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Architectural education challenges and opportunities in a post-pandemic digital age

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ABSTRACT
The current study examines the impact of Covid-19 pandemic on architectural education, focusing on its challenges and implications on students, educators, and institutions, and the opportunities that emerged from the incorporation of online/distance and blended learning in architectural education during the pandemic. Based on observations and literature reviews, this study identifies contemporary challenges and proposes three educational approaches for the transition to a model for architectural education in a digital age considering Covid-19 pandemic opportunities. These educational approaches are based on improving networking, exploration, and flexibility & adaptation, implementing transdisciplinary approach, and integrating information and communication technologies (ICT) in architectural education, in relation to learning design elements. The study presents a model using an instructional approach that provides a vision for post-pandemic architectural education and identifies challenges for educators and institutions for further investigation. This study responds to the call on the pandemic’s impact on traditional architectural education.

1. Introduction

Natural hazards trigger feedback in terms of human thinking and actions, they have a great long-lasting impact on social life, which stimulates thinking about the future and what could be the best way forward. Several educational institutions around the world are affected and were concerned that educational periods and sessions will be lost because of the pandemic worldwide effect [1]. Universities were forced to make critical decisions about how to maintain their educational offerings while protecting their community, educators, and students from this public health epidemic.

Online learning has mainly replaced traditional education at several universities during the pandemic. Online/distance education can therefore be used to lessen the spread of contagious viruses like Covid-19 [2].

Architectural education (AE) is facing numerous challenges that emerged because of the pandemic, work on solutions have been developed to deal with these challenges, and a future vision of opportunities and transformation in AE has emerged. There are continued exploration of education theories, and concepts, to leverage these opportunities and transformation, as well as on-going efforts to renovate the paradigm of architecture education and restructure its teaching process [3,4], this includes different modes of delivery, evaluation, and assessment. These challenges required the emergence of a “new normal” way of life [5]. Salama [6] pointed out that a “new normal” state of AE refers to an unusual or a typical condition that will turn to “normal” or stable or expected state hinting that we are eager to respond to change. However, traditional AE has already been challenged, and lost its stability forever, as schools of architecture are urged to change their ways and pushed away from face-to-face teaching [3,4]. The profession of the architect is undergoing major changes [7]. Despite the changes in the profession, AE in schools continues to be based on educational models that are becoming increasingly disconnected from professional demands [8,9]. Furthermore, there are continuous attempts to renovate the architecture education...
paradigm and restructure its educational process, continuously exploring education theories, ideas, and future visions. However, some contemporary challenges still exist within the AE paradigm in recent years [3,4].

In this context, the need to establish an updated framework for AE programs becomes an immediate necessity [10]. The Covid-19 pandemic has obliged the transition to this online digital off-campus teaching and learning model, this sudden shift which was unlikely expected under any normal circumstances has led to probing of the educational effects that arise in such situations. Students, educators, and educational institutions were dealing with the transition from face-to-face to online. As various challenges emerged due to this effect, work on solutions have been developed to deal with these challenges, and a future of opportunities and transformation in AE has emerged.

2. Methodology

This article follows a data collection examining the literature on the impact of the covid-19 pandemic on AE, which aimed to understand how students, educators, and educational institutions were dealing with the transitioning to a "new normal" state of AE and investigate AE contemporary challenges and opportunities. The proposed methodology requires the definition of research questions, searching for relevant papers, screening papers, keywording of abstracts and data extraction, and mapping into categories. Our research seeks to answer the following questions in the context of AE literature: What is the impact of the Covid-19 pandemic on AE? What are the contemporary challenges and opportunists of AE in post-pandemic digital age? The research questions seek to deepen the current work important aspects.

2.1. Data sources and search strategy

This section describes the data sources, search and screening processes, and classification, were developed with the purpose to answer the research questions. The scope of the search covered scholarly journal articles and the publication period was limited to the years 2020 to 2022, based on the articles identified using the Scopus database search, and relevant to the terms 'Covid' AND 'Architectural' AND 'Education'. Alternative spellings, synonyms, or related terms were incorporated, to avoid narrowing the search. Only English articles were included. This study excluded those papers that are relevant to Covid-19 in other domains rather than AE. The research discussions and objectives were expanded using proceedings, book chapters, and books. Moreover, the studies consisted of a systematic review of scientific literature on higher education during Covid-19, in which AE were used in the reviewed sample were examined. Available full papers were included and the papers available only in abstracts or presentations were excluded. By applying the search string to the Scopus scientific databases, 93 records were identified, of which 46 remained through filtering for peer-reviewed articles, and only three articles were written in a language other than English. Of the 43 sample, 18 records were excluded after the title and abstract screening that were related to other domains. In addition to 7 full texts could not be retrieved so that 18 articles were considered for the full-text final review sample, as shown in Fig. 1.

