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The Kruger Collection Reimagined: A Case Study in 3D Scanning and Interactive Exhibit Design

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This thesis examines the use of 3D modeling in museum exhibition to create exploratory exhibits that facilitate unique relationships between the visitors and the collection beyond what is provided by the collection's in person counterparts. Typical use of 3D modeling in museums is currently often representative rather than exploratory. By employing a Digital Humanities lens to approach the development of a digital exhibition utilizing 3D technology and interactive elements created in a video game engine (Unity), this thesis project evaluates these potential new relationships. Using the Eloise Kruger Collection of Miniatures as a case study, the following text details the process of selecting items from a large collection to digitize using a laser scanner in order to tell a specific story, one of the personal touch the collection's originator's design process. "At the Hands of a Collector" is a fully interactive exhibition that allows for a degree of personal control and contact with the collection items. The 3D models allow for the visitor to manipulate, zoom, and explore the miniatures in a way not possible with the in person exhibits, creating a unique and independent exhibit experience.

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Chapter 1

Introduction

Across the world, museums and their practitioners have been making efforts to implement new technologies within exhibitions. Digital exhibits are not new, but the methods and technologies that museum practitioners use to develop digital exhibits are varied due to their goals and audiences. Digital Humanities, broadly speaking, is the cross-disciplinary integrating computing or digital technologies with humanities disciplines. While no clear structure of how to integrate Digital Humanities in museum work has been defined, its interdisciplinary perspective offers concepts, techniques, and methodologies to develop innovative digital approaches for the development, production, and dissemination of museum exhibits. Digital Humanities offer a means of evaluating the connections people make with one another, items, text, and/or other forms of culture through digital tools as well as critically reflecting on the use of digital tools to develop, change, and document those connections (Fitzpatrick 2012). In this research, the focus is on 3D modeling and exhibit design as a means of facilitating new relationships between audiences and collections, and asking: How could the utilization of 3D modeling in exhibits influence relationships between "consumers" (visitors) and a collection? How could 3D interaction change experiences, or alter the potential focus of exhibits? How can the unique affordances of digital 3D models combined with other digital and physical exhibition components, such as interaction, versatility, scalability, preservation, and minimal space needs transform both the development and display of these collection

materials to enrich museum experiences through a digital humanities lens offering a space for multiple interpretations?

To answer these questions, a digital exhibit utilizing 3D models via the Eloise Kruger Collection of Miniatures housed at the University of Nebraska-Lincoln (UNL) was used as a case study. Specific to this case study, the digital exhibition of 3D modeling created by this research is the first of its kind in terms of collection type. No virtual exhibits utilizing 3D models of miniatures have been created in this way. What could be offered by the medium to such an exhibit will be a new part of this ongoing conversation. Additionally, the goal to offer deeper interrogation of the motivations behind 3D digitization and virtual exhibitions will hopefully broaden the work being done in the field.

1.1 Museum Theory and Technology

The role of digital humanities in museum studies has been a topic of academic discussion for decades, with articles parsing the "future" of museums and technology's role in that future popping up throughout the 90's covering concerns of authenticity (Trant 1999), politics (Jones-Garmil 1995), possibility (Schofield et al. 2018), and restraint (Sola 1992). Tomislav Sola was the first to coin the term "technological trap" which refers to the use of technology in museums "for its own sake" (Sola 1992). Fifteen years later, Ross Parry reiterated the concerns of the technology trap and the importance of centering theory over technology when developing a museum, even if digital additions are a priority (Parry 2005). Almost twenty years later, these concerns persist, as museums have options to acquire new technologies to integrate into their practice, an reflective

approach must be embraced to avoid what these scholars warn against - adopting technological implementations presuming they automatically enrich exhibits, particularly in the multitude of relationships people may experience with collections or exhibits. In this context, digital humanities with its cross-disciplinary perspective interrogating the affordances of the "digital" for new avenues of knowledge creation, inherently invites opportunities for "introspective and self-reflective" museum exhibits that invite multi-vocal interpretations (Gold 2012).

While arguably, many digital exhibits may not afford, or actively encourage, exploratory engagement beyond telling a "predefined" narrative, nonetheless they can still offer many opportunities to experience and engage with cultural heritage. For example, creating a digital representation of a physical museum exhibit that is viewable online can bring new eyes to collections, and perhaps encourage someone to visit in person for the first time – arguably making it an advertisement. In other cases, it may increase accessibility to a wider audience to individuals who may not be able to see the exhibition in person, but only if they have adequate broadband access and, in often the case of 3D models, sufficient computing hardware to load and interact with the models (e.g., server vs. client side delivery) (Champion et al. 2020; von Schwerin et al. 2010). While accessibility and advertising are legitimate motivations for investing in digital projects, museum practitioners must consider whether they want these to be primary driving forces behind time consuming and expensive projects. Should the goals of digital exhibits be multi-layered to also foster new ways of engaging with collections? As stated by Parry, digital heritage has the opportunity to "both represent and to facilitate our move

to some very different understandings of the museum and its relationship with its publics" (2005:345).

But, just using a digital tool to display knowledge is not inherently digital humanities/heritage. It is ultimately the motivation behind the use of technological implementation that has the ability to move any museum's use of technology into the digital humanities. In the case of this project, a digital humanities perspective was being used to motivate all technological development and use within the exhibit that will be produced at the end. Their goal was to focus on the museum guests' personal relationship to the objects on display - furniture miniatures - and implement technology to specifically add to and potentially alter the guests' ability to perceive and connect with those objects and their histories. The collection being used is the Kruger Collection of Miniatures housed by the School of Global Integrated Studies at the University of Nebraska - Lincoln. The end goal was to create a digital exhibit that housed 3-dimensional models in an interactive space that allows museum guests to navigate and engage with the digital objects and related information by means of their own choosing. An acute effort was made to make the end result additive to existing or past exhibits of the collection as well as maximize the abilities that are uniquely offered by the digital medium, and by use of 3D models themselves. By capturing and displaying data (museum objects and related information) in the specific way offered by these digital tools, users can benefit from a heightened access to customization and/or restoration without altering the original sources, an allowance of personal navigation and interaction on the part of the visitor (Sundar et al. 2015), a wider variety of potential uses due to transferability, and the

ability to integrate multiple forms of media and data into fewer (or perhaps even down to one) point of interaction and storage (Skamantzari and Georgopoulos 2016; Tausch et al. 2020).

Though these digital affordances exist as advantages of the analog medium, there is noted concern that arises about how the "relationship" with the collection and the viewer might be negatively impacted by occurring via a screen rather than by viewing an in person object. The work of Sundar and Nebel (2020) research the potential psychological implications of virtual exhibits and the use of 3D models in education, respectively. The conclusions regarding the virtual exhibits were that the online viewing of objects allowed for increased feelings of control and agency, interactivity with reciprocity, etc. - but that failure to integrate these affordances correctly and smoothly can have a negative impact on users (Sundar et al. 2015). Nebel et al. (2020) and Brucker et al. (2014) explain that the success of realistic 3D imagery in a learning setting is dependent on the viewer's natural visual-spatial abilities, but success can be further facilitated based on the "attractiveness of the visual stimuli" and the use of cues to guide the learner's experience (Brucker et al. 2014; Nebel et al. 2020). Ultimately, as with any new experience or approach to learning, it is vital to have a clear concept of the priorities for the virtual exhibit and an understanding of the collection to produce a successful end product that serves its community of learners effectively.

Keeping all of the above in mind, a case study in the form of the aforementioned 3-dimensional, fully digital exhibit showcasing a portion of the Kruger Collection of Miniatures was developed to answer the following questions.

1.2 Case Study

In order to examine potential ways of implementing 3D modeling and digitization into museum exhibits in a way that adds to the personal relationship of the visitors to the collections, a case study was conducted on the development of a digital exhibit. The exhibit utilized a portion of the Eloise Kruger Collection of Miniatures managed by the University of Nebraska - Lincoln to offer a new way of viewing and interacting with the miniatures that are typically housed behind glass. The overall layout of the development and evaluation of this case study is detailed as follows: Chapter 2 will focus on the background related to Eloise Kruger, the collection's originator, the collection and miniature collection history, and a review of similar collections and work being done by other museums. Chapter 3 will break down the steps taken to digitize and prepare the 3D models for the exhibit. The developmental and build process of the virtual exhibit is detailed in Chapter 4. The results of the case study, a breakdown of the final exhibit as displayed, and a discussion will be presented in Chapter 5. Chapter 6 will contain the conclusions of the case study and will consider future developments and applications that could result from this work.

Chapter 2

Background and History

This chapter provides background and history to contextualize the research that is going into the development of the exhibit and its content. It comprises four sections: (1) Section 2.1 provides background information on the history of the Kruger Collection of Miniatures and its primary collector, Eloise Kruger; (2) Section 2.2 summarizes the

history of miniatures to give context to the purpose and motivations for the creation and collection of miniature furniture and accessories; (3) Section 2.3 provides summary and comparison of the two most similar collections to that of Kruger found in the Midwest - the Thorne Miniature Rooms at the Art Institute of Chicago and the miniature collection found at the National Museum of Toys and Miniatures in Kansas City - gives an understanding to how the digital humanities context being provided by the case study of the Kruger Collection is additive and developmental for this field; and (4), a review of similar digital exhibition work of other collections showcases how the digital aspects of this case study offers a unique virtual approach for developing experience of museum collections.

