Modeling Inter-dimensional Narratives

Olga Mesa[1], John O'Keefe[2]
[1]Roger Williams University, Harvard Graduate School of Design [2]Roger Williams University
[1]omesa@gsd.harvard.edu [2]o'keefe@rwu.edu

The integration of VR in the creative process has caused a profound shift in the use of modeling tools and abstraction. How do instantaneous experiential feedback, body awareness, the triggering of spatial sensations, and traveling in real-time from an object-scale to a habitable-scale affect modeling in VR? This research explores the tensions and exchanges between the physical and the digital relative to spatial perception when designing in VR. The work produced by participants involved in a digital design workshop developed around these topics will be presented. In response to a written provocation, participants modeled three-dimensional dreamscapes in VR using Oculus Medium. Participants explored the connection between the body and its movements to measure, model, and control phenomena when animating virtual scenes. This research contributes to the teaching and implementation of modeling in a virtual environment by exploring the inherent possibilities of VR in relation to the conceptualization of spaces.

Keywords: *Virtual Reality, Spatial Perception, Virtual Reality Modeling, Virtual Reality in Architecture*

INTRODUCTION AND BACKGROUND

Immersing a subject in a virtual environment has been a fascination for decades. From the first concept developed at MIT in the 1960s, where researchers aspired to design a "window" to access another world where people could behave realistically (Sutherland, 1965), to pivotal moments in the 1980s where military and commercial flight simulations were accomplished, to more recent developments of fully immersive video games exemplified by the consumer-ready Oculus Rift and HTC Vive (Cipresso et al., 2018), advances in the field of virtual reality have moved into the mainstream.

With the production of affordable graphics processing units (GPU's) and related accessibility of consumer hardware and software for VR video games over the past five years, the inclusion of VR as a visualization tool has become more pervasive in many disciplines including Architecture and Architecture, Engineering and Construction (AEC) education (Horne and Hamza, 2006). This has highlighted concerns over its conscientious implementation in design teaching (Horne and Thomson, 2008) and practice.

Within this context, it is worth acknowledging the radical shift from manual representation techniques, such as drawing and drafting as primary modes of investigation of architectural concepts, towards the use of digital modeling, visualization, and simulation. Orthographic drawings (plans and sections) offer abstract objective constructs of space, and while these tools do not offer how a design would react in relation to gravity, this is complemented by the use of other tools such as physical models. Similarly, ideas related to habitation and phenomena are explored through the use of subjective experiential perspective drawings. Although each of these representation tools stands on its own and each is used more appropriately depending on the particular aspect to be explored (objective or subjective), they feed off of each other.

In contrast, in three-dimensional digital models, there is a synchronous confluence of modes of representation and points of view when exploring spatial concepts, where it is possible to switch easily from a planimetric to sectional views or perspectives without generating each of them individually. In other words, one of the main differences between architectural tools used in the representation and conceptualization of spaces is that established "paper-based" modes do not offer the instantaneous workflows enabled by designing digitally (Oxman, 2008).

By adding immersivity, virtual reality technologies disrupt the architectural discipline insofar as they redefine the way creative processes and design strategies (gestural, abstract, constructive) can be taught and learned, but also how the design work potentially becomes more efficient, how it is developed, and ultimately shared (Oxman, 2008). Therefore, it is imperative to critically question the opportunities and shortcomings inherent in this revolutionary technology for future teaching and practice.

Virtual reality presents significant challenges, as well as opportunities because up to this point, it approximates but does not fully match reality. The main challenge is that within the virtual environment the understanding of gravity and the physics of materials is lacking. The kind of structural and tactile feedback typically gained from a traditional "chipboard and wood" physical model does not occur.

Inhabiting, modeling, and visualizing proposals is a primary opportunity in VR because unlike other traditional modes of architectural representation that work more asynchronously, the designer receives experiential feedback in real-time; in VR, the fourth dimension is integrated. It is not surprising then, that much of the work that utilizes VR is aimed at the visualization of architectural spaces. However, there is a latent potential to integrate this capability in the early stages of design production via modeling. One of the main goals of this research is to investigate the possibilities of modeling when spatial perception is the main entry point in generating space.

