they will be synthesised in discussing learning frame in more detail.

First aspect: Triggers for personal development

Since focus here is on a three-week intensive course, we can hardly talk about transformation in our students that would have taken place immediately after or during the course. However, we can nonetheless discuss triggers for personal growth and self-reflection: that is, pedagogical methods that have the potential to transform participants. Figures 3 to 5 show why the participants found some of the teaching methods meaningful.

There's no limit to the amount of cheesy quotes you can find about cooking bringing people together - but hey, after our Cooking Slam I have to say, maybe there's some truth to it. What was really fun about our task was that everybody had something unique to bring to the table. I found myself constantly surprised by people's hidden talents. An engineer who also happens to be an expert in preparing beet mousse? Cool!

Figure 3. Participant describing how cooking together related to learning

Being thrown into a random team of people with(out) culinary skills, having to deal with ingredients I/ we don't usually cook with (not to mention the arbitrary combination), and then increasing the complexity of adding the "risk" and "opportunities" with the added factor of a time limit, the whole session was very invigo-rating.Stressful? Yes. and very master chef-esque, but it was refreshing. I think it felt a bit like a creative sprint?

I really like how you managed to in-corporate the effectuation theory into that session, that was brilliant! :)

Figure 4. Participant sharing thoughts on the Cooking Slam

From the very beginning, it was great to be on a team where our values aligned in terms of what we wanted out of this course. We all wanted to learn and have fun doing so and grades weren't our primary concern.

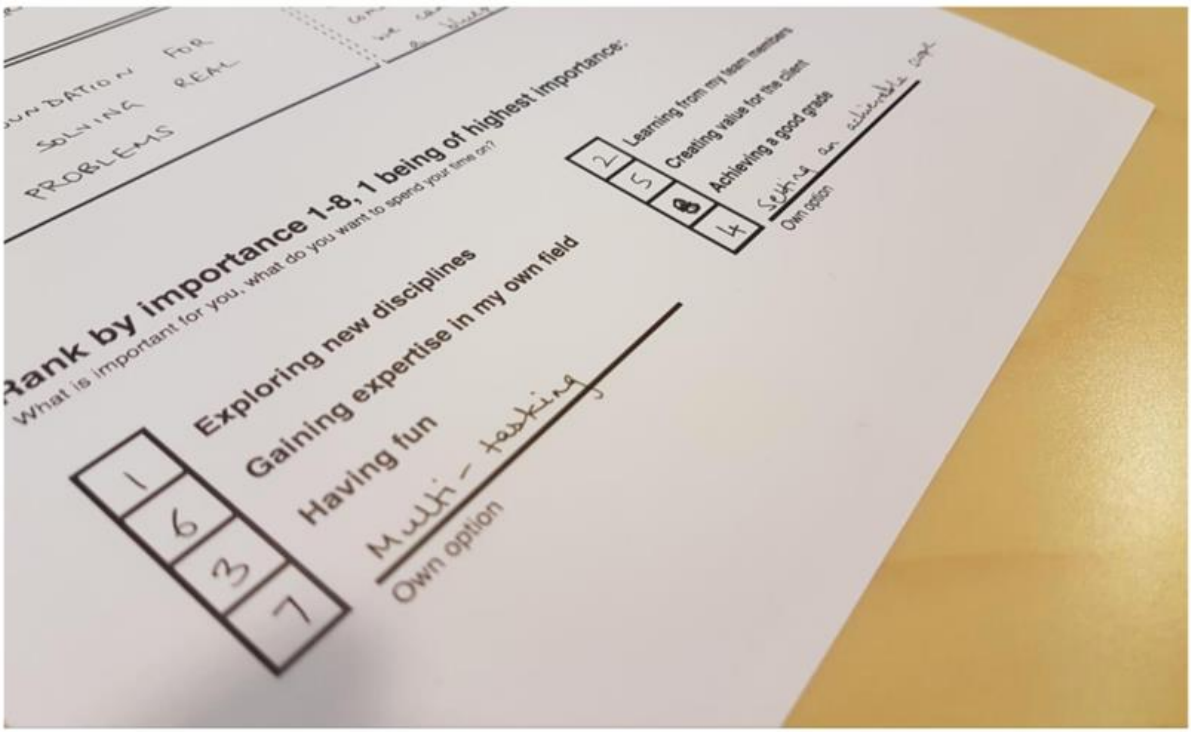

Figure 5. Participant reflecting on how rankings in the Personal Goal Setting documents were aligned within the team

'Meaningful' in this context was thus perceived as being able to get to know other people involved in the course (Figure 3), combine theory with practice (Figure 4), and reach aligned learning objectives for the course in the team (Figure 5) (in addition, there was a strong trend throughout the Personal Goal Setting documents illustrating how "Exploring new disciplines" and "Learning from my team members" were ranked higher than "Achieving a good grade"). Given that design often takes place in multidisciplinary settings, working with participants from other disciplines to achieve meaningful outcomes and experiences was something that helped the participants understand the interrelated relationship between design tools and designerly ways of knowing.

Furthermore, the excerpts from the participants' learning diaries described above illustrate how elements of the course, such as learning goals method, failure resume, and cooking slam served as potential triggers for transformation (as one of the participants wrote in their learning diary, "When I looked backed at my failures, I realized that many of past failures led me to become a better person now!"). In this context, sharing failures with others served two functions: first, it helped the participants to understand that their peers had experienced similar failures in the past, and second, identifying similarities by discussing a topic that is often avoided contributed to creating a sense of shared space within the teams.

Second aspect: Exploring ambiguity

While technology was perceived as creating – or dismantling – structures, exploring ambiguity refers to the participants reflecting on how different teaching methods and learning spaces enabled them to get to know their peers as well as locations situated outside the university premises. From design's point of view, such holistic exploration of ambiguity helped the participants to be more engaged with open-ended exploration. Given that ambiguity was so ingrained in the course, the participants regarded this as beneficial in terms of being comfortable with ambiguity. Moreover, due to the complex nature of the problem presented to the student teams, both contact sessions and online collaboration were geared towards the student teams exploring how they could frame both the problem and the solution space (as per Dorst & Cross, 2001).

In terms of describing and reflecting the problem and interpersonal ambiguity, the visual learning diaries illustrate how the participants experienced ambiguity to varying intensity throughout the course. One design student, for instance, summarised each of the three weeks as follows (Figure 6):

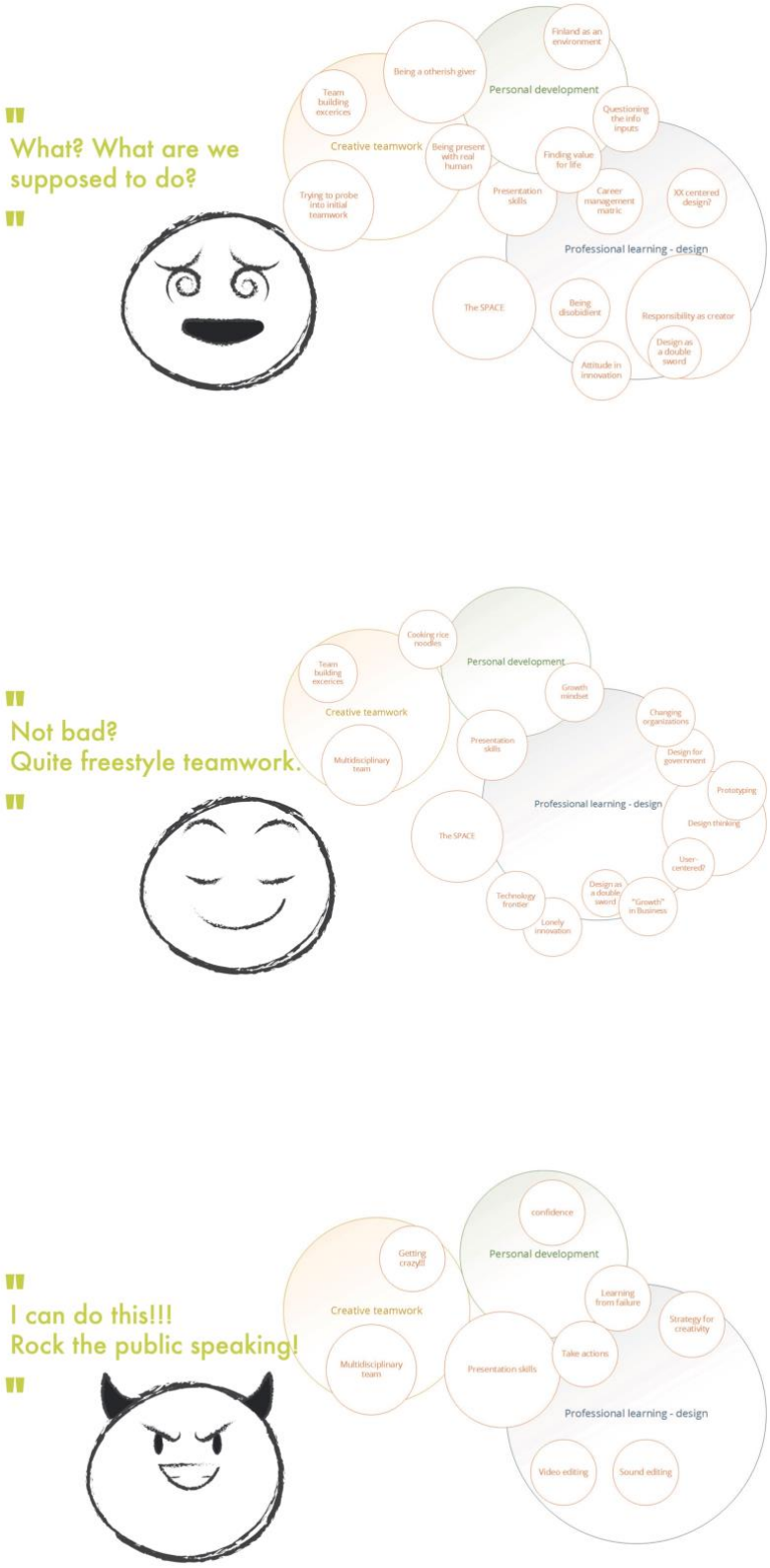

Figure 6. Three-week summary by one of the participants

After the first week the participant was reflecting on the diversity of topics covered during the week and how they all were connected. Moving to the second week, ambiguity was still present, although in a more manageable format, and ultimately during the final third week ambiguity had given way to execution. The same participant further elaborated on temporal ambiguity in their visual learning diary:

> *How am I supposed to tell my mother what happened in today's class?... To speak explicitly about the ambiguity during the design process might smooth the process for those especially not from a design background. I am familiar with either diamond model or this mess in the first phase of any design projects, but many of us might not.*

The excerpt above relates to the technological structures discussed previously in a sense that when the outcomes of the course are open-ended, structures and making them explicit are critical for the participants to deal with ambiguity. Put differently, dealing with ambiguity in a course context was perceived as manageable and at times even enjoyable by the participants, and distortions in the context or absent boundaries were seen as causing anxiety.

Third aspect: Technology as providing structure

One of the most recurring themes in terms of technology (i.e. online platforms and digital tools) in the learning diaries revolved around Microsoft's collaboration platform Teams. While some students enjoyed using Teams, majority of them felt it was confusing as a platform (Figure 7).

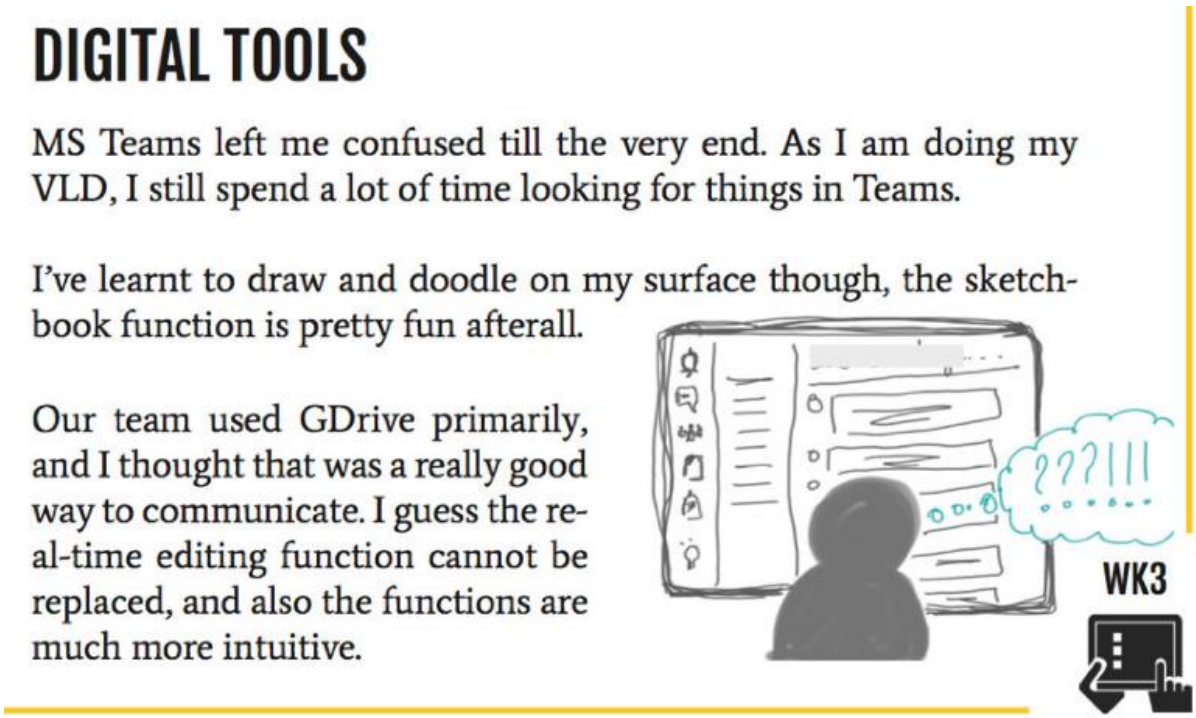

Figure 7. Participant reflecting on digital tools and especially Microsoft Teams

Microsoft Teams *per se* was not the problem, but how we as instructors had intended it could be used to facilitate collaboration between the students. Instead of providing the participants with guidelines on how to actively use the platform, we only created channels (e.g. "Course readings", and "Session slides") for storing material. While the students seemed to have

experienced no difficulties getting accustomed to the digital space, lack of adequate framing made it difficult to utilise digital tools to actively and collaboratively engage with the learning material. Given that design processes are often inherently ambiguous, findings here illustrate the need for more rigorous (though not limiting) structures when utilising digital tools in learning about design.

