Studio-based architecture pedagogies in the new normal

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Abstract: The COVID-19 pandemic struck in early 2020 and forced entire communities into widespread social distancing. This impacted education with the cancellation of face-to-face learning and a turn toward online, remote, and digital platforms for teaching and learning. The impact of this was heavily felt in studio-based subjects such as architecture, where working exclusively within the digital environment can reduce discursive qualities, limiting material observation, fabrication, and assembly as part of an evidence-based design argument. As programs and professors attempted to transpose their courses and assignments into an eLearning solution, they faced the challenge of meeting or reconsidering traditional approaches, supporting infrastructure and their definition of 'making culture' in the context of a professional architecture degree. This paper presents findings from an ongoing research study investigating student reported perceptions toward novel teaching pedagogies.

Keywords: architecture education; haptic knowledge; design technology; eLearning.

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1 Introduction

eLearning has steadily advanced and been adopted as an ideal instructional method in many educational settings (e.g., Chang and Hwang, 2019), although turning to eLearning may create an amount of technostress that can impact learning performance in the initial period (Mehrolia et al., 2021). A systematic review conducted in 2008–2012 among seven well-recognised social science citation index (SSCI) showed that mobile learning can be beneficial to foster learning outcomes, study motivations, and interests in learning (Hwang and Wu, 2014). Technology and new media forms advance, they can be found to "transform traditional teaching practices into constructivist practices" (Lam et al., 2021). This paper matches the eLearning and post digital paradigms together in the context of studio-based activities such as those found in professional architecture programmes. To continue quality enhancement of effective teaching and learning practices, it serves to raise awareness into the benefits of discovery learning with a focus on technology, both in- and out-side of the classroom environment. This is particularly critical during remote learning – as the 'new normal' re-defines teaching and learning protocols.

The paper is directed toward the question of technology adoption, problem-based learning, and the limits of eLearning for studio-based activities. It hypothesises that design studio pedagogies are traditionally based on 'haptic learning' (hands-on approach), grounded in exploring physical materials and assemblies. While eLearning is a maturing area for teaching lecture-based topics, it is less equipped to handle the testing, making, and assembly of physical objects. However, new pedagogical methods and technologies adapted for remote learning such as photogrammetry, 3D scanning, and rapid prototyping can be introduced to enhance studio assignments and projects while the physical classroom environment and facilities remain closed to students. This allows students to remain engaged in material making activities – such as creating physical study models, scanning, abstracting, collaborating, designing, and revising in an eLearning context.

Before the global COVID-19 pandemic, Hong Kong underwent an extended period of severe social unrest resulting in the wholesale closure of university campuses in November of 2019 and not reopening until January of 2020. Although unrelated to the impending health crisis, this set the stage for a challenging cohort of teaching and learning practices, with programmes already attempting to mitigate communications, delivery, and assessment of academic materials with empty classrooms, labs, and studio spaces.

The COVID-19 pandemic subsequently struck Hong Kong in early 2020 and resulted in the necessity for widespread and strict social distancing. This impacted education at all levels with the cancellation of face-to-face learning and turning toward online, remote, and eLearning platforms (Gyurkovich, 2020). In universities, the impact of this was heavily felt in studio-based subjects such as architecture and visual arts, where working exclusively within the digital environment can create "an illusion of rigor, which obscures the role of active critical assessment" (Reiser and Umemoto, 2014). It can be considered that without the integration of physical and material testing, student design proposals can lack the critical evidence necessary for design ideas to transcend beyond theoretical – a key component in traditional architecture studio coursework.

The studio represents a physical environment for students to conduct their research and develop design approaches in a variety of mixed media such as physical model making, drawing, etc. Students were also locked out of their fabrication facilities –

another key component to architectural design learning which can be considered as an extension of the studio environment. Without these spaces, programmes needed to quickly adapt their pedagogical approaches, and rework assignments and assessment criterion to accommodate a socially distanced academic term.

2 Literature review

Blended learning, defined as the fusion of face-to-face and online learning experience, has been gaining wider adoption since the late 1990s with the introduction of the internet (Skrypnyk et al., 2015). Early use of blended learning tended to be one-way (e.g., broadcasting content via TV network) or asynchronous (e.g., mailing CD-ROMs to students). The rapid advancement of communication technologies, most notably video conferencing technology, has made interactive, synchronous online teaching and learning possible without meeting face-to-face.

