Adaptation of architectural education pedagogy in addressing COVID-19 pandemic

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Highlights	Abstract
- The pedagogically distinctive implications of digital design have prompted the need for new educational frameworks in architecture. - It presents the experimental framework designed to test the adaptability of online education in the department of architecture from both instructors' and students' points of view. - Virtual study offers a chance to promote independence and a research-oriented design approach	In March 2020, the World Health Organization (WHO) proclaimed the COVID-19 outbreak a global pandemic. As a result, it has been mandated that all educational institutions complete the 2019-20 spring semester online. Despite the importance of distance education, it appears that online education has not assisted architecture education adequately. This is due to the fact that it has higher learning objectives, is taught via coaching approaches, and incorporates nonverbal communication. Architects are trained through a method focused on the 'studio course'. In this environment, students' decisions are unintentionally affected by the unanticipated backtalk and discussions that arise from the design development process. In other words, criticism, which is a graphic and oral communication between the students and the instructor, is one of the most frequent learning strategies utilized in the design studio. The necessity for new educational frameworks in architecture has been sparked by the pedagogically distinctive consequences of digital design. Thus, the primary aim of this study is to monitor and document current trends, benefits, and limitations of online architectural discourse and learning ecosystems from both students' and tutors' perspectives. It also investigates alternative pedagogical agendas in order to address the requirement to integrate different levels of students with online education. In this regard, the effects of the design medium, knowledge-based or theoretical courses, and practical courses are three common types of influences on educational system adaptability and inertia. Finally, in this research, authors attempt to formulate a theoretical framework and didactic principles for the modification of architectural online education by using multiple methods of data collection, primarily based on a systematic observation of the experiments, questioning the participants before and after the experiment, and evaluate of the descriptive results of the experiment.
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1. Introduction

These days, one of the most significant ways of facing 21st-century global challenges is a well-rounded education, which establishes a foundation for lifelong learning. Education can be defined as; "the process of receiving or giving systematic instruction" (Noddings, 2019). Nevertheless, it is obvious that educational systems and methods are variable, all around the world. These methods are growing hand in hand with progresses in technology, the level of knowledge, new students' requirements and based on the fields of studies it can be changed as well (Manley & Johnson, 2013). Therefore, the word; education meaning is changing every day. Students and universities had a contractual relation when they enrolled in the classical educational system. However, the spread of the Covid-19 virus compelled the world to confront the issue of distance/virtual education. In this respect, practically all educational institutions throughout the world were obliged to cancel face-to-face courses in the first half of 2020 as a non-pharmaceutical intervention to restrict the pandemic's expansion. In the fourth month of 2020, the lockdown was affecting about 1.5 billion students in nearly 200 nations, accounting for roughly 90% of the global school population (UNESCO, 2020; Giovannella, Passarelli, & Persico, 2020). Beyond the physical and technical issues of transitioning from face-to-face to online education, ensuring that students continue to receive the most proper possible education is a significant problem in academia. Despite the fact that teachers tended to use teaching strategies that replicated standard classroom dynamics, the ability to operate in this comfort zone resulted in a positive attitude toward using technology, a perception of enhanced digital skill mastery, and a shift in mind set about educational processes. As a result, the perceived sustainability of online education has increased, with many teachers indicating a desire to use a mixed configuration for future educational activities. The importance of digital pedagogy and the necessity to include it into training curriculum in order to prepare future generations is not a new topic. For more than two decades, the digital studio has been an unignorable section of education in the field of architecture (Iranmanesh & Onur, 2021). The pedagogically distinctive implications of digital design are driving this trend for new educational frameworks. Various educators and academics have begun to investigate various types of educational agenda in order to meet the requirement to incorporate digital design in architectural design courses (Wojtowicz, 1995; Kvan, 2001; Strojan & Mullins, 2002; Oxman, 2008; Giovannella, Passarelli, & Persico, 2020).

This first wave of practice-driven teaching approaches has ushered in a new era in architectural education. This situation necessitates a redefining of architectural intellectual and cultural frameworks, as well as the theoretical basis for architectural and design education. The necessity of adaptation to the scale of change in professional practice, as well as the emerging needs for requisite skills and knowledge, provides a new challenge to this generation of design pioneers: developing a design pedagogy and architectural education theory, which recognizes the qualities and scale of technological, theoretical, and professional changes that digital-based architecture is beginning to exert. In the case of such a large cultural transition, it is necessary, first and foremost, to reconsider the theoretical foundation, relevant knowledge, and design methodologies in light of emerging digital technologies (Oxman, 2008).