While the collaboration space was experienced by the participants as unstructured (Figure 8), the video and audio episodes were considered by many as either too long or detached from the learning outcomes.

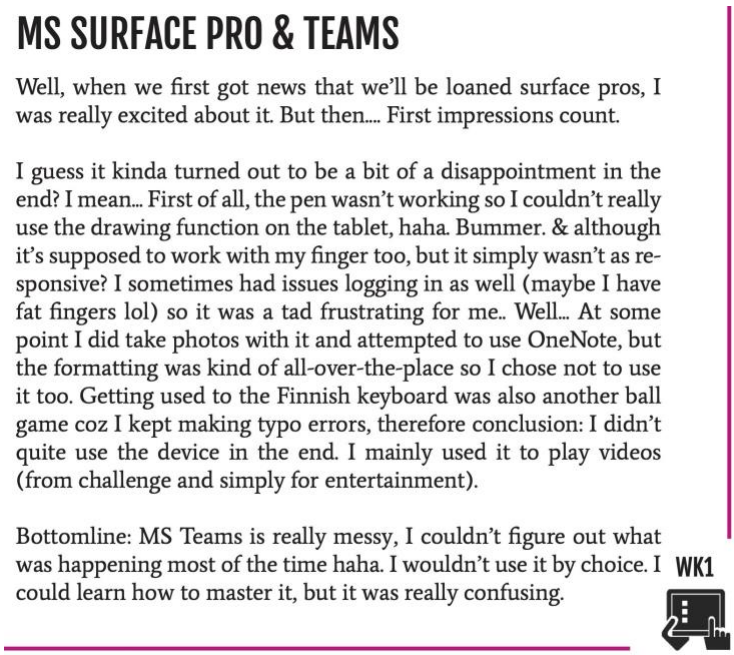

Figure 8. Participant reflecting on the digital tools

The participants did not question the content (e.g. multidisciplinary teamwork, individual strengths, design thinking, and design processes,), but frustration arose mostly from the episodes not having an explicit connection to the course contents and the lack of discussion about the episodes during the workshop sessions (as one of the participants wrote in their learning diary, "[t]here should be a particular session in which we reflect on online and offline sessions together and see what is the relations [sic] between and how they could support each other"). Conversely, lack of structure did not seem to be an issue in terms of organising the final event; another participant mentioned that they found it beneficial they "were not pre-given any structure or organising tips. This made each individual the most creative and collaborative". As such, from a course design perspective, structural ambiguities need to be mitigated so that students can develop their capacities for embracing ambiguity: "we cannot honor individual learning without simultaneously planning for the unexpected) (Lund Dean et al., 2022, p. 65).

Synthesising the three aspects: learning frame

Designing problem-based learning experiences in real-life settings implies a physical and mental departure from the university context, and the findings above illustrate that blended learning holds potential in teaching design to multidisciplinary student bodies. More specifically,

introducing blended learning aspects contributes to student agency whilst also allowing for more diverse approaches by going beyond the assumption that face-to-face learning is the most effective way to deliver design education across disciplines. Figure 9 describes how the findings are interconnected.

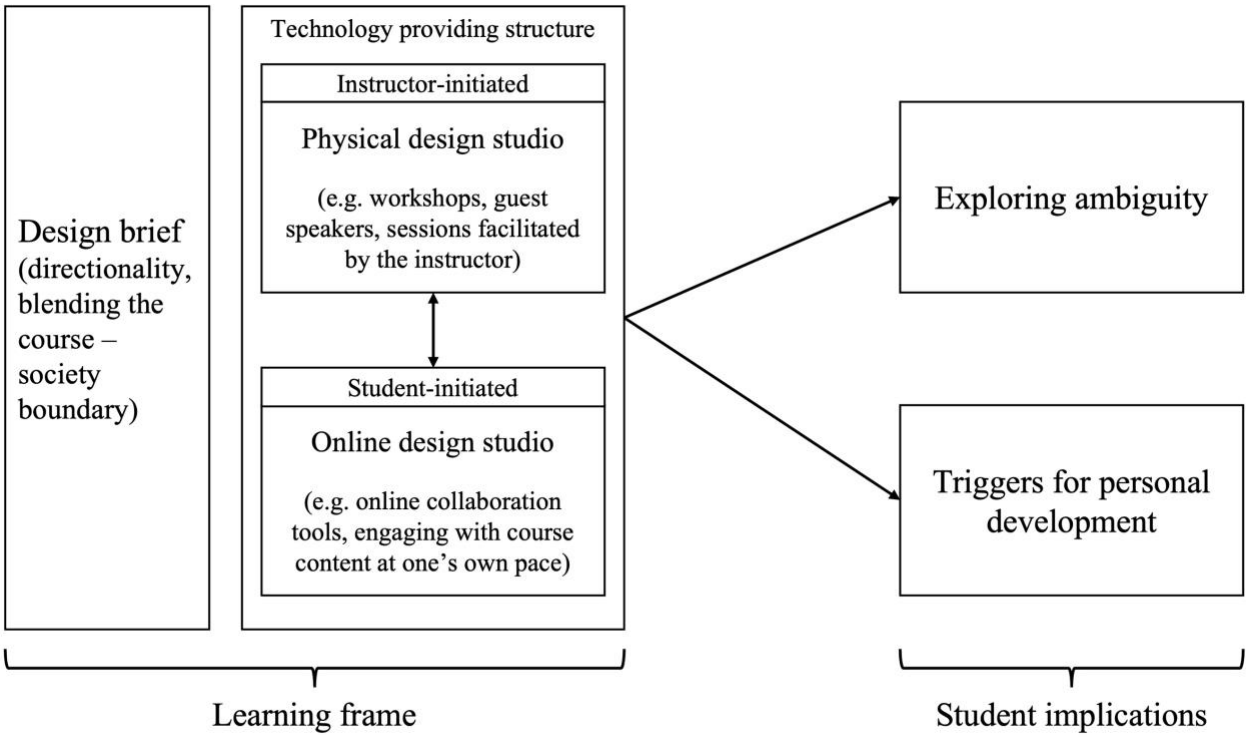

Figure 9. Framework for learning about design outside the design discipline

Learning frame, then, focuses on striking a balance between course activities initiated by the students and the instructor(s) (e.g. Lee & Anderson, 2013). In this regard, blended learning has the potential to create structures that provide more agency to the students, thus enabling them to explore ambiguity in the design brief's context as well as triggering reflections regarding personal development. Furthermore, blended learning has the potential to contribute towards crafting student-centric course by focusing on creating structures for the students to develop their design cognition (e.g. problem and solution framing) and competencies (application of tools and methods). In this regard, findings from this study illustrate how using blended learning technologies and methodologies can either hinder or support students' active learning about design. Lack of clarity, for instance, caused confusion and the audio-visual material being disconnected from the learning outcomes generated frustration, thus highlighting the importance of creating structures through the learning frame. Finally, findings presented above offer one vantage point for moving away from the physical-digital design studio dichotomy; by doing so, the concept of learning frame can be mobilised for creating learning environments that can positively contribute towards students' agency.

Discussion: blending technologies, disciplines, and contexts

Findings from this study contribute to discussions on teaching design outside the design studio (Brandt et al., 2013), making design more accessible (Lloyd, 2013), and design studio beyond the physical-digital dichotomy (Jones & Lotz, 2021; Lehtonen et al., 2021). Traditionally there

has been a tendency to equate design education as taking place in a physical design studio and often by focusing on teaching the students in confined spaces skills they might need after their graduation. By contrast, in the context of this study the participants were tasked with working on a design brief focusing on future and outer space as well as creating an event that was open for anybody to attend (in line with Sadowska & Dallas-Conte, 2017). This real-life anchoring seems to have the potential to serve two purposes: first, it enables reflection with regards to the outcomes and consequences of utilising design to frame problems and solutions, and second, it also allows for authentic feedback and reactions from potential users. Building on this, findings discussed earlier in this paper draw attention to aspects that did and did not work.

Starting with aspects that worked, ambiguity with regards to the design brief and personal reflections helped the students explore how design could be applied to societal issues. First, since blended and problem-based learning can give more responsibility and freedom for the students, they seem to be well suited in terms of dealing with the ambiguity rising from design projects' open-ended nature. In a similar vein, in the context of the course studied here, blended learning can transfer agency from the instructors to the students: that is to say, the instructor creates the learning environment, and the students carve their learning journeys within this environment. Given that we are expecting our students to embrace and manage ambiguity, we, as educators, should be doing the same by approaching course design as a design process in itself (in line with Lund Dean et al., 2022).

Second, as the findings highlight the emergence of exploration, both personal and professional, the importance of 'living learning' (Sadowska & Dallas-Conte, 2017) is reinforced when it comes to teaching design to multidisciplinary student groups. As prior research has suggested, designing in teams has the potential to help individuals acquire new insights and perspectives (Dong et al., 2013; Garbuio et al., 2018; Valkenburg & Dorst, 1998), and building on this, by interacting with the outside world in a course setting helps the students to acquire additional perspectives and insights. By providing the participants with a temporally and spatially distanced design brief (designing a concept for the future and dealing with the outer space), findings from this study support Lloyd's (2013) arguments on making design more accessible: instead of focusing on design as a managerial problem-solving tool, emphasising creativity and engaging with the world seemed to have helped the students to reflect on their professional identity and how design relates to it.

Conversely, aspects that did not seem to work focused on ambiguous structures and disconnections between online and offline content. First, while technology has the potential to provide structure, in the findings section above I discussed how students experience technology when structures are not present. Further, lack of structure seemed to have directed cognitive attention away from exploring ambiguity related to the design project in question towards trying to make sense of, and create structures to, the technologies utilised during the course. While learning to use critical tools and technologies is relevant, at the same time lack of structures is often detrimental to students' learning (as per Boelens et al., 2017).

Second, disconnections between digital content and activities in the physical domain also revealed how students' attention was diverted away from the actual content. For instance, Goodyear and Ellis (2008, p. 147) highlight how tasks, activities, and outcomes need to be aligned in blended learning, lest the way the course has been designed might divert students'

attention to less critical matters. Same holds true for assessment: “The teacher may espouse the intrinsic virtues of discussion, but if the assessment regime rewards signs rather than substance of engagement in discussion, the students will learn that token participation is more cost-efficient than deep engagement” (ibid., p. 149). Put differently, *why* specific content and activities are included in the course and *how* they relate to each other seems to be a critical issue especially when teaching design in blended learning environments.

Finally, the discussion above gives rise to two important implications. First, the study in question contributes to prior studies extending the design studio from its physical, often confined, domain by going beyond the physical – digital dichotomy (e.g. Jones & Lotz, 2021; Lehtonen et al., 2021). Purpose here is not to question the importance of physical spaces when it comes to design education, but instead to explore how and what aspects of design education could be delivered in blended learning format. As the Covid-19 pandemic has shown, it is possible to create courses that “retain the values of relationality, community-centredness” (Noel, 2021, p. 67), and findings from this study provide empirical insights into how learning about design in a blended learning environment can influence students’ approach to ambiguity as well as their self-reflections. As such, by dissolving the boundary between the physical and the digital in the design studio context, there is potential to create learning experiences that help students learn about design as a societal catalyst, become comfortable with ambiguity, and learn more about themselves and their peers. What is of importance here is to explore and reflect on what content and activities could be delivered online and what face-to-face, and consequently how to balance these two.

Second, the importance of student agency has also been highlighted. In their study on blended learning Moskal et al. (2013, p. 20) describe increased student engagement as one of the benefits, and as long as the structures are unambiguous and transparent (e.g. Lund Dean et al., 2022), convincing arguments can be made for teaching about design in blended learning environments. In the context of this study, for instance, technology was perceived as providing structures that hindered learning about design. Thus, conversely, identifying aspects where structures are necessary (and also irrelevant) helps in utilising technology in ways that benefit students’ learning. For example, O’Doherty (2020) discusses how films can be used to stimulate student creativity, and especially in blended learning contexts it should be made clear to the students *why* they are expected to watch videos and *how* they connect to the learning outcomes and other activities. Further, interesting avenue forward here would be to get student feedback on the syllabus and the learning activities prior to the course so as to ensure there are adequate connections between the course elements. In other words, what instructors perceive as evident might not be seen similarly by the students. Agency, then, seems to hold potential when considering how design education across disciplines could be delivered in blended learning format.

Conclusion and implications

The focus of this study was to explore how design education could be delivered in a blended learning format outside its disciplinary boundaries and with what kind of implications for students. Reasoning here being that prior literature seems to have equated design thinking (as design education outside design domain is often referred to) education with hands-on learning in a physical studio, yet as the Covid-19 pandemic has shown, it is crucial to explore other ways of designing learning experiences. To this end, the following research question was formulated:

How can blended learning support or hinder learning about applying design to societal issues and with what kind of implications for students?

In order to support students' learning about design, one potential avenue forward is to utilise the combination of real-life problems and blended learning, referred to here as the learning frame. Building on Kim et al.'s (2014) design principles, learning frame situates the learning outcomes in a broader context that benefits both students and teachers. In a similar fashion, by extending the design studio towards a learning environment that is more connected with the surrounding society, the students can become more exposed to the intricacies concerning designerly ways of working: as Lloyd (2013) suggested, design can serve as a catalyst for students to engage with the world and through this gain a deeper understanding of design cognition (e.g. Valkenburg & Dorst, 1998). In other words, blended learning seems to have the potential to support design (thinking) education by emphasizing students' agency over purely teacher-controlled learning environments.

In terms of practical and pedagogical implications, learning frame extends research on design education by illustrating the importance of providing the students with a conceptual anchor to contextualise the learning outcomes. In more concrete terms, I suggest introducing teaching and learning methods that contextualise the learning experience as well as trigger self-exploration. For instance, crafting a design brief that intentionally nudges the students to explore the world outside the classroom would help in gaining first-hand experiences in terms of dealing with ambiguity, while the visual learning diary serves as a relatively unconfined space for the students to explore their relationship to design. Furthermore, from the instructor's point of view, exploring ways through which to depart from top-down teaching towards community-driven learning is also beneficial as it has the potential to help students become active agents in their learning process.