The potential of blended learning to make higher education much more effective is widely recognised by education scholars (Garrison and Vaughan, 2012), as it can integrate the strengths of both the online and face-to-face approach. According to the 'community of inquiry' framework proposed by Garrison and Vaughan (2012), a successful blended learning experience contains three key elements: social presence, cognitive presence, and teaching presence. With suitable pedagogies and technological competence, it is possible to create an engaging community of inquiry among students and teachers.

In the wake of the pandemic, others in architectural education and higher learning have documented their immediate need to impose online learning. One major shift in architectural education was the lack of laboratory-based classes and a shift to exclusively online communications (Gyurkovich, 2020). Some sited more fundamental issues with online course delivery such as basic internet connectivity and issues relating to student attention, attendance, and reluctance to actively participate in dialogue traditionally held during face-to-face learning (Zulkeply et al., 2021). Overall, eLearning is embraced as a positive tool for the enhancement of architectural education, as information and communication technology can assist students, however, online experiences are noted as sufficient, but not fully replacing more hands-on activities traditionally found within the studio or laboratory environment.

While it is generally accepted that online learning can make education more widely inclusive, accessible and can be a useful substitute when face-to-face classes is no longer feasible (such as during the COVID-19 pandemic), not all higher education institutions have realised the fullest potential of blended learning in the curriculum. Part of the reason is the rigidity of traditional pedagogical approaches that are ill-suited in a digital age. Limitations of current technology have also played a role. With reference to Laurillard's framework (Laurillard, 2002), some media forms (e.g., narrative, interactive, and communicative) can be well served with existing tools (e.g., instant messaging, video conferencing, CAD software), yet others (e.g., adaptive, and productive) are much harder to achieve in an online setting alone. Unequal access to technology such as 3D scanners (Figure 2), virtual reality (VR) and augmented reality equipment among students and varying technical competency among teachers also poses a challenge to the wider implementation of blended learning.

An interpretivist paradigm of education research is suitable for an evaluation of the signature pedagogies in architectural design studio and enables researchers to seek "rich descriptions of complex phenomenon". Broadly speaking, such evaluation seeks to understand what participants feel, know, and do. This study made use of questionnaires to collect data on what students and teachers feel. Student performance is collected and compared to assess their understanding of coursework. Students' engagement statistics in online learning management platforms were also analysed to assess their activities. The proposed mixed-method approach gave a holistic evaluation of blended learning in architectural design studios.

Studio-based teaching and learning in architecture is unique in developing essential qualities among students, summarised as the 'making culture' in this study. These qualities include craftsmanship, design thinking, problem solving, and adoption of an action-based iterative approach (Fingrut et al., 2019). Pedagogical styles in studio are designed to mimic similar environments found in professional practice and are considered "ubiquitous in the discipline and associated somewhat uniquely with the profession" (Shulman, 2005). The focus of this study is on the 'signature pedagogy' (Shulman, 2005) of design studio which highlights:

a knowledge development through peer learning

b skills development through new workflows

c professional preparation.

Pedagogical approaches can be further broken down into activities associated with teaching and learning exercises (Table 1). These activities are used as methods for students to gain exposure and confidence in tasks they will encounter in professional practice, as well as aligning with evaluation criterion for professional accreditation. This study places emphasis on media forms categorised as *adaptive* and *productive* most associated with learning activities such as experimentation, practice, articulation, and synthesis. These aspects engage with learning activities requiring physicality and spatial conditions contained within studio environment, fabrication laboratory or in the field. In contrast, *narrative, interactive* and *communicative* media forms are linked to lectures, literature reviews, tutorials, and discussion groups – items that are less associated with hands-on learning.

In 2002, Laurillard published a framework of five principal forms of media analysis along with matching media forms. The forms are listed as narrative, interactive, communicative, adaptive, and productive. The framework was used to categorise media forms and cross referenced to the pedagogical approaches found within architectural studio pedagogies. The preliminary three forms can be cross referenced to activities conducted through eLearning, such as lectures, literature reviews and discussion groups (Zulkeply et al., 2021) Those activities are a somewhat natural fit for eLearning and eLearners as they are associated with "intentional use of networked information and communications technology in teaching and learning" (Naidu, 2006). However, *adaptive* (experimenting and practicing) and *productive* (articulating, expressing, synthesising) traditionally require a studio or laboratory environment. They are associated with student activities such as drawing, surveying, prototyping, fabricating, physical testing and assembling of material. These key *making* activities are critical to signature studio pedagogy and are not natural candidates for being conducted under remote learning conditions (Zulkeply et al., 2021).