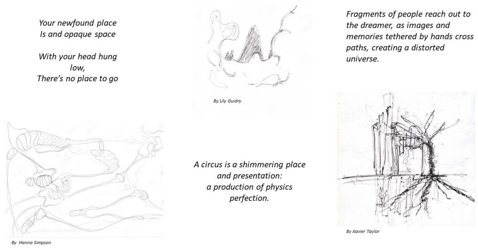


Figure 1
Sketches and initial text in response to the prompt.

Dorta argues that the "mental workload" required to combine traditional architectural drawings (plans, elevations, sections, even perspectives) into a cohesive design, is potentially eased when using virtual reality, allowing designers to participate in a more fluid creative process (Dorta et al., 1998). However, there are difficulties associated with this fluidity, such as documenting the generative steps within the creative process and extracting abstract representations that facilitate measuring and conversations revolving around scale.

As designers, we are very familiar with the notion that different scales allow for different kinds of explorations related to the creative process. Some scales and viewpoints lend themselves to studying spatial organizations, while others to examining tectonic relationships. In VR, it is possible to make use of several scales by expanding or reducing models in relation to the human scale. A VR model can be inhabited and instantly reduced to the scale of a handheld object. Thus, another aspect explored by this research is how the ability to go back and forth between scales changes the way designers think about spaces and their modeling, and how this workflow can be supported seamlessly.

Figure 2
Dreamscapes being developed. Work by: Orantes & Siemssen, Sevinc & Conner, Lalwani, Simpson, & Cinquigranno.

Another aspect to consider is that when using a head-mounted display (HMD), stimuli from physical space are muted, helping the user to be transported to an alternate reality. However, even when the body is not seen in this environment and its connection to reality is only through a rudimentary depiction of hands, the awareness of the body continues. Therefore, in virtual reality, the user's head and arm movements become the main mode of interaction within an immersive scene, instead of being mediated by joysticks or keyboard and mouse. The eye and head trackers in the HMD, as well as the trackers in the manual controls, locate the user within a set space and record the user's movements in real-time. This provides users with instant environmental feedback that dramatically raises the level of emotional investment and disconnects disturbances from the periphery of the outside world (Parsons & Rizzo, 2008; Price, Mehta, Tone & Anderson, 2011).

Although virtual reality is a visually skewed framework, there is the potential to evoke other senses and explore the connection to bodily experience. The extent to which the senses can be stimulated through VR is an ongoing research topic. For example, the work developed by the University of Washington HITLab in association with the Harborview Burn Center presents that pain could be alleviated in patients who have suffered burns by using VR simulation therapies that evoke icy environments, thus reducing the use of opioids (Hoffman et al. al., 2019). In the same way, through VR, one can trigger or confront eerie spatial sensations such as agoraphobia, claustrophobia, and vertigo. Not surprisingly, the medical industry is applying psychological therapies for people who experience phobias such as flying phobia, agoraphobia, etc. (Botella et al., 2017). Pleasant sensations associated with the experience of space are also possible through VR. For example, in recent research, omnidirectional images of environments such as forests are offered in immersive experiences to reduce anxiety, promote mindfulness and relaxation (Seabrook et al., 2020), and the use of colors and light to create the atmosphere for a space might influence gestures and emotional responses of VR users (Stout, 2002). Additional research goals were to investigate how the physicality of body awareness and the triggering of spatial sensations in real-time informs the way designers model through VR, and how crafting the ambient color palette of a VR scene affects the gestures and thus modeling outcomes.

This research presents the frictions and reciprocities between the physical and the digital relative to spatial perception when designing in VR. The research questions informed the design of a workshop where participants were asked to develop dreamscapes within a virtual environment using the awareness of their physical bodies and their spatial sensations as tools. The objective of the workshop was to study how the research questions inform teaching workflows related to creative processes. The results of the workshop will be presented in this paper.