2.2. Data processing

To extract data from primary articles, this study proposes two preliminary data classifications related to the research questions. Nevertheless, through the classification stage, these themes have evolved to give place to new sub-categories of the existing themes. This study used data extraction involved inductive data classification of the primary articles, in addition to supporting data from the related literature. The first research question deals with the impact of Covid-19 divided into three main themes: students, educators, and educational institutions. The second research question concerns about identifying the challenges and opportunities of AE in post-pandemic digital age. The classification themes of the identified challenges of AE were developed based on three main outcomes inspired by the distinction of previous work of Salama et al. [3,4]. The three themes are: improving networking, exploration, and flexibility & adaptation, implementing of transdisciplinary approach, and integrating of information and communication technologies (ICT) in AE. Accordingly, this study attempts to explore the response related to students, educators, and institutions of AE to the pandemic impact and provide evidence of the possibility of renovating the architecture education paradigm. We expect that the results can help developing a model for AE learning design, based on the opportunities presented from the pandemic.

3. Background: The impact of the Covid-19 pandemic on AE

3.1. Students challenges

Architecture is a discipline that requires shared workspaces, gathering, and special computers and equipment. Architecture is one of the disciplines where learning is experience-oriented held in a studio environment. The design studio is the core of AE, it is the climax wherein the theoretical knowledge and technical experience gained from different courses are introduced collectively with skill development of design [11,12]. Students use the studio not only as a classroom, but also as a multidimensional space where they spend their time developing design work, communicating, discussing, and sharing with friends. It can be said that the studio environment fosters a sense of belonging to the architectural profession [13].

Accordingly, the online transition to AE has created serious challenges related to students of architecture which can be elaborated through three pillars that indicate these challenges. Pillar one and the most identified in the selected study articles is “social challenges”. Bakir [14] discussed social challenges for students in design education. Firstly: miscommunication, as it was difficult to get proper feedback online. Secondly: working in silos, as a result, students felt that the competition that existed in physical design studios was lost, and absence of direct interaction as stu...
students demonstrated a desire to be socially engaged [15,16]. Thirdly: missing face-to-face interaction, as students were not able to express ideas as easily as inside the studio. Similarly, digital divide caused by online and distance learning and missing face-to-face interaction was found [10], increasing the sense of isolation and discontinuity [17]. The National Design Studio Survey, conducted on the impact of Covid-19 in UK by Alex Wright and Robert Grover [18], addressed studio teaching practices during the pandemic. The following selection of the key findings of the survey represented 29 universities, nearly 800 students and 121 educators. Learning satisfaction decreased when it transitioned into online medium, learning support was negatively affected, students’ sense of belonging to a community was damaged, and working online and off-campus highlighted resources disparity.

This introduces pillar two that is “ecological challenges”. Students in AE institutions in the Global South face great challenges due to lack of resources and online infrastructure, accessing software from off-campus, as well as accessing high-speed broadband, and accessing to dedicated computers for their work [3,15,19]. Students through their design course were required to use special software and hardware, therefore they needed access to facilities [14,15,19,20].

Pillar three is “behavioural challenges” due to effects on student’s motivation and engagement, low interactivity and engagement, lack of educator attention to students with low or weak performance, and fatigue & time management issues are the key challenges [10]. These challenges could have the most impact on students learning process. Fatigue & time management challenges can be due to factors such as, increased workload [14,20], extended working hours [17], which results in a demotivated and less interactive student behaviour [15]. Student interactivity and engagement away from the studio environment was one of the main concerns of the architectural school in the AE process during the pandemic [13,17].

In contrast, effectiveness and students appraise of online teaching for theoretical, building science and applied engineering courses was sufficient indicating a high degree of acceptability of the online medium of AE [10,21]. Educational institutions did not prefer to try online education in architectural design courses because of the strong traditions of teaching inside design studios, requiring face-to-face interaction. Switching to an online platform is easier in theoretical fields, but the migration is more difficult in architecture studio courses [22,23].

A part of these student challenges can be the cause of a lack of familiarity or sudden shift to online medium, while other are more pedagogical, which could be resolved with careful planning. Some guidelines were suggested stressed the need of setting early clearly defined goals, flexibility with progress assistance, diversity in learning material and communication, a sense of presence and social contact, and personalised feedback [24]. Systematic training of educators on online tools and distant learning platforms and the creation of a general awareness of digital resources can significantly improve the quality of education [10,13].

