

# Architectural Engineering Students' Experiences in a Hybrid Design Studio\*

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In response to the COVID-19 global pandemic's effects on the educational landscape, information and communication technologies have been used to implement diverse curriculum contents and provide a transition of traditional learning activities into remote or hybrid learning. This paper describes how a digital learning framework was implemented to transform a classroom-based architectural design studio into a setup that complements face-to-face and online activities, allowing for optimal operation under restricted conditions. The learning experience in this hybrid design studio was investigated using qualitative content analysis, while data from pre- and post-course surveys, and data from the learning platform's analytics, provide insight into the participants' perceptions of the course. Findings show that students' assessments of hybrid learning are generally positive; however, further development of this pedagogy could provide even better responses to accessibility, acquisition, and operation challenges. The study offers a perspective on how to adapt learning in order to provide continuity of educational process beyond changing circumstances and could inform further reviewing and discussion on directions of long-term redefining of a studio design in post-pandemic times when teaching modes are likely to have a more significant online component.

**Keywords:** architectural education; design studio learning; hybrid learning, emergency learning; remote education; online education; learning design experience; COVID-19

## 1. Introduction

During the COVID-19 global pandemic, online learning [1], hybrid learning, and Virtual Design Studio (VDS) [2–6] become mandatory learning strategy [7]. Although diverse educational formats that integrate classroom-based activities with online network learning, including blended, hybrid, or mixed learning, are being used in architectural education [8–20], global pandemic imposed emergency application of these educational approaches.

Implementation of a hybrid approach combining conventional studio, VDS, and live projects demonstrated that creating a learning setup that takes advantage of different instruments of communication and interaction to solve a challenge not only engages students to work collaboratively but also motivates them to build confidence in their abilities [21]. Based on the social constructivist learning theories [22], hybrid educational model allows groups to generate knowledge and meaning through co-creation. In this setting, tutors and students collaborate and communicate in a combined way, which asserts the achievement of pedagogically aided results relevant to the students [23].

On the other hand, blended learning is a student-centered and competency-centered model. Blended pedagogy uses emerging technologies to supplement traditional learning methods and increase students'

performance, motivation, and reflection ability, while also facilitating greater flexibility [10, 24–28]. The implementation of blended studio design courses is supported by the learning management system (LMS), computer applications used for administration, documentation, and tracking, such as Moodle [29], Google+ [30], or MS Teams [31] and could be further improved with the use of e-portfolio strategy [32]. Also, the iLab demonstrates potentials of distant and blended learning to reconceptualize design studio to better adapt to the current professional situation through participatory learning that links specialists from different disciplines and companies from the architecture, engineering, and construction (AEC) industry, allowing students to adopt the role of entrepreneurs [33].

The evaluation of the effectiveness of online architectural design education during COVID-19 pandemics in achieving learning outcomes was the subject of various research [7, 34–36]. An exceptional situation like the COVID-19 pandemic has impacted the *loss of a stable state* [37] in education, calling for creating an adaptive system that provides continuity within teaching beyond the current circumstances. This crisis may be one of the most crucial subjects in pivoting to digital learning. However, lived space and study plans designed to occur while in a common physical place cannot be mirrored within virtual space, and the gap between the two requires more analysis [38]. Respectively, there is a need for reviewing and discussing challenges and opportunities that could be faced in a

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post-pandemic world and provide insight into how schools of architecture might respond.

The purpose of this paper is to discuss the experiences of learning in design studio supported by digital technologies during the global pandemic. Besides having responsibilities concerning building capacities of future professionals, planning and organization of the course during the pandemic implied the inclusion of diverse mandatory restrictions in the educational process to meet health safety. Previous challenged the structure of conventional design studio, creating opportunities to reconstruct its accessibility, acquisition, and operation. Moreover, this experience could be further exploited to adjust the implicit structure of the design studio curriculum to better adapt to the new circumstances, suit the new generation of students, and respond to the professional demands. Respectively, we have analyzed the experience of the architectural students who attended a hybrid studio design course in architectural engineering at master studies during the pandemic. To understand empirical issues and review the direction of studio learning development, two research questions emerged:

- What challenges do participants in the educational process face learning in a hybrid mode due to the constraints imposed by the global pandemic?
- How could experience from learning in the pandemic situation be used to reconstruct traditional design studio, improve its operation, and create a more sustainable learning environment?

This research was conducted using literature review on architectural design studio education during COVID-19 global pandemic. Furthermore, a case study method was used to describes educational experience from the University of Belgrade – Faculty of Architecture. Without the intention of generalizing, the case study aims to contribute to the topic by providing a comprehensive understanding of the focused phenomenon, as also suggested by [39–41]. Students' experiences on learning in hybrid design studio were evaluated by qualitative analysis. Finally, challenges of reworking studio design were discussed. Although the small sample and context-dependent nature of this research (see [42] on case studies) prevent generalization, it does contribute to the creation of new knowledge on hybrid studio design learning and can be used as an input for subsequent research on this subject.

## 2. Literature Review

The sudden transformation of the educational landscape and increased use of digital learning technol-

ogy to support online course delivery during the COVID-19 pandemic produced significant challenges and opportunities for the academic community as described in various studies [43–46]. These studies have advanced our understanding of the effects of emergency learning models, diverse forms of digitized learning, and post-pandemic higher education.

The impact of the COVID-19 pandemic on architectural education has received a considerable scholarly focus in the higher education literature to date. For example, the study by Metinal and Ayalp [47] systematizes literature on this subject using bibliometrics and content analysis and proposes a framework to reduce the impact of negative consequences. On the other hand, the research of Salama and Osborne Burton [48] develops an evolutionary account of how design education in architecture and urbanism has arrived at the pre-COVID-19 condition, analyses present challenges and inquiries into the extent of changes to address these challenges. In this respect, the chronological analysis carried out in this paper identifies traits of the legacy model that is inherited from historical schools demonstrating the influence of and resistance to this model (1960s); diverse alternatives, including ten ground-breaking alternative pedagogies (1970–1990s); alternative approaches including critical inquiry, the process-based and learning-by-making pedagogies (2000s); the social construction-based pedagogies (2010s); and *transitional emergency model* during COVID-19 pandemic outlining the scope of future opportunities for a responsive design pedagogy in architecture and urbanism for a post-pandemic world [48]. Also, a theoretical study by Megahed and Hassan [49] examines the interaction of technology-based models, presents a holistic blended learning strategy, and suggests a new theoretical and instructional model to design a balanced blended learning environment starting from the impact of the COVID-19 pandemic on architectural education.