METHODS AND RESULTS

In response to a written provocation, participants modeled three-dimensional dreamscapes using Oculus Medium with Oculus Rift and Quest head-mounted displays (HMD). Recognizing the oppor-

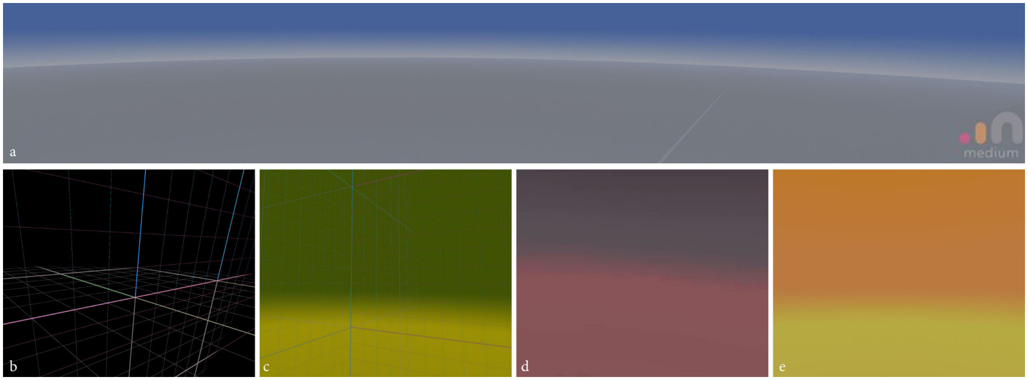


Figure 3
Default Oculus Medium interface, 3b-3e. Modified atmospheric scenes for dreamscapes by Mesa & O'Keefe.

tunities that modeling in virtual reality offers, the following sentences attempted to capture a hybrid between words that evoke physical, haptic, and ethereal concepts. Based on phrases like Cyber Spell, Buoyant Time, Infinite Circus, Entangled Memory, Opaque Space, to name a few, participants wrote about them and sketched, thus building a narrative (Figure 1). This narrative, although not completely formed, guided the modeling of the dreamscapes as participants perceived the space that they created in real time (Figure 2).

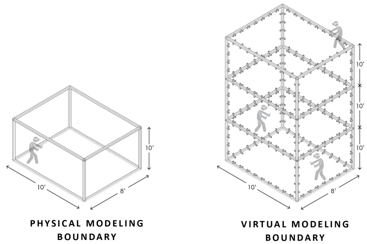
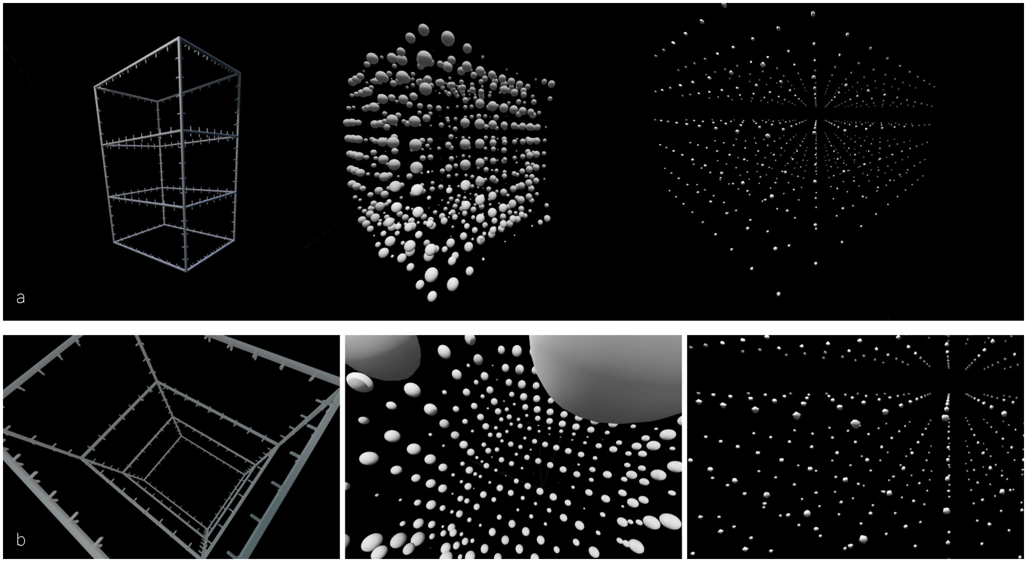


Figure 4
Physical modeling boundary and Virtual modeling boundary comparison.