2.1 Eloise Kruger

Eloise Kruger (pictured in Figure 1), the namesake for the collection employed in this thesis, is the originator of the entire collection of miniature furniture now housed by the School of Global Integrative Studies (SGIS) at the University of Nebraska-Lincoln (UNL), Lincoln, Nebraska. Eloise Kruger, originally Eloise Andrews (1914-1995), was born and raised in Lincoln, Nebraska. She dropped out of high school and worked as a secretary early in life. Despite not having completed her secondary education, Kruger purchased the necessary books to teach herself accounting and was eventually hired as an accountant pre-World

Figure 1: A photo of Eloise Kruger, courtesy of the University of Nebraska Lincoln

War II (Fedderson 2015). During war-time, while all the men at her office were off at war, she was tasked with hiring and training women to work at the accountancy office (Fedderson 2015). Following the war's conclusion, most women at the office returned to homemaking, but Kruger continued working as an accountant (Fedderson 2015). In 1939, shortly after her marriage to Carl Kruger, she started purchasing pre-made miniature furniture and design accessories to facilitate her deep passion for interior design and history–focusing primarily on 1:12 scale objects (School of Global Integrative Studies – UNL 2020), which means that every inch on the miniature equates to a full foot on the full sized object. An example of a 1:12 scale object can be viewed below in Figure 2.

Figure 2: A dining table from the Kruger Collection. This table is five inches long, 2.5 inches tall and deep. Image courtesy of the Eloise Kruger Collection and the School of Global Integrative Studies.

Per her own documents within the collection, Kruger had opportunities to travel internationally which allowed her to purchase many pieces from a wide range of

countries including Japan, China, and Germany, among others. What started as collecting by purchasing pre-made miniatures in order to experiment with interior design by arranging historically and thematically-themed rooms, evolved into a collection she intentionally curated through direct work with artisans (Taylor 2016). She would have items commissioned by these artisans to fulfill her vision. Eventually, she started designing and constructing her own pieces to fit her visions. For over five decades, Kruger amassed an extensive collection of miniature furniture totaling over 20,000 individual pieces; the height of her collection activities occurred in the 1970s and 1980s (School of Global Integrative Studies – UNL 2020). These pieces exhibit designs spanning the sixteenth to the twentieth centuries that represent a wide range of socioeconomic styles (School of Global Integrative Studies – UNL 2020).

Luckily, for anyone interested in curating an exhibit from this collection, Kruger was an excellent notetaker. The Eloise Kruger Collection of Miniatures contains a host of documentation related to her collection process, including purchase receipts, correspondence with designers, and personal design sketches. Kruger intentionally collected each object to represent a variety of styles, time periods, and professions in custom designed miniature rooms. Each room created a snapshot of a period and style in furniture design history, and each told a unique story. Additionally to sketches and notes, Kruger also took photographs of the rooms she designed. These photographs would prove integral to influencing the selection process for the digital exhibit design. Additionally, as part of the collection there is a library, also collected by Kruger, comprised of books, reports, and magazines representing Eloise Kruger's motivation for design and,

ultimately, her development as a distinguished collector as well as artisan techniques for relevant historical periods. The collection of particular books have the capacity to show what styles and time periods influenced her decision making process in collection and design. However, the magazines included have very personal insights into her procedure, as images of furniture from these magazines have been cut out by Eloise herself for inspiration and design purposes.

Eloise Kruger passed away in 1995, and shortly after, in 1997, her family donated her impressive collection to the College of Architecture at the University of Nebraska-Lincoln (School of Global Integrative Studies – UNL 2020). This donation was made to honor her lifelong support of education - especially for women. From the late 1990s until 2021, when talks of a move began, interior design students in the College of Architecture produced small public exhibits, some designed by students, highlighting portions of the collection that were showcased in the Eloise Kruger Gallery in the College of Architecture.

Figure 3: Original gallery space for the Kruger Collection while it was housed with the College of Architecture (Fedderson 2015).

In addition, the College of Architecture created the Kruger Collection website to host Kruger Masterpieces: Inside and Out, an exhibit with digital photos of twenty miniatures of exceptional quality to showcase particularly unique details of craftsmanship such as functioning hinges and drawers, inlaid details, and hidden compartments. The College of Architecture collaborated with UNL Libraries to develop an online archive to host digital images and associated metadata (e.g., description, materials, measurements, time period, date object created, etc.) of individual pieces in the collection. As of April 2024, the online archive featured 2,970 miniature furnishings or decorative arts of varying style, time period, and collection history that users can browse via images or query using key terms in a search function.

In 2022, the collection was relocated for management to the School of Global Integrative Studies (SGIS) in the College of Arts and Sciences (CAS) at UNL. Faculty, staff, and students in Anthropology and other disciplines as well as students enrolled in the Museum Studies Graduate Certificate have continued the process of cataloging the collection's over 20,000 pieces, documentation, and related library materials. The collection has a large dedicated gallery space in the Eloise Kruger Gallery of Miniatures, which displays fully designed miniature rooms and exhibitions co-created by faculty and students enrolled in an exhibits design course. The gallery will be open to the public in periodic intervals starting in the late spring of 2024.

2.2 Miniature Collection

When thinking of feats of human creation, one often thinks of the massive structures and art of ancient cultures. While impressive, feats of the miniature have

existed for as long as known artistic human culture, and are found in cultures across the world (Davy and Dixon 2019). To understand humans' long standing fascination with the miniature, one need not look further than the mere existence of miniature creations found throughout the world's historic record. In the introductory piece for Worlds in Miniature - an anthology of articles highlighting the variety of approaches various scholars are approaching the interpretation of miniatures throughout human history and their modern uses across the globe - the criteria for what makes a found object a "miniature" are defined as an object that have elements of mimesis, scaling, and simplification (Davy and Dixon 2019). Mimesis refers to both physical replication of some kind as well as the idea that the replica can represent the original object as an "echo and reverberate meanings captured in and associated with other objects, while creating new meanings of their own" (Foxhall 2015:1). Scaling reasonably refers to the fact that the miniature needs to be, to some degree, smaller than what it represents. Simplification is ultimately, as decided by multiple interpretations of the miniature (Clarke 2014:2; Davy 2019; Kiernan 2015), can be the most enlightening of the qualities when attempting to learn about past cultures. As a miniature does not need to be a one-to-one representation of the source object, what is decidedly removed can be quite telling of what were the most important qualities to the creator. All of these elements exist on a scale, as miniatures may contain more or less of each of these criteria and still certainly be a miniature by all definitions - especially as an element of imagination can alter any and all of these criteria. A miniature may look very little like the actual object it represents (Davy 2019) and does not need to function in the same way as the source object.

With this criteria in mind, one can look back at the historic record and find miniatures for millennia. 545 miniatures have been discovered in archeological excavations and surveys from ancient Egyptian settlements dating back up to 5000 years ago depicting a range of objects and activities from the culture, such as vessels, animal and anthropomorphic figures, and boats (Di Pietro 2019:43). Miniatures have been found as funerary objects in Greek tombs dating back to the fifth-century BCE - such as miniature pots, shields, and thrones (Pilz 2011). A variety of indigenous American cultures have created miniatures of important aspects of their cultures, such as the Makah people of the north west corner of continental America have a long history of creating miniatures of the canoes used heavily for sustenance through whale and seal hunting (Davy 2019). Each of these cultures' miniatures do not just represent a physical object, but a cultural practice or belief entirely - such as the miniature tripod pots from young girls' tombs in ancient Greece being representative of Artemis, a Goddess associated with youth in women (Pilz 2011). The canoes of the Makah helped preserve the history of whale-hunting and the years and generations of communal practice that led to such a difficult process to be perfected by their people - and one that they were forced by settlers to stop (Davy 2019). The miniatures preserve and educate future generations on this aspect of their people's history.

As humans moved through time closer to modern day, miniatures continued to be created to represent culture and changes in culture. In the early modern age, it was more common to encounter miniature items of extreme realism. While in some interpretations, like those featured in World in Miniature's works, an item of extreme realism shows little

cultural interpretation, and might rather be a "model" of the source object (Davy and Dixon 2019). However, Stephanie Bowry in her piece on the miniature Augsburg Art Cabinet from the 17th century (one of the many highly detailed miniatures that has a history of being gifted to nobility) argues that this miniature curiosity cabinet works to embody the world of the 17th century as it was seen by its creator and intended audience - as much as any simplified miniature (Bowry 2020).

