Original Article

Design studio remote classes and immersive learning: a Systematic Scope Review

Clases remotas en estudio de diseño y aprendizaje inmersivo: una Revisión Sistemática de Alcance

Aulas remotas em estúdio de design e aprendizado imersivo: uma revisão sistemática de escopo

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Abstract

Many universities have migrated to remote teaching due to the COVID-19 pandemic. Design studio pedagogy was faced with limitations of digital tools that did not provide the same experience of tangibility, spatiality and presence as a physical studio; therefore, some teachers resorted to immersive media as an alternative. In order to map these pedagogical adaptations, a Scoping Review was carried out, in which 15 articles were selected from a total of 182 found, and a descriptive report was prepared that can contribute to both the subsequent meta-synthesis and future research on the identified themes.

Keywords: Design Education; Design Studio Pedagogy; Immersive Technologies; Systematic Scoping Review; Remote Teaching.

Resumen

Con la pandemia de covid-19, muchas universidades han migrado al aprendizaje remoto. La pedagogía del estudio de diseño se enfrentó a las limitaciones de las herramientas digitales que no proporcionaban la misma experiencia de tangibilidad, espacialidad y presencia que un estudio físico; por lo tanto algunos profesores recurrieron a los medios inmersivos como alternativa. Con el fin de mapear estas adaptaciones pedagógicas, se realizó una Revisión Sistemática de Alcance, en la que se seleccionaron 15 artículos del total de 182 encontrados, y se realizó un informe descriptivo que puede contribuir a la posterior metasíntesis y a futuras investigaciones sobre los temas identificados.

Keywords: Enseñanza del Diseño; Pedagogía del Estudio de Diseño; Tecnologías Inmersivas; Revisión Sistemática del Alcance; Enseñanza a Distancia.

Resumo

Com a pandemia de covid-19, muitas universidades migraram para o ensino remoto. A pedagogia de estúdio de Design deparou-se com limitações das ferramentas digitais que não proporcionavam a mesma experiência de tangibilidade, espacialidade e presença de um estúdio físico, por isso, alguns docentes recorreram às mídias imersivas como alternativa. Para mapear essas adaptações pedagógicas, realizou-se uma Revisão Sistemática de Escopo, na qual foram selecionados 15 artigos do total de 182 encontrados, e foi feito um relatório descritivo que pode contribuir com a metassíntese posterior e com futuras pesquisas sobre os temas identificados.

Palavras-chave: Ensino de Design; Pedagogia de Estúdio de Design; Tecnologias Imersivas; Revisão Sistemática de Escopo; Ensino Remoto.

Introduction

Clark defined teaching method as "Method is the inclusion of one of a number of possible representations of a cognitive process or strategy that is necessary for learning, but which students cannot or will not provide for themselves" (CLARK, 1994a, p. 26). Media, on the other hand, serve as the support or vehicle through which information is disseminated. It is important to differentiate teaching methods from media (tools and resources), as this confusion can lead to incorrect attribution of learning outcomes to the media used (CLARK, 1983b).

Similarly, Bates (2017) asserts that teaching methods and learning theories are not defined by the use of supporting media, especially when considering current technologies. This suggests that educators should first choose the teaching and learning strategy and then select the most appropriate technology. However, during the pandemic, the transition to remote teaching was a necessity due to the emergency situation, and educators had to adapt their methods and explore new digital tools within a range of possibilities to ensure the most suitable combination.

The predominant pedagogical method in Design is the studio-based project learning model. One of the technological tools identified by Maher, Simoff, and Cicognani (2000) for the virtual studio pedagogical model is the use of virtual, augmented, and mixed reality environments in project-based education. Consequently, there was a recognized need to map how this transition occurred in project classes that utilized immersive technologies as a medium. To address this, a Scoping Systematic Review (SSR) was conducted with the primary objective of answering the following question: What are the main pedagogical adaptations perceived by Design teachers and students regarding project-based studio classes with immersive learning during remote teaching amid the COVID-19 pandemic?

After defining the scope, establishing search strategies, and defining the review protocol, 182 studies were initially identified. Following screening, this process resulted in a sample of 15 articles. A descriptive report was then compiled highlighting the key aspects identified within these data.

