VIRTUAL REALITY AS A RESPONSE TO EMERGENT CHALLENGES IN ARCHITECTURAL EDUCATION

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Abstract

Though Virtual Reality (VR) has become a ubiquitous medium in a diversity of entertainment media, it has remained an esoteric platform for academic use. Digital technologies have become primary means of quotidian life ranging from online forms of entertainment (including video games and streaming media) to online shopping. The COVID-19 pandemic dramatically accelerated digital pedagogy at all levels of education, most notably in the post-secondary market, and specifically within the study of architecture. Architectural praxis has been generally quick to adopt technological innovations in the production and outputs of the built world, however it has been niche and its widespread adoption and standardization has been inadvertently challenged by a lack of unifying goals across all architecture organizations from academia through to professional practice. The pandemic has served as a tipping point in the advances in architectural education, specifically through the medium of VR. With its ability to immerse users in completely different environments and bring them together in a shared virtual world, VR is poised to rapidly become a commonplace venue for design education. From serving as a presentation platform to a developmental collaborative medium, VR is a robust, interactive platform that will become a part of the “new normal” long after the pandemic similar to the rapid and extensive adoption of videoconferencing tools during the pandemic.

This paper showcases the development of frameworks for VR use in architectural presentation and collaboration within Canada’s largest undergraduate architecture program. The paper aims to establish the challenges faced by architecture educators as the pandemic undermines conventional aspects of architectural education including faculty design critiques, peer collaboration, presentation media, and final design reviews. Through a series of examples developed in the immediate academic term after the global pandemic shutdown, the paper showcases the accessibility and potency of VR as a medium that rivals conventional architectural representation tools. The paper concludes with a series of suggestions on how VR may be used as a tool for three key components of architectural studio education: design development, design collaboration, and design presentation.

Keywords: Architecture, Pedagogy, Virtual Reality, Curriculum

1 INTRODUCTION

The ideas of representation using Virtual Reality (VR) and similar immersive technologies have been used in architecture for centuries. From Alberti’s perspectival drawings and Brunelleschi’s stereographic visualization, to computer graphics, various advanced representation techniques have been used by

architects to communicate imagined, existent, and conceptual designs (Hui, Estrina, Lee, Zhou, & Kinuthia, 2020). VR allows users to visually inhabit a space other than the one they are physically occupying by placing a headset in front of their eyes. VR is one of the latest techniques to be gradually integrated into the architecture, engineering and construction (AEC) industry, used primarily for final visualization of unbuilt spaces. Furthermore, VR can aid clients in gaining a better understanding of spatial qualities during the design process and is able to more effectively entice buyers with immersive representations. Architectural academia has also begun to implement VR into the core curriculum, allowing students to not only be able to use a new visualization technique within their studios and classes, but also be at the forefront of the industry's technological innovation.

2 METHODOLOGY

Design and studio courses play an enormous role within the framework architectural pedagogy. Such courses are generally project-based, with professors working individually alongside students to help education them. Studio courses go beyond the classroom setting, with design institutions providing students with dedicated workspaces in a shared studio area, giving them the opportunity to work both individually and in collaboration with one another. Therefore, studio becomes a platform for design collaboration and experimentation where students are able to develop into designers (Nijholt, Van der Veer, & Vyas, 2013).

On March 15th, 2020, Canadian post-secondary institutions transitioned their instruction to an online format due to the worsening of the COVID-19 pandemic (Silverman, Slbbald, & Stranges, 2020). Many design and architecture programs worldwide, including Ryerson's Department of Architectural Science (DAS), faced the challenge of adapting the studio methodology into a remote learning environment. Although many platforms of video conferencing and collaboration were implemented in order to facilitate such a transition, many such media were unable to successfully replace the physical learning environment the students and faculty were accustomed to. As a result, the implementation of VR became an imperative aspect of the remote instruction. The uses for VR in studio courses are threefold, for content generation or modelling, for remote collaboration with faculty and other students, and for representation of unbuilt student projects.

