DEVELOPING INTENT AND APPLICATION THROUGH VIRTUAL DESIGN-BUILD

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ABSTRACT

The process of design-build links intention and application within a curriculum that is difficult to replicate in a traditional educational studio. While most effective in the analogue world, design-build can be simulated within a classroom by leveraging virtual reality as a curriculum connecting client, spatial immersion, precedent study, construction, fabrication, and a digital design toolset. This paper and presentation will outline a course curriculum for second-year design students at the Hammons School of Architecture that leverages the pedagogy of design-build within a virtual process. The project connects specific *intent* for our client by crafting spatial experiences for the CHIL (Children's Hospital Innovation Lab) Zone, a pediatric care unit of Montefiore Medical Center in New York that brings technology to their patients. Leveraging tools like AR (alternate reality), VR (virtual reality), and 3D fabrication, patients in the CHIL Zone are moved virtually beyond the confines of rooms when their medical limitations often reduce their opportunities for exploration. Approaching the process in a parallel modality to a design-build curriculum, student *application* happens through the construction of virtual versions of a precedent design study, including site, phasing, construction methods, details, and basic communication of the spatial concepts for their clients (kids from twelve to eighteen in a pediatric care unit). The process happens within the immersive qualities of virtual reality, creating a narrative about the architectural design that each student must communicate. Each project is resolved by finalizing a VR "docummersion" film that includes the precedent study and specific spatial elements of their own design. This process is directly generating new understandings of the design-build process. It is developing considerations of architecture and design thinking, including spatial exploration as a form of rehabilitation and health care, architectural design intended solely for use in virtual reality, and the connection of virtual reality and cognitive spatial awareness for design education.

Keywords: Virtual Design-Build, Virtual Reality

1. INTRODUCTION

What if, just by going for a walk in nature we could improve health? This issue goes beyond cardiovascular systems and muscular tonality, as there is a cognitive connection between the exploration of an environment and the well-being of a human. EcoHealth and ecopsychology are immerging sciences—with resources counting over one thousand in medical journals within the last two decades—connecting the importance of human health and the exploration of nature. "As the nature deficit grows, another emerging body of scientific evidence indicates that direct exposure to nature is essential for physical and emotional health. For example, new studies suggest that exposure to nature may reduce the symptoms of Attention Deficit Hyperactivity Disorder (ADHD), and that it can improve all children's cognitive abilities and resistance to negative stresses and depression" (Louv 2008, 35–36). The intersection of health and nature deficits is perhaps most striking at hospitals in dense urban communities lacking the public infrastructure and funding to build access to natural landscapes. For those without the means to access nature, being placed further into isolation due to health can be detrimental to health (Hartig et al. 2003). Barriers of place, economy, and health are overwhelming obstacles that often cannot be surpassed. The current pandemic has also increased our isolation and decreased our ability to move freely to new locations and explore. So the question becomes: Can we *deliver* the experience of nature to those who are isolated? It is reasonable to argue that we cannot move an experience of nature into a room, and that the goal of "simulating nature" through virtual reality is perhaps an overreach of moral expectations we should not strive for. However, if designers could create spatial experiences through virtual reality that imitate that sense of immersion, exploration, and discovery similar to what has been studied of those exploring nature, we could begin to replicate:

- The visual ambient intensity of a walk in nature—with spatial breadth and optic depth to absorb.
- The firing of the synapses in the brain that are engaged while you are actively exploring, which may also provide restorative qualities within your body.
- A moment of sneaky education teaching kids about space, design, architecture, and the impact of these items on humans.

Immersion "describes the effect caused by a situation, environment or graphic representation which makes the user's consciousness recede into the background so that the virtual environment is perceived as reality" (Engelmann 2018, 21; my translation). It is this notion of immersion that is vital to building experiences that can bring positive results when used on patients struggling physically and emotionally within an area of confinement due to their medical restriction. There are already positive results in leveraging virtual reality (VR) for medical therapy:

> Recent research has explored the potential of using virtual reality (VR) as a mode of healthcare intervention and an alternative route for care delivery (Mantovani et al. 2003; Simone et al. 2006). Virtual reality is a computer-generated graphical environment that offers opportunities for users to view and interact with the virtual environment in stereoscope (i.e., three-dimensional visuals). In interventions for physical impairments, VR has been proposed and utilized as an assistive rehabilitation technology for individuals suffering from stroke (Jack et al., 2001), cerebral palsy (Reid 2002), severe burns (Haik et al., 2006), Parkinson's disease (Mirelman et al. 2010), Guillain-Barré syndrome (Albiol-Pérez et al. 2015), and multiple sclerosis (Fulk 2005) among others. (Rose, Nam, and Chen 2018, 153)