1. Theoretical Framework

1.1. Studio Pedagogy and Impacts of Remote Teaching

Design education is primarily focused on practical activities and experiential learning, commonly referred to as "learning by doing" (Schön, 2000; Bates, 2017). The most widely used teaching strategy in this field is "studio pedagogy," also known as "studio model" or "studio-based learning" (Schön, 2000; Crowther, 2013; Fleischmann, 2020; Hardman, 2022). Typically, a studio is a physical environment equipped with large work tables and access to a variety of materials and tools, creating an informal atmosphere aimed at providing students with maximum creative freedom. It serves as a space for frequent dialogues among students and between students and instructors. According to the aforementioned authors, the studio environment can simulate the professional practice of a designer or architect, with the method focusing on three types of learning: (i) understanding design principles; (ii) project creation or conceptualization; and (iii) preparation for professional roles (architect or designer). Therefore, it can be inferred that social interaction, creative freedom, the use of ample space for project conception, and the simulation of professional activities are the key characteristics of this pedagogical model.

Evans and Söderlund (2021) argue that the pandemic directly impacted the traditional model of studio pedagogy, which was traditionally linked to physical studio spaces. Hui *et al.* (2020) suggest that critical evaluation (or "crit"), collaboration among peers, presentation formats, and prototype and project reviews were among the most affected aspects during remote teaching. Wu *et al.* (2021) further elaborate that common challenges seen across all areas of education with remote teaching included decreased student attention, low self-regulation, reduced proactivity, and difficulties with cognition and organizing ideas.

1.2. Concepts of Immersive Technology

According to Ahmad, Sosa, and Musfy (2020, p. 166), Virtual Reality (VR) "It simulates a three-dimensional immersive experience and allows

the user to control, navigate and move around a digital environment." This means that the user experiences being present and interacting in a 3D digital environment as if they were in another reality. Huang and Liu (2022) define Augmented Reality (AR) as a visual overlay integrated into the real environment with user interaction, providing a sense of presence of virtual objects in the same environment. Mixed Reality (MR) is understood as a combination of both VR and AR, blending virtual and real elements seamlessly.

2. Method

This study was conducted through a "Scoping Systematic Review" (SSR), which, according to Soares (2021), involves mapping the literature to identify research gaps and scientific trends, as well as to clarify issues, concepts, methodologies, and policies, providing a broad overview of a topic.

The Scoping Review (SR) differs little from a conventional Literature Systematic Review (SLR), with the exception of two main phases: SR does not need to evaluate studies by a quality and/or bias filter, and it dispenses with meta-analysis and/or metasynthesis. "The results may be presented as a 'map' of the data in a logical, diagrammatic, or tabular form, and/or in a descriptive format that aligns to the objective/s and scope of the review" (PETERS *et al.*, 2015b, p. 145). In the "PRISMA Extension for Scoping Reviews: checklist and explanations" guide, Tricco *et al.* (2018) also indicate that no type of meta-analysis is performed. However, for these authors, critical evaluation is an optional step and serves to qualitatively filter the results.

In this study, the scope of the Design field was expanded to include all its specialties, and the field of Architecture was included to yield more search results. Therefore, it was decided to filter the texts through critical quality assessment to obtain more accurate results related to the study's theme. Finally, following the PRISMA and Johanna Briggs Institute (JBI) guidelines, the selected sample was represented in a descriptive report.

2.1. Scope of the Review

The scope of this study was delineated as follows:

a) Regarding main themes:

- Teaching method: Design studio classes.

- Media: Immersive technologies (VR, AR, and MR).

b) Regarding the publication period: Between 2020 and 2022, during remote teaching.

c) Regarding the considered knowledge areas: Design and its wide range of specialties. Architecture, due to its intersection with the field of Design.

d) Regarding the studied population: University students and professors from the selected areas mentioned in point "c".

e) Given that this was a crisis affecting the entire world, no geographic limitation was applied.

Furthermore, the search was limited to articles in English, as it is the primary language used in scientific research according to the "Pesquisa FAPESP" website (OLIVEIRA, 2019). Since this review was characterized as a systematic review, only primary studies were sought.

2.2. Search Strategies

To define the search protocol, four indexed databases containing journals and conference proceedings relevant to the scope were selected: Google Scholar, Web of Science, Scopus, and Scielo.