Conversely, numerous case studies describe learning experiences in architectural design studios during COVID-19. For example, Bakir and Asaadani [50] in their study identified three factors that appear to have affected architectural engineering students' learning experiences during the spring semester of 2019/20: students' reliance on educational technologies, the stage of architectural educational students was enrolled in when they went into lockdown, and quality and timing of feedback received. Moreover, the study [50] found that challenges encountered during the shift to a digital environment encouraged students to take responsibility for their knowledge construction. The study by Hassanpour [51] presents the experience of

organizing online design studios for freshman architectural students during the COVID-19 pandemic. Based on the indicators of design learning (including reflective dialogue, retention, transfer of learned information to decisions, processing feedback as an investment in future performance, and self-regulation), the study [51] finds that first-year students exhibited strong presence and interaction during the online studio. In addition, students' individuality influenced the teaching environment regarding content and process.

On the other hand, the study by Iranmanesh & Onur [7] acknowledges improvement in students' ability to conduct independent research and learn new CAD software and finds VDS much more applicable for third- and fourth-year students. Also, the study [7] shows a significant decline in background informal peer learning among students. Finally, the study by Ceylan et al. [35] examines the learning experience of 1st, 2nd, 3rd, and 4th-grade students during COVID-19 – spring semester 2019/20, and indicates benefits from using digital tools, and finds that students can work efficiently even if the distance education process.

A study [52] assesses the potential and limits of an online learning environment for studio education by focusing on the case of the 2019/20 spring semester studio and reviewing the usual course until the COVID-19 outbreak as well as the effects of the unexpected switch to the emergency distance teaching. The paper highlights the creative advantages and material shortcomings of the course's adaptation into the online studio format. Another study by Ozorhon and Lekesiz [53] on a remote architectural design studio during the fall semester of 2020/21 observes that the studio's components, such as interaction, collectivism, multilayeredness, dynamism, making criticism, and juries, can survive in distance education. Although verbal communication difficulties were experienced in the remote studio, visibility/screen sharing supported the communication throughout the process. However, the content, methods, and tools for remote architectural design studio education should be developed with a different and new approach than face-to-face education.

A study by Alnusairat et al. [54] examines the attitudes of undergraduate students towards the use of online design studios during the COVID-19 lockdown and discusses how their use could enhance the learning process. This study's findings highlight that many participants felt uncertain about aspects of their online learning experience and wanted more guidance and support. Reasons for this disengagement include technical factors, such as poor network quality and lack of familiarity with new applications. Also, students' and tutors'

situations when working and studying from home are relevant due to the tutors' lack of expertise in online teaching and the limitations of peer interactions. Qualitative, quantitative, and comparative analysis of architectural design communication (ADC) by Kavakoglu et al. [55] examine the changing and transforming contents of architectural education, the thinking, representation, and production mediums using five components of ADC (effective language use, effective use of handcrafts, effective technical drawing knowledge, effective architectural software, and outputs).

A study by Asadpour [56] describes the educational experience from the spring semester of 2019/20 and methods of managing an affordable education agenda to design online courses. The article [56] proposes a model in which tutors act as consultants and facilitators, whereas students act as self-directed learners. In addition, the e-studio is considered an activity-oriented space to provide an opportunity for interaction, connection, and creativity. On the other hand, the study by Al Manni et al. [57] explores the VDS as a transformative model for the disaster and resilience context, including the factors that affect students' perceptions and experiences of this quality adaption. The study finds that a model of a hyper-flexible design studio in which students can have direct contact with their instructors when needed – in addition to online activities, reviews, and written feedback – is highly recommended for the beginner years. This model could enrich students' learning and understanding of design fundamentals and ensure that technology solutions deliver significant and sustainable benefits.

Results from previous case studies provide perspectives on how students dealt with this critical transformation in architectural education at a unique moment in history. Moreover, results of many of these studies can be used as recommendation on how to optimally implement a transition from a physical design studio (PDS) environment to teaching a digital remote or blended design studio post-COVID-19.

Other relevant papers include study by Komarzynska-Swiesciak et al. [58] which extensively analyzes tools applied for diverse activities in VDS including virtual meetings (e.g., MS Teams, Zoom), virtual site visits (e.g., Google Earth, Google Maps, Copernicus, virtual 3D city model, GIS Databases, Thinglink, Facebook, Instagram), collaborative design (e.g., Miro, digital sketches) collaborative 3D digital models (e.g., Sketchup, Rhino, Archicad, Autocad, Autodesk 3ds Max, Rhino 3D, Revit Architecture, Grasshopper), design presentation (Miro Smartboard, BIM Cloud, Autodesk Share, slideshow), and digital student portfolio (Moodle).

Marshalse and Sclater [59] analyzed preferred online tools and platforms used to support distance studio education during COVID-19. Their case study identified that most students inclined to the teaching platforms they used prior to pandemics. Social media, video-calling, and video-histing were already in use to support main teaching platforms. On the other hand, teaching staff highlighted using more than one platform to engage students in a course yet advised keeping the range of platforms and tools simple.

Also, Ozorhon and Lekesiz [53] discussed enrichment of architectural design studio setup with online environment-specific tools, including components that centralize participatory production (collaborative learning approach) and enable interaction such as workshops and seminars. Finally, the critical study by Yorgancioglu, [60] revealed that the current situation, on the one hand, opened the ways for us to test “new” tools, methods, and experiences of teaching and learning, and on the other hand allowed us to better understand the potentials and well-functioning aspects of the “existing” pedagogical models. Transition of Physical Design Studio (PDS) to emergency Virtual Design Studio (VDS) asks further studies. Rather than reducing the discussions on remote teaching and learning to a “technology-driven” paradigm change in design education, future research should focus on the effects of changing pedagogical tools and practices on the manifold dimensions of “human learning”, which in turn will have implications for the epistemology of design pedagogy [60].

