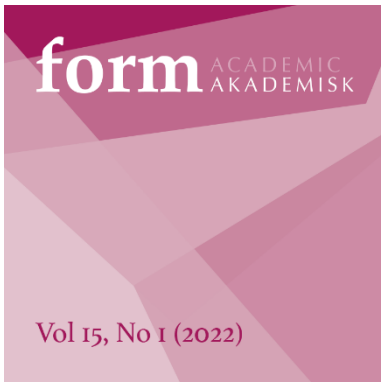

https://doi.org/10.7577/formakademisk.4540

Koray Gelmez
Assistant Professor (PhD)
Istanbul Technical University
Department of Industrial Design
gelmez@itu.edu.tr

Selin Arkan
Research Assistant
Istanbul Technical University
Department of Industrial Design
selinarkan@gmail.com

Revisiting a CAD course in the midst of the global pandemic with an activity-centered framework

Reflections from design students

ABSTRACT

Inevitably, the global pandemic that occurred in 2020 had a significant impact on the practices of design education, and apparently, design teachers were not fully prepared and equipped. In this ambivalent and emergent era, they struggled to adapt their current teaching methods to online education. Since then, various teaching methods have been developed and applied to incorporate online delivery. As we see an invitation to advance learner-centered and process-based teaching approaches regarding Computer-Aided Design (CAD) education in the literature; in this article, we address how a constructively aligned CAD course has been adapted to online learning and how it affected design students' learning experiences. Hence, we discuss the online CAD learning experience through students' reflections based on the Activity-Centered Analysis and Design (ACAD) Framework. To get insights into their online learning experience on CAD, we asked students to write their thoughts based on a structured qualitative course evaluation template. Broadly, online learning practices in CAD not only resulted in challenges in design learning but also created opportunities as mentioned in students' writings. Based on qualitative content analysis, students' reflections on a CAD class implemented under the context of online learning can include both advantages and disadvantages of the online learning platform, peer learning, peer tutoring, active involvement in the class, communication, etc. As a result, students' reflections on the CAD course made us think that the dimensions of the ACAD Framework are interwoven and interactive.

Keywords:
CAD pedagogy, online design education, the ACAD Framework, activity-centered CAD learning, reflective writing.

1. CAD LEARNING AND TEACHING

CAD is at the junction point that takes place in engineering, design, and technology curricula. In these domains, we can see varying instructional methods and best practices that design teachers can utilize. In the literature, we see an invitation to develop "learner-centered" (Gelmez & Arkan, 2022) and process-based (Yixian et al., 2014) teaching approaches regarding CAD education. By criticizing com-.mand-based CAD teaching (Chester, 2007), utilization of strategic knowledge is recommended during CAD learning (Bhavnani et al., 2001; Chester, 2008).

We can find several studies on design teachers' pedagogical approaches toward computer and multimedia use in education and CAD (see Antonietti & Giorgetti, 2006; Başa & Şenyapılı, 2005; Çil & Pakdil, 2007; Wood, 2003). Antonietti and Giorgetti (2006) stated that some teachers found multimedia impactful in developing thinking skills. Çil and Pakdil (2007) investigated how design teachers conceptualize and evaluate the connection between design and computers in architectural education. According to Wood (2003), art teachers thought that there is a positive effect of computer use in the creative process.

The perception of students toward CAD content and pedagogy has also been a common issue in several studies (see Demirci, 2011; Gelmez & Arkan, 2022; Hanna & Barber, 2001; Taşlı-Pektaş & Erkip, 2006). Demirci (2011) conducted a study uncovering students' views on computer use in a graphic design course. Gelmez and Arkan (2022) revealed their instructional strategies in a CAD course together with students' reflections. Hanna and Barber (2001) investigated students' attitudes before and after using the computer. Similarly, Taşlı-Pektaş and Erkip (2006) investigated students' perceptions towards CAD in an interior architecture department. However, it is not possible to find current particular studies addressing CAD learning and teaching in an online education context.

2. ONLINE EDUCATION

In 2020, due to the global pandemic called Covid-19, we were all obliged to experience online learning and teaching with the help of technology. Apparently, there is an increasing and inevitable interest of design scholars in online education related studies in the literature. These studies generally focus on the challenges, constraints, potentials, and implications of learning during the pandemic (Green et al., 2020; Marshalsey & Sclater, 2020; Tüfek, 2022; Yorgancıoğlu, 2020); revision of design teaching practices with the pandemic conditions (Aras, 2021; Milovanovic et al., 2020) and interconnective learning (Dreamson, 2020). However, online education has not newly emerged during the pandemic. We can also see prior applications and studies on online design education before the pandemic. These studies tend to focus on perceptions of teachers and learners (Fleischmann, 2020); the suitability of design education for online environments (Fleischmann, 2019); the social aspect of learning in online design education (see Newman et al., 2018; Wragg, 2020); implications or suggestions of new teaching models to online education (Daalhuizen & Schoormans, 2018; Ioannou, 2018).

As happened in all areas, the pandemic has had a great effect on how students learn and how teachers teach. Being unprepared for this situation, all stakeholders have taken action with the current tools and resources. To become adaptable to this ambivalent situation as teachers, *Activity-Centered Analysis and Design* (ACAD) becomes prominent.

Goodyear et al. (2021) defined *Activity-Centered Analysis and Design* (ACAD) as "a meta-theoretical framework for understanding and improving local, complex, learning situations" (p. 446). This framework sees the learning process as "physically, socially and epistemically situated" (p. 446). It is an activity-centered attitude with a particular focus on the learner's activity, which makes it distant from "teacher- or instructor-centered, content-centered or technology-centered" (Goodyear et al., 2021, p. 447).

The 'physically situated' dimension is about the effects of the quality of physical spaces, tools, and means. On the other hand, 'epistemically situated' refers to the tasks that the learners undergo. Lastly, 'socially situated' is about social interactions with peers or other agencies in an educational context. So, the ACAD is a framework to design tools (*set design*), social settings (*social design*), and tasks (*epistemic design*) in order to serve learners' activities that correspond to the Intended Learning

Outcomes. In this sense, learners 're-configure' and 'co-construct' the given task during learn-time (Goodyear et al., 2021).