Leading into more modern interpretations of miniature rooms and furniture, the first instance of what would now be considered a "dollhouse" was commissioned by Duke Albrecht V of Bavaria in the mid-16th century (Chen 2015). This miniature home was considered luxurious entertainment for adults, and over the centuries, miniature homes were gifted amongst nobility (Chen 2015). In modern day, miniatures are seen in a variety of ways. Though the average individual might see miniatures as simply toys - miniatures still offer means of preservation, education, and communication. Miniatures have long since been used in museums as a form of depicting and communicating history and practices to visitors – though the history of dioramas as they are seen today started in the early 19th century as paintings and moving light for the pure purpose of entertainment (Kamcke and Hutterer 2015). The moving light was meant to depict the passage of time, or to imply activity within the paintings, which evolved into the dioramas of museums often depicting animals or humans in action – hunting, gathering, or socializing (Kamcke and Hutterer 2015). This is in stark contrast to the collection of Eloise Kruger, or the similar collections that will be discussed in the next section. These displays often depict near empty rooms, rarely to never having life within them. But, even without people

within their miniature worlds, miniature collectors within the last century have the ability to tell stories, showcase history, preserve their own personal experiences/culture, and communicate their own interpretations of the world.

2.3 Review of Similar Collections

The Kruger Collection is not a solely unique collection in the United States, or even in the region. The two most similar collections represented in the Midwest region of America include the Thorne Miniature Rooms housed at the Art Institute of Chicago and the miniature collection at the National Toy and Miniature Museum in Kansas City, Missouri. The collectors of these miniatures had similar collection periods, and as they operated near to Eloise Kruger, it is most possible that there was overlap in motivation and interest between the three. However, while similar in content to that of the Eloise Kruger Collection of Miniatures, these collections have different goals and priorities, as evidenced by how they display their respective collections. Each has some degree of online presence to show off some of their collection items, as will be discussed further in this section.

The Thorne Miniature Rooms, primarily housed by the Art Institute of Chicago were originally created by Narcissa Niblack Thorne, primarily throughout the 30s. Thorne's love for miniatures came from the connection she had with the dollhouse furniture that her uncle would send her while traveling the world with the military (Lasc et al. 2020). According to the Art Institute of Chicago's website, Throne developed connections and worked directly with architects and interior designers during the Great Depression to produce the unique miniatures that fit into her miniature rooms. Thorne

studied historic interior design and wanted to recreate entire rooms, floor to ceiling, not just the furniture that would exist within them (Lasc et al. 2020). The rooms produced represent a variety of styles of both American and European rooms from several centuries - the 17th century to the 1930s and the 13th to 1930s, respectively. 68 of the original rooms are on display at the Art Institute of Chicago, though an additional 30 are on display at the Phoenix Art Museum. This undeniably impressive collection is both similar and varied from Eloise Kruger's collection. Both feature miniature furniture at 1:12 scale ranging several centuries of design, and both women had a strong interest in both interior design and history driving their collecting and designing. While that drive is similar, the end goals and priorities of collection and display are quite different, leading to some very different approaches to the exhibition of these collections. Thorne worked to create the entire rooms as a whole, so the way these rooms are exhibited allow the rooms to be seen as a piece of art, all the pieces working together. This is dissimilar to Kruger's approach to collection, which prioritized individual pieces to sets, not whole rooms. Though Kruger had some rooms that were designed floor to ceiling, many of the "room" pieces were blank, with little to no details beyond white walls. This priority difference is also evident in how the collection is displayed on the online version of the collection.

The Thorne Miniature Rooms has a section of the Chicago Art Institute's website dedicated to it. The primary page for the collection opens with the big idea and motivations about the exhibit. It then goes on to highlight eight of the rooms, four American, three European, and one Chinese in style. As these eight rooms are meant to give the big picture of the whole collection, the full range of the rooms is represented

within this small number. The earliest room represents an English Roman Catholic church from the late 13th century, and the room immediately after it shows a Californian hallway from 1940. There is one image for each room, but each of the eight are accompanied by a paragraph or two that gives insight to Thorne's specific motivations in designing that space. The blurbs often include quotes from Thorne herself, or relevant cultural context from the time of the space's creation that would assist the viewer in understanding all there is to know about the room. Each room has a playable audio file that reads the description of the room. One particular room, the Californian hallway, also includes the names of the specific artists commissioned to create the hanging wall art featured in the room. The artists' names are links that, when clicked, opens a new tab within the browser that shows all the pieces by that artist also within the Art Institute of Chicago's collections. Beyond the highlighted eight rooms, all 68 rooms at the Institute are viewable online, all with one image. A total of seventeen rooms have accompanying descriptions with similar context given as the eight from the highlights page. All rooms, including those with no descriptions, have the artist - Thorne, the title - which describes the style and period represented in the room, medium, estimated creation year, scale, locational origin, and all credits, proveniences, and reference numbers that the museum has.

One can interpret the goals of this online exhibition based on how the rooms and related information is presented. As stated before, the product of design in Thorne's collection seems to be the rooms in their entirety. This is evidenced by each room only having one single image representing them. There is no particular desire to highlight

individual pieces in those rooms, even if each could be seen as a piece of art on its own. The singular image may also be motivated by the fact that this online version of the exhibit is in no way attempting to replace or add to the experience of seeing the rooms in person. This is further shown in the lack of descriptions accompanying a vast majority of the pieces. This webpage only ever claims to be a highlight of the experience, "just a glimpse" of the rooms and their stories. This online experience serves more as a provocation to go see the rooms at the museum itself and perhaps lead that individual to visit the entire exhibit to learn more. This is not an unusual approach for a museum website. The two most additive elements to the digital experience of this website are the audio files that pair with the descriptions, and the web pages linked to the artists featured in the Californian hallway. The audio files serve as an excellent accessibility function. Each of the players for the audio files, however, have links underneath them that redirect to the app for the museum, where one can find audio files for a guided tour of the Art Institute of Chicago. This does mean that the audio paired with the descriptions online are ultimately intended to be part of a guided tour of the in person exhibits. This intention does not negate the benefits the audio offers by being accessible online, but it does show that the online presence of the collection is meant to be paired with the in person exhibit, not necessarily add to the experience. The only individual feature that is unique to the online collection is the links to the featured artists' work. By including links that allow the viewer to instantly load other works by the same artists featured in the Californian hallway in miniature, the web page offers the sort of navigability best provided by digital tools.

Additionally, this online exhibition of miniatures actually highlights a potential negative to using digital tools to showcase some collection materials. There is nothing added to the images or information to add a visual depiction of scale. The dimensions and scale are listed in text form, but this is arguably an inefficient way to demonstrate scale. As the images are tight to the rooms themselves, and they are so realistic, there is no way to conceptualize the true scale of these objects. Ultimately, if the goal of this digital representation of the exhibits is to encourage an in person visit, or to be viewed alongside an in person visit, then the missing scale is not so much of a loss. The scale is obvious in person. However, as an independent representation of the rooms, the lack of visuals to show scale would, for viewers who do not have the ability to visualize scale from the text based descriptions, create some difficulty in truly understanding the miniatures.

The National Museum of Toys and Miniatures (NMTM) in Kansas City, Missouri houses both the toy collection of Mary Harris Francis and the fine-scale miniature collection of Barbara Hall Marshall. In person, these two collections are split by floor, with the miniatures on display on the main floor of the museum, and the toy collection on the second floor. While the toy collection is listed as one of the largest in the nation, NMTM claims the largest fine-scale miniature collection in the world at 22,441 individual pieces. Marshall started her collection in the 1950s, starting with a miniature rocking chair acquired during a visit to Eric Pearson's gallery in New York City - a cabinet maker turned miniature artist who is also featured in Eloise Kruger's collection (Taylor 2016). Marshall did not become a serious collector until the 1970s. During this period, Marshall often worked directly with designers to create her pieces, and even

encouraged the designers to build their dream pieces that they had yet to be able to produce (Taylor 2016). Compared to the Kruger Collection, Marshall's collection has a larger amount of full room and entire house pieces. Similar to Thorne's collection, Marshall had many floor to ceiling rooms, with all elements of the room designed in miniature. However, more similar to the Kruger Collection, the in person displays include exhibits that focus on individual furniture pieces, not just the rooms as a whole. These pieces are often grouped by style or period.

The online presence of the collection materials at the National Museum of Toys and Miniatures is fairly limited compared to their extensive collection. It is very important to note before any commentary on the nature of the digital archives available to the public for this collection - it was announced in October of 2023 that the museum was awarded a grant to begin a three year project to hugely expand their digital archives and displays. As this research is being done within months of that announcement, any commentary will be reflective of the entirely non-updated version of their website. Currently, there are two separate web pages for the toy and miniature collections. Each page has 21 items featured, for a total of 42 digitally accessible objects. The featured items of the miniature collection that appear online show the range of the collection, with thirteen individual items, six entire miniature rooms, and two whole houses. Each piece is displayed with a title, artist's name, dimensions, and object ID. If clicked, the website displays the additional information as an overlay, rather than opening a new tab. Once in the overlay, the visitor can navigate through the list via an arrow that leads to the next item and its description. The descriptions are one to three paragraphs in length, and often

depict the motivations and methods the creators used to produce the piece or pieces. Additionally, the location of the objects within the gallery is also listed. Seventeen of the listings have two images, and the other four only have a single image. The secondary images provided offer different things for different objects, from closer views, an image with a clear ruler for scale purposes, and, in one instance, an image of all the removable pieces taken out of and set next to the body of the piece.

