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All Through the Night: A Comparison of Two Dollhouses

By: Karen Royer

Project Advisor: Professor Gillian Smith

Project Readers: Professors Charles Roberts and Joshua Rosenstock

Professor Gillian Smith:_____

Professor Joshua Rosenstock:_____

Professor Charles Roberts:_____

Abstract

Holograms are a newer form of digital media. Digital media is changing traditional arts. They are also shaping how people play. How holograms have influenced play and crafting is not well understood. This project used dollhouses to examine how crafting a digital dollhouse relates to crafting a tangible dollhouse. Further, the project examined how playing in both dollhouses compares. Two dollhouses were created by the author/craftsperson. She reflects on her craft practices, relating her two experiences. Adult play testers describe their play experience in the holographic dollhouse and tangible dollhouse. The author's experience creating is analyzed through its material, social and playful aspects. She found each dollhouses had both material and immaterial qualities. She preferred playing alone in the dollhouses and found the creation process of the dollhouses was both play and work at the same time. The play testers' experience was also examined through material, social and playful characteristics. Their responses to the survey indicated that grasping objects was difficult in both dollhouses. They reported that they would have preferred to play alone in the dollhouses and that both dollhouses felt playful. An area of potential research that was uncovered involved a question of ownership of the dollhouse and how this may have changed the results of the study.

Keywords: dollhouse, craft, materiality, social interactions, play

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"The ability of the adult to look upon the world with wonder is thus a technique and an essential instrument in the work of the poet, the artist, or the creative thinker." – Edith Cobb

1 Introduction

Figure 1-1 Avatars are overlaid inside the player's environment (Asobo Studio, 2017).

As technology changes and techniques for forming works of art and other objects evolve, craftspeople also develop and evolve their creation methods and output (Zhang, 2019; Bohn, 2005; Korn, 2013; Hook, 2012; Benjamin, 1936). Digital media have vastly increased opportunities for new creative endeavors (Zhang, 2019; Murray, 2017; Hook, 2012). For example, augmented reality (AR) video games like "Fragments", see Figure 1-1, indicate the wealth of new artistic and design opportunities that are possible (Asobo Studio, 2017). From origins in 2D digital design, 3D and holographic creative designs and artwork are flourishing (Shaer, 2017; Notni, 2017; Johnston, 2008; Hammond, 1973). And in some cases, physical and digital creation and use have been combined in novel ways (Hook, 2012; Ullmer, 1997). (See Figure 1-2). The influence that

Figure 1-2 A futuristic touch screen to augment a tourist experience (Moore, 2018).

these technologies have on creative process is not well documented from the perspective of creators.

Holographic art and holograms are a creative frontier with a short history of exploration when compared to traditional media. It is increasingly possible for mainstream creators to access both the tools and the platforms for holographic creations and exploration. By their nature, holograms are presented as digitally existing in the physical world which offers opportunities for combining virtual and tangible technology together. Understanding how holograms may be influencing play and creative expression is necessary for further growth and integration of physical and digital artifacts (Tully, 2017; Nissenbaum, 2016; Gibson, 2014; Wang, 2014; Whitcomb, 2007). A portion of the understanding necessary for growth and integration can be found by comparing what play looks like with a holographic "thing" and the corresponding tangible "thing" and then assessing how people interact with both realms (Westwood, 2008).

Figure 1-3 A dollhouse the author helped to create for a younger sibling.

This project studies dollhouses to investigate play. Dollhouses are an appropriate domain in which to do this because the mechanics of play in a dollhouse require very little special knowledge as they leverage "intuitive interactions with the physical world (Gal-Oz, 2013)". For nearly, 400 years, dollhouses have been and still are created by craftspeople as unique play items. Though Armstrong is specifically referring to

tangible dollhouses, all dollhouses, both digital and tangible inspire multiple generations and genders to play (Armstrong, 1996; Paulk, 2006). Further the creation of dollhouses is frequently play for their creators (Armstrong, 1996; Vassallo, 2015). (See Figure 1-3). In this report, I explore the playful creation of a tangible dollhouse and a holographic dollhouse and compare my experiences with both. The digital holographic dollhouse (See Figure 1-4) is presented in an augmented reality headset and the tangible dollhouse is made of physical materials.

Figure 1-4 A playful overlay.

This project poses two questions: 1) How is the creation process of a dollhouse altered by using digital, holographic media versus tangible media? 2) How does play in a tangible dollhouse compare to play in a holographic dollhouse?

In Chapter 2, I relate two stories that inform the project and provide a framework of themes and experience goals. Chapter 3 describes both dollhouses in detail. Chapter 4 reviews the theoretical background for the project. Chapter 5 is presented as a first-person account of the creation process while comparing it across tangible and digital media. Chapter 6 reports on the study of how the audience plays in the dollhouses. Chapter 7 delivers a synthesis of the information gained from the two studies and an interpretation of the experiences, lessons learned and considerations of future research.

2 Reflections and Experience Goals

The following two stories are related from the author's perspective. They are told to provide insight into her feelings and clearer discernment of her motivations for building and exploring lighthouse dollhouses. The first story recounts an augmented reality experience. The second story imparts real life encounters as "ecstatic memories" (Chawla, 1990).

2.1 The Holographic Museum

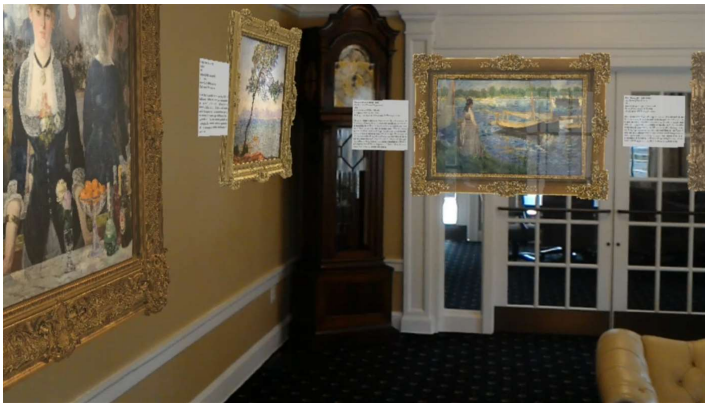

Figure 2-1 The Cortauld Gallery through Case Western Reserve and Microsoft (Microsoft)

I have my very own art gallery and I am standing within it. As I become accustomed to the onslaught of this new visual stimuli in my familiar space, I listen to a guide telling me how I can explore my gallery. She assures me that if I have questions about anything, I can ask her for help and either Neil Gaiman, Patricia Wheatley, from the British Museum, or she will offer assistance. (See Figure 2-1 and Figure 2-2).

In my art gallery, I have sculptures, incredibly large and fascinatingly miniature. A monumental sculpture of Ramses, a sarcophagus and a sphinx form a small collection of Egyptian works. Clusters of artwork by masters of the Impressionist era result in thought provoking groupings around my room. An object that appears to be a gameboard catches my attention and I want to read more about it.

In reality, I am standing in my family room with a head mounted display (HMD) on my head. In the HMD, augmenting my reality, I want to draw the game board closer so I can see all of the details better. The game board hangs suspended in the air above my hand. It is created from wood, shell, lapis-lazuli and carnelian (Microsoft). It looks old and distressed by years of use and the passage of time. I can see missing bits of lapis and shell and the surface of the gameboard appears to be uneven. I think I can safely assume because of its age and imperfections that this is not a piece that has seen the inside of a factory and is not an artifact of mass production. The information card tells me that this game spread throughout the Near Eastern and Mediterranean world in addition to India and Egypt over a period of 2500 years. As always, I am drawn toward the story of the piece. I am curious about the people who made the gameboard and who owned it. I want to grab the pieces and learn how to play the game. I seek this enlightenment and encounter to satisfy my own curiosity.

Figure 2-2 A chalice in the Cortauld Gallery (Microsoft).

Just behind the game board is an unbelievably tiny golden chariot. I pull the chariot closer and read the card containing its information. It turns out that curators believe this was at one time a child's toy. I am amazed that I am able to push and pull this rare object. In reality, I would never be able to get this close to it. In my headset, I can touch it, turn it around and examine the finest details. I want to place it next to my other toy, the game board. After the chariot is positioned next to the game board, I realize I can see detailed faces and clothing on the chariot driver and his

Figure 2-3 Gaugin in the Cortauld Gallery

passenger. I look more closely and it seems I can even see facial expressions. The reins and the spokes on the wheels look impossibly fine. Their finish is glittering, almost winking at me.

I turn to the side and almost bump through a painting. I do not care for the heavy frame around the artwork, "Nevermore," by Paul Gaugin. (See Figure 2-3). I am a foot away and I can see the heavy, dark grain. It does seem to compliment the painting though. The painting itself is a sullen mess of colors. I feel the need to explore why this piece might be considered a masterpiece. And again, my interest is framed by what draws my imagination. I am fascinated by small things like lumps and ripples in the canvas. I can see where he changed his mind about the subject's foot and shortened it. I wonder if I would have done the same.

I finally recognize something I can appreciate and to which I can relate. The way Gaugin has combined paints directly on the canvas is so subtle. From a distance, the color mixing appears to be a solid color, but from a foot away, I can see how he introduced yellow and orange and even turquoise to create texture and shadows. The canvas is so covered in paint, that I can only see hints of the underlying canvas at the very edges of the work. On the other hand, "Te Rerioa" or the dream is so lightly painted, I can see in places where his brush just kissed the top of the warp and weft of the canvas.

And finally, I circle back to the sculptural collection. I push the Manets and Gaugins and Renoirs off to the wall above my sofa and pull a large goblet closer. Its color is magnificent. The color of the drinking cup is a gradient from orange red on the bottom through to a greenish color at the top. Men are dancing all around the outside of the cup in a heavy relief. The cup is from the 4th century AD according to what I read on the information card. I can walk all the way around it, look down into it and put my hand against it. I am surprised to be using words I typically use to describe physical objects.

Without being aware, time has passed and I have moved and examined each and every item in my private gallery. I have studied brush strokes and frame construction. I examined deep gouges in a colossal sculpture of Ramses and I have fallen in love with a tiny decorative frog.

2.2 The Southeast Lighthouse

My second story has no beginning and at this point only one foreseeable ending, the collapse of a building. It's about my personal experience of the Southeast Lighthouse, on Block Island, Rhode

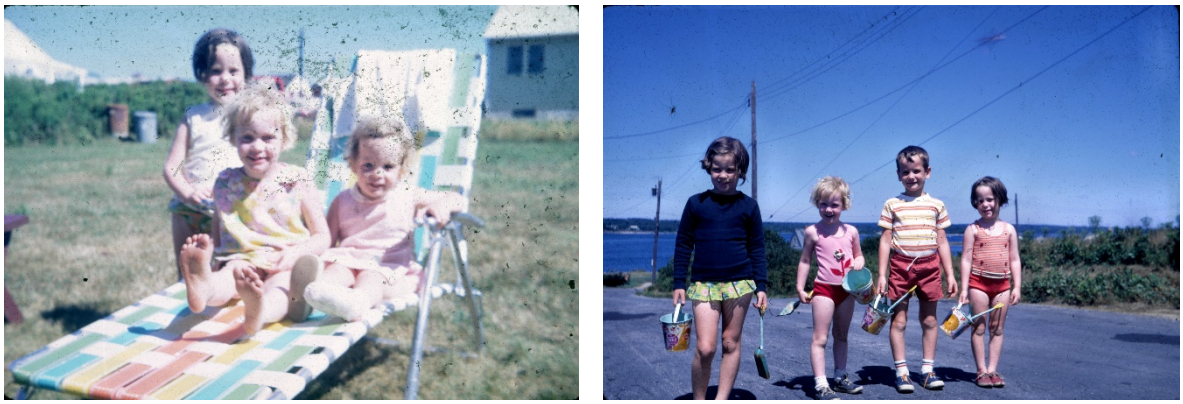

Figure 2-4 Susan, Karen and Alice on the right, Terry, Karen, Kevin and Susan on the left.