As a practical model, we can find several studies utilizing this framework. In a very recent study, Green et al. (2020) adapted their courses based on the ACAD Framework, which offers a solid contribution to their pedagogy. In another study, Bülow (2022) presents both challenges and opportunities in hybrid learning contexts, which are both online and on-site, based on the ACAD Framework. Similarly, Fawns et al. (2022) discuss the effect of the hybrid learning model in relation to this framework. By investigating how to design for learning in an artificial intelligence context, Carvalho et al. (2022) suggest the ACAD Framework to help teachers and learners while co-creating a future. Another example that utilized the ACAD Framework is about the impact of virtual and blended student mobility on transformative learning experiences in secondary education (Rajagopal & Mateusen, 2021)

Goodyear et al. (2021) clearly state that teachers can develop their instructional strategies in a 'cyclical' manner. This means that it is a reflective practice through which a teacher can modify and enhance his/her approach from the previous year/semester's teaching experience. In this current study, we particularly address a CAD course to adapt, modify and enhance our pedagogical practice by reflecting on our previous experience in the midst of the global pandemic. Depending on this, the ACAD Framework was devised as a roadmap that seems to be practical and plausible to adapt a CAD course into online design learning.

As design education in online platforms poses "a very wicked problem" (Tregloan et al., 2020), there is a need to investigate this issue systematically with special attention within design curricula. Additionally, CAD as a course holds a different place regarding online education due to its technology-related and computer-based nature. In other words, since its major medium is a virtual environment, the adaptability of it to online education should be investigated within its own context.

CAD in online education can be seen in a couple of academic studies. Seinauskas (1997) told us about the early capabilities of the internet that can be utilized during online CAD teaching. He called it the online CAD laboratory, which has three levels such as e-mail, internet search, and online computer. Bender et al. (2004) examined the impressions of CAD education by making a comparison between conventional face-to-face settings and online educational contexts. Davies and Cormican (2013) investigated the use of multimedia technology, which can include online tools, in CAD teaching. Onofrei and Ferry (2020) focused on blended learning, which embraced both face-to-face and online teaching, in an undergraduate engineering CAD module.

3. THE STUDY

This section explains the course, the participant-students, the connection of the ACAD Framework to the CAD course, the data collection, and the data analysis.

3.1. The course and the participants

This study was conducted in a compulsory CAD course (EUT 241E Computer Aided Design course). 109 second-year industrial design students took this course in separate two sections. It was carried out in the Department of Industrial Design at Istanbul Technical University in the 2020–2021 Fall Semester. Due to the global pandemic, the course was conducted on the Zoom platform.

TABLE 1. The adaptation of the CAD course in accordance with the ACAD Framework.

ACAD Framework	Before the Pandemic (2019-2020 Fall) / Physical	During the Pandemic (2020-2021 Fall) / Online
Set Design	Physical computer lab Learning management system (ITU Ninova System) Computer Rhinoceros software	The Zoom platform The Breakout Rooms Screen-sharing Learning management system (ITU Ninova System) Computer Rhinoceros software
Social Design	Class-wide discussion Working in pairs Interaction with real and hypothetical peer	Peer tutoring Peer interaction Collaboration Socialization Teamwork Interaction with real and hypothetical peers
Epistemic Design	Telling-to-peer tasks Writing-to-peer tasks Tutorial following tasks	Telling-to-peer tasks Writing-to-peer tasks Tutorial following tasks

We adapted our constructively aligned CAD course in accordance with the ACAD Framework (see Table 1). As explained, we specified three learners' tasks under this 'activity-centered' approach; which are namely telling-to-peer, writing-to-peer, and tutorial following. The ACAD Framework guided us to accomplish these tasks and evaluate the physical and online educational settings.

3.2. The ACAD Framework in the CAD course

Under the inevitable conditions of the pandemic, the ACAD Framework, consisting of set, social and epistemic design, has been a roadmap for the transition from the physical to the online educational setting of the CAD course (see Figure 1).

Regarding set design, whereas the CAD course was conducted in a physical computer lab before the pandemic, the Zoom platform was devised during the pandemic. The learning management system was utilized effectively in both conditions. Also, Rhinoceros was used as software; and video and text-based tutorials were assigned as course materials both before and during the pandemic conditions.

Before the pandemic, the class was conducted based on class-wide discussions. The telling-to-peer activities were performed by working in pairs. These are related to the social design aspect of the ACAD Framework. During the pandemic situation, we preferred to use the Breakout Room option of the Zoom. Breakout Room is a feature of the Zoom where participants can carry out separate discussions in groups apart from the meeting host. With the help of this, students undertook interaction, collaboration, and socialization with their peers. In short, the social design aspect was transferred to the virtual environment with the help of the Zoom.

Student activities were abundantly done with demonstrations before the pandemic. During the pandemic, this epistemic aspect evolved into peer tutoring and tutorial following.

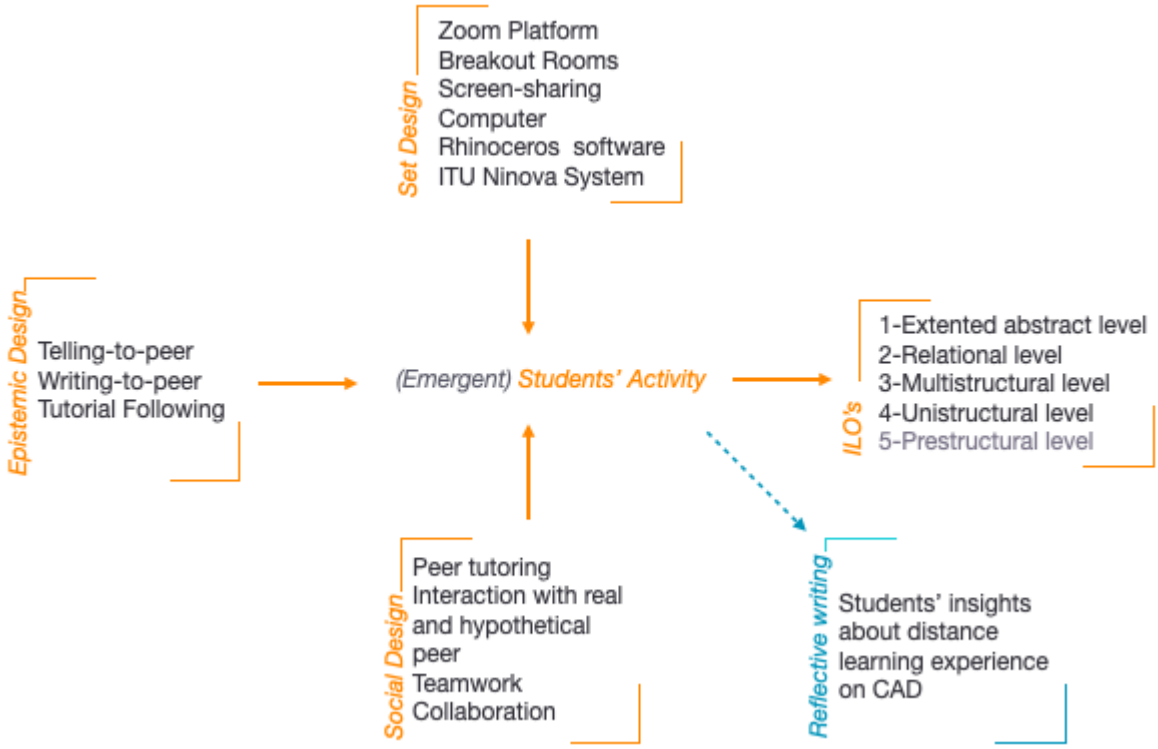

FIGURE 1. The ACAD Framework in the CAD course (adapted from Goodyear et al., 2021).