Like any other academic inquiry, this study has its limitations that can be regarded as avenues for future research. First, as I have looked into what students perceive they have learned throughout the course, future studies could adopt a longitudinal approach or alternatively collect data from the students right after the course and after a certain time period. Second, two out of twelve teams joined the first two weeks remotely with a local facilitator, which is why comparative studies investigating how teams in different locations experience the same course could increase our understanding on how to teach design in online environments. Third, future inquiries could explore the affective dimension of blended learning; namely, what kind of emotions students go through when learning about design, and what role emotions might play in terms of increasing or decreasing student motivation. Finally, future inquiries could also investigate courses that are delivered fully online or alternatively compare similar courses across institutional and geographical contexts. In this study, I have focused on one institution located in Northern Europe, and as such future studies could explore the learning frame in other contexts so as to make it theoretically more inclusive and pedagogically more nuanced.

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Design and Technology Education: An International Journal

28.1

German Design Educators' Post-Covid Challenges: Online, Artificial Intelligence (AI) and Government Data Restrictions

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Abstract

This research examines the experiences of German design educators during the Covid-19 pandemic and explores how these experiences influenced design education's transition to the online studio two years afterwards. The research is based on surveys of 33 German design educators who represent 18 higher education institutions (University/University of Applied Sciences) during the pandemic and 32 surveys and six follow up interviews two years later. This is the first study that focuses exclusively on design education in Germany by presenting a before-and-after contextual snapshot. The results present both positive and negative experiences of educators from a wide range of design domains. The 'offshoring' of the studio to Internet-based communication and file sharing platforms during the pandemic has profoundly altered the perceptions and practices of design educators in Germany, where governmental hurdles, such as data restriction laws, are blocking the full integration of online technology in design education. The findings focusing on German design educator experiences are presented within the context of their international colleagues' experiences from a study conducted earlier. This research also touches on the influence of Artificial Intelligence (AI) on the future of design education as well as a general trend to go offline by encouraging a back-to-campus policy.

Keywords

design studio pedagogy, online design education, blended design studio, Artificial Intelligence, technology-enhanced design studio, blended teaching

Introduction

The closure of universities during the Covid-19 pandemic has led to a rapid turnaround in the employment of Internet-based file sharing and communication technology in an attempt to create online design studios. Design educators who did not routinely use these online platforms pre-pandemic had to learn to use them quickly to approximate face-to-face design classrooms (Jones & Lotz, 2021). Design educators produced a wide range of solutions to convert to teaching and learning design online in what is normally a face-to-face teaching studio pedagogy. It is the face-to-face aspect of studio-based design education that has been disrupted by the Covid-19 pandemic which forced the closure of physical design studios and prompted educators to flip their approach to online models (Fleischmann, 2020c, Jones & Lotz, 2021; Marshalsey & Sclater, 2020; Yorgancıoğlu, 2020). The pandemic also digitally re-cast the design studio's experiential model and social dynamic where students share ideas and educators act as mentors in one-to-one and one-to-many physical spaces. Lehtonen et al., (2021) have characterised this online transition as "a sort of living lab".

Since the height of the pandemic, researchers have focused their inquiries on the strategies employed that helped make online studios in the higher education environment work and

detailed those student and educator experiences that presented challenges (e.g., Charters & Murphy, 2021; Fleischmann, 2020c, 2021, 2022; Jones, 2021; Hepburn & Borthwick, 2021). Although design domains varied, the literature supports the contention that online technology has an important role to play in the future of design education globally, not solely in western developed nations (e.g., Cho et al., 2022; Fleischmann, 2021; Izadpanah et al., 2022; Jones & Lotz, 2021). This paper focuses on where the German experience of incorporating online technology fits into how design is taught and learned in the contemporary design studio post pandemic. The experiences of German design educators have been absent in the debate on technology's incorporation in design education's future. The research presented addresses that gap.

This two-part study explores the initial transition of a group of German design educators from the comfort and familiarity of their physical studios to a virtual environment during the Covid-19 pandemic and investigates what changes were carried forward two years later. This study provides a unique first insight into how a group of German design educators adapted, how they are currently teaching design and how they see the future of design education in Germany unfolding–a perspective still missing from the academic discourse.

Design Education in Germany

It was in Germany where the Bauhaus–the famous German art school–operated from 1919 to 1933 and which founded the basis for how design is taught and learned globally (White-Hancock, 2023). Currently, various design domains such as Communication Design, Fashion Design and Management, Product Design, Interface and User Experience Design, Interior Design can be studied at a University or University of Applied Sciences.

Prior to 1999, a German design degree would usually take four years and students graduated with a 'Diplom' in Design (not to be confused with the 'diploma' in English speaking countries which usually takes one to two years to complete) (Wikipedia, 2022). Since 1999, degrees changed through the Bologna Process with countries of the European Union and others agreeing to a united system of Bachelor and Master programs to allow flexible study, exchange options and comparison between degrees and countries (Wikipedia, 2023). As members of the European Union, German students do not have to pay fees to study at German Universities and Universities of Applied Sciences.

The selection process to get into German design programs is highly competitive. For example, "about 1300 students are allowed to enrol in a communication design degree program each year in German institutions but ten times more apply" (Popp, 2005; translated from German). Acceptance into the program is based on submitting a portfolio, a multi-day creative examination, interview, and completing home assignments (TarGroup Media GmbH, 2023).

The way design is taught and learned in Germany and elsewhere is called design studio pedagogy (Crowther, 2013; Schön, 1987; Shreeve, 2011; STP, 2009). The design studio was based on the 'atelier' method from the 'Ecole Des Beaux Arts' model (1819-1914) and was adapted by the influential German Bauhaus School (White-Hancock, 2023). The model builds on a master-apprenticeship relationship; the master (design educator) shares their knowledge and skills with the apprentice (student) and guides students in their creative development (e.g., Crowther, 2013; Fleischmann, 2016; Hart, Zamenopoulos & Garner, 2011; STP, 2009).

The Physical Design Studio Pedagogy

Design education, whether it is face-to-face, blended, or online adheres to fundamental principles of an experiential model of learning (Kolb, 1984). Design students build, draw, conceptualise, discuss and interact socially in a physical studio that ideally embodies a sense of community and sharing and embraces informal as well as formal learning opportunities (Crowther, 2013; Danvers, 2003; Fleischmann, 2016; Shreeve, 2011; Hart et al., 2011). The practice-based design studio with its foundational characteristics of dialogical learning, the critique, and the studio as a place for learning and social interaction is considered a signature pedagogy (Shulman, 2005) of design education (Crowther, 2013; Shreeve, 2011). Design studio pedagogy differs from many other academic domains (e.g., business, sciences) in the way students learn and the way design educators teach.

The model of feedback–action–reflection (Schön, 1987) is a fundamental principle of the design studio pedagogy–it is a dialogical learning and teaching process. The design studio's dialogical learning process can be between educator and student–where the educator assumes the role as mentor who mediates the process of self-reflection–or among student peers (Danvers, 2003; Ellmers, 2006; Fleischmann, 2016; Shreeve, 2011).

Design work assessment is developed and presented through a critical review process, known as the critique or 'crit'. At its core, the critique is an organic process where students openly discuss what works and what does not about a particular design idea and process. In formal crits the educator gives individual feedback to the student in a structured way through presentations with all students participating (Blythman et al., 2007; Day, 2013; Fleischmann, 2016).

The community and social aspect of the design studio creates a culture that facilitates a sense of belonging which can motivate students to learn (Hart, et al., 2011; Wragg, 2020). Its informality is characterised by Corazzo and Gharib (2021, p. 147) as "ad-hoc opportunities for reflection-in-action" in a "low-pressure environment". Researchers argue that these informal student encounters where ideas are exchanged play a central role in learning to design and supporting peer learning (Corazzo & Gharib, 2021; Fleischmann, 2016; McLain, 2022; Schrand & Eliason, 2012; Wragg, 2020). Ideally in studios, students are surrounded by notes, sketches and drawings, in a kind of design milieu (originally practiced in the Bauhaus) that emulates a professional design studio atmosphere and that encourages informal discussions.

The Online Studio Pre-Pandemic and its Application During Covid-19

Long before Covid forced the transition of design classrooms into online platforms, design educators were experimenting with Internet technology that included the flipped classroom (e.g., Coyne et al., 2017; Fleischmann, 2020b; Yick et al., 2019) and fully online courses (e.g., Fleischmann, 2019; Jones et al., 2020; Watson et al., 2009. Social media for communication and critiquing (e.g., Schnabel & Ham, 2012; Güler, 2015; Fleischmann, 2014; Filimowicz & Tzankova, 2017) have been employed while the Virtual Design Studio (VDS) has been explored early on (e.g., Bradford, 1995; Kvan, 2001). Social interaction in online design studios has also been investigated (Lotz et al., 2015). Despite the experiments with technology-enhanced design classrooms, face-to-face teaching was still the dominant pedagogy preferred by design educators (Fleischmann, 2021).

It can be argued from recent published literature, that design educators from around the world have adapted well to the rapid changes during the Covid-19 pandemic (e.g., Ahmad et al., 2020; Fleischmann, 2020c; Marshalsey & Sclater, 2020; Yorgancıoğlu, 2020; Jones & Lotz, 2021). However, the same researchers and others have also identified multiple challenges experienced by students and design educators. Those challenges–largely based on lack of social interaction–indicate that online design studios are neither black nor white but somewhere in between in terms of effective pedagogy (see for example the special issue 'Design Education: Teaching in Crisis' in *Design and Technology Education,* edited by Jones & Lotz, 2021; also Fleischmann, 2021, 2022).

The 'living lab' during the Covid-19 pandemic spawned several strategies to best apply technology to physical studio pedagogy. Desai et al. (2021) relied on pre-recorded videos that could be accessed online in a multi-national project. Şalgamcıoğlu and Gen (2021) found that design and architecture students used the digital communication platform Discord to meet in rooms they called, 'studio', 'library and canteen' as well as WhatsApp group chats. Thompson et al. (2021) identified that online learning environments need to nurture a sense of belonging and student engagement to successfully make the jump from a physical studio to an online studio, while Fleischmann (2021) found that design domains impact the success of online studios; educators who taught hands-on domains such as fashion and product design showed little enthusiasm for online studios because of the need to teach skills on bespoke equipment.

Researchers who explored the impact of Covid-19 on how they structured their pedagogical approach to replicate the characteristics of the physical design studio faced numerous social and psychological obstacles as well as unexpected successes. Cho et al. (2022), for example, found that students had difficulties communicating and collaborating with other students in virtual courses largely because they felt no sense of community, a recurring theme in current pandemic research of studio pedagogy (e.g., Fleischmann, 2020c, 2022; Marshalsey & Sclater, 2020). Nubani and Lee (2022) called this informal peer learning the Sense of Classroom Community (SCC) and found that the SCC was "significantly" lower in the online interior design studio which resulted in "lower levels of learning" compared to the physical studio.

However, Nubani and Lee (2022) also identified advantages of online learning that included one-on-one virtual meetings with faculty and screen sharing that allowed digital mark-ups–a finding also made by Fleischmann (2020c), Hepburn and Borthwick (2021) and Tessier and Aubry-Boyer (2021). Despite many identified difficulties during the transition, some design educators found the online learning environment of benefit for design students. A study with a group of international design educators revealed that "online design studios can work well when critiquing student work online. Using online cloud-based technologies for critiques is considered effective in facilitating peer/teacher feedback and successful in documenting the creative progress of students online" (Fleischmann, 2022, p. 266)–a finding supported by Tessier and Aubry-Boyer (2021). Ellis and Grieve (2021) explain that "[m]any students excelled within the online delivery, exhibiting the characteristics aimed for the 21st century learner: committed, adaptive, goal orientated, and inherently self-motivated" (p. 414)–a finding supported by Iranmanesh and Onur (2021). And Smith (2022) acknowledges benefits of the virtual learning environment that include international guest lectures, research interviews and access to digital resources during online tutorials.

Research Design and Methods

Given that prior to the Covid-19 pandemic outbreak, the overwhelming majority of design educators globally were opposed to teaching design online (Fleischmann, 2015, 2021; Wood, 2018) the author queried design educators from Germany to gauge their responses to the loss of the physical design studio and shift to online design studios during the pandemic and whether two years after the pandemic, changes have been made to how design is taught and learned in Germany today.

This research is underpinned by the epistemology of pragmatism (based on Pierce and Dewey) which as a philosophical stance "understands knowing the world as inseparable from agency within" (Legg & Hookway, 2020; Kaushik & Walsh, 2019). Taking a pragmatic approach in this research context meant selecting methods that go to the heart of the research question to measure German design educator attitudes toward online technology (Maxcy, 2003; Teddlie & Tashakkori, 2009). The researcher could therefore select research methods that suit the real-world practice nature of the situation (Morgan, 2014; Teddlie & Tashakkori, 2009). An online survey in Stage 1 and an online survey with follow-up interviews in Stage 2 were considered the most appropriate research methods to be used. The decision to use an online survey was driven by the advantage of accessing large numbers of participants, who are geographically dispersed, in a short timeframe. The widespread use of video conferencing tools caused by the pandemic also allowed for follow up interviews to be conducted in a timely and cost-effective manner.

Research Stage 1: During the Pandemic (Survey 2020)

To gain a meaningful understanding in the middle of the first wave of the pandemic (May–September 2020), the author set out to explore the experiences of German design educators across higher education institutions (Universities and Universities of Applied Sciences). Contact details of potential participants were randomly selected from staff profile pages of design departments publicly available on websites of German Universities and Universities of Applied Sciences.

The online survey was sent to a total of 209 contacts of which 23 contacts were invalid. Responses were anonymous. Overall, 33 design educators completed the survey conducted using the online survey platform SurveyMonkey (response rate 18%, see Table 1 for participant details). Questions were designed to not only return data on measurable indicators (e.g., Reflecting on your experience to date, has your view of teaching design online changed since then? Yes, No) but were also to collect qualitative feedback through open-ended questions (e.g., Why has your view changed/not changed?).

Examples of questions asked in Stage 1:

> *Q: Can you describe how your teaching has changed during the Covid-19 crisis?*
>
> *- (open-ended).*
>
> *Q: What was your opinion on studying design online before the Covid-19 crisis? I thought...*
>
> *Answer Choices: Design can better be taught on campus/Design can be taught online/Other (please specify).*

Q; Have the experiences you have had with online teaching over the past few weeks made you change your mind about it?

Answer Choices: Yes/No.

Please explain why and how your view has changed or why not (open-ended)

Research Stage 2: After the Pandemic (Survey and Interviews 2022)

Two years later (September-October 2022) a follow-up survey, which explored whether design educators had changed their approach to teaching design, was sent to the same group of German design educators (209 – 23 = 180). Although the same group of educators were invited in both surveys, focusing follow-up questions on individual participants was rendered impossible by survey anonymity. The second survey questions explored specific attitudes toward online teaching, use of online teaching strategies in the post-covid design studio and their potential future use. Thirty-two German design educators completed the survey (response rate 17%). Like the first survey, the second survey included closed-ended questions to generate measurable indicators and open-ended questions to explore in more depth what changes to German design educators teaching practices have/have not occurred and why.