This digital representation of the collection offers some different approaches to navigation online. As the website is currently quite limited in its object availability, there is no way to navigate to alternative web pages with additional information about any artists or related pieces. This helps support the interpretation that this website, similar to the digital display of the Thorne collection - and perhaps even more so given its small number, is only intended to be a snapshot of the experience, not necessarily add to or replace the experience. The navigation of information is also limited, staying on the main page by opening the new information in an overlay rather than moving to a new page, which allows the viewer to stay in one spot to get all the available information. NMTM's website offers a bit more visual context to understand scale. Twelve objects have an image with a small, clear ruler that makes it easier for those who cannot conceptualize scale to understand the true size of the objects. The remaining objects do not have any visual scale present. Additionally, unlike the Thorne Rooms, there is not a consistent scale present. Only three of the objects have a scale listed, and all three have different scales - 1:12, 1:24, and 1:48. If the interpretation of this digitally accessible collection is correct, that it is merely a snapshot of the experience, then this lack of information would

be remedied by an in person experience. The goals of the new development to the online presence of the museum include expanding those 42 total items to 1,250. The museum additionally seeks to improve the photography and visuals present for each item. The museum team is working with many schools of all ages around the museum to ensure that the items available to view online have accompanying information that helps people of all ages understand the pieces - as well as ensure there is adequate content to be usable as an educational resource for teachers and programs. It is entirely possible that the navigation and available information will change drastically with this new development.

As for the Eloise Kruger Collection of Miniatures, the online exhibitions created by the College of Architecture at the University of Nebraska - Lincoln are certainly similar in structure to those of the Thorne Rooms and the National Museum of Toys and Miniatures. However, the online exhibition that is visitable is specifically curated for an online existence and does not have an offline counterpart. *Kruger Masterpieces: Inside and Out* has a bit more, content wise, than the Throne Rooms and NMTM online exhibitions due to its solely online position. There are more detailed photographs to highlight specific craftsmanship, allowing for a visitor to see a lot more of the miniature than is available in all images of the other digital displays discussed above. The other difference is the online archive of 2,970 individual items. The development of this archive is likely driven by the small amount of dedicated gallery space for the collection. This archive is an excellent way to highlight items that are not on display.

For the sake of this thesis' digital exhibit, it varies from the interpreted goals of those previously mentioned. An online presentation of the collection meant to encourage

or accompany an in person visit is sufficient for the two other collections featured, the new gallery space for the Eloise Kruger collection of miniatures is limited in size - allowing for far more miniature spaces to be on display at one time than ever before at the university, but certainly not enough to fully kit out all more than 20,000 pieces. Just as the extensive online archive benefits this collection by allowing many items that may not be on display to still be viewable, an additive exhibit that is different from any in person exhibits actively benefits this collection. The digital exhibit from this case study utilizes 3D models as opposed to just the 2-dimensional photography provided in the other websites discussed. This element adds a unique connection to the pieces, as the miniatures, often associated - even within the histories of each collection's originator - with toys and dollhouses as well as art and creation, gain a level of interaction beyond clicking through a series of photos. The 3-dimensional elements also assist with the repeating scaling issue. A view to understand scale, without having to view the items in real life, is necessary to create an independent exhibit. The Kruger digital exhibit was also designed with clean navigation between related information, enough information to be independent of an in person experience, as a priority.

2.4 Review of Similar Projects and Exhibits

Though it has been established that no 3D modeling based exhibiting has been done with similar collections, that is not to say that no 3D modeling work has been done with any museum or collection. Beyond 3D modeling and other digitization efforts to preserve cultural heritage within communities and by public effort, 3D modeling is also being implemented by institutions to enhance visitor experiences. All 3D modeling

implementation in museum work essentially fits on a sliding scale, one end being a one-to-one representation of an existing, visitable exhibit and the other end being experimental endeavors that are testing how to use 3D modeling - both scanning and original creation, game engines, and/or virtual reality to produce a new experience for visitors and overcome obstacles that exist when preserving and exhibiting certain collections.

An example of an exhibit that utilizes 3D elements to recreate a real exhibit is that of Alexander von Humboldt and the United States, a digital exhibit created for the Smithsonian American Art Museum (SAAM) by Eleanor Harvey and Stefan Gibson that is viewable on StoryMaps. The 3D elements showcased are a one-to-one representation of the physical exhibit that was at SAAM on Alexander von Humbolt, a highly influential Prussian explorer and scholar. However, the exhibit's time at the Smithsonian was severely stunted by the Covid-19 pandemic, and was limitedly on display before the exhibit's closing in July of 2021. This virtual exhibit was created to allow the entire exhibit to live a longer life, as its physical one was cut short due to unforeseeable circumstances. The StoryMap exhibit offers a guided tour that moves the viewer through the 3D exhibit hall as the story is scrolled through. There are occasionally clickable options that move to different views. The guided tour also switches to higher quality photos of some of the maps and art featured in the model when those items are specifically being spoken about. The multimedia nature of the experience is also added to via the embedded video about a particular artwork, "Heart of the Andes" by Frederic Edwin Church, and a map, seemingly additive to the original exhibit, that shows all the

known features and sites throughout America that were named after Alexander von Humboldt on his travels through the nation.

This virtual exhibit is an excellent example of how digital tools can be used, rather than be particularly additive or unique from the origin exhibit, to preserve and extend the life of an exhibit that is no longer visitable. An ability offered to museums that utilize digital tools is to preserve certain content in a digital space without needing the physical space. This gives longevity to what would normally be temporary. This is assuming that the creators have the means to preserve the digital space longer than the physical space. In the case of this exhibit, there is a deceptive lack of interactivity. Though the viewer is able to click into the model of the hall and move around, the maneuverability is quite difficult, and portions of the exhibit that are not the focal point of the tour are pretty limited in detail and information. This is remedied by all the pieces from the exhibit being on their digital archive. One would just need to search Alexander von Humboldt on SAAM's main website to find a page dedicated to the content from the in person exhibit, including more info on the pieces not featured in the 3D tour.

A project in Argentina (Loaiza Carvajal et al. 2020) created a 3D virtual reality experience that utilized cultural heritage artifacts and art from a series of participating museums across Argentina (confirm how many, this info eludes me…). Photogrammetry, another form of 3D model production that uses hundreds to thousands of photos of an object or location to create a model in digital space. The end products of this project were a 3D virtual museum that exhibited collections from multiple different museums that was navigable in virtual reality, as well as a retrospective experience to preserve the

exhibition. The production of a digital space for this exhibition utilized the ability to create a central hub for a range of content, increasing visibility. A visitor would need to travel to many physical locations across multiple municipalities of Argentina to view all the pieces on display in the virtual exhibit. Each participating museum is able to enrich their own communities via this collaboration. Which is another potential benefit of digital tool use in museums - collaboration. As how museum items exist in space next to other museum items can contribute to a story, being able to expand on the potential of those stories via collaboration allows for new relationships between visitors and collections - not just the new ones, but also with the collections they have visited in person as well.

A 3D model exhibit of historical clothing by the University of La Laguna in Spain (Meier, Berriel, and Nava 2021) is a project that truly experiments with what virtual exhibitions have to offer. The exhibition features 16th century clothing that largely has not survived the years. Due to the loss over time, there is very little to display in any traditional set up. So, this team worked to produce an entirely digital exhibit with no physical counterpart. While the physical costume items were lost, there are documents that describe clothing items, as well as drawings and plans from the individuals who designed and constructed clothing at the time. Utilizing those resources, the team recreated the described clothing as 3D models. The end product was a virtual museum, navigable via virtual reality headset or mouse and keyboard that displays the reproduced clothing on digital mannequins. This exhibit really embraces the recreation/restoration ability produced by digital tools. Though it is also possible to recreate these objects, using the same resources as inspiration, in physical form, the digital tools offer a reach and

accessibility to this sort of recreation that is not offered by a physical recreation. There will be, so long as the exhibit is either accessible online, or the paper written about the experience is accessible online, people from all over the world can encounter this interesting development in the historical clothing world.

A case study of a specific museum object and its 3D digitization and subsequent recreation (Amico et al. 2018), the 'Kazaphani boat', a Late Bronze Age pottery artifact found in Cyprus and permanently exhibited at the Cyprus Museum, was 3D scanned and subsequently 3D printed with a powder printer to have an accurate recreation of the original boat. There was a great effort put in to ensure all past damage, efforts to restore damage, and other markings were maintained in the recreation. Unique from the other projects featured in this section, the end product for this project was to create the replica so that the museum could loan it out - the 3D model, the digital one, was not the primary goal of the project. The loaning of the replica made it so that the museum could loan out the Kazaphani boat to interested museums with much lower concerns of damage, as well as lower insurance costs. This effectively increased the reach of the original museum object, making it more visible to more audiences. The replica, as well as the 3D digital model, additionally offer the ability to examine the boat's imperfections in detail without as many concerns of damaging the object.

It is interesting that the replica was treated just as a traditional museum piece. It was placed behind glass and not allowed to be handled by visitors. This, it is speculated in the interpretation of the case study, is due to the replication of the 'aura' of a museum object. The replica was deemed sufficiently deceptive in representing the original boat.