The keywords used were: "covid-19"; "pandemic"; "remote teaching"; "design education"; "studio learning"; "design studio"; "immersive learning"; "virtual reality"; "augmented reality"; "mixed reality". Boolean operators "and" and "or" were used within search strings. All possible combinations of three keywords were searched. Duplicate and empty searches were not recorded during this phase. Additionally, an excess of findings

unrelated to the theme was noted in Google Scholar. The system itself ranks the most relevant findings at the beginning, so only the first five pages of results for each string in this database were considered. The Web of Science database showed similar results to Scopus. Therefore, the strings were reduced to two keywords, removing those contextual to the pandemic and including a publication period filter, specifically from 2020 to 2022. All remaining possible two-keyword combinations were searched in this database with this filter.

All searches were conducted on November 12, 2022, and resulted in finding 182 studies, with 157 texts on Google Scholar, 10 on Scopus, 14 on Web of Science, and one on Scielo. Excluding the previously mentioned and uncounted excess of duplicate records, an additional 8 duplicate studies were identified among these 182 findings.

2.3. Screening Strategies

First, studies were filtered based on title, keywords, and abstract reading (Filter 1). Next, selected studies underwent full-text reading (Filter 2). The following inclusion criteria were used: studies on teaching methods in Design and Architecture studios; in English; published between 2020 and 2022. Exclusion criteria included: studies outside the scope of the subject areas of this work (e.g., healthcare); studies outside the specified scope (e.g., early childhood education); studies lacking references, access, or technical issues; secondary studies; studies without free access; studies with insufficient information (e.g., lacking authorship, provenance); studies in languages beyond the technical limitations of the researchers.

For article selection, a critical evaluation of quality was employed based on the journal's impact factor for publications. In cases where this information was unavailable, the method suggested by the JBI Guide (Lockwood *et al.*, 2020) was applied, considering the credibility level of the data presented in the article: (1) Maximum level: where the data is unequivocal. (2) Median level: where the data is plausible and supported by the arguments presented. (3) Lower level: where the data lacks scientific support or sufficient validation.

3. Results

This RSE report used basic categories of information in tabulating the results, as suggested by Peters *et al.* (2015b) from JBI, including: article title; authors; publication year; etc. A set of relevant aspects from each article was grouped and described subsequently to form a synthesis. The findings included: a) Ten articles on classes with media alteration; b) Four on teaching methods, alternatives, and solutions; c) Four research and development projects; d) Two articles on student work exhibitions; with some of these articles fitting into more than one of these themes.

3.1. Descriptive Report of the Systematic Scoping Review

Table 1 presents the relevant aspects identified in each study.

Table 1 – Descriptive Report of the Systematic Scoping Review

N°	Title	Authors/ Year/ Publication / Impact Factor	Area/Discipline	Study location
01.	*Virtual fieldwork on a ship's bridge: virtual reality-reconstructed operation scenarios as contextual substitutes for fieldwork in Design education*	Frydenber, S. G.; Nardy, K. 2022. Revista científica: Virtual Reality. F.I.: 4.697	Journal of Interface Design and Human-Centered Design	School of Architecture and Design in Oslo, Norway
Summary: With the pandemic restricting field research travel for the Master's course in Architecture and Design, the professors adapted the environment to virtual reality (VR). The goal was to gather data about ships in the Arctic Ocean to develop user interaction solutions with ship bridge systems (Interface Design). The authors concluded that despite the loss of ethnographic aspects, VR was an extremely satisfactory substitute given the contingency.				
02.	*A spherical video-based immersive virtual reality learning system to support landscape architecture students' learning performance during the COVID-19 era*	Wu, Wei-Long; Hsu, Yen; Yang, Qi-Fan; Chen, Jiang-Jie. 2021. Revista científica: Land. F.I.: 3.905	Architecture / Landscape Architecture	A university in China
Summary: To address the need for field trips, the authors opted for Immersive Videos (IV) — 360-degree photographs created using apps that stitch together panoramic photos. They found this to be an accessible resource and easier to learn for creating content. Additionally, the study evaluated the media through a questionnaire with 140 students. The results considered IV more effective than other commonly used media in remote teaching, such as videoconferences and slides.				