3.2. Educators challenges

This transition from traditional to online was phenomenally difficult in a situation marked by under-preparation. Through a continuous process of trial and error, the primary learning curve for educators is to adapt to online teaching and learning model [10]. Teaching online courses discussed by Kebritchi [25] raised two major parts of challenges related to educators. Firstly, discussed the educators’ relation to content issues were stated as follows, content development, integration of multimedia, and strategies & considerations of content development. Educators would not be able to convert all their courses into online materials overnight [17,26]. Educators must create digital materials and repositories, also raising general knowledge of digital resources can significantly improve teaching quality [10].

Secondly, Kebritchi [25] discussed the educators in relation to their educational role. This having another four challenges to adapt to online teaching which were stated as follows, changing their faculty roles (pedagogical, social, managerial, technical), time management difficulties, adapting their teaching styles, and adaptability to distant learning which include (educator comfort level with technology, student-focused environment, communication barriers, change to online teaching approaches). While students experienced technical challenges, educators must also function as technical assistants in addition to their educational role, as they also suffered from the extended working hours in the design studios [14,17]. Accordingly, a critical necessity of systemically training educators in dealing with technological and educational tools [10,26,27]. This necessity is the most identified in the selected study articles, therefore higher education institutions needed to provide professional development for educators [25].

3.3. Institutions challenges

Architecture schools and institutions had a major role in facing Covid-19 pandemic. On one hand, educators’ professional development, student training, and technical & multimedia support are the main areas of focus for educational institutions in a distance teaching and learning situation, to address the challenges and improve the effectiveness of online education and learning [25]. Moreover, to ensure student learning effectiveness in AE, new configurations should be established to redefine the contents, processes, and outcomes of the virtual design studio [19]. As for technical & multimedia support, which played an important role in the transition to online teaching and learning. Students consider “Zoom” online platform to be the most efficient platform, and students found that private university network was least efficient of all platforms, while Facebook groups, Hangout, Teams, and Skype was the most used platforms [10,13,14].

Not surprisingly, educational institutions struggled to maintain a level of learning facilitation, web conferencing platforms rescuing education in the time of Covid-19 pandemic which showed the unpreparedness of universities and institutions online platforms [28]. But it also enabled real-time action possible and provided resource savings in spatial and financial terms [29]. According to [20,30], a convenient online experience for students and instructors will be made possible by improving the institutions infrastructure to ensure they are adequate for virtual design studio educational purposes. Also, apply Covid-19 experience to recreate the programmatic and physical design of open areas and buildings to provide a living environment that is hospitable in conditions, such as those of the pandemic [26].

On the other hand, emerging from the pandemic situation, architecture schools and institutions must respond to the need to develop safe and healthy environments promoted by a trans-disciplinary framework [8]. This certainly expands institutions’ learning and networking support challenges, and actively contributes to the discussion of online/distance teaching–learning paths in a broader context. In this way, clusters of educational institutions can work together at the local and global networking level to match online teaching best practices for adoption in blended learning [10]. Architectural school deans and leaders need to be aware that the school should be an adaptive system that does not try to maintain the same state, they should promote change and exploration, flexibility & adaptation to be incorporated into the curriculum structure, design studio practices, and teaching & learning processes [3].
3.4. The transition to online/distance and blended learning opportunities

AE was undergoing a “transitional phase” which necessitated adaptation and mitigation to deal with such a pandemic crisis [3,4]. In the last decade, AE agenda has already included blended and distance learning, as learning paradigms for the future of AE [31]. By incorporating blended and distance learning models into the design studio, it is radically transformed, while maintaining its essential characteristics. Integrating Information and communication technologies (ICT) and knowledge from other disciplines, will open AE to a new hybrid, networked, and delocalized learning environment with a direct link to professional reality [8,32]. The Covid-19 pandemic has accelerated the transition to these paradigms and opened new doors for the future of AE.

First, the implementation of online/distance learning in the AE can transform its learning environment to a flexible learning environment. It has prominent benefits over the conventional physical studio environment from students' perspective [33–35]. The use of digital communication tools (DCT) such as Skype, Zoom, Hangouts, and others is beneficial for them to be able to watch the recordings of the discussions in the online sessions repeatedly. The entire class's projects and comments are visible and audible to all students. This is a feature that is frequently lacking in typical studio settings, this is called digital archiving [28,33]. Another key outcome is that students can work efficiently even in remote learning environments if they are provided the necessary tools and the opportunity to self-development [13]. Creating a more focused earning learning environment, in addition to improvements in technological literacy were welcomed benefits from students [14,36]. Lastly, as physical presence is no longer essential, it opens the door for international participation in jury assessment design concepts [17,30], and enhanced feedback quality, increasing professional socialization to a learning environment beyond the studio [14]. Furthermore, as a bonus upside, online submission and presentation save paper waste, which is good for the environment [17]. From the institution's point of view, potentials of understanding and implementing distance learning, could lead to reducing the burden on institution's physical resources, increase the number of students admissions, encourage networks of collaboration between other architectural institutions, and it will expose architecture students to diverse, and rich perspectives [30].