Many did not realize it was a replica. As it was treated as a true museum artifact, not as a replica, the original aura was also replicated. This is perhaps unfortunate for those interested in exploring the interactive possibilities of such an approach to exhibiting museum pieces. Such a replica could be an excellent way to allow guests to handle the piece, as if it were real, and to create a new tactile relationship with the museum collection. While that ended up not being the goal of this particular project, it is certainly something to keep in mind as a possibility for future projects.

The above works show a range of possibilities when implementing 3D modeling as a means to interpret museum works. Whether recreating entire exhibits, merging the works of several museums, creating entirely virtual exhibits, or bringing the 3D into the physical world for a new purpose, digital tools and 3D modeling can assist in offering new ways for audiences to engage with the content of an exhibit. In addition to the aforementioned benefits of digital tool use in museums, such as preservation, recreation, visibility and reach, accessibility, and collaboration, 3D implementation in a virtual exhibit can also increase immersion, interoperability, interactivity, scalability, as well as just offer new ways of telling stories. In order to expand on this existing work, the digital exhibit produced through this case study utilized miniatures not on display to create an exhibit with no in person counterpart. The features that were implemented focused on interactivity and scalability, which were chosen not just to see how those features might work in a virtual museum setting, but also due to their specific benefit to the collection being used. As there are a wide range of benefits and affordances offered by digital tools, this exhibit was designed to utilize the affordances that would create a new relationship

between the museum objects and the audience, one that could not be replicated in a physical exhibit with that collection.

Chapter 3

Methodology

The following chapter details the bulk of the steps taken to develop the exhibit, focusing on the digitization portion of the development. To start off, the process involved in selecting the focus and individual pieces for the exhibit is explained in order to understand the overarching story-telling goals that influenced further development. The following sections explain the procedure utilized to scan the objects used in the digital exhibit followed by all steps taken within a digital platform to finalize those scans. The final portion of this chapter will list the last actions that were taken to prepare all digitized objects for the move between programs and into the digital exhibit.

3.1 Selection

The first phase of work for this research was to identify the goals of the end exhibit in order to select relevant material to be digitized. There was certainly an interest to not just pick pieces to digitize at random, or even to be motivated by visual appeal, but rather to have a commonality that has not been highlighted by previous exhibits within the collection's lifetime. One of the most compelling components of this collection is Eloise Kruger herself. As detailed in the previous chapter, Kruger was able to travel to a wide range of countries to purchase for her collection - in addition to commissioning and even designing her own pieces. As the collection gave access to images taken by Kruger herself, there was an opportunity to showcase her personal touch on the exhibit by

recreating a miniature room that Kruger personally put together decades prior. So, the over 275 images taken of various rooms designed throughout Kruger's career as a collector were sifted through to find a worthy candidate. Across those many photos, over 70 different rooms and 18 displayed sets of miniatures were featured. To decide on a specific room to showcase in an exhibit, more practical guidelines were put in place. Ultimately, criteria that assisted in deciding what material is good for scanning into 3D models was applied to the rooms in order to set the digitization process up for success. While these criteria will be discussed in more detail in section 3.2 Scanning, in short, items that are transparent, highly reflective, or structurally unsound each offer levels of difficulty to the scanning process. So, rooms with no glass objects, limited metal objects, and primarily wood and upholstered objects were reviewed further.

After two rooms that seemed to each offer similar material difficulty for the scanning process were identified, a list of the number of objects in each room, their likely material, and their location (if known) was made. As the collection was still being processed by the School of Global Integrative Studies, the exact location of some collection items, and even if every piece is still within the school's possession was not a guarantee. This hurdle was able to be dealt with by creating missing or altering similar items - but the fewer items that fit in this category, the better. The process of making this list was additionally helpful, as it ended up being fairly surprising how many individual items fill these rooms, as the accessory items Kruger places in the room are quite numerous and not initially noticed upon looking at the room's image. As each room's list lengthened to 48 and 46 individual items, it was decided to attempt to limit the amount of

items being digitized for the sake of completing the exhibit within a reasonable timeline. This decision assisted in making the final call on which room to digitize, as one was far more reasonably broken up into smaller spaces.

A photograph of a living space (seen in Figure 2 below) with crafting accents was selected. The entire room in the photograph included 46 total items across the 22.75” x 8” x 7” “room.”

Figure 4: The original photographed room designed by Eloise Kruger. Each photograph included two rooms, so the image is cropped for clarity.

The room was split into definable “spaces.” Lines drawn between the three spaces were very intentional, and each space was defined by its purpose and furniture directionality that created separate spaces within the larger shared space. The different spaces were color coded to identify what items were able to be used for digitization.

Figure 5: "Spaces" within the room highlighted to mark how the room might be broken up for a more reasonable list for digitization.

The group selected was the section highlighted in yellow in Figure 3 above. This new group of items is only 20 individual items, which is far more manageable within the time period. Ultimately, the goal was to select the set of furniture that would feel the least like “part” of a room when existing independently in a digital space. After selection, the 18 pieces were found in a variety of ways. Five items were located via Past Perfect, as these items were already logged by the previous managers of the collection. Three items were located via photographs of lots of miniatures taken by the previous managers before they were put in long term storage. Two items were located after significant progress was made in processing and storing items by type. Five items were not located and were instead built in Blender to supplement the voids.

3.2 Scanning

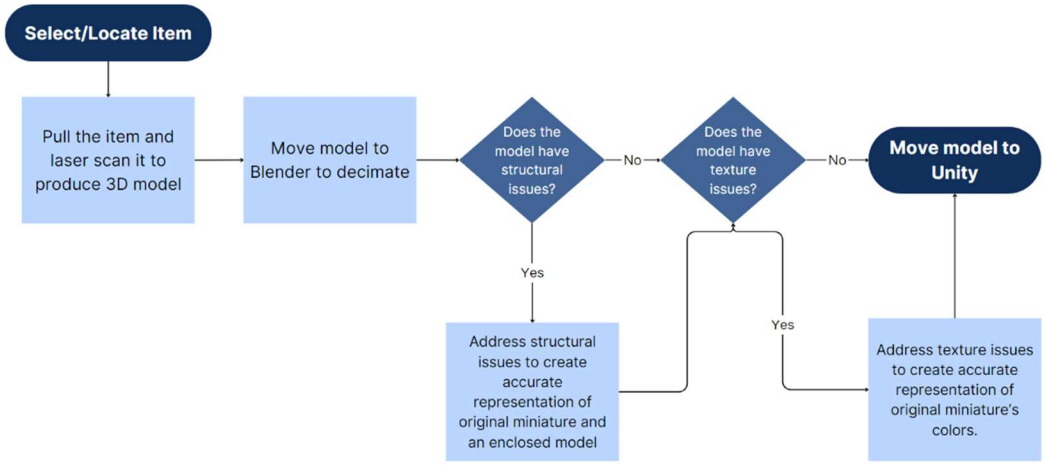

Figure 6: A flow chart that showcases the process of scanning that was adopted for the digitization of miniature furniture.

The selected items were then laser scanned using the EinScan-SP V2 which uses its own program, EXScan S version 3.1.3.0. The first step for getting a good scan is to set the items up in a way that all subsequent scans will align well. For many items, this can be as easy as just setting it on the turntable. Each piece was placed on the turntable of the scanner, which rotated in order for the camera to scan the piece 12 times per full rotation. Each piece took about 3-5 rotations at different angles to get a comprehensive and accurate model. For some items, such as objects with moving or flimsy parts, it is important to set the items on the turntable in a way that either stabilizes moving pieces, or sets a standard that one can reconfirm is being met with each pass of the scanner. For example, the reel that was scanned for this exhibit, featured below in Figure 5, has four arms that rotate. As these arms were relatively stiff, enough that they would not move unless bumped physically, they were set to have two arms set straight up and down each time. Alternatively, a flimsy handle of a basket (not an item scanned for this exhibit, but has been scanned for the collection in general), can move on its own due to the

movement of the turntable. In this case, the handle would need to be stabilized or fixed in the model later on. Typically pieces of foam core board were used to support the miniatures in order to get all angles to prevent damage to any delicate construction.

Figure 7: A miniature yarn reel set up on the turntable of the laser scanner used for the project.

Unfortunately, no scanner is perfect, and it is likely that the use of any scanner will produce a set of issues that need to be cleaned up along the way. As mentioned in the previous section, some materials are just more difficult to scan than others. Transparent objects were intentionally avoided for this project as transparent materials are arguably not just difficult, but up to entirely impossible to scan into 3D modeled form. Highly reflective objects also cause stress when scanning, but this can be mitigated. In the case of this collection, two metal objects (a clothes iron and a candlestick) were part of the scanning process, and both had some struggle getting a perfect scan. This could have

been assisted further by utilizing a light box to control exactly how much light was polluting the scanning process. However, as there was an opportunity to fix any scanning issues digitally, it was decided to get the best scan possible first, and then move the problem solving to the next step - which will be detailed in the next chapter.