Achieving an evocative atmosphere for the virtual scene was important in creating the stage for the dreamscape. Therefore, the participants were taught to adjust settings to control the light, color, and "Fog" in the space, to craft the ambient qualities of the scene and model based on its perception. These were obtained by exploring the "World" settings in Oculus Medium and challenging the default interface (Figure 3a). For example, the feeling of awe and tranquility were sought through the combination of certain colors (Figure 3c,3d,3e) or on the contrary, causing a disturbing and groundless feeling was achieved within a space where glowing colors were used to describe a three-dimensional coordinate system as if inhabiting the planar 'grid' depicted in 1982's TRON (Figure 3b).

As mentioned before, when modeling virtually, the HMDs help participants to access a mental space, where stimuli from the physical space are mitigated. For our workshop, having a common reference between these spaces was key to establishing parallels between the physical and the virtual. At the same time, it was important that the virtual space could be expanded along the z-axis to investigate spatial sensations, such as vertigo or claustrophobia, which were triggered in the design process. Participants modeled in an 8'wx10'lx10'h physical space but were able to import spatial frameworks measuring 8'wx10l'x30'h (Figure 4). That is, the virtual and physical spaces coincided in plan but not in height. The three-dimensional frameworks were predetermined using Rhino and Grasshopper. These featured fields of varying densities to offer a sense of spatial depth (Figure 5a). These frameworks also fostered an understanding of the scale of their dreamscapes in relation to their bodies and provided a reference for

Figure 5
Three-dimensional frameworks by Mesa and Norcross.

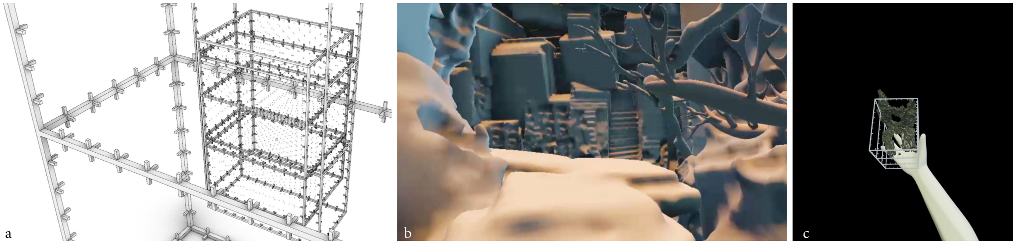


measuring what was being modeled. Participants were able to turn them off, move them up or down and lock them in place to experience their sensations from various heights and feel spatial limitations when modeling (Figure 5b).

At a certain point, participants were asked to turn off the imported 3D frameworks and scale down their three-dimensional dreamscape model, such that the scene that they had inhabited a few moments before could now fit in the palm of their virtual hands. They were asked to continue modeling at this scale and after a while, to enlarge the model to fit roughly in their arms, to continue modeling, and then to return to the original habitable size in order to experience the modifications they had made at the various scales (Figure 6).

As participants traveled back and forth between these scales, they observed the differences in modeling perspectives inherent to these scales. In our conversations, they reflected on the commonalities and distinctions between small-scale modeling after experiencing the scenes at a one-to-one scale. It was also recognized how the crux of their projects could still be identified even at various scales, akin to observing a Zen garden and being transported to a mountainous landscape.

Figure 6
Various size 3d frameworks (a). Traveling between inhabitable (b) and a hand-held object scales (c). Work by Taylor-Burto, Henderson & Loudon.



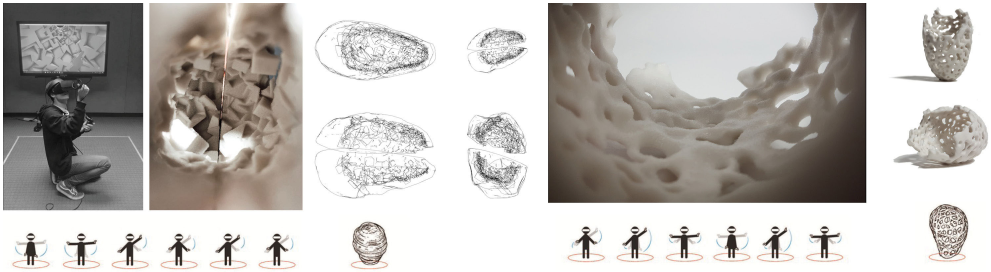


Figure 7
VR models based on body movements and ranges. Work by Mendez, Varas & Valenti, Allen & Moran, Holmes & King.