3.2.1 Set design of the CAD course

Before the pandemic, in the physical computer lab, students were using either the computers provided by the university or their own computers. They were following the class through the projected screen of one of the computers on the wall (Figure 2).

During the pandemic, the students were using their own computers and attending the class through the Zoom platform. The feature of the Zoom, the Breakout Rooms, was regularly utilized to accomplish telling-to-peer tasks. Obviously, the screen-sharing feature of the Zoom was frequently used by students during these tasks. ITU Ninova System, which is the learning management system of the university, was actively used both before and during the pandemic. Basically, we used this system to announce assignments and to share course materials such as attendance and grading sheets. The students could upload their assignments to the system.

FIGURE 2. The computer lab used before the pandemic. (Photographs by the co-author).

3.2.2 Social design of the CAD course

Undoubtedly, the social aspect of learning occupies a significant position for learners (Vygotsky, 1978). Under the constructivist approach, peer learning simply refers to "learning with and from each other" (Boud, 2013; p. 1.), and depends on the premise of the fact that "...we continually learn from each other" (Boud, 2013; p. 1.). According to Boud (2013), peer learning has great potential to foster a deep approach to learning, and it is not limited to working in groups; it covers various instructional actions ranging from in-class, extra-curricular, and assessment activities. There are also different concepts such as peer tutoring, peer mentoring, and cooperative learning, which can change the role and definition of the peer (Topping, 2005).

Regarding that, the social dimension of the CAD course was mainly constructed around peer learning and collaboration among students. In the first phase of the class, some of the tasks were executed in pairs, and students were encouraged to create class-wide discussions. In the second phase, the Breakout Rooms were used for peer tutoring. The social interactions with peers, teachers, and other agencies are explained in detail while explaining the tasks and their executions in the next section.

3.2.3. Epistemic design of the CAD course

This section includes the epistemic design of the CAD course, consisting of telling-to-peer, writing-to-peer, and tutorial following tasks.

Telling-to-peer tasks

These tasks refer to telling a particular CAD command as a class-wide event. For the tasks, students are expected to study in groups (3 or 4 students) and are responsible for the given commands. The task has two phases. In the first part, students are required to give proper answers to the questions by demonstrating the command and discussing among group members in-class:

1. What does the command refer to?
2. How is the command executed?
3. What are the steps of the command?
4. What is the common use of the command?
5. What is the relationship between the command and the manufacturing process?
6. What are real-life examples of the command?

In the second phase, students are expected to prepare and assign a 5-mins task to their classmates that focuses on the related command. This phase was accomplished in the Breakout Rooms feature of the Zoom platform. We can also call this phase peer tutoring where the teachers become non-participant observers.

Writing-to-peer tasks

These tasks are about preparing tutorials for specific CAD modeling for their hypothetical peers by revealing how to draw, model, and render. Specifically, the tutorials included how to create a pattern in 2D; how to compare commands in surface creation, and how to model a toy in 3D. The hypothetical peers are the target audience who were the students taking the same course in the following year.

Tutorial following tasks

Tutorials are the common course materials devised in CAD teaching (Dosen et al., 2012). Even if tutorial following is a passive way of teaching CAD (Gelmez & Arkan, 2022), it is crucial for students to follow particular tutorials especially while developing procedural knowledge. In this sense, students are expected to complete weekly tutorials by accomplishing both video and text-based tutorials.

3.3. Data collection: Reflective writing

In addition to semester-end questionnaires carried out by the dean's office or the rectorate, the researchers —also the tutors of the course— employed a qualitative course evaluation template based on a previous study (see Gelmez, 2020). Course evaluation is regarded as a complex issue (Spooren et al., 2013), and often bears administrative objectives such as tenure positions, employment, or teaching performance analysis (Lattuca & Domagal-Goldman, 2007; Platt, 1993). However, teachers can prefer to use various evaluation methods to enhance their pedagogical approaches (Kember et al., 2002).

TABLE 2. Course evaluation template (Adapted for the CAD course) (Gelmez, 2020).

No	Incomplete sentences (Statements)	Topics
2	The commands that I presented...	Content and process
3	The tasks that I prepared for my classmates...	
4	The tutorials that I prepared...	
5	The tutorials that I followed...	

6	The tutorials prepared by former students/in the last semester...	
1	My dialogue with the teacher(s)…	Communication
7	My dialogue with my classmates...	
8	The Zoom platform...	
9	The assessment (grading)...	
10	The relationship between this course and the other courses in the department...	Overall
11	When I evaluated this semester in general...	
12	Besides these, I would like to say...	

To get feedback from students, we asked them to write their own evaluations on Google Forms at the end of the semester. 31 students, to whom were given informed consent, participated in our study voluntarily by filling out the incomplete statements listed in Table 2.

3.4. Data analysis

We basically tried to find clues in the students' writings about the effects of online education on the CAD course. We carried out a qualitative content analysis to make sense of the collected data. In this sense, "qualitative content analysis is defined as a research method for the subjective interpretation of the content of text data through the systematic classification process of coding and identifying themes or patterns" (Hsieh & Shannon, 2005; p. 1278). In this type of analysis, researchers primarily emphasize the meaning of the text within its context and complexity (Tesch, 1990).

To analyze the data collected from the students' reflections, all answers were transferred to an Excel sheet. In total, 357 data units were specified from 31 students. Each unit/answer was re-read and analyzed by both authors of this article and also the instructors of the course.

Content analysis can be accomplished with a data-driven, theory-driven, or mixed approach. While data-driven analysis aims to generate categories stemming from the raw data, the theory-driven approach deals with the data through existing categories based on a theory (Green, 2004). In this study, we adopted a mixed approach in the data analysis stage. In the first phase of the analysis, we clustered students' reflections with a theory-driven approach. In other words, the dimensions of the ACAD Framework served as a model to filter the reflections. In the second phase, we grouped these reflections with a data-driven approach.