This condition is not exclusive to the signature pedagogy of architecture, as other fields also experience the pedagogical need to integrate physical action and sensory experience as part of their teaching strategies. Research into electrical engineering eLearning pedagogies has found that the blending of "seamlessly dynamic, interactive … multimedia content with practical hands-on engineering experimentation" (Kivaru et al., 2016) is most effective in memory retention among students.

Table 1 The summary of the signature pedagogies in architectural design studio

Category	*Pedagogy*	*Media forms*	*Traditional methods*	*Innovative methods*
Observe	Data collection	Interactive	Web/library	Web
Observe	Documentation	Adaptive	Photography	Web
Observe	Surveying	Adaptive	Physical measurement	Web referencing
Observe	Field studies	Adaptive	Physical observation	*Limited with eLearning*
Design	1 on 1 desk reviews	Communicative/adaptive	In studio/multimedia	Web
Design	Discussions	Communicative/adaptive	In studio	Web
Design	Group pinups	Communicative/adaptive	In studio	Web
Design	Reviews	Communicative/adaptive	In studio/presentation	*Limited with eLearning*
Design	Diagramming	Adaptive/productive	Studio/digital	Digital
Build	Prototyping	Adaptive/productive	Workshop/lab/studio	*Limited with eLearning*
Build	Drawing/sketching	Adaptive	Physical production	Digital Production
Build	Fabrication	Adaptive/productive	Workshop/lab/studio	*Limited with eLearning*
Build	Physical modelling	Adaptive/productive	Workshop/lab/studio	*Limited with eLearning*
Build	Testing revising	Adaptive/productive	Workshop/lab/studio	*Limited with eLearning*
Build	Drafting	Productive	Studio/digital	Digital

3 Method

The research study presented focuses on pedagogical practices employed in the delivery of two traditionally studio-based courses within an eLearning and hybrid learning context. It takes into consideration media forms and learning activities found in Laurillard's framework and when possible, adapts using non-traditional equipment and teaching methods. The course program, projects, and assignments focus on discovery learning through exposure to new tools and workflows. They emphasise the development of an original design position and proposal through an iterative, evidence-based series of deliverables.

The pedagogical approach focused on three main categories of an iterative design method: observe, design, and build. An elective course, digital design problem solving and graduate level advanced architectural design Studio were used to adopt the framework. The courses ran in synchronised online virtual learning format and emphasised the following three critical components: *scanning* (observing) of analog and physical phenomenon, *designing* based on those materials scanned, along with a discovery learning process focused on 'new tools and workflows' and *building* original creative works. This three-step process was embedded into assignments as part of a problem-based learning approach.

Traditional approaches to teaching architectural studio have a longstanding commitment toward the cultivation of a 'making culture' within their student body. The critical aspect of collecting preliminary design research through the act of observation is taken directly in this context through the literal scanning of material objects. The 'digitisation of things' is a critical step in integrating design pedagogies into the eLearning context, and 3D scanning technologies were made available to students with a sense of economy and practicality (Mizban and Roberts. 2006). Students were able to borrow equipment through an online reservation system to take home to conduct their scanning assignments. This was conducted through strict protocols for pickup and return along with cleaning materials included with the scanners.

Three micro-modules on 3D scanning technology were developed and introduced to students. The hardware included with low-cost, high-resolution scanning equipment for deployment in remote learning and socially distanced conditions (Figure 1). Photogrammetry using conventional cameras such as mobile phones was also included in the learning modules. Photogrammetry, however, offers a lower cost and accessible alternative to more professional scanning equipment.

The intent of this equipment and module setup was to enable students to introduce physical objects more smoothly and accurately into the digital environment. Further supplemented by computational tools and rapid prototyping, students were led to think ambidextrously about technology as output devices and as conduits for further design exploration, observation, analysis, and communication. Three main objectives of the teaching modules consisted of:

1 model preparation – observations and analysis of surface typology, dimensions, and complexity

2 scanning methods – balancing required detail, file size and workability based on the density of the point-cloud produced

3 post-production and optimisation – for integration into design investigations, communications, and rapid prototyping.