Examples of questions asked in Stage 2:

Q: 69% of design educators see a mix of online and face-to-face teaching as a viable approach for the future. How does it look today? Two years later, has anything changed in your design class? Do you now include online teaching and learning methods in your teaching?

Answer Choices: Yes/Not yet, but I'm working on it/No.

Please explain your answer. If you answered 'yes' or 'not yet', what online methods are you integrating now or planning to integrate soon and why? If you answered 'no', please explain why not? (open-ended).

Q: Are you ready to integrate more online teaching and learning methods into your design teaching over the next five years?

Answer choices: No, I haven't integrated anything yet and won't do so in the near future/I'll probably continue to use the online methods I'm using now/Yes, I will integrate more.

Please explain your answer (open-ended).

Follow-up interviews were used to gain a deeper insight into the researched phenomena and develop an understanding how the future of design education is seen in Germany. Six design educators volunteered their time with interviews of between 30-60 minutes conducted via video conferencing software (see Tables 1 for participant details). Semi-structured interviews were chosen as a "good way of accessing people's perceptions, meanings, definition of situations and construction of reality" (Punch, 2009, p. 144) and align with the inductive nature of qualitative research (Galletta & Cross, 2013).

Table 1. Number of survey and interview participants across design domains

Design domain	of 33 survey participants during pandemic (Stage 1)*	of 32 survey participants after pandemic (Stage 2)*	of 6 interview participants after pandemic (Stage 2)
Graphic/Communication Design	18	12	2
Product/Industrial Design	5	5	2
Interaction/Interactive Design	8	9	1
Game Design/Animation	1	-	-
Design Thinking/Social Design	-	4	-
Interior/Spatial Design	4	2	-
Fashion Design	-	4	-
Design Research/Theory	2	11	1
Jewellery Design	1	2	-
**some design educators teach in more than one domain*			

Note: The author acknowledges that specific design domains are represented by smaller survey and interview sample sizes and are therefore not representative of all of Germany. Nevertheless, this research gives valuable insights into the German design educators perspectives despite smaller sample sizes.

Data Analysis

The general approach to data analysis was inductive and had an overall drive of exploration and discovery (Morse & Niehaus, 2009). The qualitative data obtained through open-ended questions in the survey and interviews were analysed using a thematic analysis which involves interpretation of data, creating and selecting codes and constructing themes (Kiger & Varpio, 2020). It is a helpful method for exploring the different perspectives of research participants by revealing similarities, differences and potential unexpected insights (Braun & Clarke, 2006; King, 2004). The qualitative data were first coded in broad coding categories depending on the question: for example, ‘challenges’ and ‘opportunities’. Within these categories various themes emerged which are phrases to describe a broader or overarching idea, for example, ‘lacking human interaction’. Similar or same codes were combined into subthemes and are presented according to their importance (higher occurrence more important) (Thody, 2006).

Qualitative data was also quantified (counting number of mentions) (Thody, 2006). That means more data for a particular theme indicates its validity, making it possible to evaluate it as more or less important (Tashakkori & Teddlie, 2003; Thody, 2006). The qualitative data were coded using the research analysis software NVivo. Themes are presented with the number of times mentioned in brackets [ ] and are sorted from high to low. Representative quotations from participants are presented to illustrate the themes which emerged during the data analysis (Educator–S = survey; Educator–I = interview).

For Stage 2, the data collected through survey and interviews were triangulated (multiple methods and data sources). The triangulation of data obtained through different methods (survey and interviews) provided corroborating evidence for the conclusions drawn, e.g.

validation technique (Bazeley, 2004; Johnson & Christensen, 2008; Teddlie & Tashakkori, 2009). Triangulation enabled comparisons to determine if findings were congruent and allowed a deeper understanding of the researched phenomena (Johnson & Christensen, 2008; Punch, 2009; Teddlie & Tashakkori, 2009). For the analysis of the quantitative data obtained through the survey, SurveyMonkey delivered basic statistical data, including the tally of response totals, percentages and response counts.

Findings

Stage 1 Findings: The Move to Online during the Pandemic

Thirty-three German design educators who represent 18 government funded higher education institutions responded to this survey during the pandemic; all but one swapped their classes to an online delivery and one educator was already teaching design online before the pandemic. Prior to the start of the pandemic, more than two-thirds of the design educators, 74%, thought that design can be better taught face-to-face, a view reflected in the response of 87% of design educators who felt there is some content and skills that cannot be taught online; 13% felt they could teach everything online.

Survey respondents' immediate technology fallback position, like their international colleagues (Fleischmann, 2021), was to use Zoom or Webex for live classroom contact (video conferencing tool), Slack (a communication and file sharing platform), Miro (a cloud-based collaborative whiteboard), email, and mobile phones. There was near unanimity among German design educators (91%) who thought their workload was higher when teaching design online compared to teaching face-to-face on campus, while a minority (9%) experienced the workload as about the same.

A Shift in Perceptions During the Pandemic: Blended Design Studios in the Future

Based on the experiences of German design educators during the Covid-19 pandemic 69% said they would proceed with a purposeful mix of online and on-campus classes (blended teaching) after the pandemic has ended. In sharp contrast, 31% of the German design educators would continue with on campus teaching only. All 33 German design educators rejected online delivery and could at the time not envision design courses being offered fully online whether in a synchronous or asynchronous mode.

Despite strong negative opinions regarding teaching design fully online as expressed by this educator: "Any online content is a crutch for sick times" (Educator 12–S), survey responses indicate a shift into accepting that online tools and teaching methods can be a welcome addition to teaching design. The reasons for accepting online tools are reflected in respondent observations that "online worked better than expected", online teaching can "be very efficient and enriching" and that "hierarchies blur or disappear in the online space." (Educators 7, 11, 32–S)

Communication efficiencies were also cited as a positive switch to online cloud-based platforms as expressed by this educator: "There are tools such as Zoom, Miro and Slack that make it possible to communicate directly and easily with the students and to gain insights into their working methods. The teams can also communicate with each other and work collaboratively." (Educator 6–S)

Overwhelmingly this group of design educators single out the fragmentation of social interactions in an online setting as the largest critique of the online studio.

German design educators who still opted for on campus education being the most effective for design education (31%) regardless of positive or challenging experiences, gave the following reason for online's deficiencies:

- the most important is the insufficient human interaction and communication because design students learn from each other and through interaction and exchange with each other [7]
- the development and assessment of three-dimensional designs, prototypes, products and use of materials cannot be done online [5]

Design educators' largest concern for students was the isolation in front of the screen and the lack of informal exchange and student life. One design educator noted: “Not only the courses but also the exchange among the students is important for the design degree. Exchanging concepts and mindsets with other students is an important part of finding your own position in the design environment. Access to workshops and computer rooms also accelerates learning progress compared to isolated work (at home).” (Educator 17–S). However, many design educators acknowledged online technology could have a supportive role to strengthen the on-campus education, as this educator explains: “A large part of design is learning tools and methods. Some of these methods can also be taught online." (Educator 31–S)

Findings Stage 2: The Design Studio Today: Post-Covid-19 Changes

Given the willingness of German design educators to proceed with a blended teaching approach in 2020 (69%), the second part of this study set out to explore what has changed two years later. Did German design educators integrate more online teaching in their design courses and consequently offer their programs in a blended mode? What online strategies have been selected by these educators?

A Blended Design Studio Emerges: An Acceptance of Online Tools Supporting the Physical Design Studio

Seventy-five percent of the German design educators who participated two years after the initial survey and when teaching had returned to ‘normal’, now include online teaching and learning methods in their teaching, while a further 6% are working on it; 19% do not include online methods in their classes.

The following online strategies are now used in support of on campus teaching:

- video conference tools for meetings, project discussions and feedback [12]
- cloud-based collaboration tools (such as Miro) for group and individual projects to have continuous insight (24/7) into projects [6]
- pre-recorded lectures/tutorial content for technical basics [6]
- online presentations [5]
- guest presentations/lectures from experts who otherwise would need to travel [2].

A typical blended teaching approach is described by this German design educator: “I use the online tools introduced in 2020 to support, among other things, the development of semester performances, to give feedback or to provide the students with additional information and materials.” (Educator 4-I).

The 19% of design educators who do not include any online tools give the following reasons:

- design is a process that thrives on direct, personal exchange [3]
- online lessons are not suitable for teaching artistic practices [2].

The Future Game Changers: Work Environments and Artificial Intelligence (AI)

Within dynamic changes brought on by the pandemic there is the awareness that after post-Covid-19 lockdowns, not everyone works in an office anymore, particularly designers; as is expressed by this design educator: “Maybe collaboration will change in the creative agencies so that everyone works together online from the home office. If this is the case, our teaching should also be online and we should teach students how to work in such an environment.” While being open to adapt to workplace requirements, the same educator continues: “However, on campus teaching will always be important, it is a special experience to feel haptics, energies and people in the room. This has a significant impact on creative processes.” (Educator 4–I)

The internal debate between design educators in Germany about the efficacy of integration of online teaching and learning methods in blended programs is overshadowed by the rapid development and the impact of Artificial Intelligence (AI) in design practice and education. During the post-Covid-19 interviews, four participants commented that AI is a game changer in design education. Three of those four speculated that graphic/communication design as an education subject is severely endangered by the rapid deployment of AI and may not be offered as a subject at higher education design schools in ten years. One educator commented: “AI changes a lot of design processes, which can be very time-consuming. When designing, usually a very intensive examination of the subject is required. In the future a computer is fed with keywords and probably after three minutes about 40 different designs and drafts are spit out. Of course, this raises the question: Will there still be design-oriented courses at all? Will they still be necessary? And my prediction is no, they won't be necessary." (Educator 6–I)

The Future of Design Education in Germany: Factors Driving and Inhibiting Change

There is agreement by survey and interview participants that teaching parts of their classes online is possible when class sizes are between 5 to 12 students depending on content and design domain. Overall, 35% of design educators who participated in this study two years after the initial survey can imagine teaching design courses or design degrees fully online within the next 5 to 10 years.

Despite these positive views about using online technology for teaching and learning design, only 9% of design departments of these German universities are considering offering online courses or programs but have not committed to a firm timetable to roll those out. Why is that?

The interviews opened a floodgate of criticism of political roadblocks to change, with all interviewees reporting that the university directive driven by local politics is to return to campus no matter what. One educator said online teaching "is not (currently) desired by the university management." (Educator 2–I).

A major roadblock to implementing online design education in Germany is that universities are funded by actual student seats at a physical campus so online education represents a threat to their funding. There is also a fear by German leaders that online education will just reinforce social isolation in students. One design educator explains: "200,000 young people have been "lost". After graduating from school, they do not appear in an apprenticeship or in any school. Politicians fear that online teaching will reinforce this lack of social integration" (Educator 2–I). Another educator commented: "My university has also seen a huge increase in mental illnesses, which shows how important face-to-face teaching is for young people. Not only the teaching content is relevant, learning as a social and interactive process obviously cannot be replaced." (Educator 5–I)

Data Security Laws and Online Progress

Another roadblock to the institutional acceptance of implementing more online components into design education is based on data security laws in Germany which prohibit student data storage in servers not located in Germany. "We need EU-hosted, data-efficient and secure tools!" commented one educator (Educator 14–S).

Participants in the interviews also explained that Learning Management Systems (LMS) such as Blackboard or Moodle were mostly non-existent in universities at the onset of the pandemic; students did not have a university email address and data security laws makes it difficult to use open-source tools such as Google Docs. To overcome these obstacles, some universities have started developing their own content management and communication tools during the pandemic –with at least one of the interviewees reporting that the project is ongoing.

Discussion

The findings from a group of German design educators presented here demonstrate a consistency among design educators globally to adapt their teaching to incorporate technological changes (Fleischmann, 2021; Jones & Lotz, 2021) but reveal at the same time a pessimism about implementing those changes institutionally based on governmental roadblocks. The findings of this study (Stage 1 during the Covid-19 pandemic) largely align with previous findings about the rapid adoption of online technology. Like their international counterparts (Fleischmann, 2021; 2022), this group of German design educators experimented with communication and file sharing technology during the pandemic and the majority (69%) reflected positively on their usefulness to support the physical design studio as a blended learning and teaching environment–the same percentage as their international colleagues (Fleischmann, 2021, p. 120). This study also confirms this group of German design educators had problems creating the social cohesion of physical design studios with their associated opportunities for informal learning (e.g., Fleischmann, 2021, 2022; Nubani & Lee, 2022; Spruce et al., 2021).

German design educators in this study who formally supported only face-to-face design classes before the pandemic (74%) began realising there were benefits to teaching online; in Stage 2 of

the research three-quarters of German design educators (75%) were continuing to use online teaching methods two years later. Indeed, there was a major attitude shift in that 35% of German design educators could even see design being taught fully online within the next 5-10 years–a thought not possible two years earlier and also not shared at the time by their international counterparts where research showed "there is virtually no support for fully online classes in design education regardless of design domain–whether it is asynchronous or synchronous" (Fleischmann, 2021, p. 125).

Ironically, the salubrious effect of the Covid-19 pandemic on design education was the rapid deployment of online technology which forced design educators to align their pedagogy with contemporary design digital practices. This assimilation of technology transformed educator acceptance of a blended mode of teaching, a finding in many current (e.g., Dabaghi & Arbid, 2023; Fleischmann, 2021; Kamalipour & Peimani, 2022; Nubani & Lee, 2022; Smith, 2022) and pre-pandemic studies (Fleischmann, 2020a, 2020b).

Despite some educators embracing a fully on campus face-to-face teaching paradigm, there is a general acceptance among design educators in this study and previous surveys conducted by the author (Fleischmann, 2020c, 2021, 2022) that online technology has a role to play in the future of design education in various applications, such as online critiques and collaboration. However, there appear to be conflicted attitudes toward the implementation of online teaching strategies amongst this group of German design educators. These conflicts were discovered in three dominant areas.

First, a deeply ingrained conviction that face-to-face design education on campus with interpersonal exchanges will always prevail because this 'in-person' dialogical learning (Crowther, 2013; McLain, 2022; Shreeve, 2011; STP, 2009) is part of design's signature pedagogy which McLain (2022) asserts can take hundreds of years to develop. As this study confirms, 'design is a process that thrives on direct, personal exchange' and that "online design studios fall short in approximating the nuances of dialogical learning and creating a studio culture" (Fleischmann, 2022, p. 267; Nubani & Lee, 2022; Smith, 2022). This conviction prevails despite the positive experiences when using online technology by the majority of German design educators as well as with their international colleagues during the pandemic. (Fleischmann, 2021, 2022; Jones & Lotz, 2021).