Second, incorporating online education into blended learning as a teaching paradigm opens a world of possibilities that can benefit undergraduate AE [31]. Blended learning, according to the most widely accepted definition, is a seamless combination of traditional face-to-face interaction and properly chosen online learning modules. The blended teaching–learning continuum helps educators figure out how to combine different teaching and learning activities in the best way possible [30,37]. Blended learning could be a way to improve design studio classes with online technologies [30,38]. Marta Masdeu [8] speculated that the design studio under the blended learning paradigm will evolve in which students’ learning would be based on collaboration and knowledge production models that is physically and virtually networked, the learning paradigm would be based on three essential concepts: networking, transdisciplinary, and ICT will be integrated into the architectural design studio allowing it to be mobile, personalized, and networked [8]. In the design studio, blended methods of teaching and learning may be the most appropriate way to teach and learn [33,38,39]. Also, by fostering a research culture in the studio environment, blended learning and networking ensure relevance and continuity between academica and the profession [31].

3.5. Summary of the pandemic impact on AE

While these challenges cannot be generalized to AE around the world, they provide an excellent preliminary platform for mapping future post-pandemic AE. The Covid-19 pandemic challenges has accelerated the need for the development of AE, and for innovation and implementation of alternative education systems and evaluation strategies. The Covid-19 pandemic has given us the opportunity to pave the way for the adoption of online/distance learning [40].

The presented challenges and opportunities call for the development of new frameworks for AE, which will then be reflected in the curriculum design [14]. In summary, while remaining aware of the challenges that have been raised, several opportunities laid ahead by online/distance and blended learning implementation globally, accelerating the transition to their teaching / learning methods for AE. However, the investigation of technologies advancement in the field of ICT related to AE is required. Better understanding of students' experiences and utilization of online technology, allows the opportunity to develop a framework for online/hybrid design education. Fig. 2 illustrates the Covid-19 pandemic effect, challenges, and opportunities for AE.

4. Data Collection: Educating architects in a post-pandemic digital age

Salama et al. [3,4] discussed AE challenges after the pandemic. The first challenge is the role of educators and institutes toward providing flexibility, and adaptation as part of their AE curriculum structure, in addition to their role in exploration of knowledge, and embracing the global networking and communication. The second challenge is based on the call for re-examine new concepts evolving from other disciplines and the integral of new design teaching practices. The third challenge is based on the importance of ICT, showing the necessity for its integration in AE, which was highlighted from the pandemic experience and were appraised by the work of [41] to restructure architectural education curricula using policies that aims to completely revamp the higher education sector. These challenges are categorized into three major topical themes and studied in relation to learning design elements. These learning design elements are defined in accordance with the learning design relationship model [42], which emphasises the impact of context on students’ learning processes. According to this model, learning is created by the interaction of six different elements which are prerequisites of learning, setting framework, learning goals, leaning content, evaluation, and learning process.

4.1. Networking, explorations and flexibility & adaptation

Networking locally and globally between architecture educational institutions is one of the most important challenges facing AE. Not only networking has an impact on the educational experience, but it also establishes a new setting framework for design studio practice to enhance the process of interaction between students, and between students and the learning content. According to Ioannou [31], the way a design studio runs is comparable to how an office runs in a discipline like architecture. Setting framework conditions to increase collaboration and opening up the educational process to additional stakeholders is not just an educational trend; it is also directly tied to how contemporary professional practices viewed.

In education disciplines like AE, student interaction with the learning content requires multiple skills and adopting multidisciplinary approaches especially in the design studio [43], these requirements must be integrated and put into practice concur-
currently in a collaborative setting that is frequently global. Authentic learning that creates a deep connection to future employers will be a key educational tool in the future [19,44]. One of the indicative strategies listed in the “Education 2030 Framework for Action” aimed at implementing SDG 4, in the UN, is the development of policies and programmes for the provision of quality online/distance learning in higher education, with appropriate financing and use of technology, including the Internet, massive open online courses, and other modalities that meet accepted quality standards to improve accessibility. Implementation of this approach will

Fig. 2. Covid-19 pandemic effect, challenges, and opportunities for AE.
ensure inclusive and equitable quality education and encourage chances for lifelong learning for “all” [45]. Such factors introduce challenges for architectural schools and educators to adapt learning design elements and teaching methods to the digital age while also maintaining all channels of communication.