A laser scanner uses a combination of laser light and cameras to record information about an object. As the lasers project onto an object, the cameras pick up that interaction and, by using reference points on the (in this case) turntable, the scanner is able to understand where an object is in space. However, this does not get processed as a physical object immediately, instead, the scanner is picking up this information in individual points. The hundreds of thousands to millions of points being created by the interaction of the lasers from the scanner and the object exist together in a "point cloud" that is dense enough to look like a physical object unless zoomed in very closely. But, as stated before, no scanner is perfect. This scanner in particular often had a great deal of artifacting from reflecting light on the turntable, even if great effort was put into limiting light pollution during scanning. Manual deletion of such artifacting was necessary on every scan, but the issues were consistent and subsequently easy to mitigate. Additionally, this particular scanner appears to produce the texture file through images taken by the scanner itself, images that will not be altered by the intentional deletion of scan information. This leads to information that was deleted from the model remaining in the texture files. The most common instance of this creating issues was whenever support was used during scanning. The foam pieces utilized to get additional angles of certain pieces would be placed onto the texture files despite all of the support being deleted from

the point cloud. Unfortunately, there seemed to be no way to fix this within this step of the process and had to be fixed in a later step, which will be addressed shortly.

As there is no object that can be scanned perfectly in one pass, objects have to be rotated for all of their sides to be properly documented onto the model. Typically, the program being used with this scanner was able to properly align any additional scans needed to finish the models with the existing point cloud information. When it does not align properly, there is a way to manually align them by selecting shared points on the two “chunks” of point cloud to make them line. Being pretty close - close enough to not be distracting, was often enough. This is due to the next step of the process - globalization. The globalization step is essentially when the program tightens up all the points in the point cloud to exist in planes. This step would often show any glaring errors that were not caught previously, such as strange alignments or extras that needed to be deleted, but luckily, one can just back out of globalization before confirming and attempt to fix those issues. After approving globalization, the model was created by connecting the points and creating a mesh. All the finished models were then exported and moved into the next program for any modeling needs that arose during the scanning process.

3.3 Modeling

After exporting the models and importing them into the next program, Blender version 3.6. Blender allows any editing and reshaping that may be needed for the various models. The very first and arguably the most important step needed was to decimate the models, a function within the program that allows for the reduction of the total number of points and faces that make up the mesh of a model while maintaining the existing shape.

As the laser scanner used produces millions of points to form the mesh, this can make models difficult to work with when transferring between programs. It is important to note that these very high detail models are useful in some situations, and can run fine if the project using them has sufficient hardware to run the models in whatever program in which they exist. However, it was determined that the very high detail in the unaltered models was unnecessary for this project. Additionally, as the ability to access the virtual exhibit and its models via the internet was a desire, having smaller sized model files was deemed a positive. The models were decimated to 20% of their original size, resulting in a reduction from 1-3 million faces (depending on size of model) to 200,000-600,000 faces. This was still a fairly high amount of detail, allowing for the meshes that came of it to still showcase details that would not be visible from the distance these miniatures were typically seen from in traditional display while also being easier to use in other programs.

Once the models were decimated in Blender, it was possible to clean up any problems with the items. The majority of the scans required limited cleaning, such as smoothing out uneven portions of the scans. It was important to refer back to the original piece to ensure any changes made reflected the actual item. For example, the tall case clock scanned for this project had two imperfections in model form. However, only one was caused by the scan. The sides of the case portion of the clock is quite rough on the scan, in a way that is not the most visible in person. In this case, the roughness is caused by the original cuts made during the creation of the miniature, which is actually a very interesting feature that would be excellent to highlight in the final exhibit as the saw marks are not clearly visible even when close to the actual miniature, let alone from a

safe viewing distance. Removal of these features, these “imperfections,” would be a loss. Alternatively, the spires on the top corners of the case clock had some doubling in the virtual model. This does not exist in the original miniature, and was instead caused by the reflective paint on the spires creating some confusion for the scanner. So, the edits made to the clock included removing the doubled spire and smoothing the rough scan of the spires to look more accurate to the actual miniature.

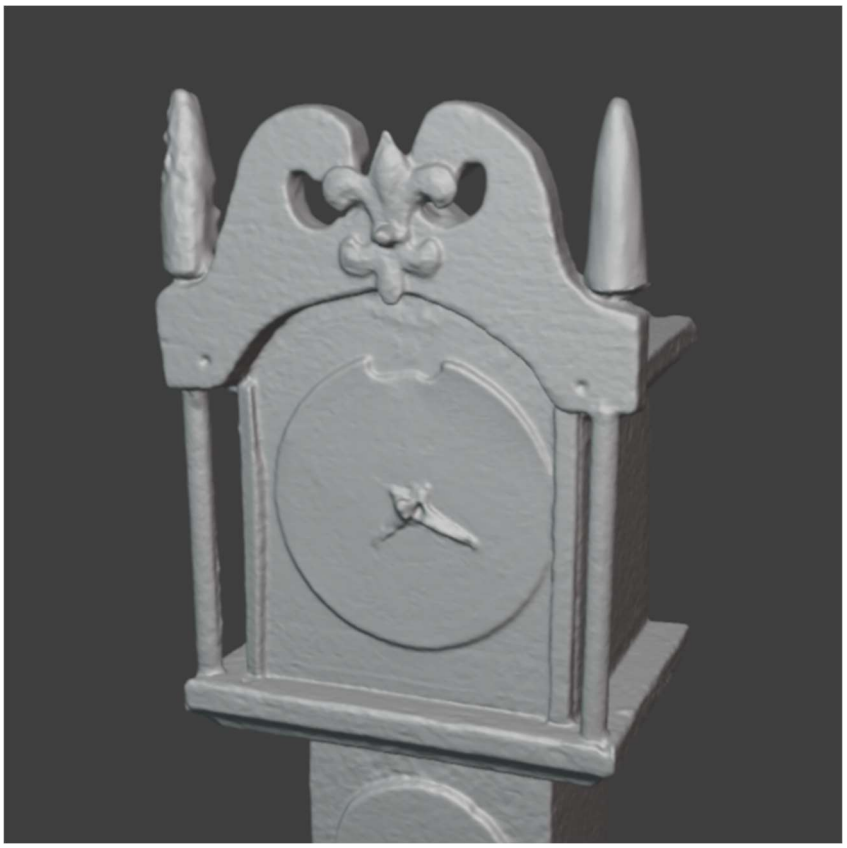

Figure 8: The spires on this clock show the before and after of the cleaning process done in Blender.

Other, larger reconstruction needs included filling unnecessary holes in the models and duplicating information that only scanned properly on one half of the model. Both of these instances occurred in the iron scan. The Kruger Collection actually had several irons on hand that are very similar in size and shape, making it quite difficult to

discern which iron is the exact iron from the reference image that is being recreated. In this case, a decision was made to select the one with the most textured and least reflective surfaces - while still being the correct size and shape. This gave the scanner the best chance to get the correct information. This approach was mostly a success, but the very thin curved arms leading up to the handle still served to be difficult. Only one arm scanned, and it scanned fairly poorly, resulting in the arm having holes molded through the model, likely where reflections of light confused the scanner. As the mesh created by the scanner's program is watertight, it creates fictional information to "fill" the holes. In order to fix this, it was necessary to delete the fictional information within those holes. All internal faces were selected and deleted. Then, while in face mode, one can hold Alt and select an edge along one of the two voids created by the deletion to auto-select all the edges of the void. Then, press Alt-F to auto fill the void in a more accurate position. The iron was small enough to not need to do much else, but on other, larger models, it was necessary to break up the automatically filled faces into smaller pieces to match the surrounding mesh quality. Doing so avoids texture issues. Once the holes were corrected, the model was entered into sculpt mode to manipulate the arm into as accurate a shape as possible to reflect the original miniature's arm. From there, it was possible to select the newly formed arm, duplicate it, mirror the duplication along the correct axis, and move it over to the position of the missing arm. It was merged with the rest of the model by deleting overlapping information, pressing Alt and shift to select the edges of both voids, and using the bridge connect function to fill in the gap between the two pieces.