03.	*Applying the arcs motivation theory for the assessment of AR digital media design learning effectiveness*	Chang, Yuh-Shihng. 2021. Revista científica: Sustainability. F.I.: 4.166	Design / Digital Media Design	National Chin-Yi University of Technology, Taiwan

Summary: The objective of this quantitative study was to demonstrate the effectiveness of the Motivation Theory through the use of Augmented Reality (AR) media. The author divided the control group in 2020, consisting of 42 students without the use of AR, and in 2021, during remote teaching, with the use of AR. According to the results, experimental teaching with AR demonstrated higher efficiency and confirmed the effectiveness of the Motivation Theory.

04.	*VRDR: an attempt to evaluate BIM-based design studio outcome through virtual reality*	Agirachman, Fauzan Alfi; Shinozaki, Michihiko. 2021 Proceedings of the 26th CAADRIA Conference – Vol. 2, The Chinese University of Hong Kong and Online, Hong Kong.	Architecture and Design / Human-Centered Design, Project Evaluation	Shibaura Institute of Technology, Japan

Summary: The authors reported difficulties in assessing students' architectural projects using online 2D methods. For this reason, they adapted the assessment to virtual reality (VR), where the criteria focused on building and user accessibility. To achieve this, they created a standard wheelchair user (avatar) within regulatory standards. Despite operational challenges, the authors considered VR a valuable new design aid because it allowed multiple iterative stages in the design process; designers could assess the design before implementation, thereby minimizing errors.

05.	*Multimodal virtual experience for design schools in the immersive web*	Guida, George; Tian, Runjia; Dong, Yuebin. 2021. Proceedings of the 39th eCAADe Conference – Vol. 1, University of Novi Sad, Novi Sad, Serbia.	Architecture / Architectural Design	Harvard Graduate School of Design, USA

Summary: This research and development project aimed to digitally scan the Harvard Graduate School of Design in full-scale 3D to create an immersive augmented reality (AR) environment. The study presented a complete prototype where users could design, collaborate, showcase work, and experience the spaces of the campus, particularly beneficial for remote students who did not visit the site in person. The authors intend to expand the project to the broader community, offer online courses and conferences, and host regular exhibitions.

06.	*Virtual reality as a response to emergent challenges in architectural education*	Hui, Vincent; Estrina, Tatiana; Huang, Alvin; Agma, Sadberk. 2020. Proceedings of ADVED: 6th International Conference on Advances in Education.	Architecture / Architectural Design	Ryerson University, Canada

Summary: The authors described the immersive technologies used during remote teaching, focusing primarily on three tools: MindeskVR, Rhinoceros 3D, and Enscape for the Architecture course. They concluded that these technologies were not a substitute for the physical studio, as material experimentation, spatial relationships, and other deficiencies in the prototyping phase could not be fully overcome. However, they suggested that virtual reality (VR) could serve as an auxiliary tool in the future.

07.	*Prototyping remotely together with 2D, 3D and immersive virtual reality design tools*	Evans, Pete; Söderlund, Carina. 2021. Proceedings of E&PDE: 23rd International Conference on Engineering and Product Design Education, VIA University, Herning, Denmark.	Design / Industrial Design and Co-design	Iowa State University, USA

Summary: This experiment aimed to compare 2D and 3D digital tools (via VR) in co-creating prototypes within collaborative environments involving 25 Industrial Design students. The prototypes created by the teams were evaluated based on quantity, quality, co-design interaction, and novelty of solutions. The authors concluded that no significant differences were observed between the two methods; however, the team that designed without using VR produced a greater quantity of projects.

08.	Interior design studio in the new normal era: a virtual reality case study	Vo, Hoa. 2022. Proceedings of International Symposium on Educational Technology (ISET).	Design and Architecture / Interior Design	Georgia State University, USA

Summary: This quantitative experimental study utilized virtual reality (VR) for 13 students to design a luminaire. The students demonstrated high interest, engagement, and unique creativity. Despite the small sample size, the author committed to accumulating data in the coming years to obtain further results.