The first phase of the data analysis: As explained in "The ACAD Framework in the CAD course", the ACAD Framework has three dimensions called set, social and epistemic design. In the first phase of data analysis, the data units were clustered based on these dimensions. As set design refers to the physical aspect and learning environment of the course (Goodyear et al., 2021), the following aspects were specified as the set design of the CAD course as shown in Table 1: the Zoom platform, the Breakout Rooms, screen-sharing, learning management system (ITU Ninova System), computer, Rhinoceros software, tutorials. Therefore, the units including these aspects were coded as set design.

Regarding the social design dimension; peer tutoring, peer interaction, collaboration, socialization, teamwork, and interaction with real and hypothetical peers were specified as a part of our CAD course

(Table 1). Hence, especially units containing peer interaction were coded under the social design dimension.

Epistemic design dimension includes the following aspects of the CAD course: telling-to-peer tasks, writing-to-peer tasks, and tutorial following tasks. Therefore, if a data unit mentions these tasks, it is coded under the epistemic design category.

The second phase of the data analysis: This phase includes a data-driven approach referring to forming meaningful clusters based on the data (see Green, 2004). After determining the categorization of the data unit in relation to the ACAD dimension, clusters were specified under each category. For instance, positive impressions on the Zoom platform were explained as a separate cluster. On the other hand, a comparison between online and physical environments was highlighted as another cluster. Via this way, we can understand the students' emphasis on each category, which makes the data easy to follow.

4. FINDINGS

The students' reflections were revealed under the categories of the ACAD dimensions. As mentioned, learners "re-configure" and "co-construct" what has been given during learn-time and the student activity emerges (Goodyear et al., 2021). In this sense, we thought that reflective writings could give us clues to better understand what was re-configured, whether there were different elements that we have not taken into account, and how these affected students' learning experiences.

4.1. Reflections on set design

In this dimension, we aimed to get students' insights about the Zoom platform and its effect on their learning experience. In the course evaluation template (Table 2), especially Statement #8 was used for this purpose, and also Statement #1 and Statement #7 gave some clues in this regard.

We did not see that the students had many complaints about the Zoom platform. On the contrary, there were positive opinions revealing that it was used efficiently and suitable for this course.

> I think [the Zoom platform] was used very efficiently. I don't know if the class could have been more interactive if it had been face-to-face. (Statement #8)

> [The Zoom platform] was much better than I had expected. I was very pleased in general. (Statement #8)

> [The Zoom platform] was used very effectively while conducting the course interactively. (Statement #8)

On the other hand, many students thought that the Zoom corresponded with the course requirements at an adequate level.

> [The Zoom platform] met what was wanted but nothing more. (Statement #8)

> Under these circumstances, I think [the Zoom platform] was sufficient by being able to split up [the Breakout] rooms and share screens, etc. It led to difficulties from time to time, but it seems OK since it's not happening constantly. (Statement #8)

> The possibilities of the Zoom platform are very adequate for the course… We have never experienced any constraints or difficulties during the class. (Statement #8)

Some of the students mentioned that learning through the Zoom platform is a better option for CAD courses rather than being in a physical class.

> In the classroom, we may have problems with hearing and seeing... However, we can easily hear and learn every command and what has been told through the Zoom. (Statement #8)

> It was one of the positive aspects that [the Zoom platform] enabled us to follow the commands clearly on the computer screen. (Statement #8)

> [The Zoom platform] was not posing an obstacle for conducting this course. In fact, while I was listening to the class at home, there were moments that I thought I could not hear what the teacher told and could not model it, if we had been in a lab. (Statement #8)

The statements above made us think that students might compare their past experiences in a physical classroom to the Zoom platform. As a self-reflection from our perspective, the quality of seeing and hearing in a physical classroom may have been affected by various factors such as acoustics of the room, noise, distance, technical equipment used and classroom setting, etc. While they were listeners on the Zoom platform, they were sitting just in front of their computers and could see shared screens from a much closer distance. It can be deduced that the menus and options of the 3D CAM software can be seen more easily from a closer distance. On the other hand, these menus can remain relatively small when projected in a classroom.

There were several comments on the Breakout Rooms in which the telling-to-peer tasks were accomplished. They were mostly related to the efficient use of the Breakout Rooms and the adaptation of the use of these rooms. In addition, some of the students saw the Breakout Rooms as an opportunity to create a dialogue with their classmates.

> [My dialogue with my classmates] was good as far as I interacted in the Breakout Rooms. (Statement #7)

> We could establish a dialogue with each other very easily in the Breakout Rooms. (Statement #7)

> I can say that doing the tasks together in the Breakout Rooms, and the frequent use of screen sharing triggered my enthusiasm for my participation in the class. (Statement #8)

We noticed that the Zoom platform provided students with different levels of interaction and engagement with the class. Some of the options such as using cameras on or off, muting microphones, or using the chat box enabled students to choose their levels of participation and ways of being active in the class.

> ...I preferred to [attend class] by listening rather than verbally participating. (Statement #1)

> I think I only turned on my camera, microphone and talked while I was making a presentation. (Statement #1)

> Preferably I didn't talk much, but it was easy to participate and communicate. (Statement #1)

> I liked to do something else in the background while my friends were presenting. (Statement #3)

Interestingly, one of the students chose the word ‘classroom’ to define the classes in the Zoom platform. This made us think that the feeling of being in a classroom is not merely about being in a physical space. From this point forth, we can assert that learning, in this sense, transcends the physical dimension and reaches a virtual experience.

> ...the teachers were the ones who gave the greatest effort to get in touch with us when we made a sound in the *classroom*. (Statement #1)

In one of the comments, we took the impression that the student thinks that online learning is an obstacle to practice-based learning activities. This urges us to discuss that the student may associate practice-based learning with a physical learning environment and think that it can only be applied in a physical learning environment.

> ...especially during the lockdown we are in, [the tutorials that I followed] seem to prevent everything from remaining theoretical. (Statement #5)

4.2. Reflections on social design

In the social design dimension, we see reflections on teacher-student interaction, student-student interaction, etc.