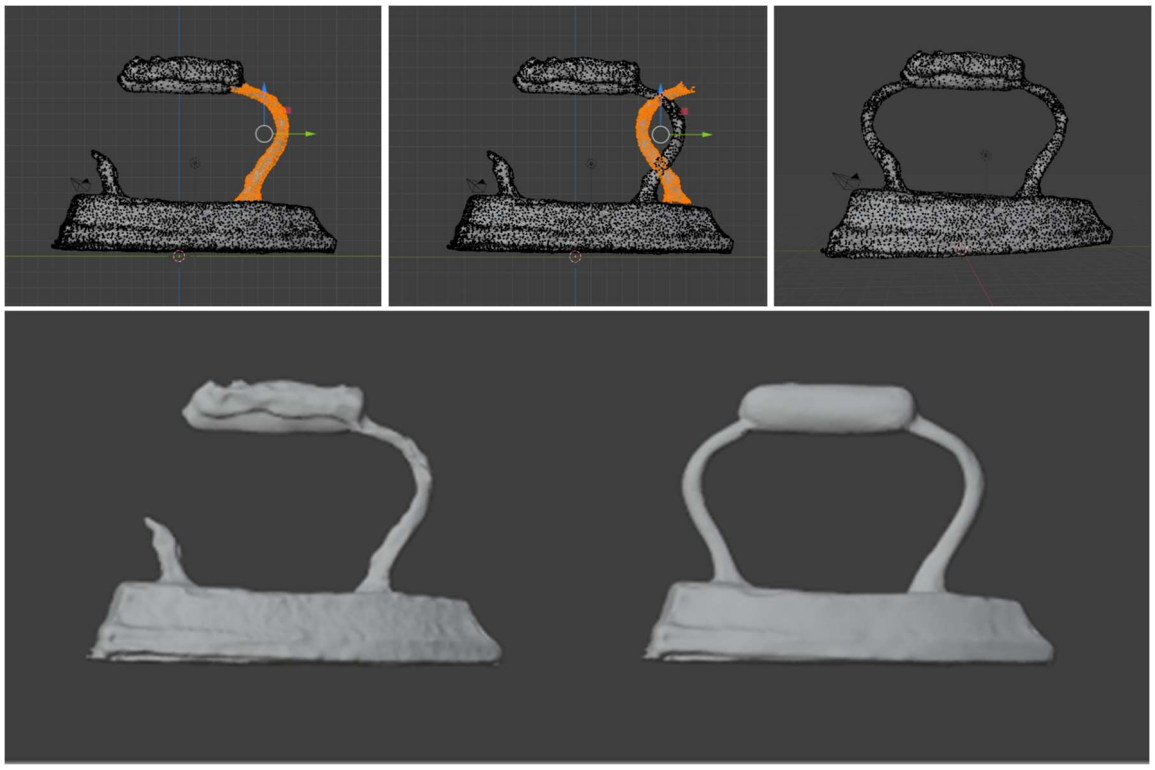

Figure 9: This series of photos show how an iron with imperfections within the scan was edited to be more accurate to the actual model.

Other common issues that had to be corrected in the modeling step of the process included fixing interior faces on the model. Anything with depth, such as shelves or other enclaves, were often difficult to scan properly with this particular set up. This would likely be solved by not relying on the turntable and rather using the scanner in handheld mode to have more control of the angles. Either way, this was sufficiently fixable in Blender. By selecting the faces that should make up the deepest edge of the interior face, it was possible to flatten the points into one plane and just move it to the correct depth. These larger reshaping and reconstruction needs were not the most common, but happened often enough for it to become an anticipated step of the process fairly early on to the process.

Once all the models are deemed acceptable, steps into new content can be made. Five items had to be created in more unique ways due to the original miniatures not being located. This was done two different ways. A similar, but not completely accurate side table was scanned and then altered in Blender to be a more accurate representation of the table in the reference photo. They were both round, tri-legged side tables with a lip around the edge of the top surface. The legs were slightly different, but the one in the actual reference photo was simpler in structure than the one that was scanned, making the edits needed fairly easy to implement. All changes made to this model, as well as all other models, were noted in detail so that all changes and edits could be disclosed in the final exhibit. In addition to edits to existing models, some simpler items, such as a set of small barrels. a cradle, and a painting, were created from scratch. These models, though simpler than the high detail models from the scanner, filled in for the items that were not successfully located during the move of the collection. It was important that the primary, most identifiable items - such as the cabinet, the chairs, and the clock - were located to scan. If those items were not located, a new room would have been selected. But, as this was a success, and all the missing items were able to be replaced virtually, the last steps to finalizing all the models could be taken.

3.4 Preparation for Exhibit

Any non-physical, visual changes that were needed to make the virtual miniatures accurate had to be made before the models were finalized. Due to how the scanner used in this project produced the texture file, a “jpeg” file created from a series of photos taken by the scanner that would wrap around the model to create accurate color information,

there were occasional imagery issues. If information is deleted from the point cloud in the first step of digitization, that information was not deleted from the texture files. The scanner appeared to select the clearest images taken to use as the primary sources for texture, which often included supports used for scanning those improved angles. Unfortunately, there was no way to select different photos to take priority while in the early steps of the digitization process. For example, a rug that was scanned used foam to prop the rug up to get a better shot from the scanner, and the white foam remained in the final texture despite none of the structural information from the foam still being in the model. This was fixed in Blender by painting the correct textures over the foam. Using the actual miniature rug as a reference, a color selector was used to pull the various yarn colors present in the correct texture to then paint the pattern of the braiding onto the mesh. Other textures which are not as easy to paint by hand (or mouse), such as wood texture on a cabinet, could be replicated using a stamp function, which uses an origin point to place textures from one part of the model to another. Meaning, if one places an origin point on a nice, clear section of wood texture and then paints using the cursor on a blank or unclear section, the first touch of the cursor would replicate the origin point. All movement from that point would be relative to that origin point, which allows for entire sections of texture to be replicated.

The very last step of the Blender portion of the project was to create significantly lower detail models of each of the miniatures so that the early parts of development within Unity are able to occur quickly. This was ultimately a personal preference for this project and the computers that were easily available during production. This lower

amount of information will load much faster than the full models. This was done by using the decimate modifier, just as it was used in the very first step of the Blender portion. Each of the models was decimated down to 1.25% of the already decimated model and saved as a separate model. Even with as low as a few hundred or thousand total polygons, the low detail is not entirely noticeable thanks to the texture files. Important detail, such as the saw marks on the clock discussed in previous sections, would be entirely missing.

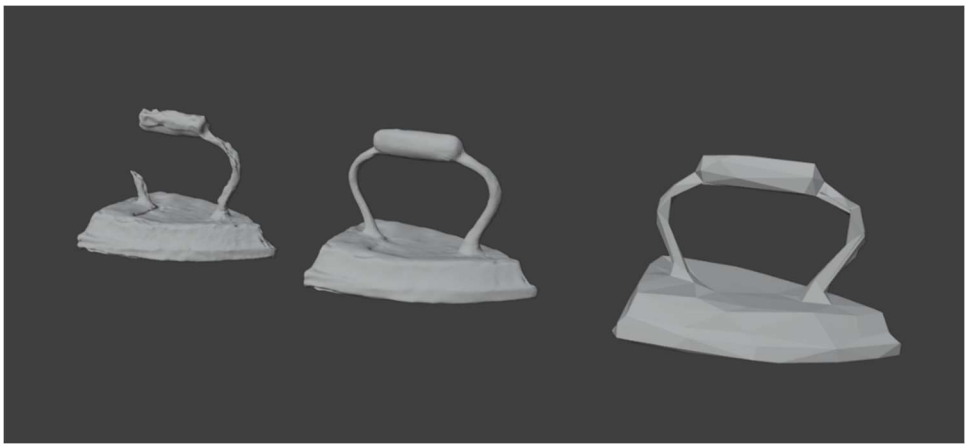

Figure 10: The iron model in three stages, from left to right: original scan, cleaned and decimated, extremely decimated for use in initial Unity steps.

Selecting the miniatures needed was the first step to designing the entire exhibit and selecting the primary factors that would motivate the features of the virtual display. The selected and located miniatures were scanned, and any issues with the structure of the models created by the laser scanning process had to be addressed. Using Blender, both the physical issues with the models, as well as the aesthetic changes and developments were able to be produced. With everything now prepared for the move to the next program, all models were exported along with their finalized textures and animations. The next step, the development of the actual exhibit, would give the models a

platform in which to live and be displayed. All of the things created, edited, and designed from the models influenced this next and final step of the process.

Chapter 4

Exhibit Development

In order to produce an interactive exhibit within which the scanned and produced models can be viewed, a program with custom interactions had to be created. Unity 2023.3.17, an engine used for producing video games, was chosen for the development. The game engine was customizable enough to be able to implement the kinds of interaction that were desired for the end product. As the interaction being used was not massively complex, most game engines would be capable of producing similar effects. Unity was ultimately selected due to access to the program and personal resources that could assist in any problem solving that ended up being necessary during the development process. To understand the process, this chapter will describe the approach to and motivations behind all elements of design - both visual and technical in nature. Then, the procedure utilized to construct the user interface that all the levels of interaction lie within will be explained. A recounting of all of the finalizing efforts to raise the exhibit to be prepared for presentation to the public will close out this section.

4.1 Design and Motivation

There were two strings of thought that were important to creating a “complete” looking virtual exhibit. First was the structural design. Structural design, in this case, refers to both the layout of the content and the flow of the content - how the viewer would move from item to item, page to page. Second was the purely aesthetic design of

the project, the largely non-functional elements that served other purposes. While those elements may not be of the highest importance to most, there was always the interest in producing a virtual exhibit that was additive - offering its own content and connections to the collection not offered in the in-person exhibits seen in the gallery. The idea pushing the aesthetic developments was that having a well-rounded visual design accompanying the exhibit would assist in creating the connections to the story being told - all elements add to the experience.