The workshop exercises also aimed to encourage participants to investigate the link between the body and its movements by modeling and controlling phenomena, when animating the virtual scenes. In terms of modeling, this connection was explored by using their bodies, arms, and legs to measure space in relation to the 3d framework or by using their own body center as an anchoring point. For example, while stationary at a point relative to the physical modeling boundary, participants model in VR spaces that reflected their own ranges of reach, thus experiencing the types of intimate enclosures that these movements defined and, in doing so, became more aware of their own physical bodies (Figure 7). In another example, they were asked to trace with their controllers the silhouette of another participant's body while modeling with virtual clay, thus experiencing a tactile sensation while visualizing the spatial effect that this activity generated even if not physically seeing the other participant.

The awareness of their bodies in motion became more apparent when they were asked to produce an experiential video as if they were choreographing a dream. By recording their view from inside the HMD, they were able to map the experience of walking through their dreamscapes, but they were also able to explore recording with a virtual camera held in their virtual hands. These two ways of recording allowed different movements and as such experiences of the dreamscapes (Figure 8). For instance, some developed a "shaky-cam" style, while others quickly rolled their cameras through space like a camera on a dolly and some used their hands to define sweeping fly-thrus (Figure 9 & 10). Their videos and percep-

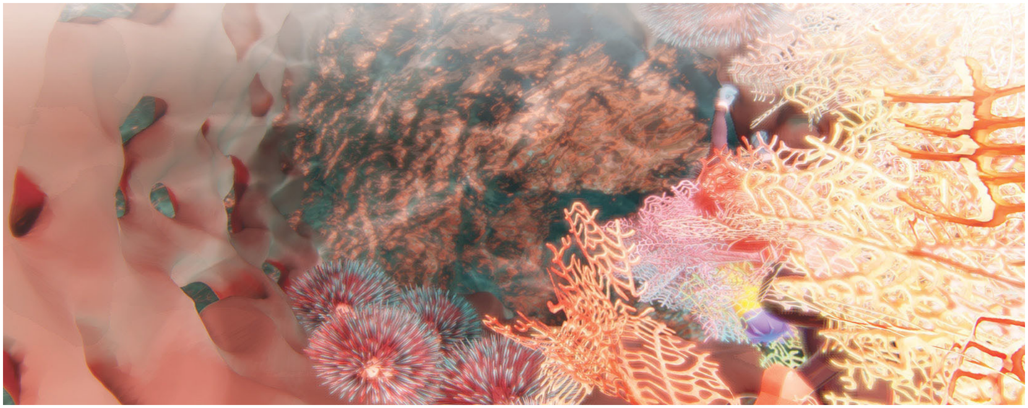


Figure 8
Image from video of Buoyant Time dreamscape. Work by Mendez, Varas & Valenti.

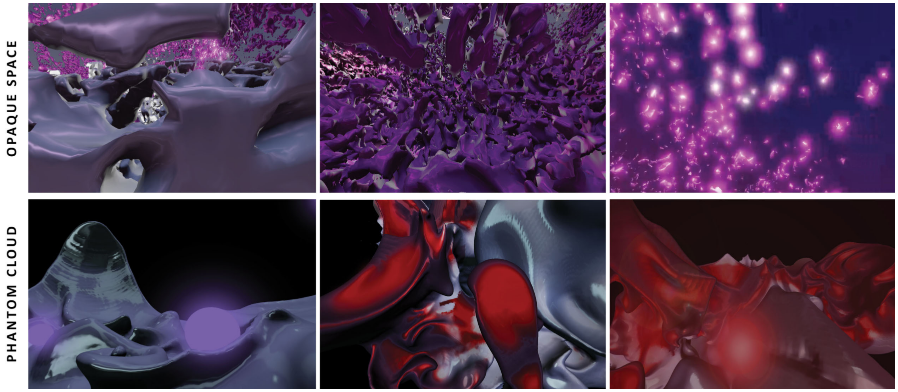


Figure 9
Image from video of dreamscape. Work by Conner & Sevinc and by Howard, Guidry & Crane.