Literature study on learning during COVID-19 shows that most papers discuss online learning models, while hybrid and mix-model learning models received far less scholarly attention. More scholarly attention should be devoted to the impact of the technology-enabled education on students’ perceptions and learning experiences. Respectively, student’s perspectives can improve comprehension of online studios to evaluate their qualities and efficiency [54]. In line with previous research from Pektas [22], the study [60] showed that most students articulated a preference for blended design studios, which offer a balanced format of both virtual and physical educational elements.

Further studies are needed to address the implementation of more immersive social experiences in VDS [7]. Also, Komarzynska-Swiesciak et al. [58] in their study recommend educators who aim to organize VDSs to carefully think about, and search for, the tools and strategies they will implement. Preferably – teachers can organize this search together with their students, for example by asking them to participate in a trial run of the selected tools [58]. Special attention should be given to freshmen

students (first year-students) of architecture who commonly need to adapt to the new model of learning-by-doing in design studio [57]. Comparative evaluations of architectural education during and after pandemic are also needed, for example [35] suggest that their study could be used also for that.

Considering all previous could contribute to preparing better hybrid learning strategies and propose a new vision to post-COVID-19 architectural education. Additionally, these hybrid learning strategies could present an alternative to continue teaching and learning in any other emergency in education.

### 3. Case Study

#### 3.1 Process

Based on the development of the pandemic in Serbia, University of Belgrade proposed a plane of hybrid teaching for the academic year 2020/2021. Following pandemic measures, the Faculty of Architecture elaborated a plan for studio-based courses, the core pedagogy in this institution. The plan included dominantly remote teaching with specified classes to be organized at the faculty, interim online submissions, and the final exam at the faculty. Previously asked for adjusting curriculums to the new circumstances.

This paper describes the new layout proposed for the course Studio Design Project – Spatial Structures, taught annually at the first year of the Master studies of Architecture – Module Architectural Engineering (MASA-AE). The course is designed for up to 16 students, and it has 15 credits of the European Credit Transfer and Accumulation System (ECTS). It aims to introduce students to the challenges of designing spatial structures in architecture through project-driven research. The learning outcomes are harmonized with the Prescriptions of qualification: ARB Criteria at Part 2 [61]. This course relies on the contextualized learning and work on a specific project task for students to refine individual design processes, but it also includes lectures, skill-ups, and workshops to provide the theoretical and methodological knowledge and skills required to develop projects.

The research involved three phases:

- *Preparation*: Learning experience design (LXD) which included the preliminary research on learning approach and methodologies, preparing project task, timeline and assignments, and implementation strategy, preparing class material, literature and learning resources, preparing guest critics and experts, elaborating of the syllabus.

- *Implementation*: realizing design research through the assignment-based process, week on-line or in-class meetings, internal and external reviews, and discussions.
- *Evaluation*: preparing and conducting surveys, data analysis, presenting and discussing findings.

### 3.1.1 Learning Experience Design

The learning experience design (LXD) approach, which combines several design disciplines (including interaction design, user experience design, experience design, graphic design, and game design) with the field of learning, was applied for the course preparation. LXD is the process of creating learning experiences that enable the learner to achieve the desired learning outcomes in a human-centered and goal-oriented way [62]. Like other creative approaches, the LXD process typically includes research, experimentation, ideation, conceptualization, prototyping, iteration, and testing, which are conducted in a non-linear way to create a design that will serve a learning purpose. LXD focuses on the learner and the process that the learner goes through and is partly based on experiential learning [63–65].

To facilitate learners to achieve desired learning outcomes, we made the learning experience human-centered and goal-oriented. The choice of form, medium, and technology for a learning experience primarily based on the learner's goals was an essential feature of course preparation because selecting an appropriate form for a learning experience is a crucial element of creating a successful one. Respectively, we de-fined activities that enable the learner to reach specific goals with the learning experience canvas. Our goal was to create learning experiences that engage with learners on a personal, cognitive, and emotional level by focusing on the human perspective in learning. To specify how products or services utilized throughout a learning experience can serve the needs and desires of the learner, we employed a goal-oriented design methodology. These needs and desires are mostly, but not entirely, about achieving the desired learning outcomes.

To answer the question of How to effectively teach the architectural design studio in the restricted situation of a global pandemic? First, we needed to research learners by getting in touch with them through conversation and using a survey of the previous generation. The results of this process were an empathy map for a learner. Second, we also had to research learning outcomes. After we studied what learners gain from this experience, we fought out the different learning objectives. In the next step, we proposed and developed a concept. Finally, we put learning

experience design into practice during the fall semester of 2020/2021. Having both theoretical and practical understanding of learning aided us in creating goal-oriented learning experiences that are applicable in real-life situations. Also, the opportunity to test learning design is valuable for understanding what works and what does not work in a specific setting.

The specifics of working on the studio during the fall semester of the academic year 2020/2021, focused by this study, were:

- Mixed-mode teaching that blends classroom-based and online activities, and
- Collaboration with experts from different fields (academy and AEC industry).

The course was designed as a collaborative learning environment where students developed competencies through an (inter)active process that included analysis, explorations, synthesis, refinement and testing of concepts and design proposals, presentations, discussions, and review of the results with tutors, guests, and peers, intermediate reflections, presentations and evaluations of the diverse stages and final design. The assignment-based process, which was at the core of the curriculum and ensured that the course objectives were met, had a variety of implementation modes (Fig. 1).

The implementation of mixed-mode studio design was supported by the MS Teams platform. This digital learning hub comprises diverse applications (including Class Notebook, Forms, Wiki, Conceptboard, Freehand by InVision) that support different educational activities:

- *Communication* between participants using diverse conversation options including Posts, Meet Now, Video and Audio Calls, individual or group Chat, Assignments options;
- *Collaboration and sharing* of materials and resources using options including Posts, Files, Assignments, as well as Collaboration Space, Content Library and Student's Notebook options in Class Notebook application; and
- *Repository* of contents and artifacts produced in individual, or group activities was done using Collaboration Space and Student's Notebook options in the Class Notebook, while large files were uploaded using the Files option.