Island. I cannot recall a time when I was not fascinated with this lighthouse. When I was a child, (See Figure 2-4) we were not allowed to enter the lighthouse for various reasons but my sisters

Figure 2-5 The Southeast Lighthouse prior to move. Note the people standing on the bluffs.

and brother and I visited every summer. We brought our bicycles over to the island and rode about a mile to the lighthouse. At that time, the lighthouse was perched precariously along the edge of a sandy bluff about 200 feet above the water. (See Figure 2-5). Everything about the lighthouse encouraged imagination, fueled daydreams and alarmed with its proximity to the edge.

On sunny days, the bright orange red bricks contrasted starkly against azure skies. The heat from the sun poured off the tower while we traced our fingers over the wind and sand worn bricks. The tower loomed over us and compelled us to crane our necks back and view the black, cast iron, gothic metalwork of the tower and the darkened and dirty windows. The mystery of those dark windows drew me in. I wondered, who had lived in this place and what were they like? Why would someone put castle like details on such a practical building?

On foggy days the reddish orange bricks darkened slightly and the already dark windows appeared to be darker still. Often the top of the tower was shrouded by the fog. We could feel the water droplets of the fog as a solid mass. On these days, the green lamp in the tower was visible and the fog horn would blast at intervals causing us to jump and thrill with the wildness of the scene. We would look at each other and see who had jumped and who had not. Nervous giggles would often

Figure 2-6 The Indian Graveyard on Block Island, Rhode Island.

give away those who had started with the sound. We could hear answering fog horns from the North lighthouse and other unknown towers in the fog. This ethereal sound of the far away towers made real the ghost stories we heard about the nearby "Indian graveyard" (See Figure 2-6) and spectral, flaming ships that roamed the Block Island sound on wintry nights.

Other thrills could be found on or around the lighthouse grounds. The golden, eroding sandy bluffs were not fenced off or guarded. The stairway, 140 or more steps, to the beach was built of silvery and splinter filled, rickety two by fours and rusted out nails. It was interesting that the silvery parts were so smooth but led to gigantic shards of splintered wood. At the time, steps were not guaranteed. Some were missing and at best you descended and ascended at your own risk. We may have climbed the stairs only once or twice in my entire childhood. Eventually, erosion and danger to visitors did require the owners to erect fences and prohibit people from climbing the stairs.

As we got older, our parents would allow us to take our bikes to the island on the ferry by ourselves. This sense of freedom was awesome. The open seas awaited. Ice cream, salt water taffy, sea shells,

Figure 2-7 Images from inside of the Southeast Lighthouse.

glittering rocks, sea glass, sunburns and sprained ankles were ours for the taking. The sum of these experiences formed who I became as an adult, including the sprained ankle (Sturm, 2008). The freedom, imagination, adventure and curiosity are mine to draw from when I need it.

Two events caused me to focus my attention specifically on the lighthouse and not just the island. The first was moving away from the east coast to the west coast, increasing my physical distance from the lighthouse and making visits there rare. The second was news that the lighthouse was finally being moved off the encroaching edge of the bluffs because the danger to its continued survival was so great. The bluffs had eroded to almost the very edge of the tower. Realizing the true danger that the tower could disappear forever was alarming. I was sad thinking I might never be able to see what it looked like inside or how the lighthouse keeper lived. I worried that if the lighthouse was gone, somehow, I would lose something of myself or never be enriched by its secrets. Eventually, money was raised and dedicated to moving the lighthouse as a building with historical significance. It was safely moved back 300 feet off the edge, though the next move will put it literally on the street.

After the move, attention poured in from around the US from people who loved this lighthouse. Money was made available to refurbish the outside and encourage more visitors to experience the lighthouse as it was built. Additions of fire escapes that marred the exterior were removed to return

Figure 2-8 Inside the tower looking up through the cast iron spiral staircase.

the exterior to its original appearance from the 1870s. More information about the history of the lighthouse was available and it was at this point that I fathomed I was in love with all of it, the building, the location, the romance of the lighthouse keeper's job, the time period in which it was built, the iron work, the bricks, the majesty of the tower and the nobility of what the lighthouse stood for. All of this was wrapped around my childhood memories and how I thought of myself as an adult.

Figure 2-9 A first order Fresnel lens inside the Southeast Lighthouse.

2.3 Experience Goals

The stories at the beginning of this chapter go into great detail about two personal experiences. After writing the stories, I reflected on aspects of my experiences that were important to me and organized my project in three main themes: materiality, social interactions, and play. The categories and their experience goals are described below along with how they informed the design of the dollhouses. Appendix A provides a table detailing the experience goals derived from the lighthouse and the museum.

2.3.1 Materiality

Throughout both of the experiences described above I felt the sway of scale on my encounters. I felt awe at the scale of the lighthouse tower, its looming, warm, tactile size. I felt awe at how large I felt looking down on the beach far below. (See Figure 2-9). I felt a similar awe at the details on the ancient digital gameboard in the digital museum. Inside the museum experience there was both a colossal but also a miniature model. I wanted study participants to feel that sense of awe at the scale and details available for them to experience in both dollhouses.

The tangible dollhouse offers many opportunities to provide tactile surfaces for the study participants. For instance, roof tiles made from sandpaper offer participants a rough surface over which they can run their fingers. The lighthouse was peaceful, and atmospheric while at the same time, occasionally when the fog horn blew it was unsettling. The digital dollhouse offers other experiences that are felt by a human body. For instance, spatial sound in the digital dollhouse provides a sense of atmosphere similar to one I felt at the lighthouse. I wanted to make both the digital and the tangible dollhouse feel as material as possible.

2.3.2 Social Interactions

On the one hand, I liked being with my family at the lighthouse but I liked experiencing the museum by myself. The digital museum felt solitary and enclosed. Though, I enjoyed the opportunity to explore on my own, as I found it meditative. I wanted to explore whether other people would be drawn toward solitary experiences as well. I enjoyed including them in my creation process. I wanted to offer the participants both the solitary digital experience and the social tangible dollhouse experience to discover which they would prefer.

2.3.3 Play

The final experience goal I had for this project involved play. I wanted to convey a feeling that playing in a dollhouse was a game. My playful activities at the lighthouse felt free and they felt like time that was carved out of normal activities. I felt transported to a unique environment at the lighthouse and inside the HMD. Frequently, my siblings and I teased each other and created impromptu challenges or games at the lighthouse. I wanted to provide this experience to the study participants.

3 The Dollhouses

The experience goals described above helped to define the contents and shape of two dollhouses made for this project. This section describes the finished dollhouses.

Figure 3-1 Details from the interior of the holographic dollhouse.

3.1.1 The Holographic Dollhouse

The holographic dollhouse is approximately 54 inches high. The lighthouse tower is capped by a copper roof and spire below which, three rows of 16 panes of glass each create the light housing. Brick is the primary material used on the exterior. It is augmented by cast iron sheathing just below the light housing. The keepers walk is also iron and is decorated with gothic elements. (See Figure 3-1).

The lighthouse keeper has a desk, lamp and anachronous telephone that are too big to fit in his upper office room. They are sitting on the edge of the walkway waiting for someone to move them to a better location. Three floors separated by spiral stairs provide the keeper with three rooms to decorate. Bedroom furniture, a bed, side chair, dresser, lamp and side table are complemented by a light blue rug. A china doll sits on the chair. A table is dressed for tea and has two ornate carved chairs that can be moved around. The kitchen is equipped with a cast iron stove, several copper bowls, a trestle table, fruit, cheese and bread. Ornaments are provided to hang on the walls of the dollhouse. And as a tutorial level for players, five full size books and a full size ornamental porcelain bird are provided. These items are larger and may be easier for beginners to use to learn the gestures necessary for moving items in the dollhouse.

Objects in the holographic dollhouse are textured and modeled in a realistic manner. This was done to encourage players to see the materiality of the holographic objects. They are left strewn about on the surface next to the dollhouse in order for players to roam through. This was done to encourage players to explore and investigate their possibilities.

3.1.2 The Tangible Dollhouse

Figure 3-2 Details from the interior of the tangible dollhouse.

The tangible dollhouse is approximately 45 inches tall and weighs 15 to 20 pounds when it is full. The roof of the tower is painted black and covers a light housing that contains a green electric light. Velcro secures the light housing to the top of the dollhouse, making the light fixture available in case the bulb burns out. (See Figure 3-2 and Figure 3-3).

Figure 3-3 Having tea inside the tangible dollhouse.

This dollhouse only has three floors as it does not include an upper office room. A ladder leads from the keeper's walk to the third floor. This room has small circular windows, green wallpaper and a green carpet. The middle floor has pink wallpaper and a white carpet. Hardwood flooring was made to cover the first floor and pale green floral wallpaper decorates

Figure 3-4 The tangible dollhouse setup.

the walls. The exterior of the dollhouse is painted brick red and is constructed of MDF molded to look like clapboard siding. (See Figure 3-4 and Figure 3-5).

The light housing and keeper's walk are painted black to simulate cast iron. Three collections of furniture provided roughly create an office, bedroom and kitchen. In the office, the keeper has a wing chair and foot rest, a desk and chair, a tool chest and a grandfather clock. The bedroom has a canopy bed with a handmade quilt, a side table with a working lamp and a hope chest. A cast iron stove, kitchen table and storage bin are the major pieces provided for the kitchen. However, there is also a porcelain tea set, enameled pots and pans, ginger bread cookies, a toy train and a hobby horse. This dollhouse is completed with three purchased porcelain inhabitants, their dog and one tiny handmade porcelain baby with an ornate ironwork baby carriage.

A multitude of accessories is intended to provide players with a feeling of bounty. Warm colors and homey touches invite players to feel free and comfortable. Textures on the exterior and interior reinforce the tactile materiality of the tangible dollhouse.

Figure 3-5 The completed dollhouse.

Figure 4-1 Dream House 1984 screenshot from emulator

4 Background

Background for this project was informed by traditional dollhouse creation and general dollhouse play and the underlying theory related to three themes: materiality, social interactions and play.

4.1 The Dollhouse Traditions

Though users have been able to access digital dollhouses like "Dream House," (See Figure 4-1) one of the earliest digital dollhouses, since the mid-1980s, for the most part they have not been able to build the dollhouses digitally themselves (Essoe, 1985). Will Wright's "The Sims," circa 1999, and "Dream House" are early examples of digital dollhouses that allowed users to decorate their houses but not build them (Internet Archive Wayback Machine, 1999). Though these are digital games founded on dollhouse play, they are both digital dollhouses that require specialized skills to create. Second Life and Minecraft are two contemporary digital dollhouse environments. Minecraft, like Second Life, allows users to build in the environment of the game, customizing

Figure 4-2 A carnivalesque upheaval

their virtual environments as if they were dollhouses. Second Life and Minecraft are both also available in virtual reality. Though users can build their digital dollhouse environments, they do not typically create the primitive shapes or building blocks with which they can modify their environments. The exception is if they have specialized skill sets that allow them to modify their games at the software or 3D modeling level.

Figure 4-3 Miniaturization changes the context

Builders of tangible dollhouses display miniature virtuosity. They are researchers, designers, electricians, furniture makers, restorers, wood workers, sewers, painters. In a word, they are craftspeople. Virtual dollhouse creators are virtuoso modelers, graphic artists, designers, researchers, furniture makers, architects and software developers. It is tempting to say that one dollhouse is more complicated to produce than another or has more value for research than another. In reality, this is not a valid assessment.

Miniaturization changes the context for objects in dollhouses (Millhauser, 1983; Pearce, 1995). (See Figure 4-3). The interior of the dollhouse still contains the same objects, chairs, tables, beds as a full size house but by being smaller than their originals they afford new and unique

Figure 4-4 Two towers out of context.

opportunities for manipulation. The contextual change leads to greater insight into the ability objects have to move, how they are moved and the information the objects can impart as they relate to other objects. Further the contextual change can lead to carnivalesque upheavals (see Figure 4-2) of hierarchy and authority as seen in Miriam Schapiro's dollhouse (Balducci, 2006).

4.2 Materiality

Developing both a tangible and a virtual version of a dollhouse enables observations about the material nature of both. With respect to their materiality, it is important to consider duality, scale, and playful opportunities for shaking up traditions.