Further, the use of VR as a tool for pain management has shown to be effective for treating burn patients during both recovery, operations, and rehabilitation (Hoffman, Patterson, and Carrougher 2000). However, creating a heightened sense of immersion is one of the core issues in terms of development with the current state of hardware, software, and accessibility to virtual reality content. Using VR repeatedly to aid in longer treatment cycles requires emulating a sense of exploration and discovery with similar thematic experiences. This builds a more immediate familiarity, allowing faster cognitive acceptance of immersion within the VR content. As a result of this situation, VR is at a juncture where it needs more experiences on the most accessible devices to deliver content to those on whom it may have the most profound impact. This need, opportunity, and desire to innovate in the field of medical VR led to the collaboration between the Hammons School of Architecture and the Montefiore pediatric wing known as the CHIL Zone.

Figure 1: Medical VR—Montefiore CHIL Zone (photo provided by CHIL Zone)

1.1 Content Creation

The need to create multiple hours of original VR content, combined with finding innovative ways to teach immerging design communication, led to the redevelopment of a compulsory class within our architectural curriculum. The class best suited for introducing a project to build VR content and provide an educational opportunity connected to the CHIL Zone is found in the second year of the curriculum at the Hammons School of Architecture: ARCH 222, Representation II. This course builds digital design skills as part of the workflow of the design process, thereby expanding student representation and communication capabilities. The course itself has evolved beyond “learning software” to also focus on intent and application to increase students’ critical thinking. Developing VR content for medical applications builds parallels to the mode of learning found in design-build by creating a digital immersive synthesis of a precedent project.

As with a typical design-build, creating responsibility to a client group establishes a sense of empathy and brings purpose to the development. For the medical VR project, the architecture students were also required to develop an understanding of the client and their needs, a sense of empathy beyond merely completing an assignment. Specifically, our client is a twelve- to eighteen-year-old patient confined to a bed and mostly isolated to a single room. The goal for the client is to build a “virtually constructed” experience to create a sense of immersion through exploration, discovery, and education. This is to be done through their development of architectural spaces to create a sense of emotive displacement developed with three specific goals within the VR construct:

Ambient spatial intensity: The goal with ambient intensity is to create a construct to engage curiosity rather than adrenaline-fueled intensity. A design goal is to build a place that is familiar so as not to distress, but distant enough to engage a sense of exploration and wonder. This is the antithesis of a video game designed for “shooting zombies”; rather it is an opportunity to engage thoughtfully in a VR space.

Iterative exploration: Kids should not spend more than around ten minutes in VR, as emotive displacement can be too powerful and trigger additional side effects. As a result, we needed to design experiences that were both repetitive (kids universally adore the phrase “DO IT AGAIN!”) and iterative—with basic modifications for each experience.

Education through immersion: VR is a new media that is not likely to displace existing forms of entertainment or communication, but it will open up new avenues to express, explore, and teach through immersion.

Completing projects within a curriculum designed with the aforementioned objectives in mind, the VR experiences become by-products of the student work. This aligns with an objective in the education of digital design by focusing on process rather than emphasizing the craft of architectural imagery. A comprehensive workflow that includes digital design technology (building information modeling [BIM], digital fabrication, rendering, virtual reality, etc.) is critical to develop an understanding of a modern design process. Allowing communicative design content to evolve as a by-product first, then conclude through refinement, evolves the student’s ability to use digital tools to inform their critical thinking.

1.2 Intent and Application

Combining the goals of creating medical VR for emotive displacement with an existing set of course objectives, we began to create a new curriculum to deliver learning content with broader intentions than just completion of the assignments. The course for our second-year architectural students, ARCH 222, Architectural Representation 2, is the introductory course for constructing virtual models, BIM, digital representation, and fabrication. The mode of work for the class became the digital creation of architecturally significant precedents. This allows the students to create experiences that are relevant to their architectural education, that are engaging spaces to communicate to kids, and it creates an environment where students can focus on learning the tools while allowing their design focus to be osmotic in nature.