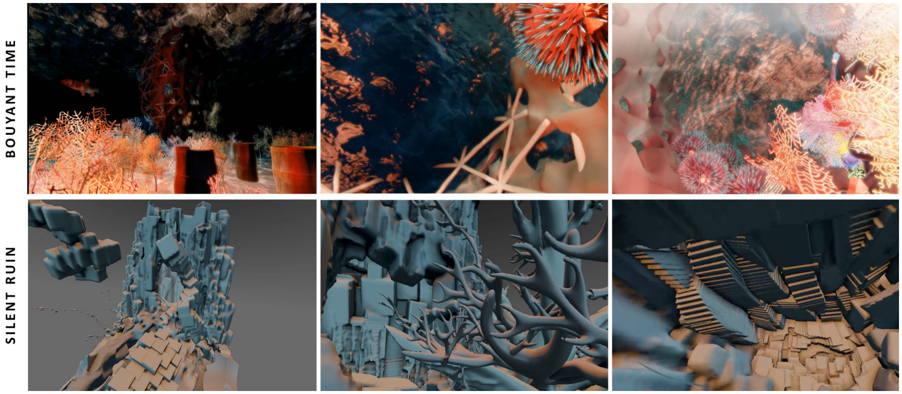


Figure 10
Image from video of dreamscape. Work by Mendez, Varas & Valenti and by Taylor-Burto, Henderson & Loudon.

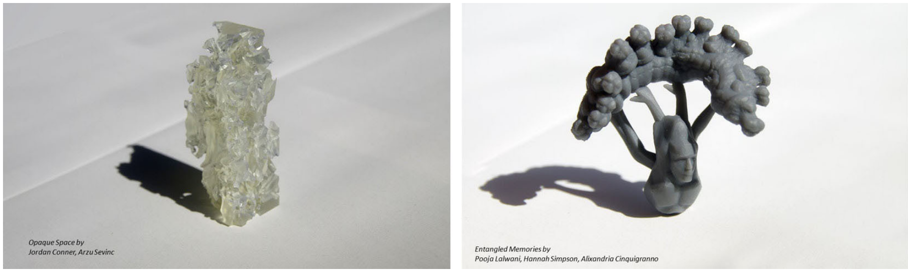


Figure 11
Mementos of Opaque Space (L) and Entangled Memories (R). Work by: Conner & Sevinc and by Lalwani, Simpson & Cinquigranno.

Figure 12
Exhibition
armature.

tion while modeling their scenes were used to finalize their written narratives inspired by their initial hybrid word pairings (Entangled Memory, Buoyant Time, Luminous Romance, etc.).

Participants chose a portion of their virtual dreamscapes to be fabricated using Formlabs 3D printers. This artifact was meant to stand as a memento to enable them to access their dreamscapes through memory, thus connecting a physical object with the experience of the virtual environment (Figure 11).

At the end of the workshop, an exhibition was curated where an armature, a sort of cabinet of curiosities, displayed the various artifacts that encapsulated the dreamscapes (Figure 12). The cabinet held the 3d printed mementos in front of an image of the dreamscape accompanied by the written piece (Figure 13). Visitors had access to the experiential video and the VR model, giving them a glimpse of the participants' creative process and journey back and forth between scales, modes of representation, and interdimensional narratives.