The Meet Now option for video meetings facilitated live lectures, instructions, presentations, discussions, and consultations. We shared screens and used a virtual whiteboard for writing and sketching and a Wiki application for meeting notes. Online interactivity was also achieved through posts, text messaging, written feedbacks, and content sharing. Different channels were used to separate commu-

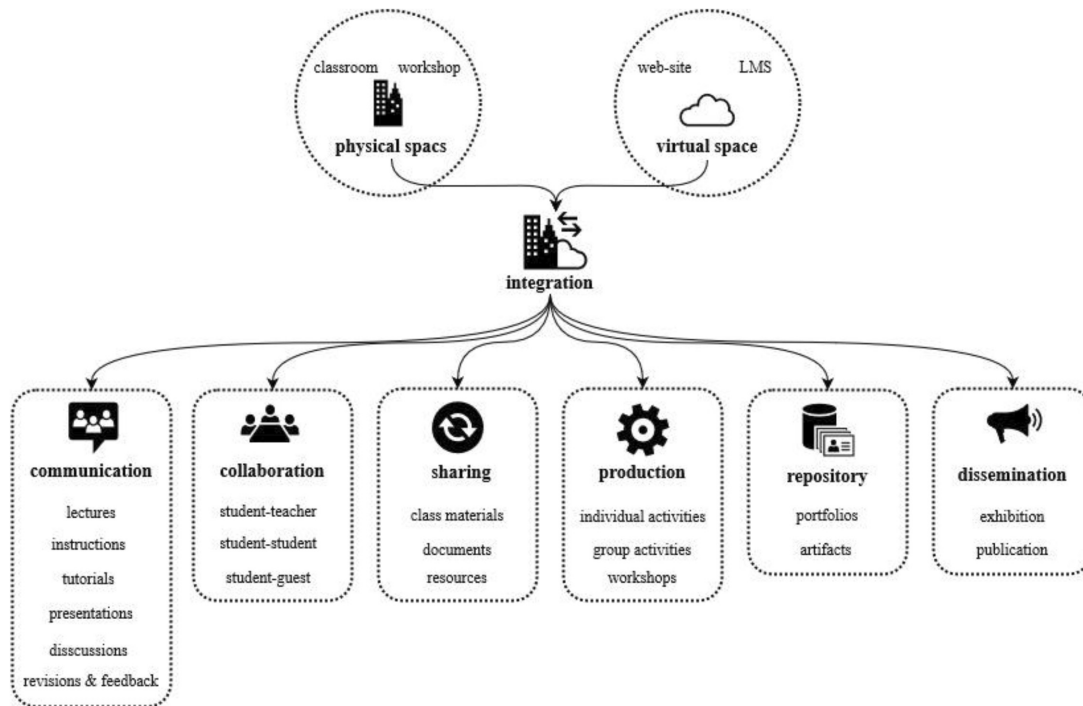


Fig. 1. Diagram of the hybrid studio design framework.

nication (e.g., on diverse topics or between groups). The learning resources were distributed through the Class Material Files folder and the Class Notebook's section Content Library. Content, uploaded during the semester, included online reader, links to the literature and referent projects, video tutorials, computational algorithms/codes, and links to other online documents. The Assignment option was used to specify class tasks, feedbacks and grading of interim submissions and the exam. Student documented their work through an e-portfolio created in Student's Notebook, which contained separate pages that follow class assignments. The group work results were presented in Class Notebook's section Collaboration space, which enables the organization of the material into units accessible as a shared resource. Digital material included text, comments, diagrams, sketches, technical drawings, renders, photographs, videos, and other contents.

The project spanned thirteen weeks but increased by the holidays and exam break to 16 weeks (see Appendix A). The applied assignment-based process enabled students to gain a holistic view of the project's scope and some experience as professionals. The work was divided into five stages: analysis, concept generation, architectural design development, structural design development, presentation, and postproduction. Each stage included specific class-assignments, with precise instructions, specifications of outcomes, a form of presentation, and a deadline. The mediums for the implementa-

tion of assignments were selected to maximize the efficiency.

The class meetings, both in-class and online, took place twice per week for five hours. Due to epidemiological restrictions, only the 1st, 7th, 15th, and 19th classes were held in physical space, while other classes were virtual. In-class activities were used for a site visit, workshops, and presentations of the design to a guest expert. Online activities included lectures, skill-ups (live tutorials on computer programs), group discussions, and individual presentations. At online interim submissions, students presented their work and got feedback from guest critiques. The online meetings facilitated the participation of guest experts from different countries, which would be much more challenging to arrange in a standard face-to-face learning. The final exam included both submission of digital material and printed material and mockups.

### 3.1.2 Qualitative Analysis Design

The assessment of the implementation of mixed-mode studio design was done through a qualitative approach focused on data interpretation [56], using numerical and non-numerical data [66] obtained from MS Teams analytics and surveys. While MS Teams analytics was applied throughout the course to monitor participant's engagement, surveys provided more vivid explanations on participants' experiences [67]. Students filled in two surveys, one at the beginning of the semester and the other at the end, using MS Forms. In the survey at the

beginning of the semester, students were asked to write, using their own words, about expectations from the course. The survey at the end of the semester contained statements which students graded using a five scale Likert (1-lowest rate to 5-highest rate) and questions with free text entry fields. Also, at the end of the course, students were asked to summarize whether the course met their expectations.

During the 16 weeks of the studio's duration, MS Teams Analytics recorded active members' engagement. A team included 23 members—14 students, a tutor, 3 graduate teaching assistants, and 5 guest experts and critics. Participation in the survey for the students was voluntary. Out of the cohort group of 14 students who attained the course during the fall semester of the academic year 2020/2021, 12 (86%) students participated in the survey. All students had previous experience learning in the classroom-based design studio, and due to the lockdown, they all spent part of the spring semester (9 of 13 weeks) of the academic year 2019/2020 learning remotely. All students were adequately informed about the purpose of the study and granted anonymity. Quantitative research is driven by information power [68], and smaller sample size could be adequate under certain conditions [69, 70].