Exploitation of opportunities might be made a foundational element of AE [46]. This exploration can be subject to introducing a diverse body of knowledge to the learning content, and it can be the process of how architecture graduates grasp market opportunities. On one hand, one of the most pressing issues in contemporary architecture education is the lack of content diversity, which results in homogenization of human behaviors and unity of the educational landscape [47]. Salama et al. [3,4] discussed decolonization in AE, in which they stated that western architectural practices were and still are dominant on global AE. The global West overlooked the regional architectural traditions, referring to an article by Mark Alan Hewitt, with a title called “Why Don’t We Teach Chinese Architecture?”. Our new opportunity is to participate in the global conversation about decolonization, focusing on ways to decolonize the curriculum by expanding and exploring it, and introducing a diverse body of knowledge to the learning content that isn’t necessarily based on Western architectural practice or established Western design studio teaching practices [48].

On the other hand, Charalambous [46] argue that the failure to establish an understanding the process of how graduates might grasp market opportunities could be due to our focus on design work in connection to finished ‘products,’ leaving other areas where architects could potentially explore new opportunities by applying their skills and knowledge. Curricula should be developed in accordance with new competencies needed for future professional activities [49]. When exploitation of opportunities becomes a foundational element of education, AE system should encourage students to explore opportunities in situations where others see risk, and act on them by providing a different viewpoint on a current situation or problem [48]. According to Khodeir [50], skills transferring through AE to practice such as leadership, self-trust, negotiation, adaptability, and career orientation are the most important aspects that are left out through the education time span from students’ perspective. This necessitates educators to establish student’s prerequisites for learning/learning qualifications in addition to learning goals that assist students to reach their entrepreneurial spirit. This mindset can be developed by developing the educational process to encourage students to pursue or develop their personal careers through the continuous learning process of AE [46].

Lastly, Flexibility & Adaptability, Architectural projects have their share of developments such as, the studies of economic and social impacts, the increasing complexity of functional demands and building standards, and the rapid development of building technology, to name a few. In many ways, AE institutes lag facing these developments, they provide an education that may not be up to current or future professional requirements [9].

The demand for flexible and adaptable higher education is dependent on education disciplines that are sensitive to learner needs while also being open to society and labor market needs [44]. However, the fundamental challenge, is the ability to be flexible in developing learning content and curriculum of the AE, which requires constant renewal and updating to adapt to the changing knowledge, technology, learners’ needs, and society needs [51]. These developments to reach a flexible and adaptive AE have the potential to become a good teaching paradigm that may address both present and future issues and a chance to re-evaluate the “hidden curriculum,” which is an appreciation of those underlying conventions established from the social relations of the learning environment [4]. This may necessitate the need of curriculum renewal, the need for educators to be updated, increasing collaboration among different areas of architectural learning, and providing the infrastructure to support the process. AE institutes have the potential to play a significant role in regulating flexible and adaptive education, by providing flexible and adaptive learning design elements for architectural learning structuring that will benefit the global architecture community.

4.2. Transdisciplinary education

Adopting the transdisciplinary approach for knowledge integration in AE, addresses the need of universities to implement a transdisciplinary collaborative format, which can be used in the development of their AE curriculum[52]. The architectural design studio, is the core subject of AE, serving as a learning platform on which all other subjects’ knowledge should be integrated [53]. Accordingly, inside the architectural design studio the integration of knowledge and expertise of all disciplines involved is required to enable maximum innovation. This can be accomplished by adopting interdisciplinary and transdisciplinary learning modes, in which creative design is explored inside a single subject while considering other discipline’s requirements. According to the types and levels of interactivity between disciplines, four learning modes are established in Table 1. The concept of each learning mode is supposed to be used in consideration of interactivity, and the identity of student and educator [54].

| Learning mode       | Interactivity                  | Student identity | Educator identity |
|---------------------|--------------------------------|-----------------|------------------|
| Subject / Disciplinary | Working within a single discipline, topic-driven and subject-driven. | Knowledge-receiver | Knowledge-deliverer |
| Multidisciplinary    | Driven by Discipline to discipline cooperation: persons from many disciplines collaborate, each relying on their own disciplinary expertise. | Knowledge-consumer | Knowledge-facilitator |
| Interdisciplinary    | Driven by learner cooperation: Integrate information and methodologies from several fields uses a true synthesis of approaches | Knowledge-collaborator | Learning-designer / Moderator |
| Transdisciplinary    | Driven by Learner participation: Create a unity of intellectual frameworks transcending disciplinary viewpoints through learner participation and new knowledge generation. | Knowledge-producer | Interactive Learning-designer / Advisor |