CONCLUSIONS

With the incorporation of VR into the creative process, designers are experiencing a profound change in the use of digital modeling tools and spatial abstraction. This reconfiguration in creative thinking is due in part to the ability to inhabit and manipulate virtual space in real-time. The research studied the tensions and exchanges between the physical and the digital when using VR in the design of spatial concepts. Through the teaching of a workshop where participants were asked to design a dreamscape using Oculus Medium, the research questions were investigated and a workflow for designers was developed for modeling and designing in VR. Recognizing the instantaneous experiential feedback granted by immersing a subject in VR and how this feedback informs the modeling and design of spaces, was central to the research. To that end, the curation and sequence of the workshop exercises inspired participants to explore the physical and spatial sensations experienced in VR and to gradually model their dreamscapes guided by their perception of their virtual scenes as they unfolded. The workflow presented participants with the ability to tune atmospheric qualities of space by adjusting the light, color, and fog to construct the ambient stage for their dreamscapes. In the panel discussion, participants reported that inhabiting these atmospheres elicited spatial sensations, emotional reactions, and body movements, which in turn influenced their gestures and the sculptural qualities of Medium's virtual clay. In relation to the exercises that were designed to engage body awareness and explored the link between the participants' physical bodies and modeling techniques, participants tended to construct intimate, personal cocoon-like enclosures, since they mostly explored the movement afforded by their dimensional ranges relative to a fixed reference. Some participants voiced that experiencing this space was comforting, while for others it triggered claustrophobic sensations, which they mitigated by eroding the enclosures to make them more spacious or invite light in. Participants reported that the three-dimensional frameworks preloaded into their VR scenes allowed them to better gauge spatial depth, and gave them a scale reference to their bodies. Some participants observed that these frameworks proved helpful when measuring the models and when they needed to reorient in the expansive virtual space. Some voiced that the option to turn the preloaded frameworks on and off was useful because at times they became either too grounding or visually distracting. The frameworks also allowed participants to explore their models at various scales, going back and forth in real-time from the habitable to the hand-held. At habitable scales, participants tended to move more physically - walking to the extents of their real-world boundary and using the extents of their bodies to model. Materiality was typically added and phenomena adjusted when experiencing the space at one-to-one scale. This became especially apparent when producing "in-model" experiential videos of their dreamscapes. In contrast, at the handheld scale, participants were more aware of the relationship between size of spaces relative to one another, sectional levels, repetition of elements, and the geometric order of a particular design. It was also observed that even at different scales the essence of a space remained discernable, reinforcing the dialogue between scale, perception of space and phenomena, and design decisions. Participants appeared to choose their tools depending on the nature of their assigned prompt. For instance, in modeling "Entangled Memory" Medium's ready-made figurative "stamps" (arms, hands, skulls, antlers, etc.) were chosen to produce a three-dimensional "kit-bashed" collage. Alternatively, in modeling "Opaque

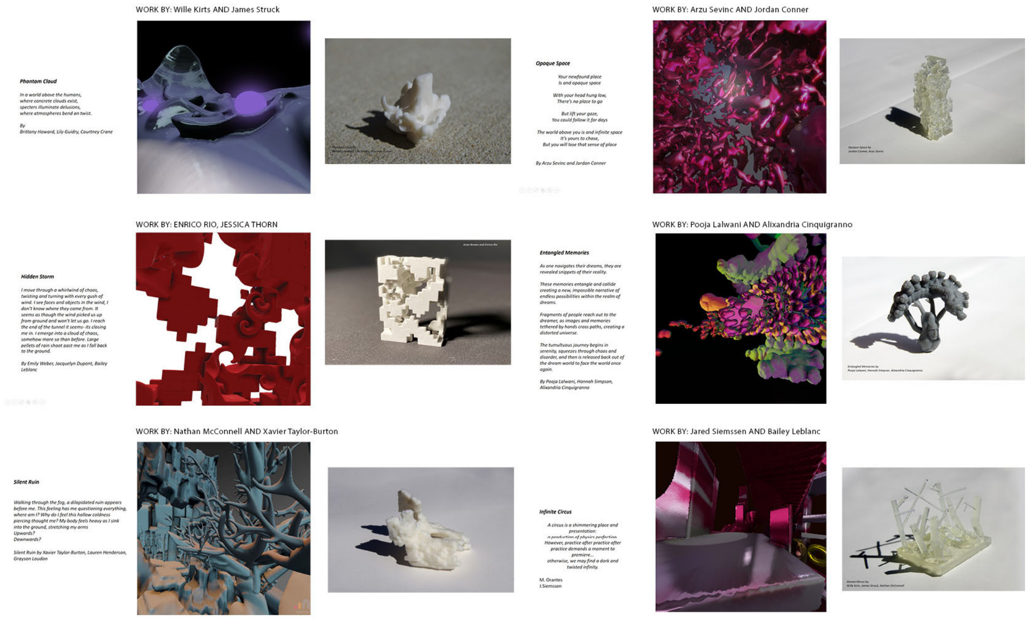


Figure 13
Images, narrative, and memento from the students' dreamscapes.