James Bryan argues about the duality of miniatures: they are both representations of objects and are objects themselves (Millhauser, 1983; Pearce, 1995; Stewart, 2012; Bryan, 2018). In contrast to typical replicas or copies of original objects, miniatures have greater value because they are detailed miniatures (Millhauser, 1983; Armstrong, 1996; Bryan, 2018). Millhauser also argues that miniatures change or flip context (Millhauser, 1983). Because the miniature is confronted as part of a greater world, it calls for recognition as being out of place while fulfilling its purpose, that of being a miniature object. The craftsmanship of a well rendered miniature combined with its duality is almost impossible to pass by (Bryan, 2018). The holographic, digital dollhouse can only be

experienced as overlaid on the real world and therefore fully in its context as a miniature replica that is out of place. (See Figure 4-4). In contrast, the tangible dollhouse stands as a physical entity composed of matter.

Figure 4-5 The holographic lighthouse against an historic building on WPI campus.

The dollhouses are interesting places to investigate the duality argument. Where you would expect a direct relationship, tangible lighthouse to tangible dollhouse, the result of building the tangible dollhouse is an abstracted version of the lighthouse. Where you would expect an indirect relationship, the result of building the virtual dollhouse is a structure that is fully recognizable as a representation of the Southeast Lighthouse. Both dollhouses are reproductions of the historical building, yet, both are also a new object, a toy, a dollhouse. Further complicating the issue is how the virtual dollhouse objects are described, wooden, brick, glass etc. The viewer can "see" the qualities of wood, brick and glass. Richard Sennett refers to this as material consciousness. He argues that at times a viewer's perception of a material may color how they perceive the object itself (Sennett, 2008). He also argues that by switching materials around or adding complexity, new awareness or innovations take form (Sennett, 2008; Csikszentmihalyi, 1996). Analysis of this study will reveal how much the viewer is willing to accept the virtual objects as having real presence in terms of authenticity, innovation and aura.

Kallinikos, Aaltonen, and Marton suggest that because digital objects by their nature are always editable, they differ from their physical counterparts (Kallinikos, Aaltonen, & Marton, 2013). Other scholars define physical objects as being constructed from matter, and therefore inherently contain affordances and constraints that are insurmountable: glass is transparent, wood is solid, and therefore physical objects can be viewed on a molecular level (Leonardi, 2010). I argue that physical objects can also be continuously editable. The wooden headboard can be removed when the bed is no longer stable. It can be reworked into the surface of a table. The table surface could be reworked into a platter or shelf. Over the course of the study, no one was told they could not repurpose the dollhouse. Thankfully for the study, no one did, though it is possible.

Fiona Cameron suggests that the value of digital objects is at risk of being stifled. Digital artifacts should be assessed in terms of the value of their more "material" physical parallels. She argues that critics, with a "repugnance for reproductions," confine the opportunity for growth and greater comprehension of digital materiality (Cameron, 2013). Digital media offer opportunities to study objects that are either inaccessible or subject to damage and would otherwise be off limits. The holographic dollhouse allows players to visit the Southeast Lighthouse in new ways with the potential for encouraging preservation efforts and inspiring novel ideas.

This miniature arena has great potential as a place of renewal and challenge to accepted authority. By presenting study participants with both tangible and virtual representations of dollhouses, divergence and convergence in terms of original material, editability and authority, scale and playful opportunities and tradition can be explored more thoroughly.

Figure 4-6 New friends made while playing with the dollhouse.

4.3 Social Interaction

Craftspeople do not create in a vacuum; their inspiration has to come from somewhere. In this, craftspeople are part of a cycle. With respect to social aspects of play in a dollhouse, it is important to consider both the creative process of the craftsperson and the experience of the players. (See Figure 4-6). According to Peter Korn, craftspeople live in the world and receive their inspiration from society. They use their skills to create objects that have been embedded with their learned practices (Korn, 2013). Korn then adds that these objects return to the world to be discussed and evaluated by others. By including family members in the dollhouse creative practice and reflecting on this, the author contributes to understanding this communication better. (See Figure 4-7 and Figure 4-8).

Figure 4-7 My granddaughter helped with the dollhouse.

The human need for a place separate from others is described in prospect-refuge theory. Malinda Colwell and her associates wrote about places that children create away from others. They referred to these places as secret spaces.

However, they also suggest that not only children need these secret spaces. She mentions even Charles Darwin acknowledged an adult need for secret spaces (Malinda J. Colwell, 2016). Edith Cobb, Quentin Stevens, Elizabeth Goodenough and others discuss how creative adults figuratively return to these spaces when they need to renew their creativity (Cobb, 1959; Sturm, 2008; Goodenough, 2003; Annemarie S. Dosen, 2016). This work contributes to understanding the creative process as a social process. Further, it investigates and contributes to knowledge about the adult need for a space away from others while also maintaining some contact with others.

Figure 4-8 Rubber bands clamp the light housing while it dries.

4.4 Play

This project expands knowledge of adult play through the examination of the craft practice of an adult as play and the playful encounters of adults in the tangible and virtual dollhouses that were crafted. With respect to adult play, it is important to think about the dollhouse as an environment that automatically provides a space that transports the players, is free and often impromptu. Both Huizinga and Caillois discuss play and provide definitions that can be applied in this project. (Huizinga, 2014; Caillois, 2001) Caillois defines game play as free, the outcome of game play is uncertain, it is unproductive, it is separated from the rest of the public arena and finally it either involves rules or some form of mimicry (Caillois, 2001). The dollhouse provides an environment that fulfills all of these requirements and the presence of these aspects of game play were of particular interest in this study.

Figure 4-9 Possible outcomes of playing with and creating a tangible dollhouse.

Before anyone can play *in or with* the dollhouse, a craftsperson has to create the dollhouse. (See Figure 4-9). This process is also play for many adults whether tangible (Jacobs, 1965; Greene, 1995) or digital (Paulk, 2006). Blundel, Koomen and Bell speak about the difficulty in studying craft practitioners in their natural environments

Figure 4-10 Ladders to success. Part of the creation of the tangible dollhouse.

(Blundel, Koomen & Bell, 2019). Further, they argue that due to the frequently embodied nature of the knowledge of craftspeople, it is often difficult to define their work. One of the ways they suggest research may be conducted is by injecting the researcher into the crafting process (Blundel et al., 2019). In this project, the lighthouses were constructed by the researcher using over thirty years of crafting knowledge as a guide. (See Figure 4-10). The results of reflective crafting are presented by the craftsperson in Chapter 4.

Figure 4-11 Playful interactions with the dollhouse.

Dollhouses provide a possibility space to observe other forms of play. Stevens suggests that "play is a product of possibility, but it is also a driver (Stevens, 2007)." He argues that people will observe objects, impediments or actions of others that don't necessarily fit into their own understanding and explore this observation through play for various reasons. He suggests people

Figure 4-12 Balancing things challenged several of the study participants.

draw others into their play while they explore and this often leads to unexpected and playful uses of space or place (Stevens, 2007). Note in Figure 4-11, the doll peeking through the stairs. Note also, the players have hidden the dishware under the coverlet. Below left, someone has laid the photos of two past inhabitants to rest on the bed and below right, someone has given the keeper a hat (see Figure 4-11). This project investigates Stevens' argument through observation of study participants while they are playing. The observations will answer the question about how this sort of play may be different in tangible versus virtual spaces.

Woodyear argues that when play is studied, care should be taken to avoid defining play with objects that represent real things as separate from play with objects that are real things (Woodyer, 2012). For instance, while studying play, avoid differentiating playing with a computer based object from playing with the real thing. She argues that "In its spontaneity, playing can occur in any space or place, or the journey between them" (see Figure 4-12) and by suggesting that play be examined in only one space, non-representational, or representational, the opportunity for spontaneity in play occurring somewhere between is lost (Woodyer, 2012). This project uses both a tangible and augmented reality dollhouse to examine the shared non-representational /representational space as occurred when the play testers tried to insert the digital furniture into the tangible dollhouse.

5 Crafting Experience

Crafting the dollhouses is the first stage of the project. This section describes the author as a craftsperson in the first person and describes the process of making the models. This is followed by a deep reflection on materiality, social interactions in crafting, play and mistakes that I felt were made constructing both dollhouses.

5.1 Methods

Skills gathered over thirty or more years allowed me to create both dollhouses. I was both the creator and the audience during the stage in which the dollhouses were crafted. Experience goals developed in the initial exploration of this project created a framework used to shape the investigation of the dollhouses. In this section, I reflect upon how materiality, social interactions and play were all a part of my crafting practice and play with the dollhouses.

5.1.1 The Dollhouse Craftsperson

Often, I think about a project in my head for a long time before I begin. In the case of the lighthouse dollhouse, I had been thinking about and planning both the tangible and virtual versions separately for many years. While I thought about creating a lighthouse dollhouse, I also researched the construction of the lighthouse and its history. When I plan a new project, I like to investigate as many aspects of the project as I can. I like to learn about the history of a craft and required skillset. I like to learn about what people were like who did the craft.

Throughout my project, I knew I would use knowledge I had gained through my own scholarship, but I knew that I would fall back on lessons I learned from both of my parents during this process

as well. For me, the social aspects of being a craftsperson generally involve my family. I learned about the natural grain and beauty of wood and appreciating fine finishes that justify the quality of the wood from my father. My mother painted and stenciled decorative motifs on trays and other surfaces when I was little. I learned about color and good design from her. Both of them insist on doing the best work they possibly can and I knew I too would follow this practice.

In my practice, I try to pass along the lessons I have learned to others. I recognize that creating things is a social conversation that takes place when I am around during the creative process, but also when I am not around (Korn, 2013; Becker, 1974). When I visit museums, I look at pottery for finger prints left by the potter or tool marks left by sculptors. For me, it humanizes the artwork. It feels like giving the artwork scale. If it was made by a human, and that human leaves evidence of their work behind, then I can comprehend the scale of the work involved in creating it. I identify with the artist and as an artist, I feel part of a long tradition. I try to convey to others how they too can be part of the tradition. And when I create, I often enlist others to learn how to do what I am doing or to contribute to my project.

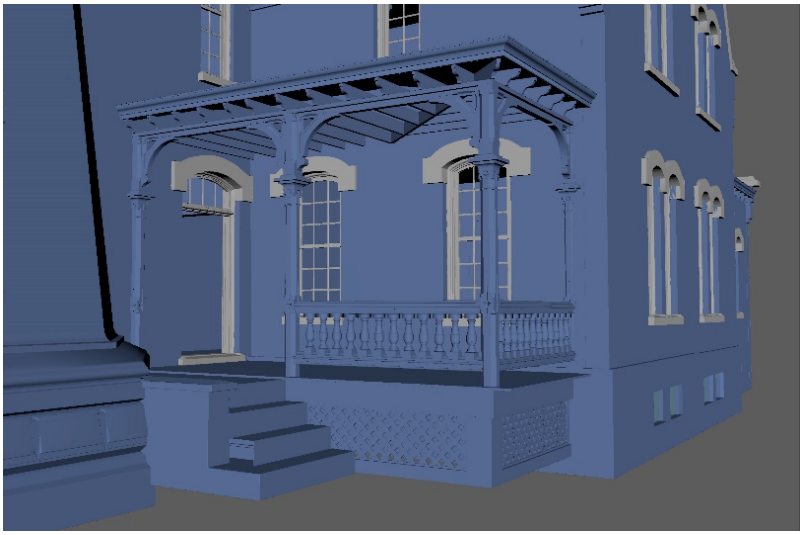

Figure 5-1 One of the earliest models I created for my own pleasure.