The students' answers were analyzed via qualitative content analysis using the MaxQDA Analytics Pro (release 20.3.0, VERBI GmbH). Following the guidelines for qualitative inductive content analysis [71, 72], open coding of all questionnaires was conducted to search for recurring themes. These themes in the form of syntax were identified as codes, representing the most elemental unit of meaning. In the final step, themes were grouped into relevant categories.

The credibility and trustworthiness of the study were enhanced by triangulation [73]. In findings, the participants' responses were presented using the identified codes and categories, descriptive narratives based on the participants' responses [74], and examples from descriptive data [75] with ample quotes to preserve the data nuances that participants expressed.

### 3.2 Findings

#### 3.2.1 Learning Platform Analytics

MS Teams Analytics had shown that online participation and students' engagement was generally always high during the course, with the activity increasing around interim submissions and final exam when much material was uploaded. Although most students maintained a consistent online presence during the entire semester by continuously uploading content, some were less involved and

instead displayed their material around interim submission dates. Out of 12 students who took the survey at the end of the semester, 5 (42%) of them stated that they needed 25 and more hours per week on average for activities in this course, 4 (33%) students stated that they need up to 20 hours, while 3 (25%) students up to 10 hours.

At the end of the course, the MS Teams analytics summary indicated that SharePoint content reached 10.56 GB, of which more than 9 GB were original material produced by students. This material was organized in accordance with the assignment instructions, within students e-portfolio in the Class Notebook. Students' content varies in number and form as they adopted different approaches to research and design and different engagement and transmission rates.

#### 3.2.2 Survey Results

The survey enabled insight on how the curriculum implemented in a real educational situation met its initial tasks and contributed to the satisfaction of students' needs, productivity, acquisition of competencies, or use of resources. The survey form included a question related to evaluating the diverse aspects of the studio, including assignment-based work process, application of online learning platform, participation, and interaction. Part of the questionnaire was related to evaluating the engagement and interaction between diverse participants in the educational process (students, tutors, teaching assistants, guest experts, and critics). Moreover, students were asked to evaluate the contribution of the educational process to the learning outcomes and realization of the design project task, their productiveness, motivation, but also to indicate limitations and drawbacks. Also, students were asked to assess the contribution of the learning approach to the knowledge construction, acquisition, and improvement of skills focusing their perception on how valuable and applicable these experiences are for the future studies or work. The average rates of the various aspects of the mixed-mode design studio learning approach are summarized in Appendix B.

The questions with the free text answers enabled students to explain their assessment and describe their view on mixed-mode studio design educational methodology. In these answers, students expressed their perception of the positive and negative side of the learning process, indicated the most and least preferable part of the course, and troubleshoots they experienced. Additionally, they could make suggestions on how to improve the course and the overall learning experience. Students were also encouraged to compare learning in the mixed mode with traditional design studio.

**Table 1.** Students' comments on the work process in the hybrid studio design

Advantages		Disadvantages	
Time savings	82%	Insufficient face-to-face interaction between participants due to small number of in-class activities	91%
The more efficient way of presentation, discussion, and tracking work progress	73%	Insufficient time to complete class assignments	45%
Dedication, engagement, availability, and professional approach of tutors	55%	Insufficient time for mock-up construction and in-class workshops and skill-ups	36%
Organization of the course, the work plan, and continuity in work due to the class assignments	45%	Technical problems with the internet connection, network overload, uploading large files	36%
Saving financial expenses	36%	Lack of adequate working space for undisturbed on-line classes attendance	18%
Participation of guest experts	27%	Loss of concentration and its inconsistency during on-line classes due to not getting used to such work and the class duration	9%
Useful information, comments, and feedbacks during work process	18%	It took more time to create the feeling of a team	9%
Acquisition and development of skills	18%	Tedious work on artifacts improvement	9%
Engaging design task	18%	Tedious work on archiving design process activities	9%
Satisfaction with work results	18%		
Group interaction	18%		
Realization of the course while providing health safety by remote working	18%		

**Table 2.** Students' comments on their expectations from the course

Expectations from the course	Fulfillment of the expectations from the course
<b>C1: Acquisition of new knowledge and skills</b>	
IQ1: <i>I want to complement my previous knowledge on design and particularly on structural systems. I expect to learn about the new design and construction approaches and to gain skills and experience that will enable me to develop diverse aspects of architecture through the design process, that will lead to the formation of a building that functions as integrity meeting the conditions of sustainability (environmental, economic, and social).</i>	IQ2: <i>I must admit that some expectations were exceeded from the initial ones, which is a special compliment for the entire organization, while on the other hand, I am sorry that we could not devote more time to computational analysis due to time constraints. At the same time, it is important to consider that we can always return and supplement that knowledge in the future if the need arises, and I am personally sure that it will. Therefore, I consider the ideas of archiving all the resources that were available to us an excellent and useful proposal.</i>
<b>C2: Productivity and accessibility</b>	
IQ3: <i>I expected that in the planned and given timeframe, all thematic sub-units of the design process (concept research, architectural and structural design development) will be realized, which is one of the main reasons why I chose this module (equally dealing with all aspects of architecture). In addition to the practical part of the course, it would be interesting to go through diverse topics from a theoretical perspective, directly and indirectly, related to the individual projects. I have expectations concerning the availability of literature and recommendations of documentaries/scientific articles/links during the work this semester, I find such an approach very inspiring and useful for my workflow, with a more comfortable mastery of specific topics. I also expect communicativeness and an equal amount of time for commenting on the work/design for each college in the group.</i>	IQ4: <i>As I stated at the beginning of the course the realistic expectations. I can confirm that they were largely fulfilled. I went through the complete process and all stages of design mostly as I expected. Although sometimes it was hard to complete all assignments, I am very satisfied with the plan implementation and results of the collective and my individual work during the course. Literature was widely available, and other interactive materials of resources, videos, links, and useful sites.</i>
<b>C3: Engagement of participants' potentials</b>	
IQ5: <i>I expect that work in the course will be useful in personal research in terms of better information on the topics that are the subject of discussions in the world. I think it leaves enough room to gather research motivation and provoke an idea and concrete work. I hope to explore that balance of design and tectonics, which will be challenging. I expect that we will have opportunities to relate all the theoretical work and practical knowledge acquired so far, connect it with new knowledge and skills, and employ it in design development. I am looking forward to the teamwork because it is significant for future professional engagement. I also have expectations from mentor guidance because it is essential for mastering the task.</i>	IQ6: <i>My expectations are more than met. I think I gathered more knowledge than I expected, and that is one of the big plus. In the pandemic situation, the realization of the course went smoothly, and the work process was of very high quality. We had dynamic classes, which to some extent contributed to better mood and motivation to work. The exercises and workshops were engaging. On the other hand, I must admit that I am very sorry that I did not have the experience that students of previous generations had in this course, simply because it lacked the atmosphere that usually exists when we work in the classroom more time. However, this was a very positive experience!</i>