The second component of this iterative process is categorised as *design*. It is instantiated by the previous observed material, adding more intimate knowledge and insight gained through the data collection process. The method is broken down into a series of critical steps described in the Signature Pedagogies (Table 1) as being primarily communicative and adaptive. The mechanics of these activities entail:

a the abstraction of observed phenomenon into a diagrammatic format

b derivation of critical insights about what has been studied

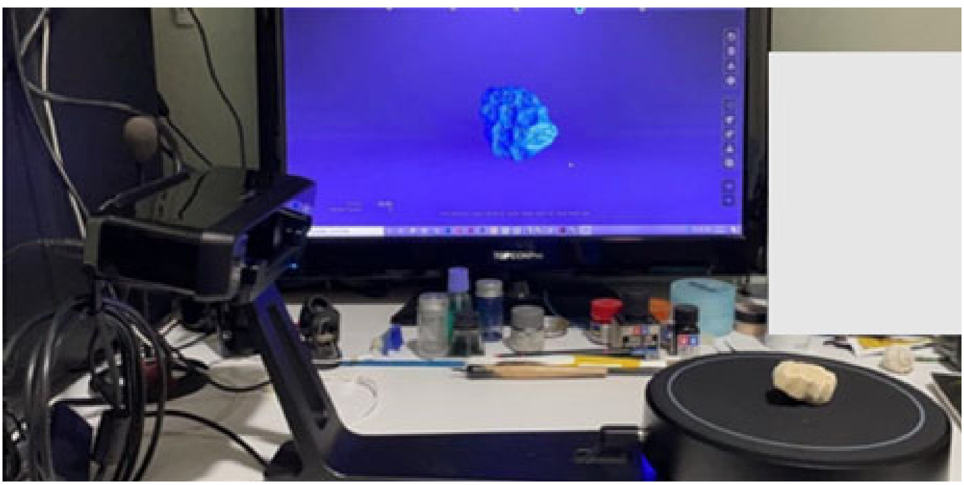
c discourse with peers and instructors

d the exploration, development, and refinement of an original workflow

e the preparation of a revised model for subsequent production and output.

In traditional face-to-face learning, these activities would be conducted in a studio or lab environment, where individuals and groups discuss, plan, and coordinate further design research, action, and production. However, under social-distancing measures, they are conducted over online and eLearning platforms such as zoom, blackboard, mural, WhatsApp, and various other filesharing tools accessible to students. Virtual reality (VR) setups available on extended loan from the School of Architecture linked to digital models would also allow for students to collaboratively explore, communicate, and revise their design work within an immersive environment (Figure 2). Upon this digital substrate, students applied their modifications as part of the individual design tools and methods they were exploring. This unique approach entailed the exploration of drawing and design tools – a declared technical and thematic practice throughout the studio, with a mandate to explore, test, and document the limits of those methods resulting in a matured design model. Documentation included more abstract entity relationship diagrams along with more conventional graphic imagery (screenshots, renders, etc.) They then applied and prepared those adapted models for physical production and output.

Figure 1 Remote 3D scanning setup from student residence (see online version for colours)

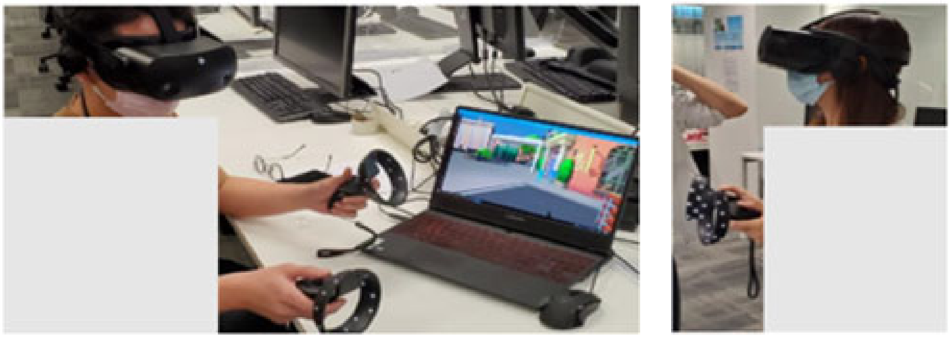


Notes: An illustration on the desktop 3D scanning devices in use at a student residence. The student had borrowed the equipment from the School of Architecture inventory and taken home for their own material exploration and integration into their design activities.

Source: Hong Kong (2020)

The third component was entitled *build* and formed the basis of a critical point in student work – as they took output from previous mostly digital steps and reform back into material models. The prototypes students produced framed another argument to include in students iterative design methodology. Their material formation and assembly successes and failures created an evidence-based record of haptic knowledge gain. The studio position explicitly expected students to illustrate iterations of material failure as opportunities to define limits, revise design and gain knowledge for future use and sharing.