My family has become accustomed to this now and knew they were going to be tapped to

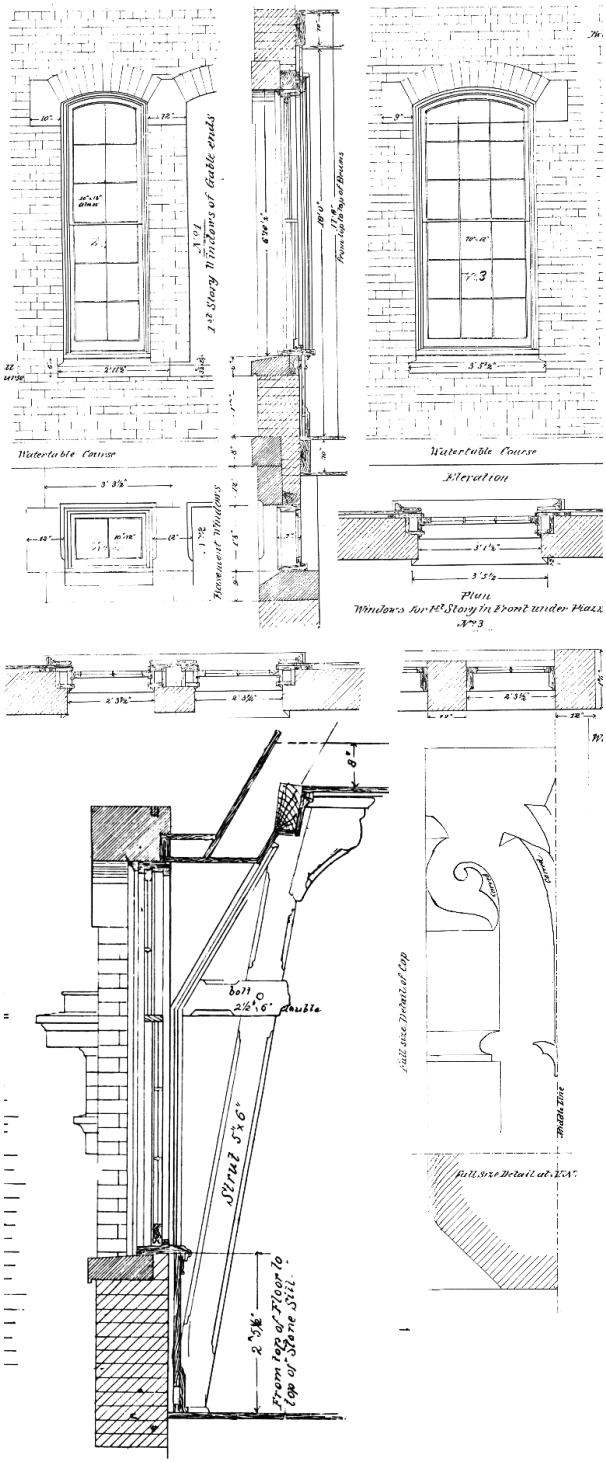

Figure 5-2 Portions of the lighthouse blueprint. See Figure C-1 for more.

help with my dollhouses. By deciding to create both a tangible and a virtual dollhouse, I complicated my desire to include others.

5.1.2 The Dollhouse Models

It had long been a personal goal to create a replica of the Southeast Lighthouse. (See Figure 5-1). I believed the creation process was a way that I could explore the architecture and design of the lighthouse in an intimately physical way. The historic architectural plans reinforced my appreciation for the structure and the architect as well. They were beautifully hand rendered with each drawing fitting precisely to the elements drawn on the next page (Historic American Engineering Record, 1968). (See Figure 5-1).

I made the tangible dollhouse from a kit purchased online at Real Good Toys (Real Good Toys, 2018). The manual recommended supplies with which to finish the kit, but, the final design choices were up to me (Real Good Toys, 2018). The base and sides of the dollhouse were made

from MDF, a type of composited wood. The exterior was milled to look like clapboard siding. Various bits of the trims and railings came preassembled. The interior had a block like staircase, requiring some assembly, to set up against the walls. Windows all around the light housing enclosed a flickering light. The light was electric and came pre-wired. The kit was designed in the standard 1:12 scale of modern dollhouses, though traditionally dollhouses could be any scale (Joyner, 1977).

The virtual dollhouse, created by the author, was imported as a 3D model into Unity, a game engine, along with all of the textures necessary to make a highly detailed, brick exterior lighthouse tower. The railings and stairs had rust on them like the real lighthouse. (See Figure 5-3).

Figure 5-3 Holographic dollhouse bedroom details.

The digital dollhouse was decorated with more accessories and greater detail than the tangible dollhouse because the selection of 3D models available on the Unity store and Sketchfab exceeded the local availability of tangible miniature furniture. The original objects that were included in both dollhouses were a cast iron stove, pots, kitchen table and chairs, food, china dishware, bed, books, night stand, pictures, lamp, desk, toys, stuffed furniture and clock. The tangible house had the addition of lights that work. The virtual dollhouse had the addition of a wash stand, a

significantly greater variety of food objects, mugs, and a decorative figurine. Though it is difficult to find tangible miniatures in my local area, they are readily available online[1].

The skills I used to build the tangible dollhouse are legacy skills learned through a lifetime of craft, whereas, I had to complete several tutorials to be able to finish the virtual dollhouse. For this reason, I spent more than twice as much time building the holographic digital dollhouse than I did building the tangible dollhouse.

5.2 Reflection

Here I describe my experience in terms of the themes of materiality (See 5.2.1), social interactions (See 5.2.2) and play (See 5.2.3). The final section describes some of the mistakes that were made in the process of creating the two dollhouses.

5.2.1 Materiality

As a result of my creation process and comparison of the two different dollhouses in terms of process, I discovered that, for me, the most interesting part of this project was the comparison of material and immaterial objects. I notice things like how the paint smells, what an object is made of, how smooth a surface is, what color it is, and sometimes how a tool sounds on a surface or how the material sounds under a tool. I recognized after finishing both houses that the digital dollhouse resembled the material lighthouse much more closely. It was much closer to the reality of the real

[1] https://www.dthomasfineminiatures.com and Etsy.

lighthouse. The tangible dollhouse was much more abstract in representing the lighthouse. (See Figure 5-4).

Figure 5-4 Both dollhouses side by side.

I find material and immaterial characteristics in both the tangible dollhouse and the virtual dollhouse. Thinking of materiality in terms of the matter that forms an object and immaterial as not being composed of matter is too inflexible. The lighthouse dollhouse as hologram is created on a screen in front of my eyes with light or energy not matter. I believe it does matter nevertheless. To understand how holograms might be an opportunity for or a detraction from craft practices or

cultural heritage that we can pass along, we have to explore the materiality of holograms and the immateriality of tangible artifacts.

5.2.1.1 Materiality of Holograms

Figure 5-5 An empty model.

The digital artifacts inside the dollhouse, which I refer to as objects, are not really objects in the traditional tangible sense. On the other hand, considering the materiality of the artifacts, that is the ability of these artifacts to allow me or others to create environments or tell stories or play games, then these artifacts serve purposes that are defined by the player as practical instantiations as described by Leonardi (Leonardi, 2010). In this way, they can be seen as material. If the virtual dollhouse was empty, presented without furniture or a suggestion of furniture, it would just be a model. (See Figure 5-5). Because it does not have a comprehendible scale like a tangible dollhouse, 1:12, it is much more difficult to sense the qualities that make it a dollhouse. Furniture helps provide these qualities. The way the artifacts look, like a chair, a desk, a bed, serve me in presenting my ideas. They communicate ideas about what I think a chair, desk or bed should look like inside a particular room. They help define the room. “Perhaps what matters most about an artifact is not what it’s made out of, but what it allows people to do (Leonardi, 2010).” If I can sit a doll in a chair in a virtual dollhouse, then the materiality of the chair is the condition that it is sit-in-able, if it hangs

in the air then it is suspend-able. It is the interactions with things that define their materiality (Leonardi, 2010; Korn, 2013). It is the presence of or context of the furniture and its materiality that defines the dollhouse.

As far as the immaterial, lacking material, created from energy, holographic digital dollhouse, I encountered some material aspects similar to those I confronted while creating the tangible dollhouse. When it came time to apply materials, surface decoration, to the 3D model, I found that materials created in one application appeared too shiny in another application. I was striving for realism when I created the textures. I wanted people to be drawn toward the brick surfaces because they looked so real. I wanted them to believe they were miniature bricks. In the same way that I sanded and smoothed the exterior of the tangible dollhouse, I tweaked settings and applied various techniques to remove the shine and add realistic bump textures to the exterior of the holographic dollhouse.

Figure 5-6 Under all of my pieces, my granddaughter painted a heart.

5.2.1.2 Immateriality of Tangibles

I experienced immaterial, not composed of matter, feelings through the creative process of the tangible dollhouse. I felt amused when I turned around one day after

Figure 5-7 A brick surface completed.

being visited by my granddaughter in my workroom to find a painting she had left behind. I left a semi dry paint roller on part of the box from the dollhouse kit. She took it while my back was turned and painted a giant heart on the box. (See Figure 5-6). She never told me, I found it after she left. Her actions embedded her sentiments into the material of the box and the paint. She communicated her feelings to me with her artwork and I received her meaning when I saw her creation.

Sometimes my mind wandered to memories of conversations I had with my father about finishes and work practices. I remembered past feelings of disappointment at my own impatience when I touched a finished surface before it dried and left a finger print.

Figure 5-8 A forgotten story left by my granddaughter.

Touching is an intimate part of completing a piece like the tangible dollhouse. I smoothed the sanded surfaces with my hands prior to painting to find any rough spots that would mar the finish. I remembered times when my father had me feel a surface that he had just finished sanding so I could learn

what was required for projects that I might undertake. A surface has to feel good to the touch. The edges of pieces have to join properly or your fingers will feel the ridge left behind. My fingers often feel things that my eyes cannot see. I have learned from my father to touch my projects, but only at the appropriate times.

5.2.1.3 Materiality of Tangibles

My granddaughter visits the tangible dollhouse every time she comes to visit. She may only move one or two things now that she has set it up the way she likes it. However, when she leaves, I generally find the evidence of some new narrative. (See Figure 5-8). She is not able to just drop in and drop out of the holographic dollhouse. I have to help her to load it on the HMD and put it on her head. Once I do however, she is able to interact with the objects on her own. Further, the digital objects she has placed in space and around the room are still exactly where she left them, on one surface, behind another, on the floor etc. The virtual dollhouse does not take up room in my house. I am not likely to step on a miniature hologram that is left behind on my floor.

5.2.1.4 Immateriality of Holograms

When I think about how the virtual dollhouse is swiftly becoming obsolete, I am sad because I really enjoy my digital experience. The creators of my HMD released the newest model before my study was even complete. I am aware that at some point in the near future, I will not be able to continue to port my creation to the next HMD or the next. The tangible dollhouse sits in my house gathering dust but I have it as a physical reminder of the creation process. I shared my skills of woodworking and painting with my children and now with their children. My family all contributed meaningfully to the creation of the tangible dollhouse. They only contributed feedback

about various aspects of the digital creation. For them, the tangible dollhouse holds so much more meaning.

5.2.1.5 Material and Immaterial

In the virtual dollhouse, (See Figure 5-7) I had a lot more control over the shape and texture of the final product. I think this control was a lot more satisfying. In fact, control over the outcome was a big factor in my satisfaction with both dollhouses. I could not control the sculpting on the tangible dolls or the finish on the purchased furniture in the tangible dollhouse. I was in control over many of these aspects in the virtual dollhouse. Flaws were not as apparent in the virtual dollhouse. I was much happier with the representation of elements that were important to me from the original lighthouse like the gothic ironwork and the brick exterior.

I made material mistakes building both dollhouses. One of the most difficult constraints that I had to overcome for the virtual dollhouse had to do with the number of polygons that were used to create the models for the virtual dollhouse. Digital models are entirely composed of polygons. The HMD had a limit to the number of polygons that could be present in an environment before the number of polygons impacted performance. To increase the reality of the environment, I included as many pieces of furniture in the virtual dollhouse as I had included for the tangible dollhouse. Also, I especially wanted to represent the organic, spiral staircase of the original lighthouse. The round hand rail and the curve of the staircase required a much higher number of polygons than a more geometric model would have required. I was willing to make the tradeoff. This meant that with a greater number of polygons used, the frame rate of the application was slower. The decreased frame rate introduced a flicker that impacted the satisfaction of most players. Unfortunately, my early decision to increase the polygon count of the models was difficult to back

out of when I created the application. This was directly related to my inexperience and lack of skills.