In Statement #1, we aimed to get insights into the dialogue between teachers and students. There were two opposing views; some of them mentioned the lack of communication and they especially emphasized that online learning is the reason for this;

> Since it was an online semester, I can't say that there was very much dialogue. (Statement #1)

> As you know, since we were in the online education process, I did not have quite much *one-to-one dialogue with the teachers*... (Statement #1)

> [My dialogue with teachers] was as much as it could be in online education. (Statement #1)

On the other hand, most of them were pleased with the social interaction;

> During the class, my dialogue with teachers was at a good level. We could easily get in touch with our teachers when we were curious or stuck in. (Statement #1)

> [My dialogue with teachers] was pretty good. I got very explanatory answers to the questions I asked. The teachers were very concerned with the students. (Statement #1)

> [My dialogue with teachers] was pretty good and fluent. I had no difficulty in accessing the teachers. This felt good. (Statement #1)

Besides being pleased, one of the students emphasized the extra effort given by teachers to enhance dialogue during the classes. This made us think that the students may see that communication in online learning is harder and needs extra effort rather than learning in a physical environment.

> The teachers were the ones who gave the greatest effort to get in touch with us when we made a sound in the classroom. Even when we asked a question in the chatbox, they asked us to repeat it out loud. (Statement #1)

We also had an impression that most of the students had higher expectations from teachers by being more understanding due to the lockdown.

> The efforts of our teachers to establish a dialogue with us and to find the best compromise with *a warm manner* were very important for us in this period and I think that a very good dialogue was established. (Statement #1)

> [My dialogue with teachers] was quite good. All teachers approached the students in an *understandable* and *sensible* manner. (Statement #1)

Although the students were pleased with the interaction in general, some of them believed that a stronger dialogue could have been built in a face-to-face environment.

> It was not as good as it was in the *normal* semester, I wished to be in more dialogue with the teachers. But this has nothing to do with the progress of the course. It is related to being online. (Statement #1)

> [My dialogue with teachers] was quite good. I think it would have been much better if the lesson had been face-to-face. (Statement #1)

In one of the interesting comments, the student made a clear distinction between relationship and interaction with teachers. This made us discuss that the student desired more sincere and sustainable interaction, but in online learning, it was accomplished only at a certain level.

> I did not have a problem with [my dialogue with teachers]. I think we established a good *dialogue* but not a good *relationship*. (Statement #1)

We prepared Statement #7 to get reflections on their dialogue with their classmates. In general, they complained that there was little interaction or no interaction at all due to online learning.

> [My dialogue with classmates] was weak due to the effects of the online education period as well. (Statement #7)

> There was no [dialogue with my classmates]. (Statement #7).

Some of the students stated that they interacted mostly -or only- with the ones that they have already known.

> Unfortunately, due to the effect of the online period, I could not get in touch with people other than people I've met before. (Statement #7)

> In general, I interacted with my friends whom I've known before, other than that I did not have a dialogue with any others. (Statement #7)

As general impressions, the students were pleased with the dialogue during the class. However, we recognized that their complaints were mostly about being deprived of socializing before, after, or during class. In other words, they could not have daily chatting or sincere conversations with the teachers or with each other. We thought that maybe this situation created the thought that the dialogue was sufficient during online learning. Broadly speaking, regarding the social design dimension of the ACAD, it would be efficient to make a distinction between the *dialogue for learning* and the *dialogue during learning.*

4.3. Reflections on epistemic design

Statements #2, #3, #4 and #5 particularly offer reflections about the designed tasks that correspond to the epistemic design of the course. However, the students mainly wrote about the content of the tasks, so we did not encounter insights about tasks that are directly related to online education.

Surprisingly, in Statement #7, which was about the dialogue with their classmates, we took insights about the telling-to-peer activity. We saw that most of the students depicted the telling-to-peer activity as an opportunity for socializing, making new friends, and meeting with new students.

> Without telling-to-peer, I would hardly have any [dialogue with my classmates], but working together has greatly increased my dialogue. (Statement #7)

> At the beginning of the year, I didn't know anyone in the class. Thanks to the 'telling-to-peer' activity, I had the opportunity to meet my classmates. I still keep in touch with my group mates. I think this activity has positively affected my dialogue with my classmates. (Statement #7)

> The group study helped me to establish a dialogue a little and get to know new people from the department. (Statement #7)

> I think the telling-to-peer activity is a very good activity in this context. While it was very difficult to socialize in online education, it [the activity] made it easy. I made good friends. (Statement #7)

> Thanks to the telling-to-peer activity, I had the opportunity to establish a dialogue and meet with my friends. (Statement #7)

As mentioned in the epistemic dimension of our course, the students prepared a 5-mins task in the second phase of telling-to-peer. We observed that the groups tended to prepare these tasks by using a tutorial format similar to the ones they followed in their weekly assignments. They also planned the distribution of work among group members.

The importance of strategic knowledge is inevitable in CAD learning (Bhavnani et al., 2001; Chester, 2008). In this case, the utilization of knowledge extends to mere modeling activity in CAD. We can assert that the epistemic design of the CAD course boosts its social dimension.

> Preparing the tasks was not so difficult. As we talked with my friends about the things like what we could draw with this command while preparing the presentation, we've easily chosen what to prepare as a task. I took screenshots, while someone was modeling. After that, we completed [the presentation] [by adding] text. (Statement #3)

Moreover, we gave an assignment in which the students were expected to model an object by following the tutorial which was prepared by a student from the previous CAD course. We also asked them to evaluate the tutorial about the issues such as clarity, quality, failures, missing parts, etc. The objective of this assignment was to encourage them to practice on strategic knowledge by evaluating the strategies and decisions of their peer. Statement #6 was prepared for taking insights about this assignment:

> Although some of my friends complain about the unclarity of the tutorial, I think following an imperfect tutorial brings a different kind of learning. (Statement #6)

> [The tutorials prepared by former students/in the last semester] made me understand the necessities for the tutorial that I am going to prepare. (Statement #6)

> Following the tutorials which were prepared by someone else, finding the missing parts and bringing alternative solutions [to them] were good opportunities for comparing two [different] points of view. (Statement #6)

We also get insights that the tasks and assignments offer fun and motivation for the students. It is noteworthy to highlight emotions frequently evoked throughout the semester. The students frequently mentioned ''having fun'' and ''enjoying the class.'' While we are all facing the negative psychological effects of pandemics and lockdowns, we think that these feedbacks are considerable regarding the overall psychology and motivation of the students.

As Gelmez and Bağlı (2018) stated, design students perceive the class as a learning experience and they have tendencies to enjoy this experience. Pekrun (2006) found enjoyment as a motivating factor that affects their achievement. We can find the following statements indicating emotions such as fun and enjoyment evoked in students during our CAD course.