After analyzing students' answers, 97 relevant single statements indicating prose and cones of the mixed-mode studio design were identified. From these statements, 21 themes were derived, out of which 12 themes are advantages, and 9 themes represent disadvantages of the course (Table 1). The themes were derived principally according to the frequency of respondents' mention and insistence on the importance.

In the analysis of textual content related to the student's expectations form the course and fulfillments of these expectations, emerging themes were identified and concise into three main categories (C) presented in Table 2, along with illustrative quotes (IQ) attributed to individual categories.

#### 4. Discussion

This research helped us better understand the students we design for the learning environment, what drives them and how we can ignite their intrinsic motivation. To focus on developing learning experiences, design methodologies, skills, and tools have been adopted and enriched by learning approaches. Continuous redefining pedagogical approaches are essential tasks for educators to grant the professional competencies and skills required to face social, cultural, and technological changes. Recognizing the implications of these changes necessitates questioning established professional images, values, reconstructing and adapting our educational setup, developing learning methods and new teaching forms, and upgrading curricula. The results indicate opportunities for further improvements of architectural studio education using ICT to facilitate the flexible application of different curriculum contents and effective transfer of conventional learning activities into a learning environment that complementary combines face-to-face with online activities. Learning is more about people and their aspirations than it is about technology. The medium or technology we use is determined by what will best assist the learner to achieve their goals.

Based on the obtained results, three challenges relevant in creation of an environment for effective learning that promotes engagement, autonomy, and behavior, are further summarized.

##### 4.1 Challenge 1: Accessibility

The challenge to enhance the accessibility of the course could be addressed through fostering:

- Feasible organization of the educational process, and
- Needs of participants.

The hybrid approach ensures the fulfillment of

the course outcomes using variable implementation modes. The studio structure traverses diverse activities while allowing students to select their degree of engagement according to personal preferences and needs. This approach offers a course with resilience to adapt to the changing circumstances, both external alternations (e.g., related to the pandemic) and internal factors (e.g., related to the participants). Digital learning platform provides all participants with an online presence, enabling those prevented from attending face-to-face activities remote participation. Furthermore, the digital platform supports sharing learning material and resources, presentation, and documentation of design processes and proposals. For specific assignments, alternative implementation methods and presentation formats were specified, enabling students to adjust to the available resources. Asynchronous work on assignments with a specified timeframe left students the possibility to adapt work, to a certain extent, to their mode of operation. Also, it must be outlined that organizing a mixed-mode studio requires careful planning and management, a level of digital competencies of the tutor, time to administrate platform, create and add contents, monitor the process, as well as alertness and the flexibility to respond to emerging students' needs. Respectively, to respond to the new pedagogical approach, it is necessary to support the online student learning experience more effectively and uphold online teaching and learning in the context of teacher education [17].

The design studio engages students in various types of tasks, meeting the learning needs of different students [76]. Its learning environment is based on inquiry and engages students to work on challenging design problems [77, 78]. The mixed-mode framework transformed the design studio into a more participatory, interactive, and open learning space, better matching the needs of *digital natives* [79]. These generations of students are highly connected through mobile computing and accustomed to being constantly exposed to multiple forms of media. They seek multitasking and stimulation in their activities, and need a learning setting that will promote communication, collaboration, and connectivity in speed, accessibility, and spontaneity. The habit of online engagement probably led to students' constant presence in virtual learning environments and participation in the studio design activities detected in this study.

Despite recognizing the importance of health safety in pandemic circumstances, alarmingly, most students reported a lack of classroom activities, and some suggested that limited social interactions affected their performance and their sense of belonging to the group. Furthermore, some

students reported that they sometimes experienced a loss of concentration during online class meetings due to the meeting's longevity. As a mitigating circumstance, the students state the possibility of recording meetings or segments they considered important. However, additional efforts could be made to improve studio learning in terms of better satisfying students' expectations and needs for socialization (e.g., through adequate balancing in-class and online activities), personalizing the learning process (e.g., through adapting certain tasks to an individual student's learning style).

On the other hand, students indicated that the advantages of the hybrid design studio are also material and time resource-saving. Generally, they recognize that remote working has certain comfort advantages; however, some reported that problems with the internet connection and inadequate space for attending online meetings in a home environment negatively affected their learning process. Also, this teaching model allowed students to recognize their capacity to adapt and be productive under sudden changing circumstances, to organize better, to foster self-discipline, and to turn time spent at home into productivity.

#### 4.2 Challenge 2: Acquisition

The challenge to enhance the acquisition of competencies, knowledge, and skills relevant for students' future professional engagement could be addressed through fostering:

- Learning ability and efficiency, and
- Interaction among participants.

Applied process-driven approach with focused assignments stimulates students to efficiently develop a deep, integrated understanding of content and process, but also to promote learning ability, responsibility, and learner autonomy [77]. In this process the tutor's task was to help students develop long-term learning skills, i.e., to teach them how to learn by being their mentor [78, 80]. Students reported a mainly positive experience with the assignment-based work process, noticing that it stimulated productivity; however, some students reported that it was challenging to complete all class obligations and always manage them within a tight timeframe. The approach allowed future architects to develop new competencies in the five domains identified by Foque [81], including professional attitude, transdisciplinary approach, global awareness and contextual thinking, research-based design and research by design, and leadership.