The second major conflict that emerged from the findings is that German design educators were resigned to stopping further exploration of their online practices on return to campus because online teaching strategies were not supported by university management. This lack of institutional support was cited as a major factor in returning to the more traditional approach to design education found in face-to-face studios. Motivations to have students learn in on campus classrooms are twofold: German universities are funded by actual student seats at a physical campus and design departments in Germany must comply with local and federal mandates or risk losing funding for their programs. There is also a fear that the Covid-19 pandemic damaged students psychologically and that remote learning would exacerbate the problems.

There are other institutional roadblocks that have been erected by the German government, which include data and privacy laws which prohibit the offshoring of student data on servers not located in Germany. On a micro level this means that cloud-based platforms, such as

Google Docs or Miro cannot be used in student projects unless these services provide server locations that comply with the German General Data Protection Regulation (GDPR) (Miro Community, 2023).

This back-to-campus edict is not isolated to German universities. The author's institution is also pressing students (and educators) to attend physical classes despite a student demand for the flexibility and convenience afforded by online design classrooms which require further financial investments from educational institutions and increase educator workloads, a common complaint by design educators (also in this study) who were new to implementing online technology at the pandemic's outset (Fleischmann, 2020, 2021; Hepburn & Borthwick, 2021).

The third major issue bedevilling German design educators is the rapid deployment of Artificial Intelligence (AI) and its current use in Higher Education, not only in Germany but globally. While German design educators contemplate the incorporation of more online elements into their design studios, they realised that they face rapid technological advancements in the form of Artificial Intelligence which is seen by some in this study as potentially hollowing out design's creative core. This was cited in interviews with educators who see a future where designing a logo, for example, may happen within seconds when fed into a computer that is operating on a database of keywords. This unemotional, machine produced design is completely anathema to studio pedagogy, whether it is online or physical.

As has been widely publicised in the popular press, AI can be used to generate everything from philosophical treatises to designing dozens of logo variations. AI places a new burden on design educators to verify original work. While the Internet is a powerful tool that can be searched quickly, AI has crossed a new technological threshold that raises a set of new, sticky problems particularly in assessing student work. Already design educators are incorporating AI into their curriculum in a limited way to re-produce repetitive tasks such as generating animation templates (e.g., Tang, Li & Tang, 2022). In the author's visual communication design course students already have the option to explore AI tools but must critically engage with its ethical challenges, potential copy right issues and its blind reinforcement of societal stereotypes (see Lawler, 2023; Solly, 2019).

Conclusion

This research was designed to explore the efficacy of online technology among German design educators during and after the Covid-19 pandemic. What it revealed are questions and considerations of a more profound nature that encompass design pedagogy.

The Covid pandemic opened the eyes of German design educators who were previously reluctant to incorporate online technology in their design classroom before Covid-19 shut down classrooms. Like their global counterparts, German design educators had to re-invent the studio classroom digitally. This meant the adoption of online communication and file sharing platforms where possible.

The results presented in this research clearly indicate that a select group of design educators in Germany who participated in this study had dramatically shifted their perceptions about the utility of online learning in design education. Indeed 75% of participants are now using online technology to enhance the physical design studio in their teaching–a blended strategy–while others (6%) are working on incorporating a blended approach.

Yet, this group of German design educators appear torn between the wish to use more online teaching technology and gripping tight to the past when it comes to studio pedagogy, while at the same time some are casting their vision to the future when identifying technology, in the form of AI, as a potential threat to some design domains.

Despite this shift in attitude, there are several external factors that are blocking the widespread adoption of online technology in Germany's post pandemic design classroom. This research uncovered three major areas of resistance in adopting online facing German design educators. Foremost among them is a policy by German Universities to have students return to face-to-face classrooms in order to receive government funding that is based on students attending physical classes.

One of the foundations of online learning is the accessibility of open-source platforms, such as Google Docs. However, data security laws in Germany make if difficult if not impossible to access these open-source platforms so students can communicate and collaborate over the Internet. These platforms, such as Miro, Zoom and Slack, which were used internationally by design educators during Covid-19, would face formidable government obstacles in Germany if not outright prohibition unless the student data was stored on servers in Germany.

In Germany there is also an institutional fear that online design education means further social isolation of students who are still anecdotally experiencing psychological damage from long periods of isolation during Covid-19, which would further jeopardise the socialisation process of the physical design studio. And there is the practical matter cited by design educators who teach hands-on skills (e.g., Product design, Jewellery design) of needing to use specific equipment in face-to-face studio spaces to teach and learn specific hands-on skills–a problem voiced internationally (Fleischmann, 2021).

Overshadowing data concerns is the sudden expansion of Artificial Intelligence in education. Many thought leaders who are promoting it, say AI tools such as ChatGPT represent the next major technology revolution. The generative capacity of AI to create original work after learning from its millions of users is what concerns educators who think students will present AI generated output as their own work. Sceptics and early adopters argue that AI can never replace the nuanced thought process of critical thinking and that AI is fallible. Yet design programs must address AI as a technology that can be a powerful tool, not a threat. The reality is that the design profession has always been adaptable to change. It is clear from the findings in this research that German design educators, like their international counterparts, can adapt quickly.

This research has revealed that the discussion of the application of online design education needs to be broadened to include complex policy issues as well as rapid advancements in technology (AI). There is scope to conduct further research on how online design education and AI intersect. It is unclear at this point what influence AI will exert on design studio pedagogy as a tool to teach and learn.

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Design and Technology Education: An International Journal

28.1

Interaction with end-users in design and technology education: a systematic review

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Abstract

This paper is a systematic literature review of works focused on user-centred design practices and their potential application in pedagogical contexts in design and technology (D&T) education. It is a response to the increasingly complex demand of allowing students to develop so-called 21st-century skills within a D&T curriculum, which is often constrained by time, resources, and policy restrictions. This review highlights a range of studies that have been completed in various countries and phases of education, which enabled students to develop empathy with end-users whilst designing specifically for (and in some cases with) them. A Preferred Reporting Items of Systematic Reviews and Meta-Analyses (PRISMA) model was used to extract works published concerning established inclusion criteria. The articles were analysed according to their relation to user-centred design in a formal education setting and categorised based on the focus of each study. NVIVO was used to code the included literature to establish themes and to support analysis. The literature highlights many advantages to students in engaging in user-centred practices, both contributing towards improved design outcomes as well as improved social and emotional skills. It presents a need to further explore user-centred design methodologies in schools, feasibly through the lens of 21st-century skill development.

Keywords

User-centred design, human-centred design, participatory design, co-design, design education, design and technology education

Philosophy, Policy, and Practice

In England, there is a movement towards adopting a supposed ‘knowledge-rich’ curriculum, which has been propelled to the forefront of educational policy, partly due to the introduction of the English Baccalaureate (EBacc) (McLain et al., 2019). It is argued that D&T takes an ‘extremist’ theoretical position towards realism, against the trend (ibid.). The renewed focus on explicit knowledge is evidenced in the most recent GCSE and A Level D&T subject criteria (DfE, 2015a; 2015b). The curriculum is narrowly focused upon examinations, rather than including elements such as creative coursework (Demetriou & Nicholl, 2022), which has a profound effect on D&T and its identity and relevance in the curriculum. Demetriou and Nicholl (2022) warn that a lack of imagination from policymakers regarding the curriculum will lead to a lack of imagination and creativity in students. The shift towards a ‘knowledge curriculum’ thus creates a gap for the development of human skills such as those supported by constructivists and pragmatists.

Pragmatic philosophies such as those developed by Dewey align with the theoretical position outlined by McLain et al. (2019). Dewey claimed that “isolation of subject matter from a social context is the chief obstruction in current practice to securing a general training of mind.” (1916, p.73). D&T aims for students to gain knowledge through reflection and action (Biesta, 2014), established around a deep understanding of context. Some authors describe the learning

experience in D&T as transformative, focusing on 'abstract knowledge' as opposed to the 'concrete'. Reflecting on pragmatism and the transformational qualities offered by D&T, it can be said that learning in D&T utilises past experiences by relating them to current interests and practical applications (Miller, 1985; Hickman, 2001; Morrison-Love, 2017), leading to abstract knowledge. Whilst D&T as a subject could be described as all-encompassing, there is however increased evidence of teachers' biased focus on practical work and potentially routine affairs that offer little value towards knowledge and experience (de Vries, 2005; Nicholl et al., 2013; Nicholl & Spendlove, 2016), which conflicts with the aims of D&T as a rigorous and creative subject outlined in the English National Curriculum (DfE, 2013) and GCSE and A Level criteria (DfE, 2015a; 2015b).

As early as 1938, Dewey expressed a warning on focusing narrowly on English and maths skills without context:

> *"It is a mistake to suppose that the acquisition of skills in reading and figuring will automatically constitute preparation for the right and affective use under conditions unlike those in which they were acquired." (Dewey, 1938, p.47)*

Whilst the EBacc does not exclusively concern English and mathematics, it is acknowledged that the implementation of the EBacc in schools narrows a much broader curriculum into one that is almost exclusively academic in nature, and it is believed to be a major contributing factor to the demise of D&T as a subject (Banks & Williams, 2023; Spendlove, 2023). It is the focus upon abstract knowledge, a unique element of D&T, in which context can be provided.

Links to Industrial Practice and 21st-Century Skills

The literature demonstrates that in the design industry, there has been a shift towards more participatory and collaborative design practices (Sanders & Stappers, 2008) and people, specifically end-users, are included in the design process as partners. Whilst such practices purportedly lead to more successful commercial products, there is significant discourse to suggest that there are many benefits to students undergoing a similar design process from an educational perspective. Human-centred design is emerging as a dominant trend in design education (Chmela-Jones, 2017), contributing towards its shift towards a more participatory form of practice (Bakirlioğlu et al., 2016; Shore et al., 2018).

So-called 21st-century skills include empathy, creativity, communication, and collaboration, which are essential skills required for engaging in human-centred design and can be developed with the support of a design-based education (Carroll et al., 2010; Noel & Liub, 2017; Tellez & Gonzalez-Tobon, 2019). It is in subjects such as D&T that social and emotional skills such as empathy can support the creative process in order to make the students' products real, usable, and meaningful (Demetriou & Nicholl, 2022).

The learning of these social and emotional skills are deemed to be a necessity in 21st-century education (Ananiadou & Magdalean, 2009) and was advocated for in the early 20th Century: "there is no education when ideas and knowledge are not translated into emotion, interest, and volition" (Dewey, 1933, p. 189), but skills such as those listed above have never been focused upon within education as a whole (Ananiadou & Magdalean, 2009) and it can be said that the current focus on 'knowledge' is detrimental, particularly for D&T (McGarr & Lynch, 2017). Earlier, Dewey (1915, p.163) stated that "recognition of the natural course of

development always starts with situations involving learning by doing.", against the trend outlined above. He goes on to claim that "education that associates learning with doing will replace the passive education of imparting the learning of others" (ibid.). Whilst this is certainly not true at the moment, not least due to a renewed focus on knowledge, D&T in all of its iterations have developed a pedagogy centred around learning by doing.

User-Centred Design and its Relevance in D&T

With roots in craft and training for industry-readiness, D&T was recognised as being a foundation subject in the National Curriculum for England and Wales as a consequence of the Education Reform Act 1988. There has been an explicit focus on the 'user' since its very first iteration in 1990, where students' design outcomes should be developed "in response to perceived needs or opportunities, as opposed to being undertaken for its own sake" (DES/WO, 1988, p.4). This is not always the case, as explored in the proceeding sections.

Whilst literature concerning user-centred design within the realm of D&T has been of interest for almost thirty years, it is gaining traction within the field, particularly due to a popularity in design thinking, a cycle aimed at producing innovative solutions to complex problems. Future generations will be faced with many so-called 'wicked' problems (Buchanan, 1992; Rittel & Webber, 1973), intricate and 'messy' problems that are ill-defined and complex to establish the root of, which impact a wide range of stakeholders. Wicked problems, for example, those relating to sustainability, are what the 21st-century workforce must face (Peng & Kueh, 2022), thus generating interest in how 21st-century skills are developed in the classroom, particularly concerning the need for students to consider the needs of a range of stakeholders.

A contributing factor in the growing popularity of user-centred design in primary and secondary school-based research is the fact that D&T in England is in crisis and the future of the subject is very much unknown. The curricular position of Technology Education in schools is fragile (Jones et al., 2013) and this fragility has become more apparent over the tenure of recent governments. As a subject with weaker epistemological roots compared to other subjects such as mathematics, it is viewed by policymakers as being less rigorous (McLain et al., 2019). This, along with other neoliberalist actions, such as the movement towards school-based teacher training and the school reform agenda, namely academisation, is diminishing D&T as a subject and is rapidly becoming unsustainable (Spendlove, 2023). Whilst this belief is certainly bleak, key figures in the D&T sphere claim that if D&T is to remain a foundation subject in schools, then the future 'version' of the subject must adapt to be entirely distinct from other areas of the curriculum (Spendlove, 2023) and encompass the development of 21st-century skills (McLain, 2023) in order to address problems within a wide range of contexts (Banks & Williams, 2023), especially involving creative, critical and emotional dimensions (Nicholl & Spendlove, 2016). It is often the responsibility of D&T departments to develop students' creative and problem-solving skills (Lane et al., 2023), and this prompts the need to explore how the approach to skills such as these may be developed further and contribute to the strengthening of D&T as a subject.

Solving real problems for real people in early key stages has the possibility of presenting a need for D&T to remain as part of the compulsory curriculum to a range of stakeholders, including policymakers.

Rationale for the Study

It is widely established that the design process is not linear and is in fact a cyclical process, however it is argued that teachers often treat design, predominantly making (Mulberg, 1992), or problem-solving, as a series of steps, which does not necessarily affect the students' thinking (McCormick, 2004), therefore they remain in the procedural knowledge space, impeding the development of authentic problem-solving skills (Nicholl et al., 2013; Nicholl & Spendlove, 2016; Demetriou & Nicholl, 2022). As a result of a lack of time and students' understanding of contexts, the design process has been described as being stunted, leading to poorer outcomes (Demetriou & Nicholl, 2022), highlighting that there is still an absence of authentic D&T activities. This provides an opportunity to investigate ways in which students engage in design-based research activities.