Continuing with the parallel modality of design-build, a specific client was identified to drive *intentionality*: twelve- to eighteen-year-old children in a pediatric wing of a hospital, primarily confined to their room, and either in a bed or a seated position. This was a client who needed custom VR experiences that were ambient in composition, evoked a sense of exploration and discovery, and included an undercurrent of education, in our case leveraging architectural design as a common point of study and learning. The client's maximum time of VR engagement would be set to 10 minutes (a recommendation for youth in VR from multiple sources), with a total goal time of one hour for emotive displacement by engaging with the experiences. Additional elements would be needed to extend the experience past VR to further engage the patients and to spark their creativity based on their discoveries and observations in VR. The *application* parallel to design-build would come from the students' construction of a series of assignments to develop their understanding of digital content creation tools through the development of precedents: *Assignment One—Constructing Cognizance* (the creation of a precedent study board); *Assignment Two—The Design of Diagrams* (the creation of physical diagrammatic toys through digital fabrication); *Assignment Three—Details and Devils* (the construction of a BIM model); *Assignment Four—Impartation through Immersion* (the communication of a design through 2D, 3D, and immersive methodology). All assignments can be read in full on the course website at: https://sites.google.com/view/hsa-arch-222-20/assignments.

1.3 Constructing Cognizance

Developing an understanding of the precedent work and context research tools is the first step in developing the digital precedent for the course. The first project, *Constructing Cognizance,* required the students to identify their projects' available materials: project context, plans, sections, elevations, site plans, and the architect's design intent. Project context is studied and imported through Google Earth. The tools within Photoshop are applied for rescaling images and adjusting dots per inch to create consistency within orthographic drawings. Meaningful architectural scales are established, including site context information captured from project documentation and explorations of the context in Google Earth.

Figure 2: Precedent study board, Kew Garden Library by WORKac (Hammons School of Architecture Student Jessica Hampton)

The students develop hand-drawn diagrams from their volumetric understanding of the design to be leveraged in the next project. The process of creating the precedent study board allows the students to build familiarity with the work, an understanding of the project's relevance, and dimensional data to accurately model the project. The project also introduced the process of using Photoshop to maintain the integrity of scale images and as a layout and communication tool for a variety of elements: text, photographs, drawings, source notations, and the process of combining various materials at different resolutions into a single print-ready image file.

1.4 Design of Diagrams

Using the hand drawings of the volumetric diagrams in project one, the students build a virtual model of the diagram. This assignment is an introduction to 3D modeling, focusing more on the diagrammatic qualities of a massing model rather than the detail modeling of BIM. Combining the introduction to 3D modeling with 3D fabrication links simple virtual forms to the complexity of 3D printing. The students are required to construct their 3D massing in a way that becomes an interactive physical piece to work with the VR experience.

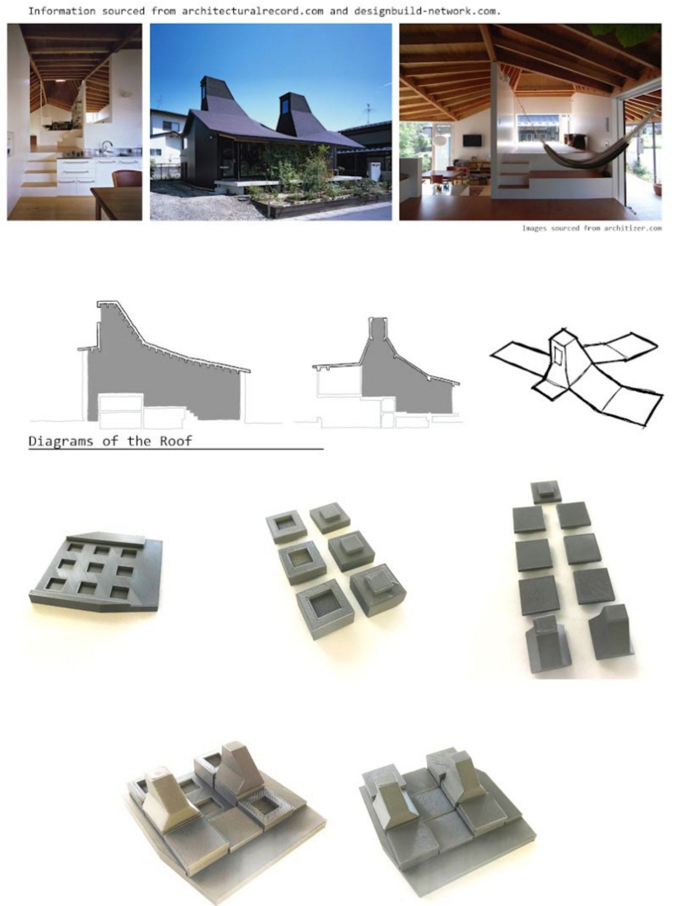
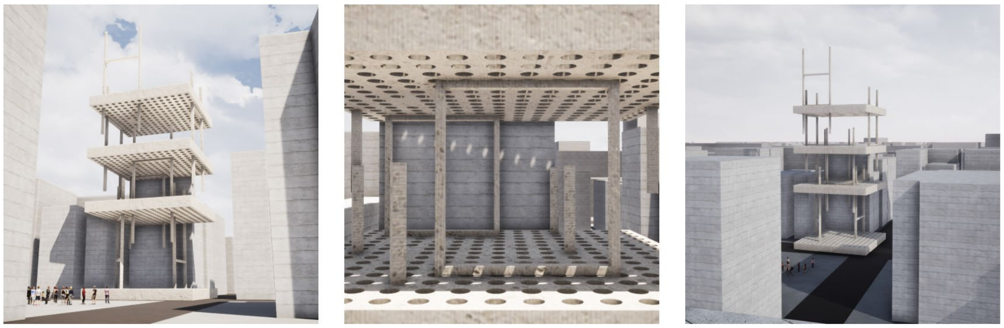