Figure 2 Student VR equipment linked to the 3D design environment (see online version for colours)



Notes: An illustration on the usage of VR equipment in the learning process. Students connect VR headsets that link into an immersive 3D environment linked to standard architectural design tools for exploring, simulating, modifying, and communicating over the internet.

Source: Hong Kong (2020)

Figure 3 Student home produced prototype using 3D printing and concrete (see online version for colours)

Notes: Illustration of home-produced prototypes using 3D Printed formwork and Concrete. Students develop their designs digitally and use rapid prototyping fabrication services that can deliver materials direct to their home. This material is then used for the manual creation of original works as cast prototypes.

Source: Hong Kong (2020)

In traditional face-to-face learning, these activities would be conducted in a studio and lab environment, where individuals and groups could access fabrication equipment. However, under social-distancing measures, they were mostly outsourced by students or conducted entirely at home using a combination of rudimentary tools, materials, and outsourced rapid 3D-prints (Figure 3). 3D printing and other fabrication facilities surrounding Hong Kong have made rapid prototyping a straight-forward procedure, including file processing, fast home delivery, and reducing the need for students to use university equipment. This was a cost-effective alternative that allowed students to work with raw materials without entering campus or gathering in buildings.

Students formally submitted their high-resolution weekly output and presentation files via an online learning platform (Blackboard). Additionally, weekly reviews were conducted online to minimise physical contact between participants. This 'virtual pinup' emulated what might occur in a physical setting allowing students and instructor to simultaneously review and discuss the output in high resolution. Students were tasked with presenting their work in a linear fashion using standard presentation software – outlining their process in three major ways:

1 A thorough quantitative explanation and technical report of their weekly activities highlighting detailed steps, learning achievements, and the limits of the technology being used. The report would discuss the ‘novel tools’ that individuals had been researching and declare updated holistic workflows being developed and integrated with those tools. These documents typically included more candid images of student in-progress work, screenshots and entity relationship diagrams articulating workflow between systems. Students would also include details about their technical troubleshooting experiences and list key resources and learning tools that they encountered.

2 A qualitative explanation of final output was also expected to be given by each student.

This was an opportunity for them to discuss ‘how they felt’ about the production, its strengths, weaknesses, and to declare of how they might continue to develop those areas of interest further in subsequent assignments.

3 This online review process also included aspects of peer review – as students were required to engage in questions and commentary about each-other’s work. This process acted as a passive participatory measure and strengthened the general knowledge transfer between peers and faculty member.

This weekly process was conducted to develop and strengthen student confidence in presenting their ideas and design thinking. The grounding of their design work in an ‘evidence based’ approach, rather than ‘conceptually driven’ allowed them to focus and reflect on actions done through assignments and to generate knowledge for sharing and injection into future assignments – forming the fundamental basis of design practice. These meetings were further supplemented with more periodic reviews with invited experts and critics.

The collection of assignments as the overall ‘program of work’ throughout the course was continually increased from simple, smaller scale output provocations toward larger collections of material assemblies. This process would form a series of evidence-based, technical, and qualitative arguments, and a body of work associated with the buildup of a practice at an ergonomic and architectural scale. A final major provocation was then posed to students as a significant architectural project, encompassing expected requirements to meet technical, graphic, modelling, and conceptual developments commensurate with professional accreditation standards.

Critical to note in this process is that no case study assignments are given. Although references are highly encouraged, students are instructed to form their own basis for design exploration and not adopt one from another practice. This is seen as disruptive to the development of the unique design methodology students were adopting. However, these activities are replaced by invited consultations and correspondence with industry technical experts, such as structural engineers, practice-based architects, and others who can offer practical direct advice and strategies to students as they develop their projects further. This strategy greatly assists in providing a singular focus for students on their own original work.

3.1 Additional feedback from students

The project presented focused on pedagogical practices employed in the delivery of two traditionally studio-based courses taught to graduate level Master of Architecture Students in Hong Kong. The programme is professionally accredited with the Hong Kong Institute of Architects and Royal Institute of British Architects. The courses focus on the investigation and discovery of novel tools by students as a conduit for exploration and the development of an original design position and proposal. This was conducted to study and emulate traditionally face-to-face learning activities with eLearning and hybrid pedagogical approaches in the context of COVID-19 social distancing measures.