However, a design studio is the fundamental pedagogical approach in most architectural schools. The design studio provides a teaching model from a design field in which the social and technological, as well as the structural and functional, must be properly merged (Chafee, 1977; Kuhn, 1988; Kuhn, 2001). In other words, the design studio is the focal point of architectural education in institutions all over the world; the phrase refers not only to a physical location (place) but also to a fully immersive process and a social structure (Kalay, 2004; Abdellatif & Calderon, 2007). In this sense, the studio's transition to virtual space generates a slew of challenges, as the studio is more than a classroom; it's a lifestyle with an essential socio-spatial characteristic (Dutton, 1987). This topic could be particularly prominent in the studios of first-year students. Moreover, today's pupils were born and reared in a world of digital communication; they can be considered native speakers of social media and digital space languages. As a result, their initial connection with digital studios may prove to be more productive since they have the ability to fully utilize it. This new

generation may have distinct perceptions of virtual space, making it easier for them to communicate in a virtual context (Pektaş, 2015; Iranmanesh & Onur, 2021). The present study's main objective is to observe and document the current developments, advantages, and shortcomings of online architectural discourse and learning ecosystem from both instructors' and students' points of view. It also tries to separately address the need to integrate different levels of students with online education by investigating various forms of pedagogical agenda for adapting different types of courses. Finally, the authors attempt to organize a theoretical framework and didactic principles for the modification of architectural distance education by applying multiple methods of data collection, primarily according to questioning the participants before and after the pandemic experiment, observation of the experiments, and analysis of the descriptive results of the experiment.

2. Literature Review

These days, traditional notions of representation are no longer as important as they once were as a conceptual foundation for understanding the knowledge and processes involved with digital design. The idea of form has been turned into the concept of formation by digital design theory. This is another fundamental divergence. Digital formation models have become a medium of conceptualization in addition to the development of complicated free forms (Oxman, 2008).

A description of the symbiosis between the result of design and the manner it is presently imagined, developed, and manifested in digital media is required to comprehend digital design as a distinct set of design logic. Certain capacities of generative and performative processes are now enhanced by digital approaches that were never available previously in traditional, paper-based procedures. They are also altering the standard design procedures and sequencing in the process (Oxman, 2006; Sass & Oxman, 2006; Oxman & Rosenberg, 2007; Oxman, 2008).

Digital design and design computation influenced the development of theoretical, computational, and cognitive techniques as a basis for design education and pedagogy by a range of scholars (Knight, 1999) (Cuff, 2001; Knight & Stiny, 2001; Ozkar, 2007). Others examined visualization and data architecture as a foundation for education (Bermudez & Agutter, 2005), as well as a framework for curriculum development (Mark et al., 2003; Kvan et al., 2004).

Lynn (1999), Rashid and Couture (2002), Zaero-Polo and Moussavi (2003), and Spuybroek (2004) are among the conceptually noteworthy monographs, all of which are key publications by and on major digital design practices [29-32]. Numerous volumes on digital designs, such as Zellner (1999) and Rosa (2003), are compilations of short descriptive monographs on specific digital methods (Zellner, 1999; Rosa, 2003). Kolarevic (2003) and Kolarevic and Malkawi (2005) are providing more methodological and technological contents on recent developments in digital design (Kolarevic, 2003; Kolarevic & Malkawi, 2005).

Emerging technologies have begun to affect core themes in design theory in the recent decade. The analysis of complicated geometries, or "free forms" (Zellner, 1999), as well as associated materialization processes of fabrication and manufacturing technologies, has been a focus of architectural design (Sass & Oxman, 2006; Kieran & Timberlake, 2004; Schodek et al., 2005). These changes have begun to have a considerable impact on design's theoretical, conceptual, and methodological substance.

Nowadays, there is a need to distinguish between DAD (design-aided development) and CAD (computer-aided design). The contrast between CAD and DAD is more than just terminology. While the ideas, philosophies, and techniques of CAD (Kalay, 2004) have mostly been built on emulating paper-based design, the unique notions of digital design models are reintroducing a new medium of conceptualization, replacing paper-based media. The formation of new conceptual language and domain knowledge is being aided by the new relationships between digital processes and digital form. It describes what may fairly be described as the early phases of a paradigm shift (Oxman, 2008).