2.1 Design Development

Conventional model making or prototyping, in the traditional sense, is a long standing and well-established practice within the AEC industry. Within the initial design phases, concepts are constructed, formed, proposed, and composed (Asdelhameed, 2014). Architecture students use visual aids such as physical models, sketches, and drawings in presenting new designs, with their primary purpose being to visualize concepts in tangible media (Abdullah, Marasini, & Ahmad, 2006). The commonality of the tools at a global scale is due to the easy manipulation and development of materials such as cardboard and hand sketching. Malleable supplies are relatively inexpensive and easy to manipulate when rapidly iterating through architectural ideas. In addition, hand sketching and trace paper allow for ideas to be quickly illustrated and layered upon each other to enhance the development process. Using the aforementioned methods of iterative design, results in spontaneity and immediate feedback to both the designer and their peers while demonstrating the effectiveness of their design intentions. This classical paradigm of design has served as the basis of architectural design conveyance and precedes relatively contemporary methods of architectural communication and drawing conventions. Designers utilize representational environments to explore what is in mind to further develop ideas. Moreover, incorporating various representational and digital media, designers are able to gain further clarity and definition of their ideas at different stages of the design process (Asdelhameed, 2014).

Digital design integration has only accelerated with the pandemic as physical distancing and isolation has mandated a reliance on online operations (Silverman, Slbbald, & Stranges, 2020). With the transition to a remote workflow, many physical elements within education are undermined due to the lack of space and resources that are traditionally supplied by institutions. The ability to make physical models are limited due to the lack of tools, construction materials, and spatial limitations available to students while working in their respective spaces. Excellence in model making mandates a high degree of craftsmanship insofar as manual dexterity and an appreciation and patience in process and craft. Conversely with design, labour can be simplified, if not outright eliminated, and the focus can be placed upon design rather than technique (Abdullah, Marasini, & Ahmad, 2006). In the remote learning context, students are encouraged to rely more on 3D digital modeling to iterate and develop their designs. However, the nature of digital modeling does not create the same spontaneity and ease of manipulation as the physical model making process. In addition, digital models can develop to become complex and deemed 'precious', leading students to be reluctant when editing and modifying. A common problem with digital models is their lack of scale perception as they are not

tangible and are only seen through a screen. This is akin to the discrepancies between representations of buildings through simulated imagery and real life. Therefore, a void has formed with the omission of models as a design tool and the deception of scale from 3D digital modelling further disconnects the user from the creation and understanding of design ideas.

With the various delays and problems in academia prompted by the COVID-19 pandemic (Silverman, Slbbald, & Stranges, 2020), VR can be utilized as a replacement tool in an effort to address the limited ability for students to create representational models of their projects. This process is able to enhance the design process in creating full scale virtual mockups of designs and incorporating live feedback (Hui, Estrina, Lee, Zhou, & Kinuthia, 2020). VR has been extensively used in design and visualization, as it has increasingly becoming easier and cheaper than building or modifying a physical model (Asdelhameed, 2014). Virtual Reality Environments (VREs) serve as a platform whereby students can create full scale models affording designers an ability to collaborate, investigate, and generate design iterations. This paradigm emulates the demands of professional practice which call for rapid and accessible design development. Early visualization at this scale allows designers to recognize any errors within the design at an early stage and in turn saves time if fixes are needed later in the project timeline. The massive expenses of model making and utilization of machinery can be diminished with the transition to VR, with much of the software and hardware provided on a discounted or educational basis. As presented in "An Analysis of the Applications of Rapid Prototyping in Architecture," a study took place comparing the traditional methods of model making with fused deposition modelling (FDM) prototyping with both procedures expending up to 9 days and costing over £1000 for a single architectural model iteration (Abdullah, Marasini, & Ahmad, 2006). Contrarily, digital 3D models have the ability to be manipulated and visualized through both the conventional rendering methods and through immersive VR spaces in 'real-time' feedback.

As a design tool, VR modelling allows for an immediacy in changes and visualization within a design workflow taking the benefits from physical model making and computer aided design (CAD). Students are able to explore conceptual models in a fully immersive environment that allows them to understand the project in three-dimensions and enhances the sense of scale and spatial awareness through taking account of head movement and hand tracking. In addition, VR can help architectural designers gain insight on how the spaces they design are being used to address programmatic and functional issues ranging from having visual lines of sight to addressing fire code compliance. Editing the 3D elements is possible using more intuitive means, such as grabbing and dropping, rather than filtering the process through a computer interface. Moreover, the enhanced experience gives a closer representation to the actual scale, giving more insight than conventional scaled digital models. During meetings for design feedback, VR can be utilized to help professors and peers understand and relate to a design within a virtual environment rather than relying upon drawings. This is especially useful for those who might not understand how to read drawings effectively (Alvarado & Maver, 1999). Where the conventions of architectural representation are codified within centuries of praxis, contemporary audiences demand accessible information. VR allows for three-dimensional creation to be experienced "directly through movement and interaction parallel to real world familiarity" (Hill, 2019). The use of VR and CAD software, paired with plugins, allow for a seamless collaboration of tools, simplifying the technical aspects of digital model making. Furthermore, the complexity in contemporary building designs, such as parametric modelling, are consistently and easily exemplified in digital visualization formats. Students are able to design in a virtual space and output models linked to their primary CAD software for further editing or visualization. Thus, VR becomes a discovery tool within the design process and helps to bridge the gap between reality and conceptual design.