Table 1

The difference between learning modes with association to interactivity between disciplines, student identity, and educator identity. Adapted from [54]
setting” an alternative to classroom and studio settings in which various educators deliver separate bodies of knowledge of AE. This is accomplished by bringing lectures and studios together through at the same time, students put what they’ve learned into practice in specific design projects led by the same team of educators, as the knowledge content is derived from several fields, and is designed to satisfy the needs of students. At the studio level and degree level, the introduction of a transdisciplinary approach can be accommodated by the graduation thesis project or the master’s degree, in which students from various disciplines such as, planning/urban design, landscape architecture, architecture, industrial/product design, and engineering collaborate on team projects. Identifying and developing projects and learning content that could be suited to such a specific approach would be a challenge. Through this involvement, students will have the chance to stay updated and informed as they grasp the knowledge combined from education and real-life projects [55].

4.2.1. Education models of 2030

Globalization is the most significant obstacle to AE, requiring significant curriculum revisions. The studio should serve as the climax of the student’s knowledge, rather than serving as the centre of design education. The reason for this shift is because the amount of data required by today’s knowledge-intensive design has increased dramatically since the turn of the century [12]. To overcome this obstacle, and to incorporate transdisciplinary approach to AE, the “Lego set model” of higher education comes in place. The book titled “Higher Education Landscape 2030” provides four models for the higher education [44] for 2030. These models named as followed, Tamagotchi, Jenga, Lego Set, and Transformer models, are summarized in Table 2. AE can greatly benefit from the Lego set model, because it caters to the labour market that is fuelled by creativity, innovation, and new developments [44]. This strategy is demand-driven and transdisciplinary in approach, allowing students to quickly gain knowledge and skills. They mix multiple learning units given by various universities and innovative educational institutes, provided in several online, on-campus, and hybrid learning settings. Each student’s personal study process is made up of a series of learning modules. The general structure of recognition within the higher education landscape influences the identification of learning modules. Students can sign a learning contract with a single institution based on learning outcomes that incorporate several learning modules. However, combining learning modules from different institutes into an academic degree and having them recognised is also conceivable. The Lego set model also considers the students’ practical experience, recognising that time spent not learning to develop practical experience is valuable [44].

| Differentiation criteria | Tamagotchi | Jenga | Lego | Transformer |
|--------------------------|------------|-------|------|-------------|
| Description | A closed environment | Provide knowledge base to build on | The course of study is made up of separately combined modules of various sizes | Students developed their own professional identities then use to their studies |
| Instructional design | Provided by the educator | Provided by the educator | Self-organized | provided by educator |
| Orientation of learning content | Designed for the average student | Individual - uniform starting point | Highly individual - no uniform starting point | Highly individual |
| Student/teacher interaction | Educators control the learning process | Students have greater personal responsibility for learning | Students control the learning process themselves. Educator’s role is an expert. | Educators control the learning process; later Educator’s role is an expert. |
| Student group | Homogeneous | Heterogeneous | Highly heterogeneous | Highly heterogeneous |

4.3. Information and communication technologies (ICT)

Technology is used extensively in the field of architecture. It makes use of technology both throughout the design and manufacturing processes. Digital computer technology is thought to have a significant impact on AE [56], and the utilization of, digital technology will be leveraged to create fundamentally new educational experiences and programs [44], and accordingly new learning design approaches, for a responsive learning in a post-pandemic AE, that embrace the necessity of reconsidering AE using virtual settings [4]. Information and communication technologies (ICT) usage in AE are reshaping the architectural design studio teaching practices [33], and improved students’ performance [36]. ICT can be divided into two categories in context of AE, the first is digital communication tools, and the second is mixed reality (MR) tools. This following section will discuss the importance to each in the realm of AE.

First, Digital communication tools. The AE had overcome its physical and temporal limitations with the support of ICT. Digital communication tools (DCT) have a huge role in that, one main impact of DCT is that it allowed the learning processes to take place in virtual environments with geographically distributed heterogeneous groups (with a wide range of experience, interests, and knowledge). Furthermore, learning content can be accessed at any moment, and conversation between participants can take place both synchronously and asynchronously [8]. The impact of DCT as discussed earlier in online/distance learning section, it is radically transformed education into a new hybrid, distributed, and delocalized learning environments, the use of digital technologies is promoted, and more active learning participation is encouraged [8]. In terms of time, distance, and interaction according to Megahed [17], digital models enable interactions in a variety of learning modes. Almost all types of mediated educational interaction are now enabled to enhance studio and classroom-based education.