Figure 3: Diagram to 3D print, precedent project: Nora House—Atelier Bow-Wow (Hammons School of Architecture Student Isabelle Holder)

Through ongoing discussions with staff in Montefiore's pediatric wing, we learned that the team from the CHIL Zone has several underutilized 3d printers. Each immersive VR experience would be paired to a 3D print based on the precedent. This would extend the amount of time a patient can invest in an experience and evoke their creativity beyond a passive participation. For the architecture students, this would require them to design a massing model with variations on a formal theme that could be reconstructed physically. Completion of this assignment requires that the students assess their precedent, design a three-dimensional volumetric diagram based on their precedent's design, expand upon their understanding of a physical object to be creatively manipulated, and create a connection between virtual and physical geometries through 3D printing. The primary modeling software for the task is FormIt, with geometry being sent to Prusa printers through the PrusaSlicer software. In particular, FormIt has an easy entry point for modeling and also has tools to evaluate the preparedness of a virtual model for 3D printing. Each design required multiple passes at 3D printing to refine print time (holding the time for the prints to under four hours) and to work within the tolerance of digital fabrication. This process became very iterative for the students, printing test pieces, creating discoveries with the physical objects, and quickly revising and resending prints from the FormIt software.

In parallel with the construction of virtual and physical models is the development of the representational skill set using real-time animation software. Based on the capability of the university labs, availability of the software, and the potential learning outcomes, Twinmotion was selected as the primary visualization software. The conceptual massing model is exported from FormIt, imported into Twinmotion, and placed into a basic interpretation of the site and context of the project. This helped the students gain a more complete understanding of the site, scale, and materiality of the project.



Ground View View of Second Level View from Other Roof

Figure 4: Diagram to visualization (Hammons School of Architecture Student Jacob McNeal)

1.5 Details and Devils

Moving from virtual massing models to BIM models with details can be tedious for most students. Working a project from a specific detail (window geometry, furniture, stair, etc.) allows for focused development that a virtual model can build around. This progression within the project develops a strategy by which students can see sequential progress happening in phases. The focus of the project is also around the less conventional architectural tools in a BIM program, allowing the student to first learn how to use software to think in 3D. This circumvents the often-used production design of BIM software working from plan view to a vertically projected building from two-dimensional planar thinking.

Developing a detail, students use the custom mass-modeling tools within Revit to model a portion of their precedent, and then deconstruct the model into 2D line work. The 2D line work is then used with a laser cutter or CNC router to create digitally fabricated patterns to reconstruct a physical version of the detail. Learning a second method of digital fabrication prepares students with multiple options for best-use scenarios, as well as diversifying their skill set.