> For me, [the assignments] were fun. I really could say that I loved very much working on Rhino. (Statement #5)

> ...doing the assignments was valuable for me because they were both efficient and enjoyable. (Statement #5)

> Weekly assignments were quite fun. (Statement #5)

4.4. General thoughts about online learning

From the general evaluation of the semester, we had an impression that most of the students prefer being in a physical class rather than an online platform. In spite of this, most of them mentioned that

they were satisfied with their learning experiences in the CAD course, which is adapted with the ACAD Framework.

> [When I evaluated this semester in general], it was positive in terms of this particular course, annoying in terms of online education. (Statement #11)

> This semester was actually an ending for me. This is because I am the one who finds strength by talking and interacting with people in the studio and classroom environment. When these were not possible, I couldn't concentrate, *I felt trapped in a city where I didn't have many friends*. The absence of my social life rather than the courses made me feel overwhelmed and I could not focus on my courses most of the time. (Statement #11)

On contrary to these views, some of the students perceived the lockdown as a focusing opportunity.

> For my part, I think it was very efficient. Being locked down at home provided me with a better concentration on my courses. (Statement #11)

From a teaching perspective, we thought that the nature of CAD courses, which is fundamentally related to the use of computer programs, relatively facilitates adapting the course to online education. In the reflective writings, we saw that some students agreed with this view. Actually, they compared the CAD course with their other courses that they have taken on the Zoom platform and added that it was the most appropriate one for an online platform.

> Regarding this course, I think the education that we took was more efficient and had higher quality rather than the one we took at school. (Statement #8)

> [The Zoom platform] was a very suitable platform for this course. (Statement #8)

> I think it is the course that can continue to be taught online if face-to-face training is started. (Statement #12)

> I think this course is very well adapted to the online semester. (Statement #12)

When we evaluate the outcomes of the course overall, we see that a great majority of the students can model a relatively complex object on the software satisfactorily (Figure 3). When we look at the students' reflections, regarding their learning experience in general, we see many quotes which give insights to us that they were pleased with their learning experiences. We also find clues on developing themselves regarding modeling skills.

> [The course] was very pleasing and efficient. I really love modeling with Rhino. I am thinking of improving myself during the semester break. (Statement #11)

> I was thinking that I would struggle a lot but I have learned much more than I expected. (Statement #11)

> I really think I've learned the modeling software as much as I can express myself. (Statement #11)

> Thanks to this course, I started to feel confident about 3D [modeling]. Now I work by myself on sculpting a blender and game-ready object modeling. Thanks to everyone who contributed." (Statement #11)

FIGURE 3. Some of the students' works as the final assignment (by the courtesy of students).

5. CONCLUSION

In these ambivalent times, we believe that it is important to see diversified studies on how design teachers have approached unexpected online education. However, these studies should not merely focus on design studio courses. Design teachers and scholars should also reveal their pedagogies about the other courses taking place in design curricula.

In this article, we particularly focused on a CAD course conducted during online education. By making a comparison with the physical and online environment, we discussed the CAD course under the ACAD Framework (see Goodyear et al., 2021), which offers a practical and consistent point of view to our existing pedagogy. Recently, the course had been constructively aligned in a previous study (see Gelmez & Arkan, 2022) based on Biggs' conceptualization (see Biggs, 1996; Biggs & Tang, 2007). In this current study, we find an opportunity to review it with a fresh perspective. Since it is constructively aligned, conducting the course in online education has been a matter of adaptation to the current situation.

As elaborated in the previous sections, the CAD course was examined in the light of students' reflections under the elements of the ACAD Framework, which are set design, social design, and epistemic design. In a general sense, even if there is a negative opinion towards the unexpected nature of online education, the students stated about opportunities of online education in CAD learning in particular. Especially, when we consider the set design of the CAD course, students have positive attitudes toward online learning on the Zoom and its features such as the Breakout Room and the chatbox. In the statements, students mentioned that they could easily follow the class by screen sharing on the Zoom platform. This feedback made us think that we can suggest using screen sharing in CAD classes in a physical classroom. Rather than following the class through a projection, being able to see on the students' own computer screens may improve their learning experiences. This could be a worthy

further exploration that a hybrid set design like this may enhance the learning experience of the students.

They had tendencies to check the sufficiency of the Zoom. As a result, the Zoom as the set design offers a spatial environment to conduct a CAD course. Regarding the social design of the CAD course, we can come across diversified comments on both shortcomings and opportunities of online learning among classmates and between teachers. On the other hand, concerning the epistemic design, we see that students tend to connect the epistemic dimension with the social aspect of the course. Furthermore, we can come across students' expressions about the online learning platform, peer learning, peer interaction, peer tutoring, active involvement in the class, task distribution, communication, etc.

As widely known, the social process during learning is essential as proposed in the seminal Lev Vygotsky's Sociocultural Theory (see Vygotsky, 1978). The importance of the social aspect of learning becomes prominent once again under pandemic conditions. As it can be inferred; in our case, the Zoom platform (set dimension) and tasks (epistemic dimension) nourished the social interaction among the class. As a result, we come across this aspect in students' writings.

All in all, students' reflections on the CAD course made us think that the dimensions of the ACAD Framework are interwoven and interactive. In other words, the dimensions do not exist discretely. Instead, they co-exist together. Whereas the set dimension creates a context for learning, the epistemic dimension builds upon this context by offering learning material. The social dimension, on the other hand, gives life to learning with the material in the provided context. Therefore, each dimension constitutes and affects each other inherently. In short, the set dimension and the epistemic dimension reciprocally cultivated the social dimension, which was inevitably —and probably the most— affected by the pandemic conditions.

This study is expected to contribute to CAD teachers' pedagogies together with current literature on online design education. It informs the literature with a comprehensive yet practical framework - the ACAD Framework. It is recommended for design teachers to reconsider their CAD pedagogies within this framework. Reconsidering the course with the dimensions called set, epistemic and social design offers a fresh and fruitful look toward CAD. Especially in emergent situations as happened in 2020, teachers can refer to this framework.

This study is based on a course evaluation template based on a previous study (Gelmez, 2020). This template was implemented in other studies (see Gelmez & Arkan, 2022; Gelmez et al., 2022; Himaki, 2021). With the qualitative nature of this template, design students can give rich insights into their design learning journeys (Gelmez, 2020). Based on this current study, we can say that it is possible to develop a course evaluation template specifically for CAD courses under the ACAD Framework. Getting insights into the set design can give teachers to reorganize the physical environment and tools. Also, feedback on the social design dimension can allow us to see deeper insights into interaction among peers. Understanding the social dimension may help teachers to develop tasks emphasizing the social aspect of learning. Furthermore, students' evaluation of epistemic design may assist in assessing the teaching performance of the assigned tasks. Being inform develop a specific course evaluation template by focusing on the ACAD dimension separately. Even though learning is considered an emergent phenomenon in the ACAD, the perception of learners seems to be crucial to informing and advancing learning and teaching processes.