On the tangible dollhouse, I tried to hurry through applying a coat of paint to the tower one day. I did not change out of my good clothes to save time. I knew I risked getting paint on my clothes but I did it anyway. Sure enough, when I put the paint brush down, I looked at my shirt and found a spot of paint. I really do not know how it got on my clothes. This is not the first time I have damaged my clothing while crafting. I would like to say I have finally learned my lesson, but I know I cannot. Another day, I placed the light housing of the tangible dollhouse behind me to fix something and forgot it was there and sat on it. Needless to say, it broke. I was able to repair it to the degree that no one else would notice the repair, I know it is there however. Neither of these event would happen with the virtual dollhouse. However, while working on the spatial sound scape for the virtual dollhouse, I over wrote a working version of the application with a broken version. Again, I had to stop and make repairs. I was unable to show the virtual dollhouse to someone because the software was broken.

What I learned was that both tangible and digital craft practices have difficulties due to both their materiality and immateriality. It is not a unique condition of a tangible thing to have material issues like dust, breakage and decay. There are parallels in digital technologies like corrupted files, erased or overwritten files, bad updates and obsolescence. I find the digital dollhouse a little more compelling to play with and to work on. I think this is merely because it is novel and digital. In general, I believe I was able to get a lot closer to the experience goals I had for this project in the digital model. My creative play with both dollhouses was satisfying but only really social in the

tangible dollhouse. However, I am far more able to move and to share the virtual dollhouse with other people than I am the tangible dollhouse.

5.2.2 Social Interactions

When I created both dollhouses, I wanted people to evaluate some of the social aspects that I discovered were important to me in my initial stories. I wanted to convey that crafting provides an opportunity for retreat. However, crafting with others creates shared stories and cultural heritage that communicates those stories to others. It is also an opportunity to learn and help others to learn. I wanted to explore for myself how social interactions could be compared when creating a virtual dollhouse and a tangible dollhouse.

It seems like a contradiction to suggest that crafting is a retreat but also a social opportunity. For me, it is both. When I create something, I often find myself carried away, time flows by without me realizing it. It gets so bad that at times, if someone needs my attention in my family when I am engrossed in a project, they know that if I say five minutes more until I finish it usually means half an hour. However, unless I am under some sort of pressure like inadequate skills or an actual time deadline, I am normally very open to inviting family in to help with a project. I frequently asked for help manipulating the larger pieces while working on the tangible dollhouse. But I was the only one with the necessary skills with which to build the virtual dollhouse so it was a more solitary engagement.

As much as I appreciate social interactions as part of my tangible dollhouse creation, I find myself drawn at times to solitary creative endeavors as well. I like to work on miniature things because I can put on my head loupe blocking out the sight of my environment so I can focus entirely on my

Figure 5-9 Colleagues playing together.

work. It is this aspect of the head mounted display (HMD) of the virtual dollhouse that I like as well. I put on the HMD and the smaller field of view allows me to focus entirely on whatever texture or feature that intrigues me about a particular hologram. I find both activities meditative.

There were aspects of creating the virtual dollhouse that were social. I have not had thirty years to absorb programming or 3D modeling knowledge and accumulate the same skills from those who have learned them before me. Working with the software was a fairly new skill, whereas modeling is a skill that I have practiced for 10 or more years. I did reach out to fellow students when I needed help with my software application. I was excited about my growing skillset in this area and shared my excitement with other people.

Because I was so excited about the virtual dollhouse, I shared an early version with fellow students. I also provided the nearly complete tangible dollhouse for them to play with as well. What I observed was that they swarmed the tangible dollhouse while I was setting up the HMD. They were all reaching in and interacting with the furniture, accessories and each other. If someone did something unexpected the others asked why and were told a story or given an explanation. As soon as the HMD was ready, my colleagues stopped acting as a group and their earlier noise and

interactivity dissipated. When I realized what happened, I took note to observe if the same thing happened in the participant study. (See Figure 5-9).

5.2.3 Play

Through a comparison of the creation process of a tangible and a virtual dollhouse, I wanted to explore play as a craft practice in both cases. I wanted to explore whether crafting the dollhouses was relaxing and I wanted to explore any play elements that were revealed in the crafting process.

In some ways, creating the dollhouses was a means to an end. I wanted to be able to encounter the lighthouse more closely. To do this, I needed access to the lighthouse. The only way I was going to get that was to build a replica. Reflecting on the process, I found creating the dollhouse fun but also a lot of work. If I was leaving a social activity to go to my workroom, sometimes I described it as going to work on my dollhouse. Some of this I think has to do with how I identify as a productive person and a person who belongs to a group of other productive people, craftspeople (Dickie, 2003). Some of it has to do with the fact that I was creating the dollhouses for this project in particular.

Figure 5-10 Familiar tools.

Yet, whenever my creative practice became more social, for instance if I enlisted the help of my family, I referred to it as play. If my granddaughter or daughter helped, I suggested that we go play with the dollhouse. I believe it was the social

encounters that made the work into play. When I reflect on this, I remember all of the times that I spent playing with my children at various craft projects. Our excuse to create was always that it was playing. (See Figure 5-10).

Building the tangible dollhouse felt more playful than building the virtual dollhouse. I am more fluent with the tools and practices of creating objects that have matter than I am with creating software. I think my fluency gives me more choices when I need to make adjustments or solve problems. Building the virtual dollhouse felt more difficult because part of the time I was learning new skills. When I was sculpting or modeling in 3D, I used skills with which I was very familiar. I really enjoyed modeling the dollhouse on my computer. I also really enjoyed creating textures and adding the surface materials to the virtual dollhouse for the same reason. Learning about how to create the application was a challenge, the challenge was fun but it was also work.

When I judged that my work was fulfilling my design goals, I was able to relax and enjoy expressing myself creatively. Time flowed by without my awareness. Generally speaking, my fluency with the tools and skills of creating the tangible dollhouse helped me to find greater relaxation with that process. I felt a much greater sense of reward though when I overcame some difficulty. This happened more frequently with the virtual dollhouse.

The concepts of flow and feeling perlustrated along with a sense of reward or winning at some internal competition conform to Huizinga's definition of game. If I were to compare the tangible dollhouse experience to a game it would be like Go Fish (Bicylcle Playing Cards), a comfortable, not very challenging game with opportunities for nice social interaction. I would compare the process of creating the virtual dollhouse to the game Chess (Chess.com). Though I knew how all

Figure 5-11 The holographic dollhouse on campus at WPI.

of the pieces moved from the time I was little, to get better at playing Chess, I had to read books and play many games with people who were better at it than I. I had to accept many defeats before I could final win a game. I could feel myself making forward progress with my chess skills most of the time and so I did not give up but I had to work really hard for that first win. Of the two games, the one I am most satisfied winning is Chess. For similar reasons, I am most satisfied with the virtual dollhouse. The first time I was able to place the virtual dollhouse in my home, I was elated. (See Figure 5-11).

6 User Experience Study

To compare play experiences in the two dollhouses, I performed a user study. (See Figure 6-1). The methods section (Section 6.1) describes the participants and environment in which the second stage of the study took place. Following the methods section, the results section (Section 6.2) presents the responses of the study participants.

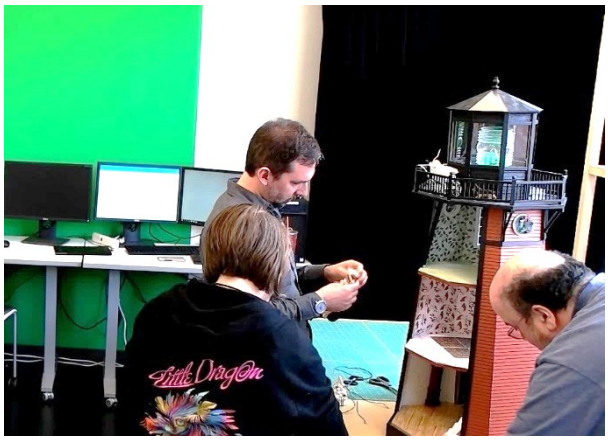

Figure 6-1 A sample of study participants playing in the dollhouse.

6.1 Methods

The overall goal of the research study was to compare the play experiences of the study participants inside a tangible dollhouse and a holographic dollhouse. For example, participants were asked to play with each of the dollhouses and then describe the environment of the dollhouses, rules they may have made, things that may have caused displeasure or pleasure or detracted from play.

Answer	%	Count
18 - 25	57.14%	16
26 - 35	14.29%	4
36 - 45	7.14%	2
46 - 55	10.71%	3
56 - 65	10.71%	3
65 or older	0.00%	0
Total	100%	28

Table 6-1: Contains the answers to the prompt what is your age group.

The participants of the study were recruited from the IMGD department and Global Lab at Worcester Polytechnic Institute. In total, twenty-eight participants responded. (See Table 6-1: Contains the answers to the prompt what is your age group.).

The design of the study had several people playing with the dollhouses at any one time. No one interacted with the dollhouses without more than one person in the room. The most people that ever interacted in one time slot was four.

The study was conducted in the Foisie Innovation Studio on the WPI campus. When the participants arrived for their appointed time slot, they were first told what to expect from the study. They were informed that they were going to be playing with both a tangible and a virtual dollhouse. They were shown the tangible dollhouse, which was sitting in the center of the room on a table

Figure 6-2 Tangible dollhouse setup.

Figure 6-3 Accessories in the holographic dollhouse.

and the HMD they would use to view and interact with the virtual dollhouse. They were given consent forms for participating in the study and after they signed the documents, the study began.

The tangible dollhouse sat on the table surrounded by the furniture and accessories provided for their participation. (See Figure 6-2). They were told that they could interact with the dollhouse in any way they wanted to. They were explicitly told that they could simply decorate the lighthouse, play a pretend game of some sort or find some other way to amuse themselves with the dollhouse.

Following this, they were given a brief tutorial on the gestures that are used with the HMD to select items. They were informed that in the HMD, they would be able to move and rotate the objects in the y or yaw right, yaw left directions. They were told the virtual dollhouse itself could not be moved and the surface underneath it could not be moved. (See Figure 6-3 and See Figure 3-1 for more images of the setup inside the HMD). They were recommended to try to move some of the

larger items first in the HMD as this would help them to become accustomed to the selecting gestures. This instruction was repeated when they actually had the HMD on their heads.

For both of the encounters, the participants were asked to speak out loud about what they were thinking, experiencing or playing as they were interacting with either dollhouse. The researcher took notes about these occurrences. Inside the dollhouse sat two pieces of paper with Persian carpets printed on them. A pair of scissors was placed on top of the paper. They were not told what to do with these items. The participants gathered around the dollhouse where they found dollhouse accessories scattered on the table surface. Based on their choice of interaction, objects were selected and placed in whatever manner they chose, inside, on top of or behind the dollhouse. This was free tangible dollhouse play time.

After 10 minutes of tangible play, the participants began to rotate through the HMD application one at a time. The participants received a brief review of the hand gestures and then they were

Figure 6-4 A study participant in the HMD.

shown again, how to put on the headset. All of the participants were watched for the first few minutes of holographic play to make sure they would find a measure of success at moving objects in the HMD. After it was clear they were able to move something, a timer was set for five minutes and they were allowed to play without any intervention.

While one person was using the HMD, all of the other participants were asked to continue to interact and play with the tangible dollhouse. (See Figure 6-4).

When everyone had received an opportunity to interact in the HMD, they were briefly queried about any narratives or rules that they had developed. And finally, they were asked to complete an online survey about their experiences. The results of the survey would answer questions about how the tangible and virtual dollhouse experience compare as far as how adults play and socialize in the dollhouses and how their environments and materiality compared. The study concluded after the survey questions were answered.

6.2 Results

The section presents the results of the user experience and survey in terms of materiality, sociality, playful interactions. Of primary concern was how participants would compare their experiences in the digital dollhouse and the tangible dollhouse according to these aspects.