At DAS, students utilized *MindeskVR*, a virtual environment modelling platform, that is integrated as a plugin within the modelling software *Rhinoceros3D*. The tool allows users to manipulate their designs in a VRE using basic modelling tools with live feedback. While in the VRE, students are able to interface with their creation, scaling and transforming their design in a free manner, which would be impossible through the medium of physical model making. Moreover, the modelling toolbars directly reflect those in *Rhinoceros3D* and make for a seamless transition to understanding how to model within the software with prior knowledge of tools. Modelling sessions are mirrored onto the desktop and act as a real-time preview of what users see while in a virtual space, allowing for peers to see and give feedback to the VR modeler. *MindeskVR* implements *Grasshopper*, a parametric modelling tool within *Rhinoceros3D*, granting users access to the adjustable slider nodes from existing scripts to see real-time changes of the parameters within the VRE (Fig.1). This is useful in giving designers the opportunity for fine adjustments to the parameters of the model while in virtual space. Once finished, users can end their session and review their design within *Rhinoceros3D*, transitioning seamlessly into the desktop interface. The employment of *MindeskVR* has allowed students to both view and edit their designs within a VRE, while being immersed in familiar CAD

software. Therefore, the tool becomes an extension of design capability rather than an additional software needing time to learn.

Fig.1. Students using *MindeskVR* in their modeling workflow

VR processes are also able to provide live feedback to the user while designing in a virtual space. With one-to-one spatial projections and real time rendering engines, students can easily experience their projects at any stage throughout the design process. The increasing efficiency of computing technology and rendering engines has now made advanced image production, within the realm of 'medium to high end' laptops, with live preview while the user is making changes. The exponential advancement of technology will only evolve the ease of visualization tools, and is initially stated in Moore's law: "the speed of computers, measured by the number of transistors that can be placed on a single chip, will double every year or two" (Mollick, 2006). Evidence showcased in Clark Cory's paper on "Architectural Illustration: The Advancement of Light, Shad, and Shows Knowledge with 3D Digital Technology," reveals the advantages of using digital means of representing "light, shade, and shadows" within architectural spaces to a realistic perception as opposed to traditional means of hand rendering (Cory, 2000). Rendering software are designed specifically to aid designers in realizing their spaces and to mimic the photorealistic qualities of materials. Their utilization within conceptual stages of design help designers plan perceptive qualities within their unbuilt space to reinforce their design intentions. Editability, in combination with VR's capability of immersive and interactive walkthroughs, give students a better understanding of their designs within the initial conceptual phases while showcasing the spatial qualities of their architectural models along with lighting and sensitivity to material palettes and processes.

An effective tool for process visualization added into the curriculum at DAS is *Enscape*, a real-time rendering software that is integrated into industry standard CAD software such as *Rhinoceros3D* and *Autodesk's Revit*. During the conceptual and schematic design phases, students are able to use *Enscape* to visualize their designs, analyzing elements such as lighting quality, spatial composition, and materiality (Fig.2). The ability to visualize while modelling simultaneously allows for students to better understand their designs, as modeling in CAD viewports does not emphasize visual qualities, instead they give the user insight on assembly and form. Although the workflow of combining rendering and modelling is not revolutionary, it has been made simpler and more efficient with real-time rendering technology, which significantly reduces rendering time in order for designers to cycle through changes rapidly, speeding up the design process.

Fig.2. *Enscape* material testing and manipulation in real-time previews.