Space", participants chose generic brushes and platonic solids (cubes, spheres, cones) and used additive and subtractive processes to build geometric abstractions to define a dense space. It is worth highlighting that when using figurative stamps, an inherent scale was associated with the recognizable object helping participants orient spatially and providing an initial scale (a sort of datum) which was not as easy to discern when using abstract solids, even if in both cases license was given to change the object sizes. The synchronicity between modes of modeling and experience was challenged when participants were asked to produce a physical artifact from their dreamscapes. When preparing the 3d models for 3d printing, participants addressed physical aspects of their designs unaccounted for in VR. Participants had to choose a portion and determine the scale and level of detail of their dreamscapes that embodied the essential qualities of their virtual experience once outside of it, and adjust modeling if necessary for 3d printability as some designs depended on zero gravity. The spatial narrative was enriched at every step of the offered workflow. Transporting mentally between various scales while engaging in the physical and spatial sensations inherent in VR. Through the visually complex, fourth-dimensional dynamic environment, participants generated spatial concepts that emerged from the journey between dimensions.

ACKNOWLEDGEMENTS

The authors wish to thank Steve White, Dean of SAAHP at Roger Williams University because his support made possible this research, to Niloufar Emami and Zachary Angles for organizing and inviting Olga Mesa to participate in the 2020 Virtual Frictions Workshop at the School of Architecture at the Louisiana State University. Special thanks to graduate assistant, Chris Norcross, for his valuable research and for being Mesa's teaching assistant at the workshops, to Aaron Brode for fabricating the cabinet displayed at the workshop exhibit, and to Josef Horacek for his insights on written narrative. Thanks to the students and participants of the workshop and whose work is featured in this research.

REFERENCES

Botella, C, García-Palacios, A, Villa, H, Baños, R, Quero, S, Alcañiz, M and Riva, G 2007, 'Virtual reality exposure in the treatment of panic disorder and agoraphobia: A controlled study', *Clinical Psychology and Psychotherapy*, 14(3), pp. 164-175

Cipresso, P, Giglioli, I, Raya, M and Riva, G 2018, 'The past, present, and future of virtual and augmented reality research: A network and cluster analysis of the literature', *Frontiers in Psychology*, 9(NOV), p. 2086

Dorta, T and Lalande, P 1998 'The Impact of Virtual Reality on the Design Process. Digital Design Studios: Do Computers Make a Difference?', *1998 ACADIA Conference Proceedings*, Quebec City (Canada) , pp. 138-163

Horne, M and Hamza, N 2006, 'Integration of virtual reality within the built environment curriculum', *Electronic Journal of Information Technology in Construction*, 11, pp. 311-324

Horne, M and Thompson, E 2008, 'The Role of Virtual Reality in Built Environment Education', *Journal for Education in the Built Environment*, 3(1), pp. 5-24

Oxman, R 2008, 'Digital architecture as a challenge for design pedagogy: theory, knowledge, models and medium', *Design Studies*, 29(2), pp. 99-120

Parsons, T and Rizzo, A 2008, 'Affective outcomes of virtual reality exposure therapy for anxiety and specific phobias: A meta-analysis', *Journal of Behavior Therapy and Experimental Psychiatry*, 39(3), pp. 250-261

Price, M, Mehta, N, Tone, E. B and Anderson, P. L. 2011, 'Does engagement with exposure yield better outcomes? Components of presence as a predictor of treatment response for virtual reality exposure therapy for social phobia.', *Journal of Anxiety Disorders*, 25(6), p. 763–770

Seabrook, E, Kelly, R, Foley, F, Theiler, S, Thomas, N, Wadley, G and Nedeljkovic, M 2020, 'Understanding how virtual reality can support mindfulness practice: Mixed methods study', *Journal of Medical Internet Research*, 22(3), p. e16106

Stout, K 2011 'Emotional responses to color and nonverbal language: A survey of emotional responses to color swatches and human poses', *Master's Thesis in Art Education, Texas Tech University*

Sutherland, I 1965 'The ultimate display. Multimedia: From Wagner to virtual reality', *Proceedings of the IFIP Congress*, pp. 506-508