09.	*Evaluating students' behavioral intention and system usability of augmented reality-aided distance design learning during the COVID-19 pandemic*	Huang, Hsinfu; Liu, Guiru. 2022. Revista científica: Universal Access in the Information Society. F.I.: 2.629	Design / Design Style or Product Language	National Yunlin University of Science and Technology, Taiwan

Summary: This study focused on adapting "Product Style" (or Product Language) classes using augmented reality (AR), with the effectiveness of learning evaluated among 120 students in Industrial Design. The authors concluded that AR was more efficient than online 2D media for enhancing learning outcomes in this context.

10.	*New collaborative workflows-immersive co-design from sketching to 3D Cad and production*	Novoa, Mauricio; Howell, Bryan; Hoftijzer, Jan Willem; Rodriguez, Jose Manuel; Zhang, Wendy; Kramer, Nikolaj. 2022. Proceedings of E&PDE: 24th International Conference on Engineering and Product Design Education, London South Bank University, London, UK.	Design and Research on Project Sketches	Western Sydney University, Australia; Brigham Young University, USA; Delft University of Technology, Netherlands; European Union Intellectual Property Office, Spain; University of Canterbury, New Zealand; VIA University College, Denmark

Summary: The authors are part of the international research team "Design Sketching Special Interest Group" within the Design Society, which conducts studies on design sketching and representation. In this article, they presented findings from two online co-design workshops involving 25 participants from educational institutions and industry partners. The authors concluded that immersive technologies have the potential to transform the design process; however, there is a need to reduce costs and enhance interactions to minimize training time, making them more accessible for both educational and industrial applications.

11.	*The future of teaching post-COVID-19: microlearning in product design education*	Gill, A. S.; Irwin, D. S.; Ng, R. Y. K.; Towey, D.; Wang, T. C.; Zhang, Y. H. 2020. Proceedings of IEEE - International Conference on Teaching, Assessment, and Learning for Engineering (TALE).	Design/ Product Design and Micro-learning	University of Nottingham, China

Summary: This essay describes a rapid teaching method known as micro-learning, also referred to as "just-in-time" learning. According to the authors, both micro-learning and augmented reality (AR) are already commonly and effectively used in industry. This teaching method involves short pedagogical modules lasting a maximum of ten minutes, utilizing various media formats for delivery.

12.	*The transformative potential of the ongoing digital revolution for the studio model of design education*	Hardman, Paul David. 2022. Chapter from a Book: Impact of Digital Transformation in Teacher Training Models.	Design/ Studio Teaching Methods	University of Coimbra, Portugal

Summary: In this book chapter, the author discusses studio pedagogy and the digital transformations required for remote teaching, focusing on pedagogical challenges. The author concludes that Design studios have been evolving gradually over the years, with this transformation being accelerated by the pandemic. Furthermore, it is noted that despite the use of advanced technologies, online teaching should not replace in-person teaching but rather supplement it with advantageous elements.

13.	*Interior design teaching methodology during the global COVID-19 pandemic*	Ahmad, Lina; Sosa, Marco; Musfy, Karim. 2020. Revista científica: Interiority, F.I.: 1.11	Design and Architecture / Interior Design	Zayed University, United Arab Emirates

Summary: In this study, the authors presented the results of organizing an annual exhibition of works using virtual reality (VR). Despite believing in the potential of utilizing the digital environment developed to host other exhibitions and conferences in the future, they observed that VR was unable to provide the same spatial experience as in real environments, and therefore cannot replace the representational forms of in-person events.

14.	The agile, culture-building hacker: advancing through uncertainty	Macasaet, Patrick. 2021. Revista científica: Charrette, vol. 7, n. 1. F.I.: -	Architecture / Studio Teaching Methods	RMIT University, Melbourne, Australia

Summary: This study explored the "hacker" mentality in the sense of appropriating technologies or infrastructures for purposes different from their original intent. A "processual typological experiment" was conducted with 12 Master's students in Architecture, where they compared tools for online project classes. By the end of the course, students developed 3D projects and leveraged concepts from open-world multiplayer games to create their own virtual city. The author concluded that while some teaching methods are still more effective in in-person studio settings, the manner in which the final delivery and exhibition of works were executed proved to be extremely positive.