2.2 Design Collaboration

The design studio framework relies on a feedback-based model, where students have one-on-one

conversations and critiques with their professors to develop their designs. Architecture studio is characterized by the conversations between students and professors. Such interactions are likened to those between a music teacher and student, in which “reflection in action” takes place (Ockman & Williamson, 2012). In these very open conditions, peer-to-peer interactions, following the Socratic method, become another staple (Ockman & Williamson, 2012). As students are expected to converse with their instructors throughout all stages of the design process, there is a frequent need for ideas to be discussed through on-the-go sketches and physical models. Non-verbal cues play a large role in discussions, as this accounts for 55% of one’s face-to-face communication (Gunhan, Senol, & Zeynep, 2012). A studio space tends to be a shared working area, so students find themselves discussing and aiding one another with their designs. Although an instructor’s comments and ideas are a crucial part of a student’s design development, feedback from peers also plays a significant role. Such conversations sometimes emerge by chance from encounters within the shared space, with quick discussions about design ideas. Occasionally, students are also required to work in groups on design-focused assignments. Discussions for the development of such projects commonly involve similar physical means of communication, but also require group digital modeling. 3D modeling becomes a challenge when a student must coordinate their process with peers, and as it frequently does not update on a live basis, the progress of the other group members is unclear.

When design education transitioned to the remote model with the COVID-19 pandemic (Silverman, Sibbald, & Stranges, 2020), much of the collaborative nature of design became much more difficult. Although video conferencing provided the ability for students and faculty to discuss and represent their ideas visually, the primary method of communication - drawing - became very demanding digitally. Without the common locale, the sharing of models became all but obsolete, as the qualities of three-dimensional objects do not tend to translate through video conferencing. In such a context, collaborative modelling becomes an entirely new challenge when working remotely, due to the miscommunication that frequently comes about without being in a shared space. There is a lack of awareness and visibility of what other collaborators are generating within the modeling environment, as when a change is made on one computer interface, it does not immediately appear on the other. Discontinuity proves harmful in the collaborative process and makes it very difficult to contribute meaningfully in the modeling process. In the remote learning environment, VR is able to play a large role in the collaborative process, not only to allow for designers to occupy the digital space but also to replicate some of the more traditional methods of communication, such as drawing and sketching.

With the rise of virtual conferencing over the past decade, it is unsurprising that VR meeting software has also entered the market. Such applications, also known as immersive virtual environment design studios (IVeDS), mimic their real-world counterparts in VREs (Schnabel, 2011). Although traditional media, such as video conferencing and online chat platforms, allow for physically distanced people to be aware of each other’s presence, which leads to “casual interactions, social browsing and peripheral awareness” (Nguyen & Tan, 2011). On the other hand, IVeDS platforms not only provide users with the ability to converse at a distance like their video counterparts, but also transport all the parties into Collaborative Virtual Environments (CVE) (Han & Turner, 2001). Rather than representing users in separate windows, CVEs project avatars of users in a shared VRE, providing opportunities for more traditional interactions (Nguyen & Tan, 2011). Capitalizing on the abilities of VR headsets and controllers, users are able to be visible to others within the CVE as avatars, mimicking movement and even speech. Additionally, these software packages allow for users to import media such as images, videos, and 3D digital models into the shared space for all users to see and interact with. Such tools become invaluable for architectural collaboration and communication especially within the context of online learning (Schnabel, 2011). Instructors are given the capability to discuss designs with students not only verbally, but also visually. By incorporating 3D models, drawings, images, and even the ability to convey non-verbal cues, the CVEs provide a near-accurate replication of the real-world studio environment, helping both professors and students feel more at ease and relieve the frustrating restraints of more common media forms of communication.

The VR meeting software *Spatial*, was tested at DAS to help transfer the in-person studio desk critiques to virtual conversations. Through *Spatial*, students were able to upload their 2D imagery, such as orthographic drawings and renders, while also uploading 3D models into the VR meeting rooms (Fig. 3). When instructors and other students joined the CVEs from their own VR headsets, they found themselves all in a shared space and were able to see all the work displayed. The group manipulated the content around them and annotated over the work, in a similar fashion to a typical studio setting. As a result, the discussion became significantly more natural and constructive in comparison to video conferencing, alleviating misunderstandings.

Fig.3. A virtual critique space within the *Spatial* software, with a professor and a couple of students examining models and images.

Several 3D modelling software platforms have initiated examining various collaboration capabilities. Synchronous modeling and Building Information Modeling (BIM) allow for the linking of various model components together, solely accounting for model collaboration with an absence of synchronous design discussions. When 3D modeling possibilities are introduced into CVEs, such capabilities are combined with synchronous modeling abilities. Collaborative VR modeling software creates platforms for designers and students to 3D model space while occupying it with others. These platforms are built into existing widely used 3D modeling software, so the learning curve in the transition from computer-based to VR-based modeling is diminished, while inter-software compatibility is increased. Not only are users able to discuss and iterate more effectively, similar to what would generally occur in a physical collaborative space, but they are also able to capitalize on all the previously outlined benefits of modeling in a VRE, such as the 3D-nature of the design process and live feedback. Additionally, several users are able to simultaneously see the progress of the other creators within the same CVE, allowing them to build off of one another's models rather than waiting for synchronization to occur, as is typical with computer-based collaborative modeling platforms.