6.2.1 Materiality

In order compare the environments of the dollhouses, defined as the buildings and their surrounds, study participants were asked to select adjectives that best describe their experience of the dollhouse environments from a list of fifty words. Results of the most commonly used words

are used in Table 6-2 and Table 6-3. Words that are often applied to tangible objects, tactile, physical and material, are used to describe the tangible dollhouse environment. In contrast, words that are more often used to describe immaterial things, intangible, strange, complex and ethereal are used to describe the holographic dollhouse environment. Study participants described the tangible environment as crafted and familiar and the holographic environment as innovative and intriguing.

	intangible	intriguing	innovative	strange	complex	ethereal
Total	12	11	11	9	8	8
Percentage	33.33%	30.56%	30.56%	25.00%	22.22%	22.22%

Table 6-2: Response to prompt to select words describing the holographic dollhouse environment.

	crafted	tactile	physical	material	familiar
Total	16	14	10	9	17
Percentage	43.24%	37.84%	27.03%	24.32%	45.95%

Table 6-3: Response to prompt to select words describing the tangible dollhouse environment.

Observations indicated that no one had difficulty picking up the tangible objects, although some were nervous about knocking things over and breaking objects. However, the gestures for moving things in the virtual dollhouse had to be taught and then reinforced for most of the participants. These observations are reinforced by the responses to a question about things that caused

displeasure in the dollhouse. Participants related a flicker was present in the holographic application. An example of the physics that were causing displeasure is the lack of gravity present in the holographic application.

The responses were open ended text responses. The codes, eyestrain, grasping, Field of View (FOV), framerate, physics, lonely, not tactile, nausea and sparse, were found via inductive coding. The responses led to codes chosen to best capture the participants responses. The researcher applied the codes to the responses again. The structure of the coding in this case was flat. Table 6-4 contains the codes that were most frequently applied to the holographic dollhouse.

	Grasping	Frame Rate	Physics
Total	12	5	7
Percent	42.86%	17.86%	25.00%

Table 6-4: Response to prompt to detail things that were not pleasant in the holographic dollhouse.

When asked about things that were not pleasurable, participants commented on being worried about breaking the delicate furnishings in the tangible dollhouse. Study participant X01 said, “The tangible dollhouse 's props were very delicate and not very solid. Some of the parts of objects were broken.” The words, grasping and sparse were inductively coded and applied to the participant responses for the tangible dollhouse. (See Table 6-5)

	Grasping	Sparse
Total	5	1
Percent	17.86%	3.57%

Table 6-5: Response to prompt to detail things that were not pleasant in the tangible dollhouse.

In the tangible dollhouse, the level of furniture or accessory detail was the most pleasant thing. This was followed by the level of detail in the dollhouse itself and the scale of the dollhouse. The participants chose the same characteristics as pleasant in the holographic dollhouse. Of note, the number of responses was more frequent in the tangible dollhouse, resulting in higher percentages of pleasure reported in most categories. (See Table 6-6 and Table 6-7).

	scale of the dollhouse	boundaries of the play area	rules	materiality	dolls	level of dollhouse detail	level of furniture or accessories detail
Totals	15	7	2	14	9	18	20
Percentage	53.57%	25.00%	7.14%	50.00%	32.14%	64.29%	71.43%

Table 6-6: Responses to a query asking which are pleasant characteristics of the tangible dollhouse.

	scale of the dollhouse	boundaries of the play area	rules	materiality	dolls	level of dollhouse detail	level of furniture or accessories detail
Totals	14	7	2	4	0	14	14
Percentage	50.00%	25.00%	7.14%	14.29%	0.00%	50.00%	50.00%

Table 6-7: Responses to a query asking which are pleasant characteristics of the holographic dollhouse.

Interestingly, observations indicated that some participants wanted to insert the holographic furniture into the tangible dollhouse. The holograms occluded anything that came between the viewer and the hologram. The occlusion made it difficult to put the holograms “inside” the tangible dollhouse. They simply appeared to float outside the tower.

6.2.2 Social interactions

Typically, three participants were in the room at a time to play with the dollhouses. Due to safety/health concerns, time was limited in the HMD to 5 minutes. Also, the application was only created as a solitary experience due to limitations of the HMD. This meant that for everyone to be able to use the HMD, they were allowed 10 minutes at the beginning to play in the tangible dollhouse followed by 5 minutes in the holographic dollhouse. Observations by the researcher indicate that after the initial 10 minutes of tangible play, while people were being cycled through the HMD, most of the social activity near and inside the tangible dollhouse stopped and if the person in the HMD spoke, it was ordinarily to the researcher. This was despite the fact that the person in the HMD could still see the room and the other participants.

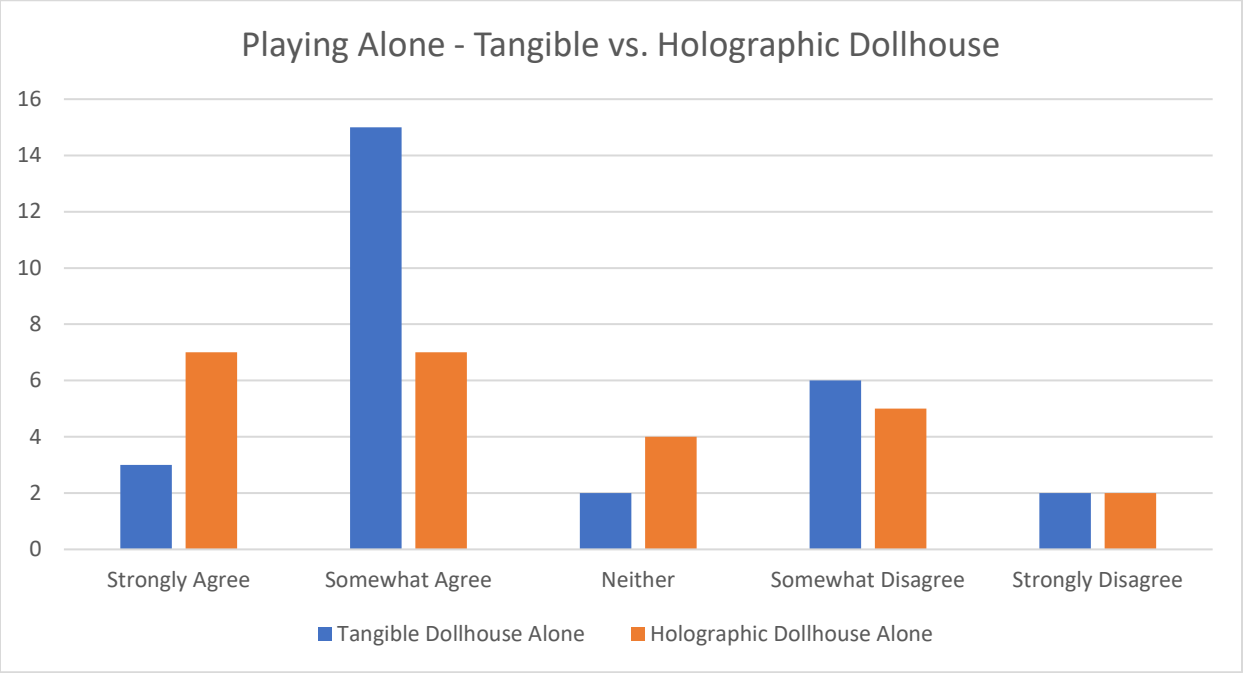

Table 6-8:Response to a prompt about whether you would prefer to play alone in the dollhouses.

Researchers were aware from earlier prototype testing that the HMD was a less social activity. To investigate if this was preferable or not, the participants were asked if they would choose to play in the either dollhouse alone. The results in Table 6-8 indicate that most participants would have preferred to play in the dollhouses alone. This response was a surprise because observations indicated that more social interactions happened inside the tangible dollhouse.

6.2.3 Play

Many of the participants in exploring the tangible dollhouse recognized that the light on the tower had a plug attached that was not able to reach an outlet. Participants were visibly disappointed when they could not plug it in. There were battery operated lights that were used in various ways. Some participants wrapped the light strings around the railings of the keeper's walk. One participant pushed a single LED light up through the lighthouse keeper's clothing, illuminating the keeper's face from below like a child with a flashlight at a sleepover. (See Figure 6-5). Most often, some form of lighting was used in the tangible dollhouse.

Figure 6-5 A light inside the keeper's jacket shining on his face.

build a virtual dollhouse from a tutorial	decorate a dollhouse with crafted items	decorate a dollhouse with manufactured items	build a dollhouse from a kit	build furniture or accessory items from a tutorial	build a dollhouse from scratch	build a dollhouse from a kit	only play with the dollhouse	none of the above
14	14	13	12	12	11	12	3	3
50.00%	50.00%	46.43%	42.86%	42.86%	39.29%	42.86%	10.71%	10.71%

Table 6-9: Response to the prompt which would you rather do?

As creating the dollhouse was a playful activity for the author, a question was posed to the study participants about what they would most likely do around a dollhouse. They were offered the choices to build, decorate or play with the dollhouses. The results indicate that half of the participants would want to be actively involved in a creative process, either building or decorating. It is very clear from Table 6-9 that most of the participants would not simply engage in mimicry or simulation with the dollhouse.

To provide a more natural environment for the tangible dollhouse, one in which players could add things by making them, the researcher provided what looked like paper oriental carpets and some antique looking portraits printed on computer paper. A pair of scissors was placed on top of the paper and a couple of empty frames that could be hung on the wall were also added to the interior of the house. In one instance, the scissors were removed and the furnishings were added to the interior right over the top of the paper. In that specific case, participants did not address the paper until the very last and then they had to clear off the furniture to get to it. In most cases, researchers observed that the carpets and the pictures were recognized and used. Sometimes, the results were unexpected. Participants cut out the center of the carpets and used the border to frame the windows in the light housing. Some participants used the portraits by placing them in the windows themselves as if someone was looking out.

In fact, largely, groups managed to find ways to make things interesting by trying something unusual or unexpected with the tangible objects. Some participants hid a few of the objects under or inside of other things. The activity was also reported by players using the HMD. Other participants played with the constraint of gravity. (See Figure 6-6). It was observed that participants sought out objects that they could attempt to balance on the spire at the top of the tangible lighthouse tower. Balance was the most frequent way that gravity was challenged in the tangible dollhouse. This kind of activity was also reported by some of the participants who used the HMD. One participant using the HMD decided they would distribute the dollhouse furniture throughout the testing lab, leaving it suspended in midair for the next player to find and collect. Another participant was fascinated by pulling objects in and out of the walls of the virtual tower. They left some of the objects buried in the floors and walls for other participants to find and recover.

Figure 6-6 Balancing was a challenge to impress other participants.

To investigate what dollhouse play looks like for adults and to compare if play is different for either dollhouse, study participants were asked about any rules that they may have developed for the dollhouse. (See Table 6-10). Answers to this question expand on Caillois' statement that games either have rules or are make-believe (Caillois, 2001). What was found is that the majority of the adult participants related that either they did not have rules or that the rules were flexible and more about common courtesy in a social environment. The researchers noted that in the few groups that

Figure 6-7 Adult play in the holographic dollhouse.

reported rules, one person in particular often dominated the group activity. In these groups, the level of playful activity was muted. Observations did reveal that due to the limited social nature of the virtual dollhouse, a question of rules or no rules did not apply. (See Figure 6-7).

Stories told about the dollhouse residents described their lives. Members of these groups often chose to conform to these narratives and absorbed communications that enabled the group to remain cohesive and in character.

Example narratives:

- Playing set design
- “We made a story about the characters being wizards and every prop was used to further this story”
- “The people are all wizards. The maid is on strike. The baby's real father is a ghost.”
- Creepy grandma and trapped woman
- A murder/horror story about a lighthouse keeper that had gone insane from the isolation

The rule that was most prevalent involved set design or designing the rooms. The next prevalent response indicated that participants did not believe they had created rules. Observations suggest that it was the narratives that created the informal rules of play not the other way around.

	Design	No Rules	Story	Polite/Social	Neat & Complete	Entertaining
Totals	11	9	5	5	5	2
Percentages	39.29%	32.14%	17.86%	17.86%	17.86%	7.14%

Table 6-10: Response to the prompt which rules were implemented during play?