Each of the 12 assignments was paired with an open problem/provocation focusing on output such as life drawing, surface model, volumetric model etc. Each subsequent assignment was introduced with the following statement “with knowledge gained from previous course activities”, as the challenge and complexity of the open problem would increase. For example, in a one-week exercise, students would develop a system for designing a tile element, and to build a tectonic system for assembly into a wall in the following week. This trend would work from small to big, flat to volumetric, and from simple to complex and specific. Every assignment was accompanied by a physical output requirement to be re-scanned, analysed and integrated into subsequent design activities throughout the remainder of the term. This process description is parsed into discrete steps but is presented and executed by students in a more holistic and fluid fashion.

Two questionnaires were given to the students at the beginning and end of the term. The first asked students to discuss their initial interest and aptitude toward technological tool adoption and integration into their design explorations. It also asked for details about their initial relationship with design technology, preferred tools, and expected outcomes from their use. The second asked to provide a reflection on their experiences in adopting new tools, details of the type, learning resources and how their impressions may have changed through their coursework.

4 Results

The 87 participating students were invited to complete a short questionnaire at the beginning of the academic term. Specifically, students were invited to respond to two questions. The first one being: *What types of tools are you most interested in exploring further as part of your digital skillset,* and the second: *What tools do you think are most applicable for your professional development*. These questions are important to understand student habits and the perceived value of integrating tools and technology into their learning experience. Students could choose more than one option from each question based on the variety of tools and avenues for technology exploration within the programme.

There are more students who expressed their interest in learning the related tools, in fabricating (N = 69), assembling (N = 49), analysing (N = 53), and simulating (N = 55), but not in scanning (N = 32). One student provided an additional option to learn about VR and augmented reality tools (see Table 2).

Table 2 The summary of the response to question 1: what types of tools are you most interested in exploring further as part of your digital skillset?

Options	*Category*	*Interested*		*Not Interested*		*Total*
Fabricating	Build	$N = 69$	79.31%	$N = 18$	20.69%	$N = 87$
Assembling	Build	$N = 49$	56.32%	$N = 38$	43.68%	$N = 87$
Scanning	Observe	$N = 32$	36.78%	$N = 55$	63.22%	$N = 87$
Analysing	Design	$N = 53$	60.92%	$N = 34$	39.08%	$N = 87$
Simulating	Design	$N = 55$	63.22%	$N = 32$	36.78%	$N = 87$
Other		$N = 1$	1.15%	$N = 86$	98.85%	$N = 87$

To further understand the data, the options were further grouped according to the observe-design-build model (see Table 3). Specifically, the observe component consists of scanning, the design component consists of analysing and simulating, and the build component consists of fabricating and assembling. Most students are interested to learn how to build (N = 118) and Design (N = 108), but only 32 students choose to learn how to Scan with technology. Yet, because of the varied number of options in the model, we have taken the average number of each item.

Table 3 The summary of the subsequent analysis of question 1

Category	*Interested*	*Not interested*
Observe	$N = 32$	$N = 55$
Build	$N = 118/2 = 59$	$N = 56/2 = 28$
Design	$N = 108/2 = 54$	$N = 66/2 = 33$

When asking about the perceived usefulness of tools in their development, the majority of students selected scripting tools as useful (N = 70 selected and N = 17 not selected). There are almost similar numbers of students selected and unselected the Analysis tools (N = 42 selected and N = 45 not selected), the CNC fabrication tools (N = 43 selected and N = 44 not selected), and Simulation plugins (N = 43 selected and N = 44 not selected) as applicable to professional development. However, there are more students who do not select 3D scanning tools as useful (N =33 selected and N = 54 not selected). This finding indicated that courses should emphasise the applicability of tools for their future development (see Table 4).

Table 4 Summary of the response to question 2: what tools do you think are most applicable for your professional development?

Options	*Category*	*Interested*		*Not interested*		*Total*
Scripting (grasshopper, python etc...)	Design	$N = 70$	80.46%	$N = 17$	19.54%	$N = 87$
Analysis tools	Design	$N = 42$	48.28%	$N = 45$	51.72%	$N = 87$
CNC fabrication tools	Build	$N = 43$	49.43%	$N = 44$	50.57%	$N = 87$
3D scanning tools	Observe	$N = 33$	37.93%	$N = 54$	62.07%	$N = 87$
Simulation plugins	Design	$N = 43$	49.43%	$N = 44$	50.57%	$N = 87$
Other		$N = 1$	1.15%	$N = 86$	98.85%	$N = 87$

When further categorising the options according to the observe-design-build model, most students perceive that learning how to Build is applicable for their professional development (N = 112), and then Design (N = 76). Only 43 students perceive that learning to scan with technology is useful in their future development. Because of the different options fall into the category of the observe-design-build model, we calculated the mean number of each component.