15.	Virtual studio 1.0: a virtual tacit-forward learning management framework	Flohr, Travis; Tamminga, Ken; Johnson, Tim. 2021. Revista científica: Journal of Digital Landscape Architecture. F.I.: 0.54	Landscape Architecture / Studio Teaching Methods	Pennsylvania State University (Penn State), USA

Summary: Faced with challenges in adapting project classes during the first semester using Zoom and Canvas, the authors developed a VR software to simulate the Design studio environment. The tool was utilized in the subsequent semester by 41 undergraduate students and 3 graduate students. Its effectiveness was evaluated through a questionnaire. The authors reported that while the software could not fully replace the physical studio, it proved more effective than online 2D media. They highlighted potential improvements requiring faster internet and more expensive equipment, potentially hindering access for students.

Source: Developed by the authors, 2022.

4. Discussion

It is noticeable that the studies were primarily focused on the areas of Industrial Design (ten) and Architecture (eight), with four of them addressing teaching methods in a similar manner. Regarding specialties, certain ones appeared more frequently, such as Architectural Design, Human-Centered Design, Product Design, and Interior Design. These mentioned disciplines require articulation among space, user, and object.

Regarding the geographical locations where the research was conducted, four studies were carried out at renowned universities in the United States (USA); two in Taiwan; two in China; one in Japan; one in Norway; one in Canada; one in Portugal; one in the United Arab Emirates; and one in Australia. One of the studies resulted from two workshops involving six universities and industry partners across different countries: Australia, USA, the Netherlands, Spain, New Zealand, and Denmark. It is evident that most of these countries are also leaders in research and development in innovation, technology, industry, and construction sectors, according to the Global Innovation Index (2021) report.

Nine articles concluded that immersive media cannot replace the physical studio; however, eleven articles assert that there is potential to use online resources as new auxiliary tools post-crisis. Hui *et al.* (2020) argue

that in the case of the studio, the most common digital tools (2D) have not proven to be fully compatible. They further assert that:

> [...] many such media were unable to successfully replace the physical learning environment the students and faculty were accustomed to. As a result, the implementation of VR became an imperative aspect of the remote instruction. The uses for VR in studio courses are threefold, for content generation or modelling, for remote collaboration with faculty and other students, and for representation of unbuilt student projects (HUI *et al.*, 2020, p. 208).

Flohr, Tamminga, and Johnson (2021) developed a 3D software aiming to address this need; however, it also did not prove to be fully compatible. Macasaet (2021) suggests that some teaching techniques, such as "pin-board" or "slow crit," are still more effective in the physical studio. Despite Evans and Söderlund (2021) not noting differences between online 2D and 3D media, four other studies claimed that immersive media proved to be more efficient for online studio teaching.

5. Conclusion

This study aimed to develop an overview representing how design educators and students adapted studio project classes using immersive media during remote teaching. To achieve this, a scoping systematic review was conducted, resulting in a descriptive report based on 15 selected articles from a total of 182 identified.

The main limitations of immersive media cited by the authors of this review are high cost and the need for specific training, along with the tools requiring significant time investment to learn. In the experiment by Novoa *et al.* (2022), the authors observed a notable disparity between academia, which has fewer financial resources to invest in immersive media, and industry, which has more resources available for cutting-edge technologies. Meanwhile, Wu *et al.* (2021) believe that researchers need to develop more affordable and accessible means for

these technologies to reach design education.

While the physical studio benefits from the availability of appropriate tools, material experimentation, furniture, and suitable environments—all conducive to designing and prototyping—digital environments (both 2D and 3D) seem unable to provide the same sensory, communicative, and spatial experience. However, many positive aspects have also been noted in the use of immersive media, with the primary one being the multiple possibilities for iteration before faithfully prototyping and/or implementing the project, thereby reducing the chance of errors. Additionally, for both Wu *et al.* (2021) and Frydenberg and Nordby (2022), immersive media is highly effective for situated learning and was crucial in cases where physical access was restricted. This signifies an expansion of accessibility and exploration of study fields remotely.

This report opens the possibility for further analytical contributions through the development of a meta-synthesis, as well as future research that gathers more data regarding the compatibility of teaching methods (studio pedagogy) and supporting media (immersive technologies), improved efficiency in learning between digital media (2D and 3D), and other related themes addressed.

Conflict of Interest Statement

The authors declare no conflicts of interest with this study and have not received funding from any source that could influence the research and compromise the impartiality of this work.

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