This article presents a study from students' points of view on the emergent situation in a CAD course. Apparently, the conditions posed by this situation also affect the teaching process and the teachers. As the instructors of the course, we experienced an emergency, especially while organizing the set design dimension. As we were not well-prepared for online education, we were responsible to adapt the conditions of the physical environment into the virtual context. However, we think that the epistemic dimension was not influenced abundantly. In short, we reorganized the tasks according to the features of the Zoom platform. Correspondingly, the social dimension was designated by considering both pandemic conditions and Zoom opportunities. We presented this as a pedagogical implication from our teaching experience. However, this needs a rigorous academic study by investigating design teachers' experiences during pandemic conditions as future research.

As happened during the pandemic, emergent technologies will definitely affect CAD education, which can further be studied under the ACAD Framework.

ACKNOWLEDGEMENTS
We would like to thank the students who participated in our study voluntarily. We would like to extend our gratitude to Pelin Efilti and Onur Yılmaz for their contributions.

REFERENCES

Antonietti, A., & Giorgetti, M. (2006). Teachers' beliefs about learning from multimedia. *Computers in Human Behavior, 22*(2), 267–282. https://doi.org/10.1016/j.chb.2004.06.002

Aras, L. (2021). Liberating design education after Corona Days. *Academia Letters, 2*. https://doi.org/10.20935/AL670

Başa, İ., & Şenyapılı, B. (2005). The (in)secure position of the design jury towards computer generated presentations. *Design Studies, 26*(3), 257–270. https://doi.org/10.1016/j.destu d.2004.09.006

Bender, D. M., Wood, B. J., & Vredevoogd, J. D. (2004). Teaching time: Distance education versus classroom instruction. *The American Journal of Distance Education, 18*(2), 103-114. https://doi.org/10.1207/s15389286ajde1802_4

Bhavnani, S. K., Reif, F., & John, B. E. (2001). Beyond command knowledge: Identifying and teaching strategic knowledge for using complex computer applications. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 229–236). https://doi.org/10.1145/365024.365107

Biggs, J. (1996). Enhancing teaching through constructive alignment. *Higher Education, 32*(3), 347–364. https ://doi.org/10.1007/BF001 38871

Biggs, J., & Tang, C. (2007). *Teaching for quality learning at university. What the student does* (4th ed.). Maidenhead.

Boud, D. (2013). Introduction: Making the move to peer learning. In D. Boud, R. Cohen, & J. Sampson (Eds.), *Peer learning in higher education learning from & with other* (pp. 1–20). Routledge. https://doi.org/10.4324/9781315042565

Bülow, M.W. (2022). Designing synchronous hybrid learning spaces: Challenges and opportunities. In E. Gil, Y. Mor, Y. Dimitriadis, & C. Köppe. (eds) *Hybrid Learning Spaces. Understanding Teaching-Learning Practice* (pp. 135-163). Springer, Cham. https://doi.org/10.1007/978-3-030-88520-5_9

Carvalho, L., Martinez-Maldonado, R., Tsai, Y. S., Markauskaite, L., & De Laat, M. (2022). How can we design for learning in an AI world?. *Computers and Education: Artificial Intelligence, 3*, 100053. https://doi.org/10.1016/j.caeai.2022.100053

Chester, I. (2007). Teaching for CAD expertise. *International Journal of Technology and Design Education, 17*(1), 23–35. https://doi.org/10.1007/s10798-006-9015-z

Chester, I. (2008). 3D-CAD: Modern technology–outdated pedagogy? *Design and Technology Education: An International Journal, 12*(1), 7–9.

Çil, E., & Pakdil, O. (2007). Design instructor's perspective on the role of computers in architectural education: A case study. *METU Journal of the Faculty of Architecture, 24*(2), 123–136.

Daalhuizen, J., & Schoormans, J. (2018). Pioneering online design teaching in a MOOC format: tools for facilitating experiential learning. *International Journal of Design*, *12*(2), 1-14.

Davies, W., & Cormican, K. (2013). An analysis of the use of multimedia technology in computer aided design training: Towards effective design goals. *Procedia Technology, 9,* 200-208. https://doi.org/10.1016/j.protcy.2013.12.022

Demirci, A. (2011). Bilgisayar destekli eğitimin grafik tasarım dersinde kullanımına ilişkin öğrenci görüşleri [Student views on the use of computer aided graphic design courses]. *e-Journal of New World Sciences Academy, 6*(4), 472–484.

Dosen, A. S., Sher, W., Gajendran, T., & Gu, N. (2012). Teaching CAD: The challenges of online delivery to distance learning students. In *Proceedings 37th AUBEA International Conference* (pp. 48–56). http://hdl.handle.net/1959.13/933946

Dreamson, N. (2020). Online design education: Meta-connective pedagogy. *International Journal of Art & Design Education, 39*(3), 483-497. https://doi.org/10.1111/jade.12314

Fawns, T., Markauskaite, L., Carvalho, L., & Goodyear, P. (2022). H2m pedagogy: Designing for hybrid learning in medical education. In E. Gil, Y. Mor, Y. Dimitriadis & C. Köppe. (eds). *Hybrid Learning Spaces. Understanding Teaching-Learning Practice* (pp. 61-76). Springer, Cham. https://doi.org/10.1007/978-3-030-88520-5_5

Fleischmann, K. (2019). From studio practice to online design education: Can we teach design online? *Canadian Journal of Learning and Technology / La Revue Canadienne de L'apprentissage et de la Technologie, 45*(1). https://www.learntechlib.org/p/208589/

Fleischmann, K. (2020). Online design education: searching for a middle ground. *Arts and Humanities in Higher Education. 19*(1), 36-57. https://doi.org/10.1177/1474022218758231

Gelmez, K. (2020). In quest of a successful design studio course: A course evaluation template. In R. Almendra & J. Ferreira (Eds.), *Proceedings of 1st International Conference on Research and Education in Design* (REDES 2019) (pp. 110–118). Paper presented at Lisbon, 14 November 2019. CRC Press. https://doi.org/10.1201/9781003046103.