In studio learning environment, students construct knowledge and improve skills by active learning while interacting with the environment, tutor, peers, experts, working independently or

collaborating in teams on the development of a products/projects [78, 82–84]. During meetings, the class behaved as a *learning community* [78] and the tutor as a supervisor and moderator. The study confirms that the application of digital learning platforms facilitates versatility in the modes of communication and contributes to reducing the problem of the excessive authoritarian influence of the tutor [85]. Discussions and presentations stimulated students to reflect and analyze their work, and examining experience leads to learning [80]. Additionally, students consider that hybrid studio overcomes limitations by the physical environment and isolation, perceived as the downside of the classical approach [86, 87], and expands learning experience. Also, the student's assessment of the online learning environment indicates that the real-time engagement of teachers contributed to immediate feedback during the problem-solving process.

The inclusion of experts from other departments and industry in the certain phases of the project development created a situation closer to a real professional environment in terms of interaction and cooperation with different expertise levels, and opportunity for students' activation to become part of a wider network [88]. Since architecture is a collaborative discipline [4], previous is vital for success in the real world, where architects need to know how to work with people from different backgrounds. Rapid changes in socio-economic circumstances ask for permanent acquisition of new competencies and more flexibility in working with others, as well as fostering the individual student's notion as a lifelong learner who is always connected and interdependent with others.

#### 4.3 Challenge 3: Operation

The challenge to enhance the operation could be addressed through fostering:

- Optimal use of resources, and
- Engagement of participants' productive potentials.

In order to address diverse challenges of the design studio, including tutor's content knowledge, students' lack of experience, knowledge, and skills to develop ideas self-reliantly, the task was to introduce various online channels of communication between students, tutor, experts from the academy and industry, that could support efficient and economic learning and exchange of knowledge and experience over an extensive network of resources. Previous was enabled by designing an open, participative system for the creation of content and exchange of resources that supports both classroom-based and online activities and records them digitally.

The survey results show that students highly appreciated the open-resource character of the digital hub and the possibility to share information, documents, and materials openly, present and discuss their views, design process and results, and follow peers' work progress. The survey discloses that saving time, financial, and material resources were a considerable advantage. Timed class assignments traced the design process, and provide more time in class meetings for presentations, discussions, conversations with the tutor, or reviewing peers' work, reducing the problem arising from time stress [80, 89] and contributed economic savings.

Students' productive potentials were fostered by introducing inspiring topics and tasks that encourage them to apply prior knowledge and skills creatively and propose innovative designs. The survey shows that some students were overwhelmed by the skills needed to work on assignments at the start of the course. This situation was improved by organized workshops and skill-ups. Although these activities were challenging because of the time constraints, the requirement for the presence, and instant results, students found them very util. Also, the survey indicates that in addition to engaging task, motivation for students were working in the creative learning environment, the research character of the studio that allowed them to explore new concepts, an opportunity to participate in the competition, and public and web exhibitions.

#### 4.4 Limitations

The study is limited to describing a single teaching experience and based on the data obtained from students who attended the course during the fall semester of the academic year 2020/2021 and did not include the points of view of tutors and decision makers. Respectively, we recommend care in generalizing our findings as the teaching approach is context-dependent, and some issues identified in the study are related to specific settings and institutional constraints. Finally, the practices of learning during the COVID-19 pandemic crises should be instrumented to re-examine existing educational approaches and methods [90].

## 5. Conclusions

The paper presents a teaching and learning perspective on the hybrid studio design during the COVID-19 pandemic. Starting from the research questions

outlined in the Introduction section, the paper was written to offer a practical example that contributes to:

- Understanding challenges that participants in the educational process faced learning in a hybrid mode during the global pandemic.
- Considerations on opportunities for reconstructing and improving the operation of the traditional design studio based on that experience.

The COVID-19 global pandemic made us transform the learning environments to meet imposed restrictions and test different educational approaches and extreme solutions. The case presented in this study shows how the transformation of the traditional design studio into a mixed-mode affects interaction style and creates a dynamic, engaging educational context using various media while saving resources and providing health safety. Moreover, the study shows that hybrid learning can preserve the realization of the expected learning outcomes of a studio design course, including developing competencies architects should acquire to act professionally in new working environments based on collaborative methods and virtual organizations supported by new digital technologies.

The presented educational experience was shared to make a case for the potential of the hybrid studio as a model in teaching design. This paper's findings can assist instructors thinking about delivering programs in the post-COVID-19 age by adopting a hybrid studio design model. Evaluating this experience, perceived advantages, and disadvantages gives perspective on how to approach studio learning more sustainably. From the viewpoint of digitization in education, the teaching-learning process represents the field of opportunities for new pedagogical initiatives. The pandemic enforced and catalyzed recognition of distant education and emphasized the need for a shift in traditional learning models, outlining methods that are more likely to be effective and flexible, such as hybrid studio in design teaching. However, further research is needed to embed lessons from this experience in future curriculum proposals, particularly from the perspective of teachers. This research could help understand the specific educational environments that enable interaction, providing a variety of learning possibilities.