However, despite their great potential, distance education and digital design have been constrained in the past by technical issues such as CAD programs limitations, internet bandwidth, cost and accessibility, and also limitations of digital media for housing and recording design studio sessions (Wojtowicz, 1995; Kvan, 2001; Reffat, 2007; Schnabel & Kvan, 2001; Russell, 2001), but today, many of these concerns have been alleviated by the rapid development of digital technology it's time to establish new empirical frameworks for distant education and as a result digital design, ones that aren't constrained by technical constraints but rather by a resistant-to-change existing system (Iranmanesh & Onur, 2021).

The experiment's concept and techniques were based on the work of Althaus (1996) and Leh (2001) on the appropriateness of utilizing distance education. Althaus (1996) explored the depth of the text-based conversation, concerns of participation, and user reviews of the experiment to see if it could be applied in the classroom (Althaus, 2009). Despite the fact that Leh (2001) explored a distinct learning environment and discussed social features in text-based emails in distance learning for a small sample group of students, her work was beneficial in the means of selecting variables and parts of the experimental methods (Leh, 2001).

Other scientists focused on the impact of Avatars in virtual worlds on distance education and communication. For instance; Talamo and Ligorio (2000) reported an experiment utilizing a comparable virtual environment called "Active Worlds," with the objective of establishing a community of learners and practice (Talamo & Ligorio, 2000). They used and created a method for evaluating chat transcripts and synthesizing data from surveys. There, Brown and Bell (2004) investigated a virtual environment used in a social activity. This study was influenced by the approach, used to document online behavior, which is referred to as "virtual ethnography," which makes heavy application of textual connecting materials such as chat transcripts, as well as the observer's experience and interpretation (Brown & Bell, 2004). In this regard, Kemp and Livingstone (2006) investigated the advantages of combining a digital design studio with traditional learning methods and presented useful principles for experimental design in the virtual world (Abdellatif & Calderon, 2007; Kemp & Livingstone, 2006).

Studio education, which was essential to architectural education in the United States for most of the 20th century, is a provocative and fruitful paradigm for engineering and design-focused education. The architecture studio, a 19th-century American version of the atelier-based instruction at the Ecole des Beaux-Arts in Paris (Drexler & Chafee, 1977), provides a teaching model from a design field in which the functional and structural, social and technical, must be effectively mixed (Kuhn, 2001).

This initial wave of practice-driven teaching approaches has ushered in a new era in architectural education. The intellectual and cultural frameworks for architecture must be redefined in light of this situation, as must the theoretical foundations for architectural and design education. This generation of design pioneers faces a new challenge in developing a theory of architectural education and design pedagogy that recognizes the scope and qualities of professional, theoretical, and technological changes that digitally mediated architecture is beginning to assert in order to accommodate the scale of change in professional practice as well as the new demands for requisite knowledge and skills. First and foremost, it is essential to re-evaluate the theoretical underpinnings, pertinent information, and design processes in light of developing digital technologies in the context of such a significant cultural transformation (Oxman, 2008).

In this sense, it is critical that the virtual class students participate in the lectures and discussions. To do this, involvement must be self-directed, goal-oriented, task-oriented and it should take place between the instructor and the student or in groups of students. Furthermore, effective learning should be student-centered, include two-way discussion, continuous evaluation and feedback, self-reflection, and interaction engagement, and this can be accomplished through a variety of teaching methods such as pair discussion, group discussion and presentation, and sharing conference notes between everyone in the conference room (Khogali, 2020).

Schon's theories on reflective learning have been crucial in the development of architectural pedagogy (Schön Donald, 2014). The worldwide pandemic of 2020 provides an opportunity to reflect the rising phenomena of virtual design studios (VDS). It increases self-reliance and a research-oriented design approach possibility, which can help the improvement of the multidisciplinary character of architectural teaching (Wojtowicz, 1995; Webster, 2007). VDS allows for reflection-in-action and learning-by-doing since it emphasizes a student-centered process (Iranmanesh & Onur, 2021; Akoury, 2020).