Whilst research of empathic or human-centred design at primary and secondary education levels is considerably limited (Bosch et al., 2022; Dindler et al., 2020), this review will focus on how context is provided through a user-centred design methodology at all stages of design education, and how this has been implemented in the classroom as part of curricula in formal design and/or technology education.

The research questions used to frame the review are:

1. What key skills are developed when students are involved in user-centred design activities?
2. What methods are employed to facilitate user-centred design activities in formal education settings?
3. What instruments were used to measure the impact of the interventions?
4. What difficulties were faced when implementing the interventions?
5. If the study has taken place in higher education, how may this translate to D&T in a school?

Article Selection

The study applied a Preferred Reporting Items of Systematic Reviews and Meta-Analyses (PRISMA) methodology to review how user-centred design activities have been implemented into a D&T curriculum. The PRISMA process has four steps: (1) identifying articles according to keywords; (2) screening of abstract, title, and keywords according to the set inclusion criteria; (3) checking the eligibility of complete articles; and (4) obtaining them. Figure 1 shows a flowchart of the procedure used.

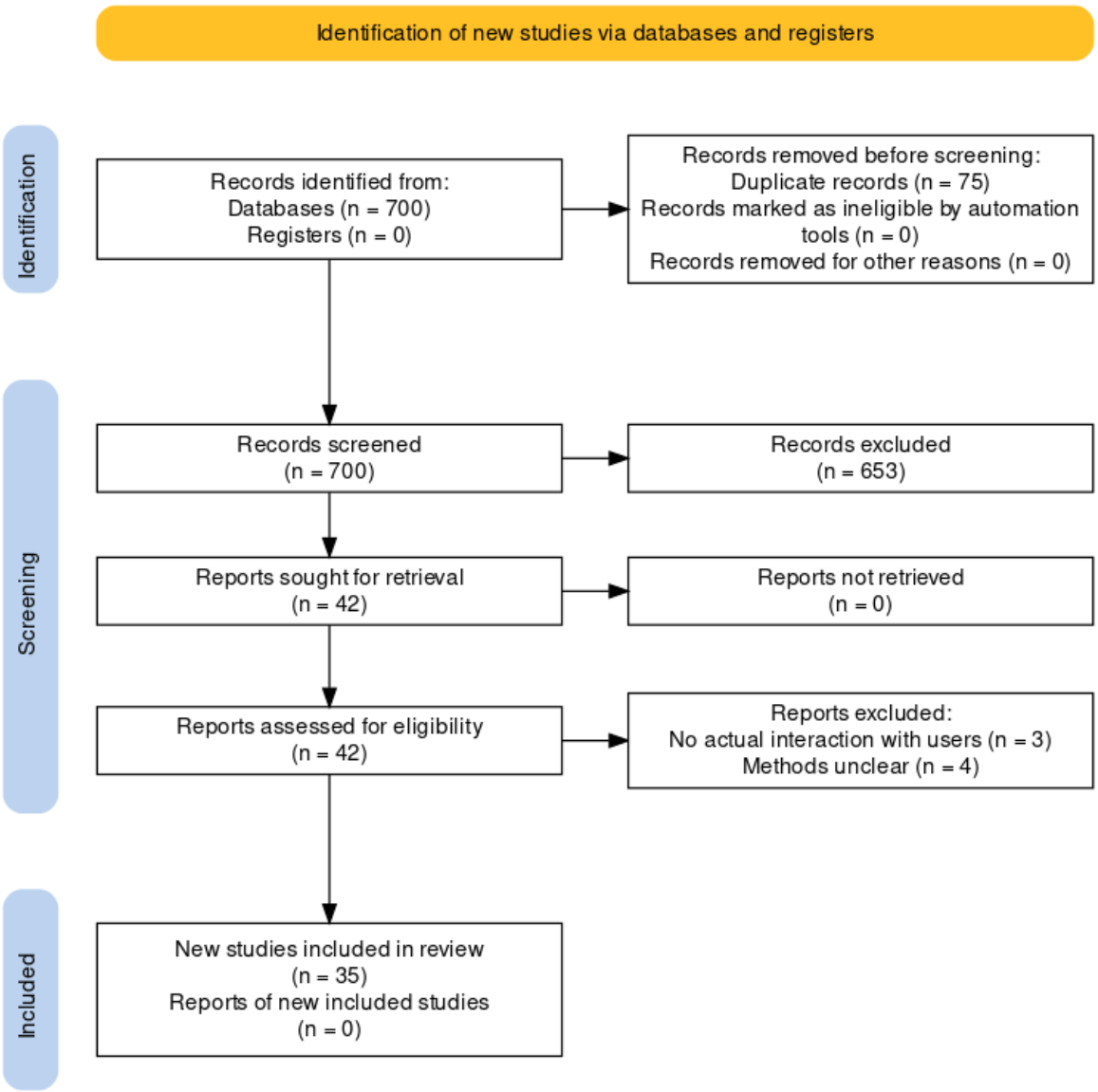

Figure 1 – Article selection procedure (Haddaway et al., 2022)

All types of available data were included in the literature search, with articles screened as being from peer-reviewed journals or conference proceedings due to their increased reliability, as well as being written in English for the purpose of analysis. The two prominent journals within the field of D&T are the *International Journal of Technology and Design Education* and *Design and Technology Education: an International Journal*, these two journals were searched extensively using a set of keywords relating to the field of enquiry. The 'Primo' search engine by Ex Libris was used to search these terms for the *International Journal of Technology and Design Education* and a second search was performed on the *Design and Technology Education: an International Journal* open journal platform. The search terms were 'empath*', 'human', 'context', 'user', 'design thinking' and 'participatory'. Table 1 shows the number of results returned for the criteria, as well as additional criteria used for a wider search of all available material, also using 'Primo'.

Table 1: Key terms used in the literature search

	International Journal of Technology and Design Education and *Design and Technology Education*	*Design and Technology Education: an International Journal*	All databases (including the additional term AND any field contains 'design education'.
'empath*'	n=3	n=11	n=24
'human'	n=33	n=19	'human-centred' n=93
'user'	n=42	n=9	'user-centred' n=36
'context'	n=21	n=84	n=62
'design thinking'	n=20	n=37	n=147
'participatory'	n=7	n=12	n=40
Total	126	172	402

The established inclusion criteria were that each study must involve interaction between students and end-users, either face-to-face or facilitated in another way, and be part of a design curriculum in formal education at primary or secondary level, or in further or higher education. Following screening, n=35 studies were included in the literature review. The included articles were analysed in detail and later categorised based on the research questions.

Findings

All the included studies involved face-to-face or another form of live interaction between students and end-users, with most face-to-face activities facilitated by teaching staff. Of all studies identified, one study related to D&T in a primary school, four to D&T in a secondary school, although one of these studies concerned students from higher education collaborating with secondary-aged special school students (Torrens & Newton, 2013), and the remaining 30 studies related to design education at higher education institutions. A lack of evidence of user-centred studies in primary and secondary schools was also found by authors of articles within the included literature (Bosch et al., 2022; Klapwijk & Van Doorn, 2015). Most of the research tended to be small-scale and was heavily qualitative, presented as phenomenological case studies, describing the user-centred intervention and its impact, whereas a small number of studies were quantitative or mixed-methods and focused on measuring motivation, creativity, or influence on design outcomes. Intriguingly, of all the literature included in the review, the study by Demetriou & Nicholl (2022) utilised the Torrance Tests of Creative Thinking (TCCT) as a standardised measurement tool. The TCCT involves subjects engaging with several creative figural and verbal assessments, requiring subjects to respond to stimuli that can be reliably measured for their creative strengths (Demetriou & Nicholl, 2022). The inclusion of a standardised assessment to measure the effectiveness of an intervention was unique to this study.

The literature highlights that design education is going through a period of transition (Bakirlioğlu et al., 2016), blurring the lines between design and design research (Shore et al., 2018), towards revealing the potential of considering user knowledge, human factors, experiences, and interactions in the engagement of participatory practices with end-users and stakeholders. This is supported by the fact that the included studies in this review took place in

19 different countries, highlighting the worldwide interest in investigating this phenomenon. Most studies took place in England (n=9), Turkey (n=5) and the USA (n=5).

The utilisation of end-users as contributors to the design process was evident in all selected literature. There were references to many different approaches such as user-centred design, human-centred design, participatory design, and co-design; whilst each of these is different, for the purpose of this study, they all require students to engage in contact with potential end-users, which is the focus of this review. There were a wide range of end-users chosen as the focus of each study, ranging from victims of flooding in Bangladesh to stray cats and dogs in Turkey. Some of the studies focused on more than one end-user. Interestingly, of the studies including children, five had a disability, raising the total studies involving disabled users to fourteen, or one-third of all included studies.

All included literature cited that students were required to conduct extensive research to better understand the end-user and their context, which mostly involved observation of and interviews with the intended users. Much of the literature discussed the importance of developing empathy as a way of improving design outcomes.

Several themes were identified from the literature: 21st-century skills including problem-solving and empathy, as well as user-centred strategies implemented, and disability. The literature was coded using NVIVO according to these categories as the themes emerged.

What key skills are developed when students are involved in user-centred design activities?

The value of involving end users in a participatory design process lies in learning different 21st-century attributes and in producing design outcomes (Bosch et al., 2022). Problems faced in the 21st-century are fundamentally more complex and multi-layered (Kaygan & Yargın, 2019; Kwon, 2018), especially due to human longevity (Peng & Kueh, 2022), thus demanding more skills from design students and designers (Dhadphale & Wicks, 2022; Mitchell & Light, 2018). Designers, compared to the general population, can approach problems differently and bring a fresh perspective to multidisciplinary teams by using empathy, user centred techniques, co-design methods and making skills (Zitkus et al., 2020). The skills of problem-solving, creativity and empathy were repeatedly explored in the selected literature.

Exposure to Real-World Problem-Solving

Involving students in 'real world' problems is not a new idea (Zitkus et al., 2020) and neither is involving end-users in the process (Nicholl et al., 2013). Much of the literature discusses the importance of problem-solving in the current climate and beyond, particularly the need to provide students with ‘problem-solving’ contexts, especially in higher education (Powell & Underwood, 2018; Wormald, 2011), which is the domain in which 86% of the selected studies took place. Hill (1998) and Peng & Kueh (2022) describe the complexities of understanding problems and stress that design education can play a part in teaching an effective problem-solving mindset through designerly thinking. It is through design that fundamental problem-solving skills can be developed, particularly focusing on finding problems, leading to innovation (Wormald, 2011; Zitkus et al., 2020). Problem-finding skills, an aspect of problem-solving, which was the focus of many of the included studies, meant students were required to find a problem for themselves as a result of their research, rather than a problem being presented to them,

leading to more effective learning and confidence (Emmanouil, 2015; Hill, 1998). This supports the earlier assertion that students must be prepared to work within wicked problems that are ill-defined and convoluted, despite that it is acknowledged there is no 'solution' to a wicked problem as further problems are likely to be identified as part of the proposed solution (Peng & Kueh, 2022). The literature suggests that problems cannot be solved with a particular type of thinking, and it is up to the student to decide upon the best way of approaching such complex problems by selecting from a wide range of skills, depending on the design context, rather than approaching a problem in a prescribed manner (Gibson, 2016; Williams Goodrich, 2019).

To understand a problem fully, the literature encourages students to conduct a significant amount of research, particularly through joining conceptual and procedural knowledge, as well as utilising thought and action, to reflect on design possibilities (Hill, 1998). Whilst there are many ways of researching a need, in order to develop an understanding, all literature supports the development of a relationship with end-users within real problem-based contexts. It is accepted that when researching a specific problem, more problems arise, creating a more complex situation for the student (Wormald, 2011), as is typically the case when engaging with complex problems (Peng & Kueh, 2022).

In a pertinent study to the focus of this review and its relation to schools, Klapwijk & Van Doorn (2015) note that the value of involving end-users in the participatory design process is in the students' development of 21st-century skills, especially empathy. 21st-century skills are a feature in a wide range of the literature, noting social and emotional skills as being particularly relevant in preparing students for navigating working life (Demetriou & Nicholl, 2022; Mitchell & Light, 2018). There is a need for a broad base of cross-disciplinary knowledge and skills, particularly those related to emotions (Demetriou & Nicholl, 2022; Kwon, 2018), for students to successfully solve complex problems and adopt an improved approach to problem-solving.

The Development of Empathy

Mitchell & Light (2018) claim that empathy began to be a feature in design-related literature around the late 1990s when companies realised that to design better products, they needed to be more attuned to their user's needs. Empathy is a core attribute of a designer (Bosch et al., 2022), yet there is some debate as to what empathy is (ibid.) and as a result, there was a range of tools highlighted in the selected literature for measuring empathy, according to the school of thought on empathy that the authors place themselves within. Definitions of empathy vary from an empathy where there is an understanding of another's perspective, to an empathy where similar feelings are experienced (Demetriou & Nicholl, 2022). The teaching of empathy has not been widely adopted due to a lack of frameworks available for educators to use (Mitchell & Light, 2018), perhaps due to the evidential lack of agreement on a universal definition of empathy.

All of the selected studies found that students engaging with end-users developed greater empathy, although the study by Conradie et al. (2017) found that engagement with end-users did not affect the design outcomes of a group of students. The authors hypothesised that this would not be the case, nevertheless, a quantitative methodology led to the finding there was no statistically significant difference between the design outcomes of intervention and control groups. It is worth noting that the findings of this study are very much the exception compared to the other selected studies; user involvement generally has a positive influence on design

outcomes Conradie et al. (2021), with almost all studies supporting this claim. The study by Conradie et al. (2017) concerned design outcomes only, whereas the majority of the other studies measured the impact on students or educators, and in some cases, alongside design outcomes.

Much of the literature highlights the importance of empathy as a key skill for designers, as well as a useful aim in education, especially for preparing design students to develop empathy when problem-solving in the future, (Mitchell & Light, 2018), in addition to reducing egotistical design responses due to a lack of empathy with others (Chmela-Jones, 2017; Demetriou & Nicholl, 2022). Cummings et al. (2014) cited an undergraduate design activity whereby students would design for aliens, in an attempt to remove any preconceptions or misunderstandings based on the student's understandings or experience, emphasising the important role empathy plays in designing authentic products based around user needs.

Designers must have knowledge of and be able to develop empathy with the people they are going to design for (Klapwijk & Van Doorn, 2015), they found that as a result of developing empathy with elderly people in their study involving primary-school-aged-children, the students gained new knowledge about the people around them, developed a respect for a diverse group and were more attuned to the needs and wishes of the end-users, which led to more effective design solutions. The embedding of empathy within the design process is the formula for fostering creativity and leads to more successful design outcomes in D&T (Demetriou & Nicholl, 2022).