2.3 Design Presentation

Although typically architectural presentations are done in a variety of more traditional media, VR becomes a valid and more effective alternative. Such a medium allows for those both within and outside of AEC praxis to readily understand the complexities of a design, and also enables any stakeholder to intensively examine and refine features shared by all proposals. In a typical architectural studio setting, the final presentation components include architectural drawings and physical models, complimented by 2D or 3D renderings. Although architectural drawings are critical in the construction of a built project, they do not provide much clarity on the spatial aspects of the design and are difficult to understand for those outside of the construction industry (Alvarado & Maver, 1999).

Although the aforementioned representation methods are traditionally used in the industry, they can be replaced and enhanced by the evolving VR technologies. While renderings serve as an effective tool to communicate the spatial and material qualities of architecture, still imagery on a screen does not provide as wholistic a visualization when compared to the immersion induced from a VR interface (Pausch, Proffitt, & Williams, 1997). Architectural rendering takes creative license with not only scale of space but also lighting, lenses, entourage, and context, making the imagery deceiving as to the physical realities of the design. With the use of VR, a user is able to achieve an accurate representation of the space, free from any of the artistic interpretations that frequently are incorporated into renderings. Unlike traditional physical modeling, VR can be easily modified in the final stages of the digital model's completion and can be altered up until the final presentation. While physical models offer the spatial qualities at a smaller scale, in a VRE the viewer can be fully immersed into the architectural space. The ability to provide a human scale experience incorporates various qualities of the space, such as lighting and materiality aspects, allowing viewers to form a more holistic and comprehensive understanding of the architecture. Although the use of architectural drawings are a necessity for construction, VR can help our understanding of the final project by being able to combine aspects of renderings and physical models. These components are the easiest form of visualization to understand for those outside of the AEC industry. VR software is able to represent designs into a medium where the clients and members of the general public are capable of easily comprehending the architecture, without any previous expertise in the discipline. VREs can be produced in various media, including 360 stills, animated walkthroughs, and interactive environments.

A ‘still’ or “static” VRE, a 360-degree image, allows for the user to be plunged into a panoramic space while being confined to a prescribed sphere of view. Stills can be easily incorporated into final presentations as they are simple to generate. They can be accessed on a smartphone without the need for a VR headset, making this medium more accessible for a greater audience and not as financially straining for the users. Despite the limited user control, stills provide viewers with an understanding of the scale of space, materiality and assemblies via the VRE. Additionally, they give the user the opportunity to control where the viewer is located and what they are seeing, hence providing a more curated experience of the design.

In the DAS curriculum, VR-based presentation is integrated as early as the first year of architectural studies. By making use of the straight-forward *YulioVR* platform, first year students are able to very easily generate static VREs for their presentations. *YulioVR* is a plug-in directly into commonly used modelling software, and function by rendering six conventional views, also known as a cubemap, and stitching them together into a 360-degree still image (Fig.4). As students are early in their architectural education, the ease of access for this platform aids them to rapidly generate static VREs from their digital models and successfully demonstrate their designs to a varied audience. (Hui, Estrina, Lee, Zhou, & Kinuthia, 2020)

Fig.4. A student's *YulioVR* - produced flattened still VRE image.

Within the presentation of virtual spaces, VR software can be used to extract the metadata from viewers to track where users focus their sight in the virtual space, represented in heat maps. The analysis helps to reveal the patterns of viewers' perception of the design, as well as their interaction with the space. As a result, designers will have data to showcase the efficiency of space utilization and provide data for development and validation of architectural intentions. At DAS, heat map analysis is utilized in the *YulioVR* software where students upload their VR still images to be viewed and shared among an audience. For a design project conducted by architectural science students at DAS, VR still images were utilized to give the clients a better understanding of the unbuilt spaces with the support of traditional still rendered images (Fig.5). After several viewing sessions by multiple groups of people, *YulioVR* was able to analyze 40 viewing sessions showcasing the heat map of the most focused-on and seemingly interesting elements of the architectural design.

Fig. 5. *YulioVR* heat map analyzer for DAS student design.