In other words, hypotheses on the classification of paper-based design thinking as a basis of design education have gained widespread acceptance. Early in the 1980s, Schon and his associates (Schön & Wiggins, 1992) started to add additional layers to cognitive research by concentrating on the designer as opposed to, for example, domain knowledge (Oxman & Oxman, 1994) and the investigation of design thinking. These pieces started to evoke cognitive traits that may depict the complexity of "what goes on in the designer's mind" (Lawson, 1997). These studies also highlight traditional paper-based drawings as a medium for the conceptual and exploratory phases. These methods emphasize the designer's interaction with the issue representation and offer design as a process of receipt (perception), reaction (transformation), and reflection. They are frequently referred to as "reflection in action" (interpretation). These theories have up till now been seen as having an impact on design research (Cross, 2001).

For the past two decades, this design paradigm, which is heavily based on visual thinking, has had a significant impact on design research and instruction. The unexpected 'backtalk' that occurs throughout the design process frequently influences a designer's decisions (Kvan, 2001). In this respect, Schon's fundamental classification of visual reasoning in design as a 'conversation with the materials of the issue' and the process of 'backtalk' from visual pictures has been persistently connected with paper-based media (Schön Donald, 2014).

Three levels of communication were used in an experiment by Gabriel and Maher (1999), and the outcomes were compared. Their experiment's major focus was on how textual and graphical communication mediums affected the way, students and instructors in architecture school exchanged design ideas (Oxman, 2008). The link between digital design and digital design model as a form of architectural knowledge has started to emerge as a useful source of inspiration for design and design education, in addition to the use of digital media as a tool. Based on the cognitive effect of digital technology, theorists have attempted to develop paradigmatic architectural methods (Lynn, 1999; Iranmanesh, & Onur, 2022).

As a result of the development of a new body of knowledge beyond the level of expertise of the digital designer, architecture as a design discipline has grown rich in theories and concepts, shifting methods, and a distinctive body of conceptual material (Oxman, 2006; Aranda & Lasch, 2006). Oxman and Rosenberg (2007) noted the cultural process of the emergence, migration, and crystallization of new conceptual structures over the last decade under the influence of digital design, demonstrating how concepts with digital design as their theoretical source are beginning to occupy a central role in current architectural language and discourse (Oxman & Rosenberg, 2007). Another important criterion of online education in architecture is the explanation of this conceptual substance of digital design. Certain of these ideas are diametrically opposed to formalist approaches to syntactical and formal knowledge.

Here, the initial assumption is that we are in fact dealing with new territory in design thinking and that a reason for digital design didactics is required. This paper does not claim that VDS is the new method answer to architectural pedagogy; rather, it suggests that its use be reconsidered since it certainly has a lot to offer. The prospect of investigating the role of digital media in the relationship between design models, concepts, knowledge, digital processes, and techniques in digital design is presented.

3. Methodology and Discussion

This research proposes an experimental framework for evaluating the feasibility of an online education system for design-based and visual distance communication. It includes the participants, the protocol for

conducting the experiment, and the data collection methods. The findings of the data analysis are then reported, followed by a discussion of the criticism's primary aspects. In this regard, it was held at Final International University in Northern Cyprus at the end of the spring semester of 2019-20. The architecture program is divided into eight semesters, with eight design studios and various theoretical and practical courses. The spring semester of 2019-20 started like any other semester, with courses starting in February 2020. The majority of students at the Faculty of Architecture where international students from various nations.

On the 10th of March, all outside activities, including educational activities, were banned as concerns of the pandemic spreading across the country. Different studios applied diverse mediums such as Facebook groups, WhatsApp groups, YouTube videos, and Skype in the early days of this transition. The central university's remote learning platform, resumed lessons in virtual space via LMS (the university learning model system) and Google Meet by the next week. In this regard, the essential premise here is that we are in fact dealing with new types of terrain in design thinking and that a reason for digital design didactics is required. It is discussed here how to investigate the function of digital media in connection to how knowledge, concepts, design models, digital processes, and techniques are interconnected in digital design. The study was developed to evaluate how students from various levels utilize the LMS environment as a computer-mediated tool for learning and connecting with their teachers in a virtual critique in order to explore the probable potential of adopting LMS in online classes in architectural education.