Author's Note: Relevant to the time of this paper, on Friday, March 13, 2020, our university closed for spring break, and shortly thereafter made the determination to conclude all classes with remote learning. For my students, this meant the loss of shared workspaces and collaboration in common spaces, both of which are key to learning complex software skills. Many of my students did not have personal computers and were relying on campus labs. Those who had computers often did not have a system with the necessary specifications to run the course software. As a result, the key learning objectives were modified with a focus on understanding the core elements of working with a computer as a design tool. Many of the following images were completed as examples for the class as the curriculum was developed and are items produced *for* the class rather than *by* students in the class.

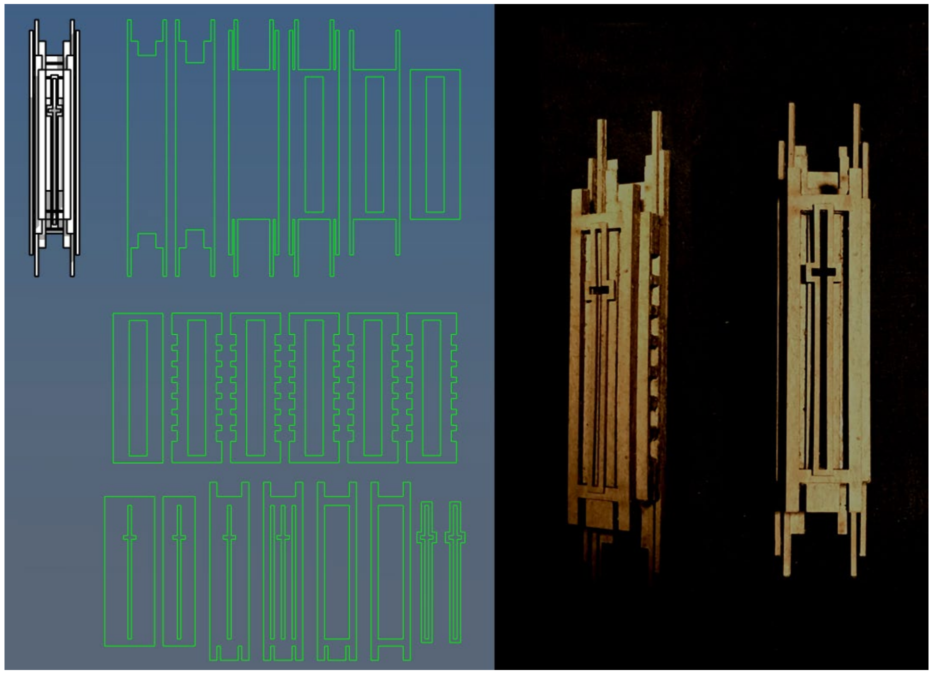


Figure 5: Detail to physical model: (left) Light fixture from Thorncrown Chapel by Fay Jones; (right) BIM detail model and fabricated physical model by David R. Beach

Building around the detail, and using this mode of design consideration to provide intent and scale, the BIM model is further developed to begin moving the design past a massing level of representation and into a more complete architectural model. By starting with a detail, a level of expectations within a digital model is established to move past the often-reviewed hollow shell of interior space developed in student projects.

1.6 Impartation through Immersion

Final development for the semester introduces the tools necessary to complete the students' precedent study as a BIM model. This portion of the semester includes the majority of the 3D work but takes place in only about one-third of the semester timeline. Previous projects have created a set of software skills that allows the work to be accomplished quite efficiently based on previous iterations of the course. The final project introduces site topography acquisition from CADMapper, the creation of orthographic project drawings (plans, sections, and elevations) from Revit, basic visualization from Revit, and immersive visualization in Twinmotion.

Within Revit, building the virtual model and constructing orthographic projection drawings are key objectives for the class. Implementation of BIM into working drawings and construction documentation takes place later in the architectural curriculum, allowing the students' effort to be directed toward understanding the process of crafting a virtual model. However, the creation of plans, sections, and elevations is a key element in communicating design ideas and is necessary to help students develop their design thinking.