Table 5 The summary of the subsequent analysis of question 2

Category	*Interested*	*Not interested*
Observe	$N = 33$	$N = 54$
Build	$N = 43$	$N = 44$
Design	$N = 155/3 = 51.67$	$N = 106/3 = 35.33$

5 General discussion

Students had initially declared a relative disinterest toward investing time in scanning (observing) and building (making) for prototypes, models, and assemblies. From this we can gather that their initial perceived emphasis of architectural studies within a studio course is expected to remain firmly in the realm of 'design' (diagrammatic, abstract, and conceptual in nature). Scanning (observing) natural phenomenon was also less of an interest as few student participants had been exposed to 3D digitisation equipment later introduced in assignments. It may also be the case that students perceive 'build' components as derivative. For example, they may feel that activities such as model making are a final act or deliverable after design work has completed, with little connection toward how knowledge gained through physical production can be re-inserted back into the design process.

The methods discussed through this research consider the three aspects of scan, design, and build as components within a singular iterative, cyclical, and fluid system for teaching. By considering student assignments, projects, and programmes with this framework in mind, they may be led to think differently about the significance of production, and subsequently how the act of prototyping, making, and assembling can be re-inserted (through scanning and observation) back into an iterative process.

One observed limitation to this approach, is the significantly increased amount of time, energy and money students had invested into productive (build) aspects of their assignments. Although this resulted in a large amount of student physical output and newly developed technical capabilities, the design work itself would often be developed without sufficient context. For example, students may develop innovative and original methods to design and construct a chair prototype, but ergonomics and other qualities may have been overlooked (resulting in an uncomfortable final prototype). These may be addressed by increasing design cycle iterations on a single project, with multiple consultations with a more diverse collection of invited critics.

Students did not perceive the applicability of technology integration with their future development into professional practice. This is an issue that is being broadly discussed across many disciplines in academia, as the need for computational literacy remains pervasive into the future. Specifically, in architectural education, this disparity between student expectations of professional practice, and their impressions of technology adoption in the industry are primarily due to a lack of direct discourse between the two. Furthermore, while professional practice in architecture is motivated to continuously upgrade its technological footprint, the phenomenon of hiring innovative design thinkers with some experience in digital tools adoption could be cultivated locally through graduates.

A few compelling ways to bridge this gap may be to:

1 consider the types of external consultants and guests who can encourage and offer similar experiences from professional practice

2 provide or suggest opportunities for students to translate knowledge gained through academic coursework as part of their own professional practice.

A compelling way of bridging this gap is to encourage and help to create opportunities for students to carry their work into the field after graduation. By framing design thinking as a practice-based activity, that is crafted over a career's worth of iterations and opportunities to gain new knowledge through experiences of success and failure students may take more ownership over their intellectual growth as a body of work and experiences.

6 Conclusions

The impact of eLearning has steadily increased as technology adoption has become more widespread in the academic experience for university students and teachers. It has shown to provide novel and effective learning benefits when combined with traditional methods of teaching and learning. This study matches eLearning and studio-based learning activities such as those found in professional architecture programmes and others grounded in material assembly. What makes this research unique is the focus on studio-based learning environments, where haptic knowledge gain, and physical and material explorations are intrinsically tied to the traditional academic experience. The study explores the opportunities and limitations of online teaching tools that can focus on the cultivation of 'making cultures.' Through this discovery process, research findings add new knowledge in ways to effectively augment haptic knowledge gain through eLearning and hybrid pedagogies.

This knowledge benefits teachers and students by highlighting effective approaches in remote and hybrid teaching through technology adoption techniques. It allows them to transcend typical limitations found in eLearning usage as fundamentally a communication tool, and into the realm of physical and material 'making cultures' found through the traditional development of haptic knowledge (Mizban and Roberts, 2006). Finally, this study confirms that eLearning "can be an alternative or replacement for traditional learning methods" (Nejad and Nejad, 2012) by including more challenging topics linked to the physical, material and hands-on learning approaches typically reserved for laboratory and studio learning environments.

As part of future works, the authors are expanding research and technology adoptions in the areas of observe, design, and build in a hybrid or remote learning context. Additionally, the PI will further expand on the design aspects of the pedagogical system, breaking it down into more discrete components as part of enhancing 'design thinking' methods.