This research is a quantitative study based on a survey sent to the Department of Architecture students and tutors. The survey is designed to record their responses about the efficacy of teaching and learning in virtual classrooms. After they finished their final exams and juries, an anonymous survey was distributed to 30 instructors and 85 students separately. On July 15th, 2020, a survey with 80 multiple-choice and open-ended questions was released. The survey took around 20 minutes to complete, and it consisted of a five-section (category) questionnaire with a total of 80 questions. Section I (6 questions) deals with demographic information and individual circumstances while confined (age, gender, school level, school curriculum and teaching subject). 43 items were used in Section II (23 questions requiring whether numerical answers or multiple choice and 20 open questions or requests for explanatory comments). This section concentrates on how respondents perceived the learning ecosystem's response to the pandemic and the operational circumstances during what we refer to as the "steady state" of lockdown measures, or around two months after the lockdown of schools has been started. In other words, this section focuses mostly on students' and teachers' responses to theoretical courses and design studios. Section III focuses on the technological issues that students face throughout the virtual session by posing 5 multiple-choice questions. Section IV asked five multiple-choice questions and five open-ended questions about the individual's confinement situation, health issues, current and/or previous psychological/psychiatric treatment, current use of psychoactive medications, the perceived impact of confinement on social relationships, and personal, self-reported concern about the crisis' effects on one's own, one's families, and one's friends' health. Section V contains 31 items in total. (There are 17 open-ended questions or requests for explanations, along with 14 questions that have multiple-choice answers). This section looks into any shifts in instructors' attitudes about technology and online learning, as well as their future expectations.

Eventually, according to the mentioned criteria, the authors have tried to summarize and present the results of the interviews in few tables and charts to make them more understandable. In this case, the main target of this paper can be considered to present the experimental framework designed to test the adaptability of online education in the department of architecture from both instructors' and students' points of view. This aim will be achieved by separately addressing the need for integration of different levels of students with online education by investigating various forms of pedagogical agenda for adapting different types of courses, which may lead to formulating a theoretical framework and didactic principles for modification of architectural online education.

The results of students' filled questionnaires have been presented by separating them according to the students' educational years. In this respect, the results show that senior students mainly prefer to have their education online. However, this willingness has been reduced by new students and the majority of them (around 70%) prefer to have face-to-face classes. This is mainly because of the fact that students become more familiar with the atmosphere of the department, their instructor's expectations and also different presentation techniques and software, which help them to present their projects better in digital format (Table 1).

Table 1.

Design studio and Online Education (2020-2021)

Level of Students	Number of responses (85 students)	Face to face	Online
1st year	20	70%	30%
2nd year	23	65%	35%
3rd year	21	35%	65%
4th year	21	25%	75%

The next table shows the instructors' viewpoints on the effectiveness of the online education system in the Faculty of Architecture. Instructors are also agreeing with the students that a face-to-face system is essential for fresh students. They believe that sophomore and junior students, who have more experience in the department can handle online education easier. However, although senior students consider the most experienced ones in the department, still instructors are not sure whether online education can be evaluated as a satisfying method for students of this level. This is because of the complicated level of the graduation project and the last small nonverbal communications, unanticipated backtalk, and critiques, which can only be applicable in the studio (table 2).

Table 2.

Design studio and Online Education (2020-2021)

Level of Students	Number of responses (30 instructors)	Face to Face	Online
1st year	30	90%	10%
2nd year	30	70%	30%
3rd year	30	45%	55%
4th year	30	50%	50%