7 Discussion and Conclusion

This project had two stages. In the first stage, the craftsperson related two personal stories that suggested two questions. The first question was how the creation process was different for the two dollhouses and how was play different. Next, the craftsperson created two dollhouses and reflected on her experience. The second stage invited study participants to play in the two dollhouses. The results were presented after a description of the study participant experience. This section reveals insights that pertain to both creating and playing in the dollhouses.

7.1 Discussion

One of my realizations that surprised me the most in this project was that it was preferable for me to create and play in the dollhouses alone. I learned through reflecting on crafting the dollhouse that although I did enjoy moments of social interaction, I really wanted to have control over the finished product and I wanted to be able to say that I had built the dollhouses myself. My observations and the answers on the survey questions indicated that the adults playing in the dollhouses similarly would have preferred to be playing alone. In the description of the rules that were developed during play, it is clear that many of the participants had ideas that sounded a lot like trying to control their environment.

When I play digital dollhouse games like Minecraft and Second Life, my play is all about controlling my environment. I do not feel repressed, nor do I identify any connection to an increased desire for domesticity. I do worry mildly that someone might judge me as less than an independent minded adult because they think playing in a dollhouse means I am willing to assume the role of domestic goddess. On the contrary, I own the space. I dominate it, not the other way

around. When I play in the tangible dollhouse with my granddaughter, I intentionally cede some of that control over to her. When I play in the virtual dollhouse on the HMD, I am the solitary consumer of the game. I enjoy the sense of getting away and playing with the miniatures. I enjoy creating my environment, crafting the pieces and placing the finished work. I was surprised to observe and read in the survey that like me, most participants preferred to either play in the dollhouses alone or to be creating the dollhouses instead of playing in them.

The materiality or immateriality of the dollhouses was a fascinating aspect of creating the dollhouses. For the study participants, the level of detail in the models was of much more consequence. The question of materiality or immateriality was rarely considered by the participants. They did find the virtual dollhouse intriguing and innovative but preferred to interact with the tangible dollhouse despite fears of breaking things. My fascination comes from the perspective of investigating a new representational media that is finally available for me to use.

7.2 Limitations

Time was a limitation for all aspects of this project. Time was a factor in the decision to create the tangible dollhouse from a kit instead of from scratch. Building from a kit revealed areas in which I was dissatisfied. I have questions about whether I would have been more satisfied with the tangible dollhouse if I were to have made it from my own plans and materials. Time limits were imposed on the virtual dollhouse play due to physical concerns for the study participants. In a way, even the frame rate of the virtual dollhouse was impacted by time. The HMD could not deliver the number of frames per minute to the study participants that would offer them a smoother experience.

I wanted to investigate the limits of the HMD to deliver the content to the player. Because of this, I intentionally allowed the polygon count to go higher than my research indicated that it should go. Further, the amount of detail and the size of the texture maps caused significant difficulty for the frame rate as well. When the polygon count became excessive, the limitations of the HMD were clear. Physically, the weight of the HMD was a limitation that I only felt because I wore it for hours. The study participants only ever had the HMD on for five minutes at a time.

Figure 7-1 Note the lights behind the hologram changing its opacity.

The tangible dollhouse is very heavy. It is measures about 4 ½ feet tall and 2 feet wide. Though I can lift it on my own, I prefer having help. This complicates moving the tangible dollhouse and limits where it can be stored and displayed. Further, the furniture pieces have to be completely removed before moving the dollhouse and then reassembled after moving it or they will fall out and get lost or broken. This is not a limitation of the virtual dollhouse.

Light is a limitation for both dollhouses. If there is too much light for the virtual dollhouse, it does not show up very well. Seeing the hologram clearly relies on having a dim enough ambient light that a user can see the projected image of the hologram on the HMD lenses. (See Figure 7-1). If the interior lighting is too dark however, the HMD cannot map the environment and will not

display the holograms. The tangible dollhouse does not have built in interior lighting. It is very dark at the back of the interior rooms. I do not find the dimness enjoyable at all and have included battery operated lights to combat that.

Both dollhouses require electrical power, limiting where and how they will be displayed. The HMD requires charging to be able to see the virtual dollhouse. The batteries last for about two hours. As described above, the tangible dollhouse has LEDs that need batteries, but it likewise requires electrical power for the light inside the light housing.

Social aspects of play are limited in both dollhouses as well. Only two or three people can play in the tangible dollhouse comfortably. More than two or three people playing in the tangible dollhouse causes them to bump into each other and the furniture on the interior. The HMD is a single player device. It is possible to screen share what the player sees with a computer, however, in this instance, the frame rate was not fast enough to handle this connection. Future work is being considered that would allow players to connect either several augmented reality headsets or a combination of augmented and virtual reality headsets for social interactions.

7.3 Future research recommendations

One question that could be addressed in a future study involves ownership of the dollhouse. According to "The Digital Dollhouse," in The Sims Online, visitors were accorded the courtesies they might receive in a player's actual home (Stromer-Galley, 2007). "Making a mess in someone else's home is considered rude, just as it would be in a real home, and homeowners feel an obligation to provide visiting players with food and entertainment. Indeed, players will frequently

invoke the concept of the house in reinforcing norms by noting, 'this is someone's home,' 'not in my house,' or '[say] please in this house (Stromer-Galley, 2007).'"

If study participants were told that the dollhouse belonged to them specifically, would the interaction between the dollhouse players be any different? That is, if one of the three players were told the dollhouse was theirs would they try to enforce rules? Would the other players behave as visitors, having somewhat less agency in the outcome of the play? A further question involves allowing several players to interact with the virtual dollhouse at the same time. How would that change the dynamics of play with the virtual dollhouse?

7.4 Conclusion

This project explored two questions: 1) How is the creation process of a dollhouse altered by using digital, holographic media versus tangible media? 2) How does play in a tangible dollhouse compare to play in a holographic dollhouse? A framework organized the comparison of the dollhouses. The framework expanded the knowledge of materiality, social interaction and play of adults in a specific environment, the dollhouse.

Creators of integrated digital and tangible media require insight into how each media impacts the other. Dollhouses provide a recognizable, multi-generational platform from which to study both creative processes and play. As a master craftsperson, I created two dollhouses, one digital and one tangible, while reflecting on my practice. My reflection contributes to understanding materiality, social interactions and play in terms of creative activities. The participant study contributes to understanding how media, tangible or digital, influences play. The two stages,

reflection and study, invite continued conversation about the growth and integration of digital and tangible media.

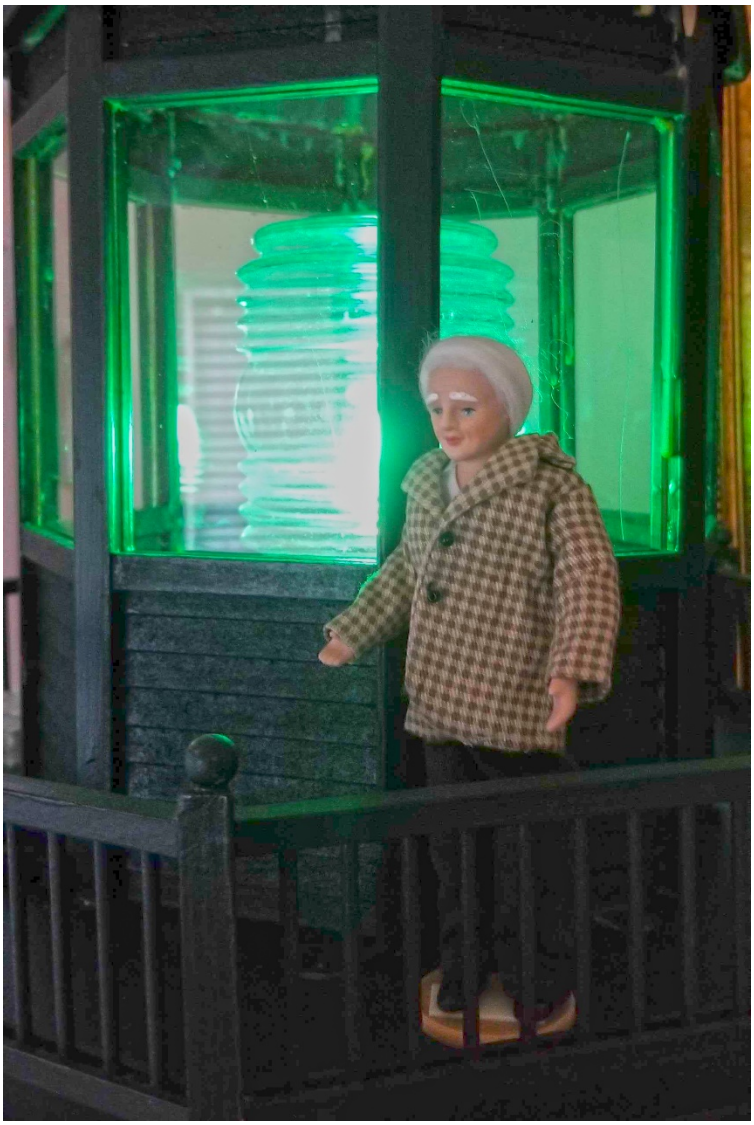

Figure 7-2 The dollhouse lighthouse beacon.

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Appendix A

Category	Lighthouse Experiences	How or Where	Holographic Museum	How or Where
Materiality	Precarious	The lighthouse was on a cliff that was slowly eroding away	Scale	Most of the objects were life sized. Some of the objects, though they were lifesized, were huge. The Ramses statue was immense. Some of the objects were miniatures of real things. Some of the objects were just very small figurines of very small real things.
	Exposed	You can see the lighthouse from all directions for a long way off. The wind whipped through, the fog rolled in, rust covered most of the metal surfaces.	Bounteous	The museum gallery had a pleasing assortment of objects that entertained my attention for close to an hour.
	Warm	Not only was the brick surface warm to the touch most days, the color of the bricks is a warm and inviting reddish orange.	Practical	When I was ready to put away all of the objects, I just had to remove the headset.
	Tactile	The bricks were rough, the wood was smooth and jaggy. The sand was gritty. The rust was dirty and gritty. The paint was rough because it was flaking off.	Familiar	I recognized many of the artists that were featured in the gallery. Though I was not able to identify all of the artists, their subjects were quite familiar.
	Scale	Standing next to the tower made you feel like a miniature doll.	Engendered scrutiny	The detail that was present on the objects drew me in and made me want to learn more about the objects.
	Old/Crumbling	The bricks were cracking in places and rounded off. You could follow the cracks up with your fingers and then follow them up with your eyes the rest of the way.	Imposing	The sculpture of Ramses was really big. I could not take it all in at one time. I had to embed the hologram in the floor to see the top and when I went to see the bottom, it loomed over my head.
	Awe	There was a majesty and nobility to the tower and what it stood for.	Awe	The details present in all of the objects was awesome.
	Atmospheric	You could transport the tower to a mountain or a desert and it would still feel like the seashore.		
Social	Social	We generally went to the tower as a family. If the entire family didn't go, I could usually count on my sister to come along with me.	Solitary	This was a solitary experience. I did not have to think about how long I was examining one piece of artwork. I pleased myself with where I looked and what I investigated. I did not have to negotiate any social niceties.
			Secretive/Enclosed	I really enjoyed feeling like I was hiding away from everyone. I was comfortable and at ease with the HMD on my head. I could see my environment but no one else could see what I was doing.
Resource Affordances/ Creativity	Curious/Fascinating	I always wondered who had lived in the house portion. I wondered what it would feel like to be a lighthouse keeper. The cast iron stairs were so interesting to look at, I wanted to know all about where they came from and how they were fitted together.	Intriguing	I am fascinated with the creativity of the artists present in the gallery and the technology of holograms. I loved being able to move things and embed them or hang them.
	Dichotomous	Contrasts abound in the tower. Smooth and Rough, Loud and quiet, contemplative and playful, social and lonely or isolated. Tall and miniature	Engaging	I was so engaged in my experience, time flowed by without my awareness.
	Restorative/ Meditative	Looking out to sea for long periods of time is quite soothing. We generally came to the tower during vacations so I associate visits there with relaxation and play	Controlled	The illusion of the gallery only worked in certain controlled conditions. I couldn't see the objects if the lighting was too bright. I could not see the gallery if I did not have the HMD on my head. I was not able to select which objects were going to appear.
Play	Alarming	Playing games with who would jump when the horn went off. Who would get close to the edge, generally my brother and older sister. It was a long way to the beach below and a little scary to get too close to the edge. The stairs were rickety.	Freeing	I have never been so close to museum objects. I felt like I was holding them. I could examine the objects as closely as I wished. I played with trying to get them to appear as if they were really hanging on my walls or sitting on my floor.
	Free	The property was fairly sizeable and did not have fences when we were younger. We were not concerned about dunes and conservation. We rambled and climbed and probably did things we shouldn't have. We played pretend and tag.	Playful	I lined up three tiny objects in a row in front of me. I enjoyed feeling like I was standing eye to eye with Ramses. I left the sarcophagus on the floor next to the dog, though he was not aware of it.
	Wild/ Changeable	The coast line was slowly eroding away even when I was little. I remember see bits of a building that had fallen along with part of the cliff. Eventually, the bits were even gone.	Wandering	I was able to take my time and set up my gallery any way I wanted to. I wandered from object to object as I wished. I was free to choose my path of investigation.
	Self Determined	While we were at the lighthouse, instead of collecting all of us inside a car or coralled somewhere, we were allowed to ramble outside wherever we wished. At the time, the lawn was still fairly big. There were places where we couldn't go, but we could go anywhere else.		
	Mysterious	The windows were usually dirty and dark. We could not see in. This was a great source of "let's pretend"		

Table A-1: Experience goals derived from the lighthouse and the museum.