In contrast to their static still VRE counterparts, VR walkthroughs provide viewers the ability to maneuver and travel with greater freedom within a virtual space, on all axes. Such an experience provides a better understanding of the procession of spaces and spatial transitions within the design. In addition to the free maneuvering, the viewer is able to control various visual conditions of the environment, such as the time of the day or the seasons, in order to examine the solar implications of the design. Such additional interactive options significantly increase the insight into the design's materiality and spatial qualities.

Enscape, a real-time rendering engine designed for architectural visualization, is also used by DAS students to generate presentation materials. The software is capable of rendering images using technology similar to

modern video game engines to leverage the speed in rendering, allowing for the viewer to travel through spaces and examine their surroundings easily. In addition, students can create VRE's of their designs in *Rhinoceros3D* to view and present their designs to others. As a result of the software's integration into the department, the ability to create realistic representations has become easier and more efficient for students to utilize in design studio courses. Students are not limited to producing walkthroughs with this software, as they can also generate still images, animations, and VR images using *Enscape*'s intuitive tools in a reasonable time frame as opposed to waiting for extensive periods for renders to finish in a more traditional bucket rendering software (Fig.6).

Fig.6. Still views from a student's *Enscape* walkthrough model.

While primarily done within software geared explicitly toward architecture, multiplayer games have also begun to move into the realm of architectural VR visualization. Multiplayer social games function as VREs, providing various 'World' or 'Room' environments for players to visit and interact with, thereby bringing features of CREs into a malleable space. Within these environments, users are also able to converse with one another, attempting to closely replicate real-world social interactions. As these occupiable environments can be customized by players, students and faculty are able to generate such environments from existing digital 3D models of designs, thus creating multi-user occupiable spaces of their own creations. Virtually generated environments can then become architectural showrooms, allowing for any students, faculty, industry professionals or members of the general public to enter, explore, and stimulate a dialogue about its architecture. Retaining its capability to host multi-user access, such spaces double as a social platform for discourse and discussion of work, both within architectural studio critiques and more casual commentary outside of class hours. These game frameworks not only provide online hosting capabilities for models, allowing them to be easily transferable between devices, but also implement more interactive capabilities into the spaces, such as moving elements, lighting, and sound effects. These occupiable CREs are able to host multiple users, allowing for interaction with the design and the spaces and between the different users in this space.

In order to incorporate more multi-user interactions into VR experiences, the VR social platform *AltSpaceVR* was incorporated into the curriculum at DAS. Used by students for final presentations, they are able to guide visitors around their projects in VR providing the ability to not only traverse space within the environment but also converse and interact with others. In the remote learning context, *AltSpaceVR* provides presenters and reviewers the ability to inhabit the design and discuss it within the same software, removing the need for any intermediate platforms. As it was conceived as a social gaming software, *AltSpaceVR* incorporates not only traditionally VR headsets but also allows for computer viewing, eliminating the requirement for all users to possess a headset in order to participate in the experience. This is particularly useful when incorporating VR into the curriculum under remote learning conditions, as the majority of students and guest reviewers do not have access to expensive equipment at home.

Fig.7. Still views from an *AltspaceVR* tour of architectural projects by Arthur Mamou-Mani from the 2020 virtual Burning Man event.

3 CONCLUSION

Though the global pandemic has foisted a myriad of parameters defining the “new normal”, digital and online workflows have become a critical dimension to not only maintain currency, but to define advances in the near future. While VR introduced decades ago has rapidly shifted from an esoteric medium to an accessible and ubiquitous tool for entertainment, it holds the potential to address many of the shortfalls that have emerged in many collaborative design professions. Atop these disciplines is architecture. For a discipline entrenched in physical interaction and collaboration to suddenly face the prospects of its absence requires a rapid and appropriate response. While the authors of this paper do not contend that virtual reality holds the same value, impact, and experience as physical operations found in traditional architectural design pedagogy, they posit that the medium has a great deal of potency in not simply serving as an intermediate solution to this paradigm shift, but holds the potential to play a role in future pedagogical models well after the pandemic subsides. The outlined methods and outcomes of the initial investigations using VR in architectural education in the wake of the COVID-19 pandemic have been met with positive responses within the largest architecture program in Canada specifically within the framework of architectural design development, design collaboration, and design presentation. It is premature to extrapolate the value of VR integration in architectural pedagogy from these initial examinations however the outcomes of these exercises serve as a baseline for future design professionals and educators to draw upon in responding to, if not overcoming, the emergent challenges they face in an increasingly online landscape.

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