Eventually, in order to have a better comparison between the data collected from both instructors and students' group, all the results are presented in a chart (fig. 1). As it was discussed both groups agreed that at the beginning of architectural education, face to face method of education is more effective. However, this method can be replaced or even better replaced by online education gradually in the next years. Therefore, according to the participants' viewpoint; hybrid types of studios can be considered the best option in the new circumstances.
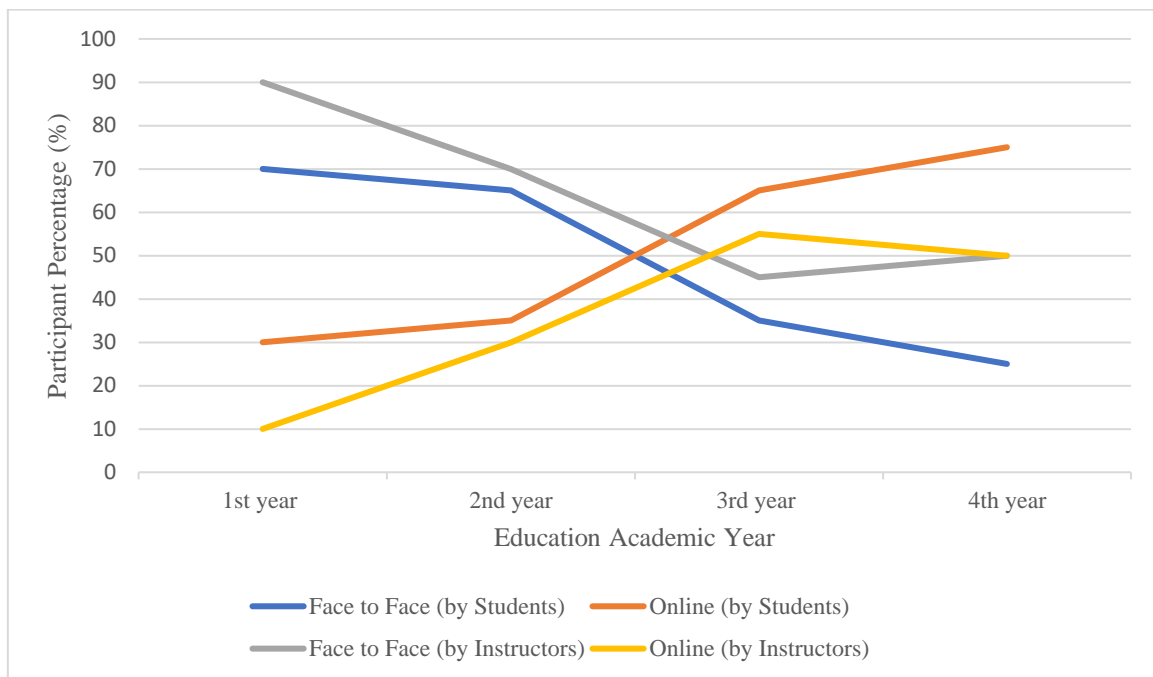
Fig. 1. The survey result from students and instructors during the pandemic

4. Conclusion and Suggestions

The development of architectural pedagogy has been heavily influenced by Schon's theories on reflective learning (Schön Donald, 2014). The global pandemic of 2020 offered an opportunity to re-evaluate the new phenomena of virtual study. As this example demonstrates, the virtual study offers a chance to promote independence and a research-oriented design approach, which can improve the multidisciplinary nature of architecture pedagogy. This research shows that fourth-year students can benefit from using virtual study. The third and fourth-year students were proficient in digital communication techniques and had acquired the knowledge and abilities needed to be more independent. In this situation, the virtual study might have been a more effective educational tool for fourth-year students, fostering their independence. The first-year students, on the other hand, required more intensive one-on-one and practical tutorials designed to improve their abilities in abstraction, conceptions, and critical spatial thinking.

Despite the fact that the first-year students have also demonstrated growth in their AutoCAD program and digital communication abilities, they may have found the virtual study to be more challenging and less successful due to their lack of spatial experience. According to the study's findings, virtual study aids in the development of independent research and learning new abilities. The findings of this study demonstrate that students strongly prefer hybrid studios over physical or virtual studios because they are more relevant to today's reality, where the digital realm is intertwined with all facets of daily life. Finally, this research as result finds some advantages and disadvantages as follows:

- Advantage:
- Digital presentation
- Distance education for international students
- Good presentation techniques in 2D and 3D
- Homesick
- Communication improvement in the 4th and 3rd years of study

- Less stress 4th, 3rdand 2nd years of study

- More sustainable

- Saving time for the 4th years students

- Using less materials

- Economic

- Disadvantage:

- Different time zoning from a different region

- Lack of consideration

- Conceptual approach (weak)

- Lack of commination in 1st and 2nd years

- More stress for 1st year of study

- Teacher challenging.

References

Abdellatif, R., & Calderon, C. (2007). SECONDLIFE: A Computer-Mediated Tool for Distance-Learning in Architecture Education?. *3rd Int'l ASCAAD Conference on Em'body'ing Virtual Architecture* (pp. 17-34). Alexandria: ASCAAD-07.

Akoury, C. "(2020). Apprehending the creative process through drawing in the foundation design studio. *International Journal of Art & Design Education, 1*, 113–25.

Althaus, S.L. (2009). Computer-Mediated Communication in the University Classroom: An Experiment with On-line Discussions. *Communication Education, 46*(3), 158-174. https://doi.org/ 10.1080/03634529709379088

Aranda, B., & Lasch, C. (2006). *Tooling*. Princeton Architectural Press.