Second, Mixed reality (MR) continuum. Its application in AE showed the potentials of VR and AR applications in terms of learning processes that includes ideation, design education, building management and collaborative design [16]. In addition to, virtual and augmented evaluation such as (pin-up, jury, desk critic), develop organizational strategies that encourage interaction between different stakeholders (both inside and outside academia), organize communication protocols to show design results to various audiences [8,35], and can affect knowledge transfer positively [21]. In terms of learning settings and environments, VR and AR can also open and expand environments in the three-dimensional space, allowing users to experience and modify objects, devices, and processes that do not yet exist. As a result, research-based learning can be incorporated in practical ways.
throughout a course of study [57]. Evidence of AR promoting motivation, engagement, interest, increasing opportunities for interaction, reducing cognitive load, and allowing abstract concepts to be visualised was found [58]. AR was also found to lead to stronger interactions between students and educators [59], between students and learning content [60], and among students themselves [61]. But according to [34,35] educators thought that virtual design studios was inferior to physical type for most variables, however students found that most virtual design studio dimensions were comparable to or better than the conventional studio.

The distinction between physical and virtual learning settings might be blurred thanks to technological advancements. This opens the possibility of providing personalised support for students’ learning trajectories [44]. Recent hardware advancements, such as self-contained headsets that may imitate holographic additions to real settings, is expanding the technology supporting augmented reality and virtual reality educational environments [62]. Software development of Mixed Reality (MR) Continuum is necessary to allow smooth integration of many educational processes in a model on a unified platform. In the long run, combining such models with virtual and augmented reality will increase visualisation, representation, and communication, potentially transforming models with virtual and augmented reality will increase visualisation, representation, and communication, potentially transforming how architecture design processes are represented [63]. Also, when using technology-based solutions, student accessibility to these technologies is important [44]. Meanwhile in a post-pandemic scenario, academic leaders agreed on a future trajectory of transformation to hybrid formulations of educational content delivery, evaluations, and other academic components [64]. Also, students in general appeared to appreciate the online/distance learning [14,39], but as socialization is a key part of the studio environment, and most social activities are unstructured and instantaneous, and this type of socialization is easily accessible in a physical studio environment [13]. Technology advances in the augmented & virtual reality realms could bridge this social gap and promote more socially active studio environment. This concept of such learning settings is not new, and the technology is already in place to a great extent. However, according to the advantages and disadvantages of the impact of using ICT in education illustrated in Fig. 3, continued development of digital and virtual environments that could mimic and even outperform the benefits of teaching in the conventional design studio environment will be a major challenge [65].

5. Results and discussion

The educational triangle of networking, exploration, and flexibility & adaptability structures promotes efficiency addressing current and future issues of AE. In the center of this triangle mediates the learning design elements illustrated in Fig. 4. Institutions and educators role using those three main aspects to establish a new setting framework for design studio, promoting the process of interactions between students on local and global scale, and between students and curriculum that is adaptable and flexible to the changing context of learner needs and social needs, while exploring new bodies of knowledge decolonizing the learning content, and the process of exploring market opportunities and risk seeking, by establishing student’s prerequisites for learning/learning qualifications and learning goals.

The available literature on architecture shows that AE and practice have always been and still are based on the relationship between science and art, with the design studio at its heart [11], design studio remains the spine of the AE combining the (theoretical & technical) knowledge and the skills acquired from the other courses. Thus, creativity and Innovation need spaces outside the organizational and planning processes of universities. We can argue that the use of Lego set model in creative discipline like AE could promote the integration of transdisciplinary approach in AE. As a result, combining the Lego set model and transdisciplinary approach in AE, in relation to the three methods & practices of learning named pedagogy, andragogy, and heutagogy [68], is illustrated in Fig. 5.

AE students’ learning path starting from the end of pedagogy learning path and starting the andragogy learning path, in which students has flexible and diverse modules to choose from according to their abilities and interests. These modules are delivered either by academic architectural institutes or by professional architectural institutes, offering Lego modules of academic courses, vocational training, and workshops. These modules are constructed with the design studio at its heart combining all other disciplinary knowledge with a transdisciplinary approach. This path has a checkpoint of degree recognition point in which finishing...
several modules could be translated to a degree to become an architect, that could be authorized by the educational accreditation organizations for these modules e.g., RIBA or NAAB. Leading to the heutagogy learning path with more modules that help the architect to evolve the skills needed in professional practice. This approach is primarily focused on achieving the ideal level of integration between AE and professional practices and could find that answer to that paradigm of complexity.