Gelmez, K., & Arkan, S. (2022). Aligning a CAD course constructively: telling-to-peer and writing-to-peer activities for efficient use of CAD in design curricula. *International Journal of Technology and Design Education, 32*, 1813–1835. https://doi.org/10.1007/s10798-021-09656-8

Gelmez, K., & Bağlı, H. (2018). Tracing design students' affective journeys through reflective writing. *International Journal of Technology and Design Education, 28*(4), 1061–1081. https://doi.org/10.1007/s10798-017-9424-1

Gelmez, K., Efilti, P., & Yilmaz, O. (2022). "Well, a tough question. Congratulations:" How and in what aspects do design students evaluate a design studio course? *International Journal of Technology and Design Education*. https://doi.org/10.1007/s10798-022-09775-w

Goodyear, P., Carvalho, L., & Yeoman, P. (2021). Activity-Centred Analysis and Design (ACAD): Core purposes, distinctive qualities and current developments. *Educational Technology Research and Development,* 1-20. https://doi.org/10.1007/s11423-020-09926-7

Green, B. (2004). Personal construct psychology and content analysis. *Personal Construct Theory & Practice, 1*(3), 82-91.

Green, J. K., Burrow, M. S., & Carvalho, L. (2020). Designing for transition: supporting teachers and students cope with emergency remote education. *Postdigital Science and Education, 2*(3), 906-922. https://doi.org/10.1007/s42438-020-00185-6

Hanna, R., & Barber, T. (2001). An inquiry into computers in design: Attitudes before-attitudes after. *Design Studies, 22*(3), 255–281. https://doi.org/10.1016/S0142-694X(00)00029-6

Himaki, S. E. (2021). *How to sketch things with words: Exploring the relation between verbal and visual expressions of novice design students* [Master thesis], Graduate School of Istanbul Technical University.

Hsieh, H. F., & Shannon, S. E. (2005). Three approaches to qualitative content analysis. *Qualitative health research, 15*(9), 1277-1288. https://doi.org/10.1177/1049732305276687

Ioannou, O. (2018). Opening up design studio education using blended and networked formats. *International Journal of Educational Technology in Higher Education, 15*(47). https://doi.org/10.1186/s41239-018-0129-7

Kember, D., Leung, D. Y. P., & Kwan, K. P. (2002). Does the use of student feedback questionnaires improve the overall quality of teaching? *Assessment & Evaluation in Higher Education, 27*(5), 411–425. https://doi.org/10.1080/0260293022000009294

Lattuca, L. R., & Domagal-Goldman, J. M. (2007). Using qualitative methods to assess teaching effectiveness. *New Directions for Institutional Research, 136,* 81-93. https://doi.org/10.1002/ir.233

Marshalsey, L., & Sclater, M. (2020). Together but apart: Creating and supporting online learning communities in an era of distributed studio education. *International Journal of Art & Design Education, 39*(4), 826-840. https://doi.org/10.1111/jade.12331

Milovanovic, A., Kostic, M., Zoric, A., Dordevic, A., Pesic, M., Bugarski, J., Todorovic, D., Sokolovic, N., & Josifovski, A. (2020). Transferring COVID-19 challenges into learning potentials: Online workshops in architectural education. *Sustainability, 12*(17), 1-21. https://doi.org/10.3390/su12177024

Newman, G., George, B., Li, D., Tao, Z., Yu, S., & Lee, R. J. (2018). Online learning in landscape architecture: Assessing issues, preferences, and student needs in design-related online education. *Landscape Journal, 37*(2), 41-63. https://doi.org/10.3368/lj.37.2.41

Onofrei, G., & Ferry, P. (2020). Reusable learning objects: a blended learning tool in teaching computer-aided design to engineering undergraduates. *International Journal of Educational Management, 34*(10), 1559-1575. https://doi.org/10.1108/IJEM-12-2019-0418

Pekrun, R. (2006). The control-value theory of achievement emotions: Assumptions, corollaries, and implications for educational research and practice. *Educational Psychology Review, 18*(4), 315–341. doi:10.1007/s10648-006-9029-9.

Platt, M. (1993). What student evaluations teach, *Perspectives on Political Science*, *22*(1), 29–40. https://doi.org/10.1080/10457097.1993.9944516

Rajagopal, K., & Mateusen, L. (2021). Designing virtual mobility as a transformative learning experience. *Edutec. Revista Electrónica De Tecnología Educativa,* (75), 9-30. http://dx.doi.org/10.21556/edutec.2021.75.1953

Seinauskas, R. (1997). A distance laboratory for computer-aided design. In *Proceedings of International Conference on Microelectronic Systems Education* (pp. 107-108). IEEE. https://doi.org/10.1109/MSE.1997.612569

Spooren, P., Brockx, B., & Mortelmans, D. (2013). On the validity of student evaluation of teaching: The state of the art, *Review of Educational Research, 83*(4). https://doi.org/10.3102/0034654313496870

Taşlı-Pektaş, Ş., & Erkip, F. (2006). Attitudes of design students toward computer usage in design. *International Journal of Technology and Design Education, 16*(1), 79–95. https://doi.org/10.1007/s1079 8-005-3175-0

Tesch, R. (1990). *Qualitative research: Analysis types and software tools.* Falmer.

Topping, K. J. (2005). Trends in peer learning. *Educational Psychology, 25*(6), 631-645. https://doi.org/10.1080/01443410500345172

Tregloan, K., Soccio, P., & Thompson, J. (2020). BEL+T designs a DIAgram … a relational framework for teaching online. *Distance Design Education [Online]*. https://distancedesigneducation.com/2020/08/20/belt-designs-a-diagram-a-relational-framework-for-teaching-online

Tüfek, T. E. (2022). An unexpected shift to an online design studio course: Student insights on design critiques. *International Journal of Art & Design Education, 41*(1), 158-170. https://doi.org/10.1111/jade.12400

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes.* Harvard University Press.

Wood, J. (2003). Open minds and a sense of adventure: How teachers of art and design approach technology. *International Journal of Art and Design Education, 13*(1), 179–191. https://doi.org/10.1111/j.1476-8070.2004.00396.x.

Wragg, N. (2020). Online communication design education: The importance of the social environment. *Studies in Higher Education, 45*(11), 2287-2297. https://doi.org/10.1080/03075079.2019.1605501

Yixian, D., Qihua, T., Xuan, D., & Kongde, H. (2014). CAD/CAM courses integration of theoretical teaching and practical training. In *Procedia—Social and behavioral sciences, 5th World Conference on Educational Sciences—CES 2013*, *116*, (pp. 4297–4300). https://doi.org/10.1016/j.sbspro.2 014.01.935

Yorgancıoğlu, D. (2020). Critical reflections on the surface, pedagogical and epistemological features of the design studio under the “new normal” conditions. *Journal of Design Studio, 2*(1), 25-36. https://doi.org/10.46474/jds.744577