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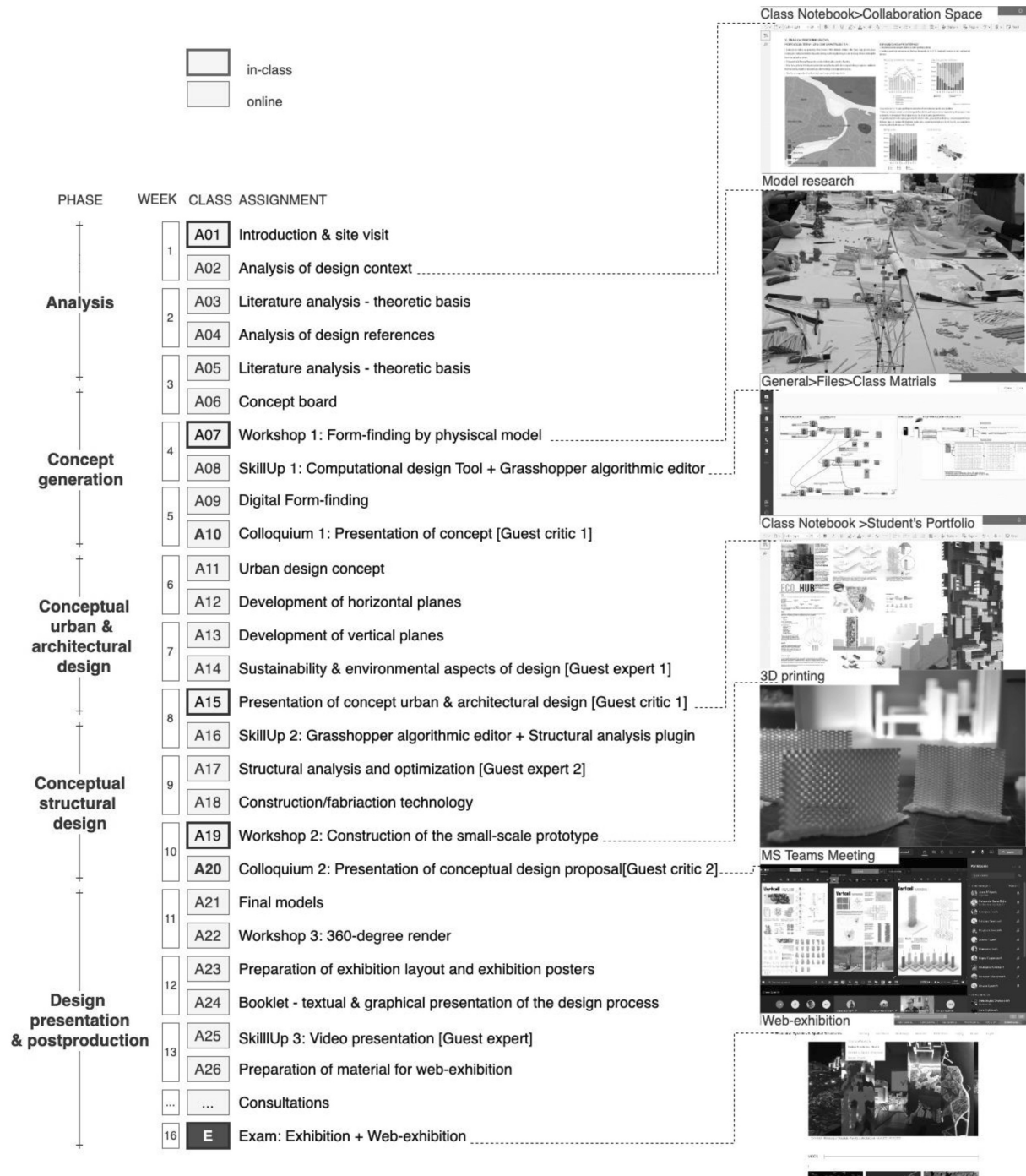
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of Urbanism in Belgrade for the project New models of housing for those at risk in floods in the category of student works, and with the same work, he received a special recommendation from the Council of the Salon of Architecture in March 2015 as the architectural event of the year for the project New Housing Models for Flood Vulnerables in the category of student works. He participated in the organization of several student workshops and professional trips.

## Appendix

### Appendix A

Hybrid design studio assignment-based process diagram illustrating the main phases, activities (A), involved participants, outcomes, and modes of realization.



*Appendix B*

Summary of the evaluation of the mixed-mode design studio realized in the autumn semester of the academic year 2020/2021.

<b>Statement</b>	<b>Average rating</b>
1. Evaluate the mixed-mode design studio learning process and its contribution to mastering the task.	4.33
2. Evaluate how interesting and motivating was the assignment-based mixed-mode learning.	4.25
3. Evaluate how laborious or restrictive was assignment-based mixed-mode learning process.	3.17
4. Evaluate your experience of using the digital platform as a medium for communication and presentation in the mixed-mode design studio.	4.18
5. Evaluate your experience using the digital platform as a medium for collaboration, content sharing, and group assignments realization during the mixed-mode design studio.	4.67
6. Evaluate your experience using the digital platform as a medium for documenting and archiving the work during the mixed-mode design studio.	4.25
7. Evaluate the preparation, design, and benefit of digital teaching contents and materials in the mixed-mode studio (assignments, readers, tutorials, web resources, open-source computer codes, etc.).	4.50
8. Evaluate the importance of group presentations and discussions, and peer reviews and the possibility of monitoring peers' work process.	4.58
9. Evaluate how much the use of the digital platform in the course work process has contributed to productivity.	3.58
10. Evaluate how much the use of a digital platform in the course work process has contributed to resource savings.	4.58
11. Evaluate the extent to which the digital platform has been used to personalize the learning process (i.e., for adapting certain activities to your mode of operation – pace, time, style of learning, etc.).	3.67
12. Evaluate the importance of an open, public internet presentation of the work results on the studio design – web exhibition.	4.67
13. Evaluate the contribution of teachers' comments and feedbacks.	4.67
14. Evaluate the contribution of guest experts and their comments.	4.33
15. Evaluate your contribution and participation in the implementation of activities on the course.	3.33
16. Evaluate how much you were encouraged to be independent in your work.	4.00
17. Evaluate the opportunity to express your creativity during the work on the project assignment.	4.08
18. Evaluate the possibility of applying prior knowledge, skills, and experience during the work on the project assignment.	3.92
19. Evaluate how satisfied you are with the software skills you developed during studio design (CAD system, programming with the graphical algorithmic editor, environmental analysis plugin, structural analysis plugin, visualization software, etc.).	4.08
20. Evaluate the importance of experience from this subject in the context of the application of acquired knowledge and skills in further learning or career as an architect.	4.67
21. Evaluate how much mixed-mode studio allowed you to realize your capacity to adapt and be productive under sudden changing conditions.	4.50