Fig. 5. Architecture student learning path starting from the end of the pedagogy learning path, through andragogy learning path consists of an educational Lego module adopted from [44] in the form of transdisciplinary enabled design studio education adopted from [43] in which led to an open heutagogy learning path.
Through investigating AE contemporary challenges and opportunities, this study proposes a model for AE learning design. This model is based on, improving networking, exploration, and flexibility/adaptation in AE, implementing of transdisciplinary approach, and integrating of information and communication technology (ICT). The transition to this model is accelerated by the Covid-19 pandemic effects by adoption of online/distance, and blended learning as illustrated in Fig. 6. However, this model is facing some challenges conducted from the pandemic experience. The most identified challenges for architecture students during the pandemic was social related challenges. This model proposes that implementing blended methods of teaching and learning may be the most appropriate for AE as it combine the traditional face-to-face interaction and online learning [33,38,39]. Also, in the definition of new AE curricula planning strategies, students social support should be considered [19], as some studies indicate that well planned integration of ICT into the AE result in maintain or improve communication and peer learning [34,35]. This necessitates institutions to provide training for educators to incorporate ICT tools and systems in their teaching methods [10,20,24,26,27].

Furthermore, since the design studio is the heart of AE [11,53]. Challenges emerged from the pandemic experience related to the design studios in some studies such as miscommunication between students and educators [10,14]. However, some studies indicated the existence of a generation gap in which students positively evaluated virtual design studios in contrast with educators that preferred the more traditional physical design studio [34,35]. Asadpour [19] called for a strategic planning that would encourage every-one to revisit the interactive space of the virtual design studio [19], and the integration of AR and VR which are no longer bound by technical limitations [35]. This stresses the necessity for providing training to educators in distance teaching methods using ICT. Also, implementing blended learning could also improve design studio classes with online technologies benefits [30,38], such as independency of time and place that directly promote networking and transdisciplinary in AE. Accordingly, a demand to recreate the procedural and physical design of open spaces and buildings using the expertise from Covid-19 to produce a friendly living environment in situations like the pandemic [26].

While earlier experiences must not be forgotten, acknowledging the loss of the stable state is the most important first step. There are numerous potentials to influence AE's future. Educators, students, and institutions must carry these potentials forwards [3,4]. This model aims to answer a call for critical transformation of the field. While several opportunities of this model are presented, there are still some challenges that are visible, further research to overcome these challenges is necessary, as speculation due to worldwide hazards is to yet have a large repercussion on education in the future. The aim remains is to develop a modern architecture education framework that is built on the foundation of the pandemic experience, inclusive and responsive to technological advances, and flourishes in a comprehensive transdisciplinary education ecosystem, this is based on well networked ecosystem, exploration of knowledge, and flexibility/adaptation of curricula in AE. This is an opportunity that should be pursued by striving to reinvent the future rather than attempting to retreat.

6. Conclusion

While remaining aware of the challenges that have been raised by the Covid-19 pandemic, several opportunities emerged by online/distance and blended learning implementation globally, accelerating the transition to their teaching/learning methods for AE. This study suggests an educational approach, in which learning design elements are in the centre of the educational triangle of networking, exploration, and flexibility/adaptability. This triangle aims to promote efficiency addressing current and future issues of AE, interactions between students on local and global scale, interactions between students with adaptable/flexible learn-
ing design elements and exploring new bodies of knowledge along with exploring career opportunities. In addition, digital technology, and new ways of utilizing them are expected to result in new forms of learning and learning environments [44]. Information and communication technologies (ICT) educational models must be leveraged to create fundamentally flexible and adaptive educational experiences and programs.

Architectural education is well positioned to lead the change in redefining education as action, using a paradigm that spans knowledge, disciplinary, and academic divides and combines scientific rigour with innovation and intuition [46]. As a result, architects will have the chance to develop the ability to respond to complicated, ever-changing conditions and transform them into emergent, ground-breaking architecture that illuminates a more promising and fascinating future. This study presents an educational approach using the Lego set education model to foster the integration of transdisciplinary approaches in creative fields such as AE, which could find an answer to the complexity of the AE paradigm. This study also proposes a model for AE learning design, based on the opportunities presented from the pandemic, while facing some challenges as a result from the pandemic experience.

While these findings cannot be generalized to AE around the world, they provide a promising preliminary platform for mapping future post-pandemic AE. The model presented is based on a theoretical approach that is not yet tested practically. AE contemporary challenges and opportunities were identified and inspired by the previous work of Salama et al. [3,4]. Accordingly, in future work, a systematic mapping study to conduct contemporary challenges and opportunities of AE is required. Strategies that can embrace blended teaching and learning methods by renovating both spatial and procedural design of open spaces and buildings that help prevent a pandemic like the Covid-19. Further research into a detailed implementation framework that takes advantage of the potentials of this model is required. Thus, the road to renovating AE in a post-pandemic digital age is still evolving.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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