References

Chang, C.Y. and Hwang, G.J. (2019) 'Trends in digital game-based learning in the mobile era: a systematic review of journal publications from 2007 to 2016', *International Journal of Mobile Learning and Organisation*, Vol. 13, No. 1, pp.68–90, https://doi.org/10.1504/IJMLO.2019.096468.

Fingrut, A., Crolla, K. and Lau, D. (2019) 'Automation complexity: brick by brick', in Haeusler, M., Schnabel, M.A. and Fukuda, T. (Eds.): *Intelligent & informed: Proceedings of the 24th CAADRIA Conference*, Vol. 1, pp.93–102, Victoria University of Wellington, Wellington, New Zealand, 15–18 April 2019.

Garrison, D.R. and Vaughan, N.D. (2012) *Blended Learning in Higher Education: Framework, Principles, and Guidelines*, John Wiley & Sons, https://doi.org/10.1002/9781118269558.

Gyurkovich, J. (2020) 'New challenges in teaching architecture students in the third decade of the 21st century', *Global Journal of Engineering Education*, Vol. 22, No. 3, pp.162–167.

Hwang, G.J. and Wu, P.H. (2014) 'Applications, impacts and trends of mobile technology-enhanced learning: a review of 2008–2012 publications in selected SSCI journals', *International Journal of Mobile Learning and Organisation*, Vol. 8, No. 2, pp.83–95, https://doi.org/10.1504/IJMLO.2014.062346.

Kiravu, C., Yanev, K.M., Tunde, M.O., Jeffrey, A.M., Schoenian, D. and Renner, A. (2016) 'eLearning hands-on: blending interactive eLearning with practical engineering laboratory', *The International Journal of Information and Learning Technology*, Vol. 33, No. 5, pp.278–99.

Lam, P., Ng, H.K.Y., Tse, A.H.H., Lu, M. and Wong, B.Y.W. (2021) 'eLearning technology and the advancement of practical constructivist pedagogies: illustrations from classroom observations', *Education and Information Technologies*, Vol. 26, pp.89–101, https://doi.org/10.1007/s10639-020-10245-w.

Laurillard, D. (2002) *Rethinking University Teaching: A Framework for the Effective Use of Learning Technologies*, 2nd ed., Routledge Falmer, London.

Mehrolia, S., Alagarsamy, S. and Jeevananda, S. (2021) 'The dark side of technology-enabled teaching: impact of techno stress on student performance', *International Journal of Mobile and Blended Learning (IJMBL)*, Vol. 13, No. 3, pp.36–57, https://doi.org/10.4018/IJMBL.2021070103.

Mizban, N. and Roberts, A. (2006) 'The place of e-learning in architectural education-a critical review', *Communicating Space(s) [24th eCAADe Conference Proceedings*, Volos, Greece, 6–9 September 2006, pp.494–501, ISBN 0-9541183-5-9.

Naidu, S. (2006) *E-learning: A Guidebook of Principles, Procedures and Practices*, Commonwealth Educational Media Center for Asia (CEMCA).

Nejad, M.B. and Nejoad, E.B. (2012) 'Impact of e-learning on learning and realizing information society', *Research Journal of Applied Sciences, Engineering and Technology*, Vol. 4, No. 23, pp.5016–5020.

Reiser, J. and Umemoto, N. (2014) 'Some thoughts on pedagogy', in Spiller, N. and Clear, N. (Eds.): *Educating Architects: How Tomorrow's Practitioners Will Learn Today*, pp.212–219, Thames & Hudson.

Shell, B. (2014) 'The digital generation', in Spiller, N. and Clear, N. (Eds.): *Educating Architects: How Tomorrow's Practitioners Will Learn Today*, pp.138–143, Thames & Hudson, London.

Shulman, L.S. (2005) 'Signature pedagogies in the professions', *Daedalus*, Vol. 134, No. 3, pp.52–59.

Skrypnyk, O., Joksimović, S., Kovanović, V., Dawson, S., Gašević, D. and Siemens, G. (2015) 'The history and state of blended learning', in Siemens, G., Gašević, D. and Dawson, S. (Eds.): *Preparing for the Digital University: A Review of the History and Current State of Distance, Blended, and Online Learning*, pp.55–92, Athabasca University Press, Athabasca AB, Canada.

Zulkeply, N., Mat So'od, N.F., Mat Rabu, Z. and Sidik, S.I. (2021) 'Teaching architecture for tertiary students during Covid-19: issues & reflections', *Environment-Behaviour Proceedings Journal*, Vol. 6, No. 16, pp.55–60.