The Emergence of Disability as a Focus

One-third of the selected studies focused on users with disabilities. A bias towards 'extreme users' or the softer term 'lead users' was unsurprising given that the approach to involve very specific users with increased needs and diverse experiences, and who are motivated to find solutions (Conradie et al., 2017) may be more likely to engage in such projects. The aim of the selected literature was for students to design with end-users; if the end-users were very similar to the students, then as the literature suggests, the students would not develop their skills as much as they would if the end-user was unfamiliar. Empathy was a key skill discussed in each of the studies concerning disabled users. Engaging with elderly people, especially in nursing homes, was a common context in the literature. Many elderly people are likely to have disabilities or difficulties in completing daily tasks, therefore the rationale provided above also applies to this context. Due to the fact much of the literature employed qualitative methods, it is difficult to establish whether engaging with disabled users is more effective than engaging with people without disabilities, however, it does highlight that more empathy is required to design for these individuals, developing 21st-century skills more widely and deeply, potentially developing a need for further investigation. Of the studies involving disabled people, none of the studies took place in a school, although the study by Nicholl et al. (2013) involved students designing products for young children with asthma, which is arguably not classified as a disability per se, however, it did encourage students to consider the needs of users who are markedly different to themselves.

What methods are employed to facilitate user-centred design activities in formal education settings?

To answer the second research question, all articles were analysed based on how the students interacted with end-users.

The involvement of users in the design process is widely taught and advocated, both in industry and in design education (Conradie et al., 2021). The selected literature describes the need for face-to-face contact with users to enhance sensibility and awareness of social issues, rather than organising activities such as role-playing (Salazar Ferro et al., 2020) or personas (Conradie et al., 2021). Personas are commonly used within the design process to encourage designers and design students to consider the needs of users; these were often cited in the selected literature, yet the difference between the traditional use of personas and those employed within a participatory methodology (Zitkus et al., 2020) is that they are populated with data collected by the students themselves, thus creating a more authentic resource for design.

Of the many methods used to engage with end-users, including, shadowing, customer journey maps, workshops, visual journals etc., the most common methods were observations, interviews, focus groups, and questionnaires.

There is a growing emphasis on ethnographic and observational research within design (Giambattista et al., 2021; Liem & Sanders, 2013; Shore et al., 2018; Thamrin et al., 2019). Much of the field research conducted by students involved observation of the end-user in their context, talking with them in the form of interviews or focus groups, and co-designing. Some of the selected studies utilised creative methods such as live model-making with the user using Play-Doh or sketching out ideas with the users. In the studies involving animals, the authors felt that empathy was best achieved when observing the animals in their usual environments (Kaygan & Yargın, 2019; Yavuzcan et al., 2019), which led to improved emotional investment in the design project.

Participatory Action Research (PAR) was the chosen methodology used by Salazar Ferro et al. (2020) when working with architectural students in Colombia, and Kwon (2018) in the USA, to improve the effectiveness of the interventions in cycles, rather than case study which is the principal methodology across the selected literature, describing the intervention that has taken place. Both Salazar Ferro et al. (2020) and Kwon (2018) highlight the need to view the interventions in cycles where students reflect on thought and action when interacting with end-users and develop ongoing design work.

Broadly, the process that students went through across all of the studies was to observe, understand, ideate, develop, and evaluate/test, which is a common approach to the design process across many educational institutions and in industry, however, the literature suggests that the observe and understand phases are typically less emphasised in education. The factor that was different to the accepted norm is that the studies sought to include the user at all stages of the process so that they were able to have an input in the product's development and provide feedback, as well as immersing themselves in the user's context and an emphasis was placed on gaining a much deeper understanding of the user and their needs and desires. A range of design process models were cited across the literature, predominantly the Double Diamond Model (Design Council, 2005) or variations of this, followed by design thinking models

produced by the d.School at Stanford University and at IDEO, a commercial organisation where empathic practices are firmly established in an industrial context.

What instruments were used to measure the impact of the interventions?

Questionnaires and interviews tended to be used to help analyse the impact of the interventions in the selected literature. Questionnaires were often given to the students at the end of the intervention to measure their perception of its effectiveness, although some studies gave students questionnaires more often. Some studies also required teaching staff to complete questionnaires relating to their perception of the effectiveness of the intervention. Relating to empathy, Klapwijk & Van Doorn (2015) cite that in all previous empathy studies in schools, researchers have analysed data taken from questionnaires, interviews, design work and field notes, which was also the case in many of the selected studies following a qualitative case study methodology.

Each of the studies in the selected literature had a different focus, for example, to what extent did user interaction have on the motivation of students or to what extent was creativity developed as a result of engaging with end users, nevertheless, questionnaires remained to be the most common method of measuring impact, usually alongside other instruments as outlined above.

Some studies utilised video recordings of activities to support analysis, although most of them did not. The study by Demetriou & Nicholl (2022) employed the Torrance Test of Creative Thinking (TTCT) as a way of measuring the impact of their intervention, alongside interviews to support their analysis.

What difficulties were faced when implementing the interventions?

The studies highlighted some challenges faced by researchers when implementing their interventions or faced by students when conducting their user-centred activities.

It is acknowledged that there is some difficulty in collecting data at the beginning of the process and students are often keen to start designing without gaining a rich understanding of the user's needs first. Gaining the data in the first instance can also be challenging. Authors cited the logistical challenges of recruiting end-users (Yalman & Yavuzcan, 2015), particularly if there are ethical implications, such as those studies centred around people with disabilities or in healthcare settings. The studies engaging with patients tended to interact with healthcare professionals as an alternative (Chmela-Jones, 2017; Zitkus et al., 2020) or used test rigs or simulations to support their design development, however, those studies that achieved ethical clearance were able to work with end-users directly. Some studies cited that a way to avoid undergoing a more intense ethical approval process is to approach the study from a service improvement angle (Godbold et al., 2019), which reduced the need for full ethical approval. One difficulty highlighted was students' ability to synthesise such a large amount of data collected during their fieldwork, and some students, given the extent of the data collected, found it difficult to know what to share with consumers later on in the process. In the study by Lee et al., (2019), feedback was sought online via social media which was text-based, which students found difficult to interpret, consequently supporting that face-to-face contact with end users could be seen as more effective.

When working with animals as end-users, students needed to understand that they may not be able to meet their true needs based on a lack of understanding. Students who took part in animal-based projects found the task challenging due to its non-human focus, which was different to the practice they were more familiar with.

Some of the studies involved other parties, alongside end-users, such as manufacturers. This posed the issue of bias due to students being influenced by the other parties, rather than focusing solely on the end-users. Some of the contexts were complex, such as those in hospitals, and students found it difficult to find problems to focus on due to a lack of expertise and experience in the field, this implication is an important factor to consider if user-centred activities were planned for younger students in schools, as a lack of understanding would lead to even more difficulties at that level.

The majority of studies in the included literature were undertaken in higher education where class sizes are considerably larger than in schools. Some authors described the difficulties with implementing user-focused activities when working with large groups of students. This is a factor that would have less of an impact in a school due to smaller class sizes, although, Klapwijk & Van Doorn (2015) found that the researcher worked at times with a small group of four children, whereas teachers will in general work with the complete class. This has the potential to make facilitation more difficult, yet not as difficult as it could be in higher education settings.

Klapwijk & Van Doorn (2015) also found that while end-users provided a rich description of their experiences, the students only tended to write a short number of words, which led to a lack of understanding later. They recommended that interviews were to be undertaken in pairs in future, with one of the students documenting the responses whilst the other asks the questions. They also found that storytelling was lacking, and the students tended to rigidly ask the questions they wanted to know more about regarding activities. If students were more aligned with storytelling and its role within a semi-structured interview, then this would have improved the process of creating a persona to work with during the ideation phase; a further factor to consider if implementing such activity within a school.

The purpose of all included studies was to explore the effect of involving end-users in the design process. Some of the users within the studies were more familiar to students, such as people their age or a dog which they may have experience with already, however, some of the users such as those who were visually impaired or suffered from a chronic illness, were likely to be very different to that of the students, thus offering a more diverse perspective using their experiences, potentially evoking a more empathic response from the students. Whilst the alien nature of engaging with these kinds of users was the aim of some of the studies, some students found it difficult to engage with them and were not forthcoming during the process, due to cultural or language differences (Boess & Lebbon, 1998; Peng & Kueh, 2022), highlighting that if the user is vastly different to the student, then this has the potential to inhibit learning.

Implications for Practice in D&T

The final research question relates to how practices in higher education may translate to D&T in schools. This section will also concern the findings and future implications from studies conducted in primary and secondary schools.

Implications for D&T in Schools

There is an appreciation that a focus on the 'user' is explicitly featured in the English National Curriculum (Kaygan & Yargın, 2019; Klapwijk & Van Doorn, 2015; Nicholl et al., 2013) at all key stages. It is imperative that students conduct in-depth research on the user (Klapwijk & Van Doorn, 2015; Nicholl et al., 2013) to maximise success in the design process. As early as Key Stage 1, teachers must provide students with contexts that are closely related to their own, including research on users that the pupils are closely related to, e.g., "their grandparents, house pets or the butcher next door." (Klapwijk & Van Doorn., 2015, p.154). It can be argued that authentic learning in D&T can only be possible when pupils develop local and specific knowledge of the people they are designing for (Nicholl et al., 2013), therefore the social and emotional skill of empathy is required, igniting, and infusing the creative process for pupils (Demetriou & Nicholl, 2022), consequently leading to improved outcomes. A lack of involvement in the inclusion of end users within participatory design (or indeed user research more generally) is evident in the literature, highlighting that without exposure to end-users, students build models of understanding context and products based on their previous experience as a user (Kaygan & Yargın, 2019), inhibiting empathy and its influence on the development of products, therefore schools are encouraged to pay more attention to this as a way of allowing students to develop empathy (Bosch et al., 2022; Demetriou & Nicholl, 2022; Nicholl et al., 2013). Bringing users into the design process is feasible for small-scale projects (Dong, 2010), and even short immersive experiences can have a large impact on students' understanding of design (Cummings et al., 2014), further supporting this opportunity available to schools.

Nicholl et al. (2013, p.930) explain, in the context of policymakers' desire to include user needs in the D&T curriculum that, "it is participating in the authentic social practice(s) of engineering design that links D&T to the real world", similarly in the Netherlands, pupils' activities should mirror the activities of professional designers and scientists according to Klapwijk & Van Doorn (2015). It is evident that design curricula are inspired by industrial practice in many other countries according to the included literature, with much of it focusing on how design education emulates industrial practices, not only to prepare design students for industry (in the case of higher education) but in the development of wider, 21st-century skills. There is a need for future studies on how community-based participatory and empathic practices can be implemented in formal education (Bosch et al., 2022), with an aim that students complete certain tasks to feed implicit learning goals within the process, further addressing the problem identified by Nicholl et al. (2013) in that students were not exposed to an authentic user context in the schools they studied, leading to poorer outcomes for students.

The literature highlighted that schools often reduce levels of student creativity and problem-solving by designing activities in such a way that they are narrow or prescribed (Kimbell, 1994; Hill, 1998; Nicholl et al., 2013; Demetriou & Nicholl, 2022). The fact that this attitude towards pedagogy within D&T is still present over an almost thirty-year period is surprising. When students work very prescriptively according to a narrowly defined design or problem brief, this guides decision-making which leads to predictable, often pre-determined outcomes (Gibson, 2016), which is also present in design education within higher education (Thamrin et al., 2019). Denton & McDonagh (2003) suggest the use of focus groups in schools in order to provide such an opportunity to engage with potential users, an early suggestion in the journey towards a participatory approach outlined in the selected literature. Noël (2016) concluded that design

education must be based on real needs and people, prompting a potential to explore this phenomenon in future research.

Implications for Design Education

Research is a vital aspect of all design work, both inside and outside of education, whilst this is fundamentally important in the development of effective products, it also has a secondary value in developing the young designer's understanding of products and the social context of their use (Denton & McDonagh, 2003), providing a clear rationale for the need of authentic research by students within D&T curricula.

Many of the included studies commented on the effect that engaging with end-users had on student motivation and confidence (Bakirlioğlu et al., 2016), whilst these increased in many of the studies, this was not always the case (Chmela-Jones, 2017; Yavuzcan et al., 2019). Many studies refer to the students' excitement when involved in such activities, especially during those between students and end-users. This is echoed by Hill (1998) in her study of technological problem-solving in a secondary school in Canada, who found that when activities are set in the context of authentic world problems and real human needs, exciting possibilities emerged for students and design education more generally. Many students within the included studies found that this 'real' interaction was the most meaningful way of designing for 'real' people, compared to other methods employed in previous projects such as the use of basic personas, providing a similar opportunity for pupils in schools.

Numerous studies conducted in higher education emphasised how important the students felt their interactions with end-users were, with some explaining that this was the first time they had the opportunity to work with end-users (Salazar Ferro et al., 2020), and provided them with the experience necessary to be successful when working in the field. Several studies concluded that students changed their attitudes as a result of the interventions, towards being more open-minded and focused more on lateral thinking.

Participatory practices are a relatively recent phenomenon in some areas of higher education, depending on the locations of institutions (Salazar Ferro et al., 2020) and the design discipline taught (Thamrin et al., 2019), as well as a belief from industry that education is not supporting human-focused opportunities (Shore et al., 2018), yet, it must be acknowledged that there is now an established body of knowledge in this area on which further research could be built, not least within schools.

Conclusion

This study has emphasised the fundamental link between the act of designing and the pursuit of improvement, not least for the experience of users. The relationship between designer and user is essential in improving the value that users place on products and services.

The literature has demonstrated that there is an established body of knowledge concerning students engaging with end-users as part of the design process. It also highlighted that there is a need to explore user-centred design further, particularly in schools, and there is much to learn from the studies completed in higher education. Whilst there is a broad consensus on the design process and where end-users may fit into it, there is little literature concerning an authentic user focus in D&T in schools, therefore presenting an opportunity to explore this further.

Whilst there are clear barriers to enabling students to design with and for people, especially those with disabilities, the gains from working with a wide range of people are distinctly apparent. The skills of creativity, empathy and problem-solving surfaced in much of the selected literature, providing a considerable rationale to base further research on the development of 21st-century skills through an authentic user focus within D&T in schools.