Bermudez, J., & Agutter, J. (2005). Data architecture studio: premises pedagogy and results. *Proceedings of the 9th Iberoamerica Congress of Digital Graphics*, (pp. 720-724). Lima: SIGRADI.

Brown, B., & Bell, M. (2004). CSCW at Play: 'There' as a Collaborative Virtual Environment. *Proceedings of CSCW'04.* (pp 350-359). Chicago: ACM2004.

Cross, N. (2001). Designerly Ways of Knowing: Design Discipline versus Design Science. *Design Issues*, *17*(3), 49–55. http://www.jstor.org/stable/1511801

Cuff, D. (2001). Digital pedagogy. *Architectural Record, 9*, 200-206.

Drexler, A., & Chafee, R. (1977). *The architecture of the Ecole des Beaux-Arts*. Secker & Warburg.

Dutton, T. A. (1987). Design and studio pedagogy. *Journal of Architectural Education, 1*, 19-25. https://doi.org/10.2307/1424904

Giovannella, C., Passarelli, M., & Persico, D. (2020). The Effects of the Covid-19 Pandemic on Italian Learning Ecosystems: the School Teachers' Perspective at the steady state. *Interaction Design and Architecture(s) Journal, 45*, 264-286. https://doi.org/10.1111/jade.12223

Iranmanesh, A., & Onur, Z. (2021). Mandatory Virtual Design Studio for All: Exploring the Transformations of Architectural Education amidst the Global Pandemic. *International Journal of Art and Design, 10*(3), 251-267. https://doi.org/10.1111/jade.12350

Iranmanesh, A., & Onur, Z. (2022). Generation gap, learning from the experience of compulsory remote architectural design studio. *Int J Educ Technol High Educ* 19(40). https://doi.org/10.1186/s41239-022-00345-7

Kalay, Y. E. (2004). *Architecture's new media: Principles, theories and methods of computer-aided design*. MIT Press.

Kalay, Y. E. (2004). Virtual Learning Environments. *ITcon, 9*, 195-207.

Kemp, J., & Livingstone, D. (2006). Putting a SecondLife "Metaverse" Skin on Learning Management Systems. *Proceedings of the Second Life Education Workshop at the SecondLife Community Convention.* (pp 13-18). SanFrancisco: The University of Paisley.

Khogali, H. A. (2020). The Effect of COVID-19 CORONA VIRUS on Sustainable Teaching and Learning in Architecture Engineering. *Modern Applied Science, 14*(8), 1-15. https://doi.org/10.5539/mas.v14n8p44

Kieran, S., & Timberlake, J. (2004). *Refabricating architecture: how manufacturing methodologies are poised to transform building construction.* McGraw-Hill.

Knight, T. (1999). Shape grammars in education and practices: history and prospects. *International Journal of Design Computing (IJDC), 2,* 1-7.

Knight, T., & Stiny, G. (2001). Classical and non-classical computation. *Architectural Research Quarterly Cambridge Journals, 5*, 355-372. https://doi.org/10.1017/S1359135502001410

Kolarevic, B. (2003). *Architecture in the digital age.* Spon Press.

Kolarevic, B., & Malkawi, A. M. (2005). *Performative architecture: beyond instrumentality.* Spon Press.

Kuhn, S. (1988). The Software Design Studio: an exploration. *IEEE Software,* 65-71. https://doi.org/10.1109/52.663788

Kuhn, S. (2001). Learning from the Architecture Studio: Implications for Project-Based Pedagogy. *International Journal of Engineering Education, 17*, 349-352.

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

Kvan, T., Mark, E., Oxman, R., & Martens, B. (2004). Ditching the dinosaur: redefining the role of digital media in education. *International Journal of Design Computing (IJDC), 1-7.*

Lawson, B. (1997). *How designers think: the design process demystifie.* Architectural Press.

Leh, A. S. (2001). Computer-Mediated Communication and Social Presence in a Distance Learning Environment. *International Journal of Educational Telecommunications, 7*(2), 109-128. https://www.learntechlib.org/primary/p/8470/

Lynn, G. (1999). *Animate form*. Princeton Architectural Press.

Manley, S., & Johnson, A. G. (2013). Towards Inclusion: Rethinking Architectural Education. *Construction Management and Economics, 31*(8), 914-927. https://doi.org/10.1080/01446193.2013.797093

Mark, E., Martens, B., & Oxman, R. (2003). Preliminary stages of CAAD education. *Automation and Construction, 6*, 661-670. https://doi.org/10.1016/S0926-5805(03)00045-1

Noddings, N. (2019). *Philosophy of education*. Routledge.