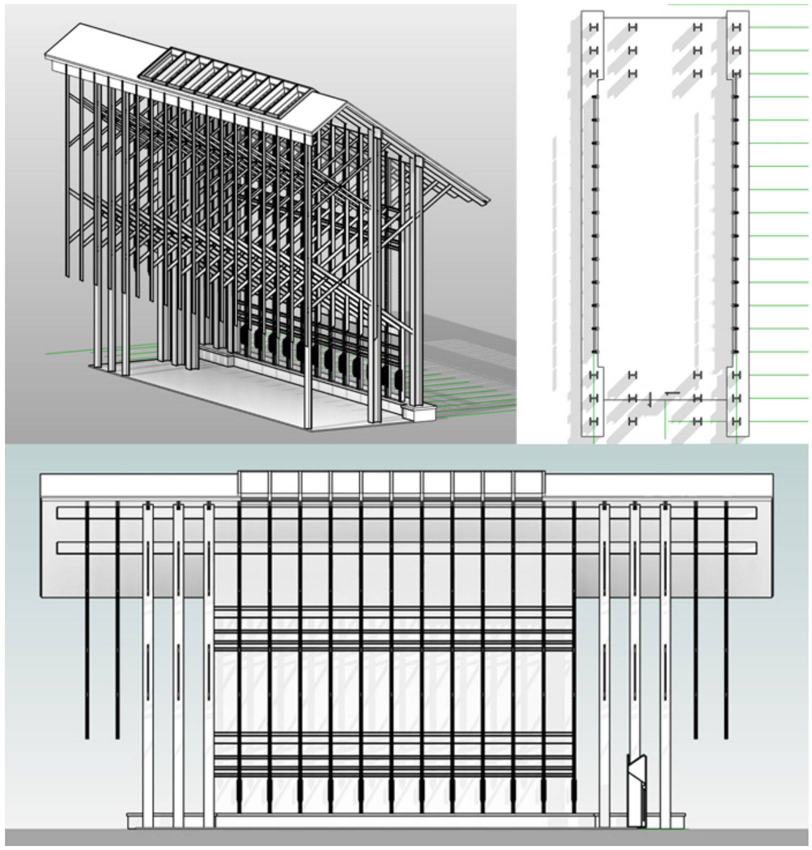


Figure 6: BIM modeling precedents: Thorncrown Chapel by Fay Jones; BIM file and images by David R. Beach

BIM software is often not conducive to the development of material strategies in the design process. The depth of the menus and process of applying materials in BIM software has its relevance, but it is not the best mode of helping students consider materials as part of the design process. As the BIM model is coming together, continual visualization work is done in Twinmotion to develop materials and build an immersive understanding of the architecture, spatial strategies, and communication of the project. The final file is then rendered into a 360-degree animation from Twinmotion for immersive visualization in VR and distribution to a library of immersive experiences for medical VR.

2. CONCLUSIONS AND FUTURE WORK

With multiple BIM models completed, the next phase of the work is to build the docummersion films showing the assets and sites to their best potential. The content will be matched with a voice-over explaining the project and its concept, with key motion paths and branching selections being developed in Adobe Premiere and Adobe Captivate. Upon completion, the files will go into their first phase of viewing and testing with the pediatric team at the CHIL Zone within the Montefiore hospital in the Bronx, New York. Currently, we have a second team of students from our computer science department that is beginning to build interactive game versions with the architecture, allowing for creation of architectural spaces inspired by the building precedents and constructed by the kids inside the VR experience. As the interdisciplinary collaboration continues, music scores developed by the music therapy department will also be part of the final collaboration, building an ambisonic soundscape within VR that not only enhances the immersion but can also be used to further the process of healing engagement.

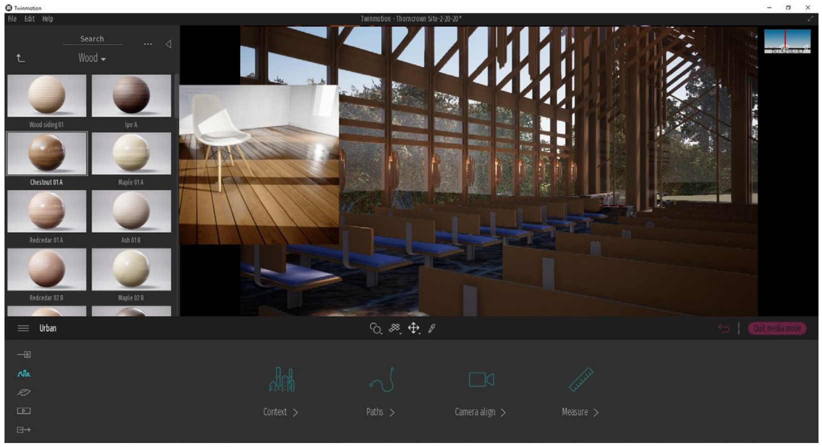


Figure 7: BIM modeling materials and immersion: Thorncrown Chapel by Fay Jones; Immersive file by David R. Beach

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