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28.1

Book review: Debates in Design and Technology Education (2nd Edition), Hardy, A. (ed) (2022)

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Introduction

This second edition of Debates in Design and Technology Education is situated within the somewhat precarious position that design and technology currently (still) holds in schools in the UK, and we are reminded of this context at a number of points through the book. At the same time, as stated by Alison Hardy in the introduction, it is also an acknowledgement of the new generation of research emerging within the subject, and as such is presented in part as a renewal or reframing. Much has happened, politically, socially, environmentally and technologically, since the first edition of Debates was published in 2013, and this second edition is a clear reflection of the related developments, though also at times the lack of development, in design and technology education. This volume presents debates around the subject in three distinct sections: political and international debates, the nature and perceptions of the subject, and classroom teaching, which provide the framing for the review that follows.

Overview of chapters

Part I opens with *Government policies and design and technology education*, in which Daniel Wakefield and Alison Hardy succinctly trace the subject's struggles with identity since long before, and indeed long since, its inception in the national curriculum in 1988. Up to the current (2014) curriculum for D&T, the authors account for the fluctuations of the subject and yet point out that the core aims of D&T have remained a constant presence since 1988, and this chapter provides the backdrop for much of what follows. To complement this, Chapter 2, *International perspectives on technology education*, Frank Banks and P. John Williams provide summaries of international approaches to the subject from nine countries, positioning these alongside the four separate approaches from devolved responsibility for education within the UK. The ensuing summaries oscillate in curriculum focus between technical vocational and skills-based approaches that may be directed towards countries' economic wellbeing, and the more holistic approaches to the subject that promote personal, environmental, cultural and planetary wellbeing. When we do arrive at the UK curricula, the core aim of creativity and imagination stands out as an important driver across all four approaches.

The final chapter in this section is arguably its most significant. The authors of Chapter 3, *How do we do race in design and technology?*, begin by suggesting that this may be the first example of a dialogue on issues of race and racism for D&T, and this is certainly concurrent with my own reading and experience. The chapter is therefore intended by Bhavna Prajapat, Rose Sinclair and Alison Hardy as a conversation starter, and as such it brings together a wide variety of issues and considerations in order to open up the space for change. Notably, the authors point out that while representation of diversity in D&T is important, as a response to decolonising this is insufficient and there is a need to "reclaim, reconnect, reapply and regain the use of methodologies, and design practices, that have been submerged or hidden or marginalised because of the community from which they come" (p.46). In light of this, it is just a little noticeable that the teacher narratives towards the end of the chapter deal almost entirely with

issues of representation, with little mention of the deeper issue of methodologies in practice. That the final narrative, from NSEAD's Marlene Wylie, sets out the approach to anti-racism from the subject association for art and design perhaps points glaringly to the fact that in D&T we are not there yet. As the first of its kind, this chapter and the teacher narratives do an important job in laying out the ground for the discourse on race and racism in D&T, and lack of representation as a problem is real. However, there is clearly much more to do, and I look forward to what follows and to future volumes that discuss the more complex issues touched on here.

Part II takes us into debates around design and technology as a subject. In Chapter 4, *Why did design and technology education fail, and what might replace it?*, David Spendlove presents a critique of the current situation through consideration of the networked and complex political, pedagogical and organisational ecosystem for D&T in the UK. As well as to highlight the complexity of the situation, this serves to position change from within an ecosystem which is distinctly different to that which conceived the first iteration of the subject. While the path to the current situation for D&T is well trodden (Barlex, 2007; Miller, 2011; Owen-Jackson, 2013), the value of Spendlove's analysis here is through his networked approach, which offers a way of understanding, perhaps even accepting, the status quo and, he hopes, of opening up ways to take action from *within.* This sets up McLain's positioning of signature pedagogies for D&T in Chapter 5 very well.

Acknowledging the value of practical skills and processes, in Chapter 5, *What's so special about design and technology anyway?*, Matt McLain argues for renewed attention on learning intentions through careful consideration of pedagogy and alternative approaches to the signature 'project', which he suggests is the deep structure of D&T's pedagogy. This, he argues, can overcome problems associated with a dominant focus on the practical or material outcome of a project, and can be achieved by reframing the conventional designing, making and evaluating into the fundamental activities of ideating, realising and critiquing. Usefully, McLain models what he terms the four-fold approach through treatment of examples taken from DATA's project bank. In naming D&T practice through his extensive exploration of the signature pedagogy in this chapter, McLain is making a case for a D&T paradigm that, he argues, should be both celebrated and challenged, but that stands up to prevailing disciplinary and knowledge-based approaches.

Chapter 6 provides something of a departure at this point, in discussing *Does food fit in design and technology?* In this chapter Suzanne Lawson and Susan Wood-Griffiths present a range of views on this debate against the historical backdrop and Lawson's own previous arguments that the inclusion of food in D&T was simply a matter of survival (Lawson, 2013). The following sections include discussions on the relationship between food and health, supported by debate around high profile celebrity campaigns, and consideration of some of the social, cultural and socio-economic ramifications of the NEA unit of the (2016) GCSE specifications. What seems missing here are deeper discussions on, for example, issues concerning the removal of Food from the D&T GCSE, the subject knowledge content in the GCSE specifications, and indeed on how food is currently taught in schools at key stage 3. Nonetheless, the authors conclude by pointing out that 'Does food fit?' may be the wrong question, which, they argue, ought to be about how food education can be fit for purpose. That it feels like something of an odd fit at

this point in the book probably says more about the challenges still surrounding food's place within D&T than anything else.

If we take McLain's Chapter 5 as suggesting a pedagogy of process, then Chapter 7, Mike Martin's *The role of making in D&T*, is perhaps a more natural follower. Notwithstanding, and also embracing, the advances of technology in the last 30 years, Martin develops the rationale for making in the curriculum in relation to knowledge when both designing and consuming; to designing, modelling and decision-making; and to the cognitive benefits of simultaneously thinking and acting. This is followed by consideration of teachers' resources, subject knowledge and experience, and the sometimes uncomfortable imbalance between what may be possible within a school and how products are designed and made in the world outside school. This is a brief but emphatic call to carefully planned making activity as a way of learning about being human and living in a technological world.

Chapter 8, *Entrepreneurship in technology education*, focuses attention a little more in the world outside school. As Andri Du Toit points out, education about the world of work is a concern of global proportions and yet this is not widely embedded in technology education. The chapter initially examines the role that technology education can play, principally through the multifaceted design process, in developing in young people the '21st century skills' needed in the world of work. Putting this into practice, though, requires careful consideration and suitable training for teachers, and Du Toit considers some of the difficulties of this before discussing how it might be done. The range of proposals that follow are largely concerned with the contextualisation of learning around real-world scenarios that develop entrepreneurial knowledge, skills and competencies. That Du Toit examines the debate through global perspectives is refreshing at this point in the book and helps to take the reader and D&T beyond the UK classroom in more ways than one.

In the penultimate chapter in this section, *Gendering the curriculum*, Ulrika Sultan acknowledges the ongoing gender difference in uptake and engagement in D&T globally, before suggesting that certain factors contributing to this may be socially constructed. This, she points out, includes among other things gendered self-perception of intelligence from an early age. Though initially considering this through the lens of education, Sultan reaches beyond education to the interdisciplinary field of gender studies and presents an examination of four theories grounded in sociology, interspersed with suggestions for D&T educators and key areas in which stereotypes may be disrupted. Sultan ultimately concludes by discussing approaches to gender-conscious pedagogy, and the nuanced and multi-layered considerations that teachers can make towards broadening pupils' self-perceptions and horizons in D&T. This is an engaging and thorough chapter that grasps hold of the gender debate for D&T and positions it squarely in the socially constructed classroom.

In the final chapter of Part II, Sarah Davies addresses *Managing curriculum change*. Davies pertinently frames the typical drivers for change through research that identifies natural events, policy reform and voluntary reasons, this last including "dissatisfaction, inconsistency and intolerability with the current situation" (p.150). Given the backdrop of previous chapters, the scene is set for considering more closely how it might be done. Davies goes on to briefly discuss how teachers might deal with change, how teachers might be enabled to respond, and factors during change processes that might be alienating or disempowering. The second half of

the chapter is given over to a series of case studies that provide three very different examples of curriculum change, driven by both external and voluntary reasons, and in their breadth help to underscore the place and need for change in D&T. Summarising these challenging but largely positive experiences, Davies gently but clearly exemplifies some of the opportunities to upgrade from within that Spendlove highlights in Chapter 4.

Part III is concerned with teaching design and technology and begins with Dawne Irving-Bell's *Influence of teachers' perceptions of subject knowledge on pedagogical approaches*. Chapter 11 examines the relationship between teacher perceptions of pedagogical content knowledge (PCK) and their efficacy and impact, and this is contextualised around the current challenges of teacher recruitment and retention, curriculum marginalisation of D&T and teachers delivering lessons beyond their immediate areas of expertise. Through the analysis of a range of issues relating to PCK Irving-Bell touches on opportunities for the co-production of knowledge between pupils and teachers, pupil-led learning activities and those that promote risk taking, for example, all for the facilitation of greater engagement and deeper learning for pupils. All of this, we are regularly reminded, requires the confidence of the teacher in the moment of transforming subject matter into accessible and engaging learning material (PCK), and as a starting point at least, being mindful of the need for confident content knowledge is a key take away here.

In Chapter 12, *Transition between primary and secondary school*, Cathy Growney takes as a starting point the 'glaring' differences in teaching D&T between primary and secondary phases, and research that suggests regression in learner autonomy and progress in D&T from Year 6 to Year 7. This sets up an analysis of strategies and approaches that may be taken to avoid this, focusing on structured dialogue and partnership learning between primary and secondary teachers. Considering obstacles such as planning and delivery time, resources and commitment, Growney concludes with some notes of optimism, noting in particular the opportunities that arise from a greater focus on iterative designing and collaboration in secondary curricula which is more resonant with primary approaches, alongside the foregrounding of pupil well-being when it comes to transition.

Chapter 13, *Teaching for technological justice: Embracing indigenous designs*, joins Chapter 3 in signalling a significant shift for D&T in terms of inclusion and diversity, in which Mishack Gumbo foregrounds indigenous knowledge as a way of achieving justice and decolonising for indigenous learners. Gumbo has long advanced the importance and position of indigenous knowledge in technology education (for example Gumbo, 2017, 2020) and this chapter represents to the UK D&T community an important acknowledgement of the relevance of this work in both indigenous and non-indigenous contexts. Technology, argues Gumbo, is deeply implicated in colonialism, marginalisation and oppression, and this provides the springboard for the ensuing discussion on reclaiming indigenous knowledge of technology from colonialism in India, Zimbabwe, Australia and South Africa. Gumbo goes on to demonstrate a model for teaching technology education for indigenous learners, and importantly for this book, in non-indigenous contexts where indigenous learners are in diaspora. In this second model, teachers are encouraged to consider the relevance of D&T to indigenous and not just Western contexts, and this demonstrates one possible approach to the methodologies of teaching for justice, beyond just representation as highlighted in Chapter 3.

The final three chapters of the book centre around the roles of cognition, critical thinking and feedback in D&T, and are usefully positioned together in considering how, when and where aspects of learning take place. In Chapter 14, Design cognition in design and technology classrooms, Nicolas Blom presents two prevalent theories of cognition: information processing, which distinguishes between thought and action, designing and making; and ecological psychology theories, in which design thinking is considered largely to be external and embodied, with sense-making embedded in cycles of action in the physical and material world. Identifying problems with each, Blom advances a new theory, Extended Design Cognition, in which attention is paid equally to internal and external influences, and which necessitates careful consideration from teachers about how and why learning environments and learning activities can support learner cognition.

Following this, in Chapter 15, A hybrid design sketching approach that can drive critical thinking in design and technology, Yaone Rapitsenyane, Richie Moalosi and Thatayaone Mosepedi present their research with undergraduate students in Botswana in advancing hybrid sketching as an intuitive practice between traditional pen and paper and digital methods. The authors argue that the skills associated with sketching bear relevance across all phases of education and in professional practice, and in presenting this hybrid model they are making a case for the benefits of traditional manual methods within the current tide of digital influence. The study suggests that sketching holistically supports critical thinking and creativity, and the authors emphasise transferability to the secondary context through cross curricular links to art and design and the importance of practice, metacognition and reflection. What is not discussed here are the possible challenges some teachers may find in using and teaching for these digital skills, but this is where Chapter 11 and PCK may come in handy.

Finally, in Chapter 16 Alice Schut discusses *Exploring the potential of feedback within the creative processes of a design and technology classroom*. Presenting findings from research, Schut centralises the designerly notion of critique to support pupils' creative cognition and points out that it is not a question of if, but how and why design feedback should be used in the D&T classroom. Feedback in this case is argued to be a shared endeavour that encourages pupils to think independently to make sense of and sort out a multitude of possibilities. Challenges of giving feedback are considered, principally concerning quality and challenges around interpretation and the predominance of convergent questioning, as well as those concerning receiving feedback, which include pupils balancing emotions and knowing how to be active receivers. Particularly useful in this chapter are the suggestions for implementing design feedback practices in the classroom, which involve pupils learning through regular practice of high quality feedback supported by explicit teacher guidance, as well as the discussion of findings around pupils' developed cognitive modelling and evaluative abilities and the guided nature of activities encouraging pupils to take an active role in the process.

Conclusions

Just as the first edition of Debates followed some critical movements in design and technology education, so does this second edition come at an important time for the subject and its future. For me, one of the most useful aspects of the book is Spendlove's examination of the ecosystem that constitutes the current state of play for design and technology education. Through this viewpoint on the entangled networks involved, it is possible to position change, and the potential for change, from within any number of factors, and the chapters that follow

from this point do all contribute to the renewal and reframing that Hardy sets out as a key aim of the book.

At a few points the ordering of chapters feels a little disjointed, and there are opportunities to make more of the networks and networking between themes, either explicitly or implicitly. However, as commented above, this perhaps speaks to the complexities of the situation D&T finds itself in, and bringing together such a range of issues and possibilities into a fully cohesive whole is challenging to say the least. Where there are crossovers with the previous edition (debates on making, food, gender, and primary transition for example) these are generally, and sometimes radically, updated and reflect developments in theory and broader socio-political shifts that, as argued in these chapters, maintain the relevance of the D&T curriculum in schools. These debates are also now joined by those on race, indigenous knowledge, entrepreneurship, design cognition and others, and although there is clearly much more to do, each of these sets up a different way in to the debate on 'What now?' which is no small or isolated task. Overall the book treads some careful lines between where the subject has come from, where it is and where it could be, and although Hardy acknowledges that there are many areas and debates that have not been included in this volume, those that are included are well pitched and position D&T within a rich research base that offers plenty of possibilities.

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