Oxman, R. (2006). Digital design thinking: 'Is the new design is the new pedagogy'. *Proceedings of the 11th International Conference on Computer Aided Design Research in Asia.* (pp 37-46) Kumamoto: CAADRIA.

Oxman, R. (2006). Theory and design in the first digital age. *Design Studies, 27*(3), 229-265. https://doi.org/10.1016/J.DESTUD.2005.11.002

Oxman, R. (2008). Digital architecture as a challenge for design pedagogy: theory, knowledge, models and medium. *Design Studies, 29*(2), 99-120. https://doi.org/10.1016/j.destud.2007.12.003

Oxman, R. (2008). Digital Architecture as a challenge for design pedagogy: Theory, knowledge, models and Medium. *Design Studies*, *29*(2), 99–120. https://doi.org/10.1016/j.destud.2007.12.003

Oxman, R., & Oxman, R. (1994). Computability of architectural knowledge. *The electronic design studio: architectural knowledge and media in the computer era*, 171-187.

Ozkar, M. (2007). Learning by doing in the age of design computing. *CAAD Futures, Proceedings of the 12th International Conference on Computer Aided Architectural Design Futures*, (pp. 99-112). Sydney: Springer.

Pektaş, Ş. T. (2015). The virtual design studio on the cloud: a blended and distributed approach for technology mediated design education. *Architectural Science Review, 58*(3), 255-65. https://doi.org/10.1080/00038628.2015.1034085

Rashid, H., & Couture, L. A. (2002). *Asymptote: flux.* Phaidon.

Reffat, R. (2007). Revitalizing architectural design studio teaching using ICT: reflections on practical implementations. *International Journal of Education and Development Using ICT, 3*(1), 39–53.

Rosa, J. (2003). *New generation architecture.* Rizzoli.

Russell, P. (2001). Creating place in the virtual design studio. *Computer Aided Architectural Design Futures 2001*, 231–242. https://doi.org/10.1007/978-94-010-0868-6_18

Sass, L., & Oxman, R. (2006). Design Studies. *A Special Issue on Digital Design, 27*(3), 325-355.

Schnabel, M. A., & Kvan, T. (2001). Implementing the first virtual environment design studio, in Architectural Education for the Asian Century. *Proceedings of the 1st ACAE Conference on Architectural Education* (pp. 157–66). Singapore: EAAE.

Schodek, D. (2000). *New technologies in architecture, digital design and manufacturing techniques.* Harvard University Press.

Schodek, D., Bechthold, M., Griggs, J. K., Kao, K., & Steinberg, M. (2005). *Digital design and manufacturing: CAD/CAM applications in architecture and design.* John Wiley & Sons.

Schön Donald A. (2014). *Educating the reflective practitioner: Toward a new design for teaching and learning in the professions*. Jossey-Bass.

Schön, D.A., & Wiggins, G.E. (1992). Kinds of seeing and their functions in designing. *Design Studies, 13*, 135-156. https://doi.org/10.1016/0142-694X(92)90268-F

Spuybroek, L. (2004). *NOX: machining architecture.* Thames and Hudson.

Strojan, T. Z., & Mullins, M. (2002). The identity of place in virtual design studios. *Journal of Architectural Education, 56*(1), 15-21. https://doi.org/10.1162/104648802321019137

Talamo , A., & Ligorio, M. B. (2000). Identity in the Cyberspace:The Social Construction of Identity Through On-Line Virtual Interactions. *1st Dialogical Self Conference.* (pp 1-17). Netherlands: Nijmegen.

UNESCO's education response to covid-19. UNESCO. (2022, June 20). Retrieved October 18, 2020, from https://en.unesco.org/covid19/educationresponse/support

Webster, H. (2007). The Analytics of Power. *Journal of Architectural Education, 60*(3), 21-27. https://doi.org/10.1111/j.1531-314X.2007.00092.x

Wojtowicz, J. (1995). *Virtual design studio*. Hong Kong University Press.

Zaero-Polo, A., & Moussavi, F. (2003). *Morphogenesis: FOA's ark.* Actar.

Zellner, P. (1999). *Hybrid space: new forms in digital architecture.* Thames and Hudson.