Appendix B

	Aspect/Theme	Tangible	Virtual
Materiality	Impact of mistakes	Paint on good clothes – permanent	Inexperience with HoloLens – overwrote working file with broken one eve before presentation. Loading Unity at school stripped vital tools – time consumption to understand problem and reload from home network.
		Broke light housing – sat on it	Mistakes in sculpting were time consuming to fix but not permanent.
		It fell, student broke it moving dollhouse	
	Material considerations	Dust, breakage, loss, tipping or falling. Difficult to see in overly dark environment. Change of appearance with passage of time.	File corruption. Obsolescence. Cannot be seen in overly bright environment.
	Portability	Located in special spot in house. It is too heavy and large to easily move by one person.	Can move anywhere. Easy to carry HoloLens.
	Presence	Never lose sight of environment	Environment fades into the background. In VR version, even fooled myself with railing on keepers walk.
Social	Privacy - retreat	Could shut door on crafting room if I wished for a retreat. Time raced by when working on dollhouse. Aware of time while I am playing in dollhouse	Creation of dollhouse and programming never felt like I had enough time. Playing with dollhouse time raced by.
	Social contributions – shared story	Granddaughter watched and left heart painting on cardboard packaging. Daughter and granddaughter helped with interior decorations. Daughter made quilt. Husband helped with lighting. Husband helped with extra hands to erect sides. Granddaughter fiddles with objects whenever she comes over because it is accessible	I was the only one in the house with experience in digital arts. I reached out to fellow students for advice. Received software suggestions. HoloLens is only accessible to novices when I am around to show how to use it and load application. Could not really use the live streaming to my computer to co – experience HoloLens with others.
	Opportunity to pass on cultural heritage		
	Sharing results	Digital images from phone directly to twitter. Visiting guests to house can see it immediately.	Digital images from HoloLens connected to computer, download images and then upload to twitter.
	Learning opportunities	Did not learn anything new while building tangible. All established skills.	Studied tutorials to build HoloLens application. Researched language commands to build software.
	Cost of tools	Already had many tools on hand. Required paint, disposable paint brushes, sand paper (on hand), wood glue, painters' tape (on hand)	Specialized tools required. Computer with 1080 graphics card for VR. HoloLens. Necessary to get special access to university wireless to use HoloLens.
	Skill set required	Wood working	3D modeling
		Painting	Digital painting
		Basic wiring	Unity game engine
		Wood finishing	C++
		Sewing	
Resource Constraints	Battery considerations or power	Exterior light requires electricity to function. Interior lights use long lasting coin cell batteries. Lack of either does not affect the ability to play with house	Both HoloLens and computer have short battery life (2 hours on HoloLens). Game play is restricted if the HoloLens is tethered to electric power. Game play is impossible when battery is flat.
	Satisfaction with results – did it reproduce lighthouse successfully.	I see many flaws with tangible. Does not really make me think of Southeast Lighthouse. Dissatisfied as compared (competition) to other dollhouses I have seen. Disdain for MDF. Kit was not designed how I would have designed joints. Quality of kit materials was out of my control. I only had control of quality of finishing techniques. Did not like modeling on keeper doll. Did not like the clothes on dolls. Bed ordered was not finished well. Fabric threads hanging. Size of original lighthouse made building a true replication impossible due to space concerns.	Much closer to original lighthouse. Flaws are not as apparent. Better representation of brick exterior and gothic iron work. No real virtual dollhouses to compare to. Textures too shiny.
	Constraints	Space, time, cost, kit	Time, frame rate, poly allowance, FOV
Play	Creative thinking	Lighting interior with made switches. Floor from wooden stir sticks.	Translate digital historical plans to dollhouse. Plans for the future of networking several people playing. Spatial sound scape.
	Subversive		
	Relaxation		
	game		

Table B-1: Reflections resulting in framework.

Appendix C

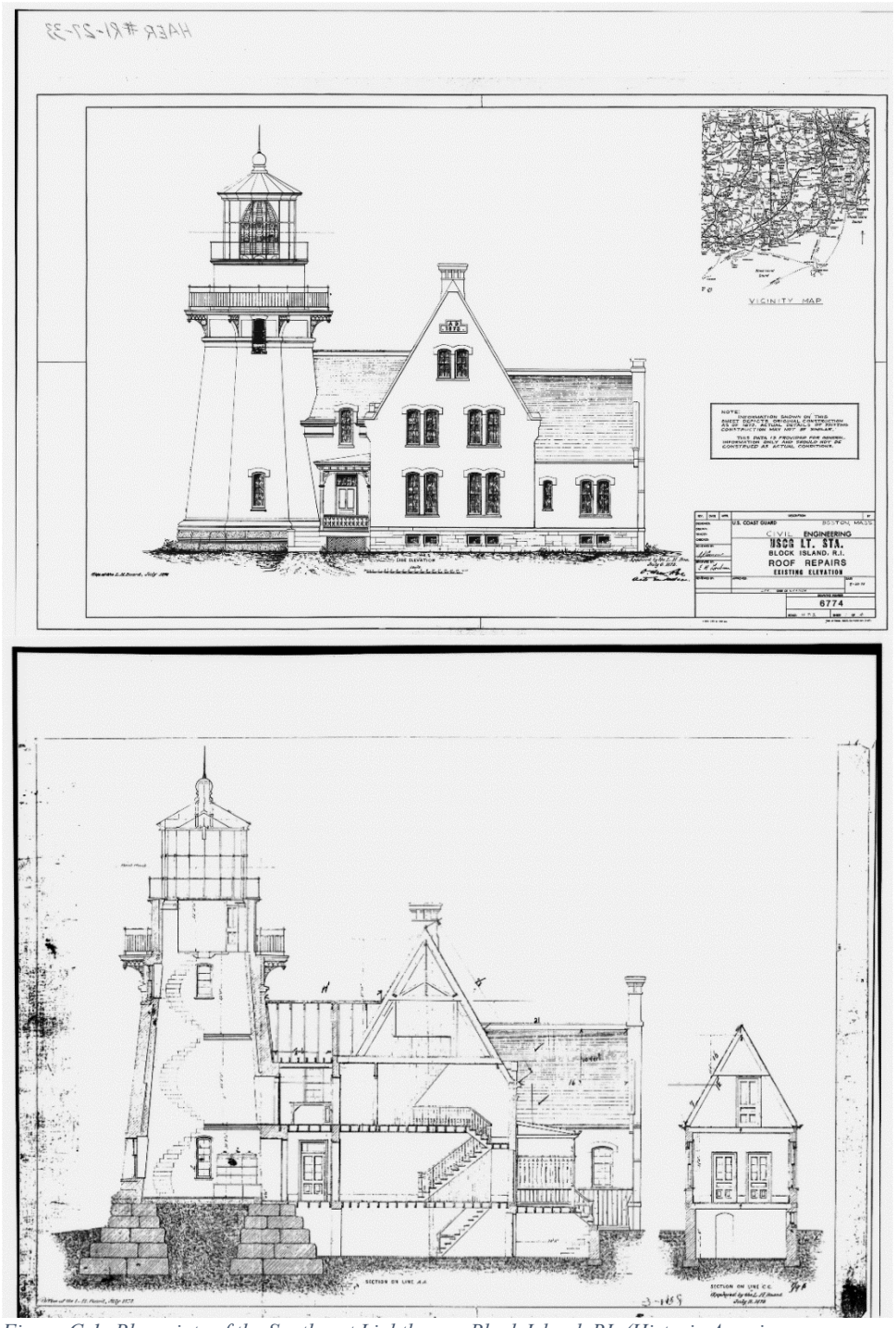

Figure C-1: Blueprints of the Southeast Lighthouse, Block Island, RI. (Historic American Engineering Record)

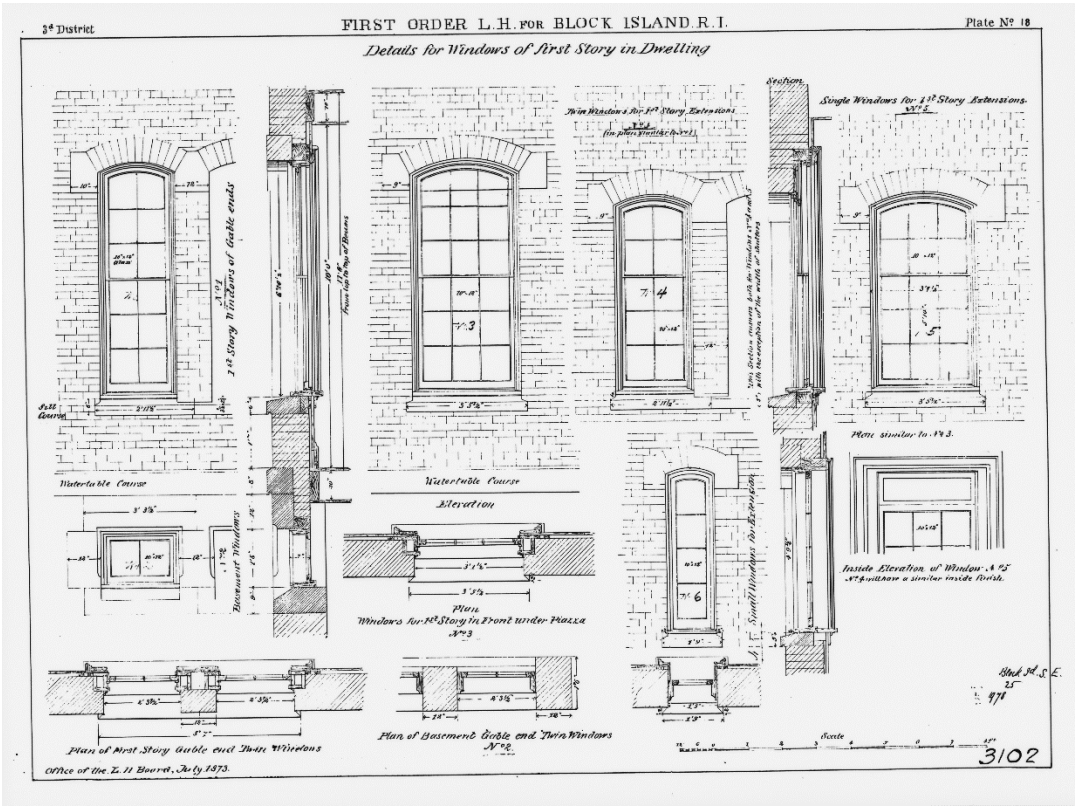

Figure C-2: Blueprints of the Southeast Lighthouse, Block Island, RI. (Historic American Engineering Record)