The functional elements of the design were necessary to creating an effective layout and flow. There was a desire to avoid overcomplicating the experience. Though a game engine like Unity is capable of producing a fully interactive gaming experience, that was deemed unnecessary for this project - at least for the purposes of flow. It was decided that the simpler flow experience would come from all navigation between content being facilitated by always visible menu systems. That way, viewers could click to pull up whatever content they wish to see and learn about. In order for the menus to be set up as efficiently as possible, all desired content was listed and split into groups. Two primary content groups became obvious. The first content group was made up of preset views of the 3D models, including both the individual model views and groups of 3D models. The views that were decided on were a default view showing the scanned models in the room orientation, a similar view that included the digitally built miniatures, a list to view each scanned model individually, and a scale view showing the minis next to their full sized counterparts. This content was decided to be the primary menu, which would be

along the top of the screen of the exhibit, unchanged, at all times. That way, the viewer could move into another view at any time. View Figure 9 below to see the layout.

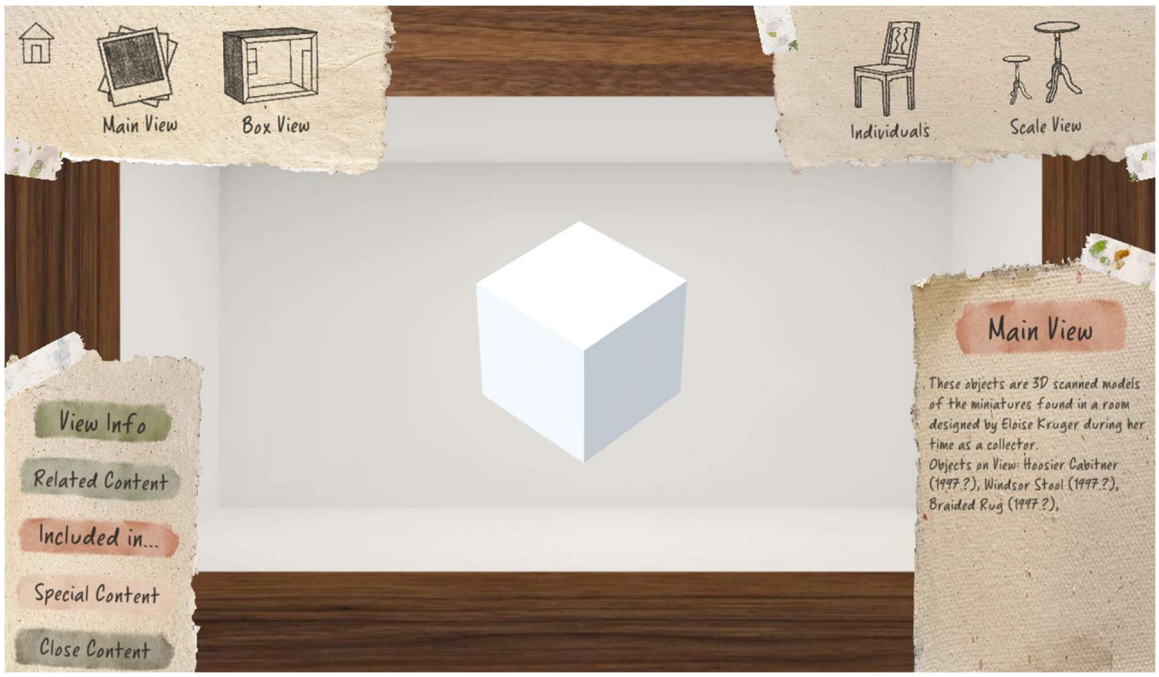

Figure 11: An in progress screenshot of the 3D model view portion of the exhibit.

If a view was selected, the 3D model would load in the center of the screen, and would allow for zooming and rotating to examine the scene. A secondary menu was then decided on to house the other half of desired content - all the contextual content for understanding the items being featured. As different views had different needs for this part of the exhibit - i.e. the original photograph as a reference to its 3D recreation, the modeling process/history of a chair, or animations for models that have that - this secondary menu would need to update with the active view. The menu would always be present, decidedly at the left edge of the screen, but the menu items would change depending on what relevant information was needed to understand the context of the current view. The content of that menu, and any other necessary collection information,

would load into a content panel on the right side of the screen. The very last flow decision was to have a main menu to which the program could reset. A home button would be added to the content sections of the program so that the view could go back to the main page at any time.

On the aesthetic front, the content and story of the exhibit was to be considered. The miniatures being featured were directly being pulled from a photograph of Eloise Kruger's personal design photographs. An exact replica of Kruger's personal designs had yet to be displayed. While information related to the manufacturing and design of the individual items would be important to the exhibit, the visual story would be focused more on the personal touch of Kruger. To reinforce the personal collection/design of Kruger, and due to her being an artist in her free time, as well as designing her own pieces in her collection career, the aesthetic goals were to have elements of a home work space, like that of an artist or miniature craftsman. Visual aspects were designed to have an "in progress" art style, but of non-virtual work. Backgrounds, buttons, text, and panels that would soon make up the interactive elements of the virtual exhibit were ultimately designed to look like paper scraps, paint splotches, and handwritten script. The true goal of this approach was to encourage the user to feel more of a connection to the touch of Eloise Kruger's personal collection, design, and placement of these particular items within the roombox by using these "artist in process" visual elements. The artist approach also implies creation or construction, which, in addition to room design and placement, are the most haptic and interactive parts of miniature collection. As this is the only

exhibit with this collection with interactive elements, having all customizable elements centered around that seemed like the best way to draw everything together.

4.2 User Interface

The user interface, which is made of all elements in the program that the viewer interacts with to control what content is visible, was really going to do a lot of the heavy lifting for this exhibit. It was vital that the menus that facilitated navigation through the content were simple and intuitive enough that any user can find the information they wish to find, as poor navigation will likely dissuade interaction. To keep the movement between content fairly simple, all that was needed was a button system. In Unity, in the simplest of terms, one creates different "scenes" in which content exists. Any models, images, text, or animations that make up that scene are placed in the digital space to create an environment. Then, a camera, or series of cameras, that dictate how the user will view the space are placed and programmed to behave a certain way. Though it is entirely possible to load all of the content of this exhibit into one scene and just move the camera around the content, the content was split into 18 scenes for organizational purposes. This exhibit can be done with fewer scenes to avoid lengthy loading times, but the totality of the project is relatively small, so that was not a concern. Unity uses the C# programming language to dictate what is seen and how one is able to move throughout the program. There was an effort made, due to time and preexisting knowledge, to achieve the desired exhibit with limited coding. There were ultimately three camps of programming needs: buttons to move the user through the content, buttons to load in different text groups, and code for camera behavior (rotation and zoom).

Figure 12: The main menu of the exhibit, designed to look like the desk of an artist.

In order to use buttons to move through the content, all the menus and scenes had to be decided on. The main menu, which utilized the artist's work desk visuals mentioned before and lived in its own scene in the program, contained the name of the gallery, the name of the exhibit, a summary of the goals, and a button that led to the rest of the exhibit. This menu, seen above in Figure 10, is made by having a background image – the wood desktop, which was made by adding individual desk items onto a raw wood image and adding shadows – take up the entire view of the camera. Then, panel (paper) and interactive buttons (paint splotches) laid over one another can create the desired menu. The button leading to the exhibit had to be programmed to load into the primary exhibit scene upon clicking. The next scene contains a default 3D model view (all scanned models in the same orientation as the reference photo) on loading and the two menu systems and content panel mentioned in the design section, seen below in Figure 11.

Figure 13: This view includes only the 3D scanned models that have physical counterparts.

The view menu along the top of the screen loads the various view options, the main view, the box view (same as main view but with digital elements added), an individual menu (with the ability to view individual models one at a time), and a scale menu (shows models at different scales). This view menu, along with the content menu that lists the available information for each view and the text/images that will load when the content menu is interacted with, are all locked to the camera to appear static when the exhibit is in use. As portions of the menu, as well as large portions of the coding, are repeatedly used in different views, the prefab function was able to be used to the development's benefit. Unity allows assets to be saved as a prefab in your project folder, which makes it possible to just drag premade content into your project at any time. This also makes it so that any changes made to the prefab updates all cases of the prefab. Now,

once the code had been designed and implemented for a menu once, it could just be easily applied to multiple scenes and views.

The main menu has a static camera, so it did not need any programming. The cameras that view the 3D models are programmed to orbit around a central point within the models. They are designed to rotate along X and Y axis directions relative to the click and drag of the cursor across the screen. This creates the illusion of the object rotating along with the drag. Additionally, the camera also allowed for limited zooming in and out when viewing the models. Any individual model can be viewed by clicking on it in the menu, which will load the camera centered around that miniature's scan, which the viewer can then orbit around and zoom into to see any detail they desire. Though this seems fairly hefty, each movement was designed in a way that attempted to use the prefab function as much as possible. Only a few instances of coding were needed, and then replicated to produce this exhibit.

4.3 Content Implementation

With the coding and movement designed, it was necessary to add both the content of the exhibit and the environmental structures to make the exhibit feel finished. The most important content was, of course, the 3D models and scans. All the necessary models from Blender were imported into Unity and placed into the desired orientations and scales next to one another. The background image, a roombox (which sat behind all models, locked to the camera in the same way as the menus), had to be relocated and scaled relative to the total space taken up by the models to produce the highest quality without clipping the models.

Figure 14: An individual view, which allows the visitor to freely zoom and rotate the miniature.

To get all the menus to be presentation ready, all the finishing touches were needed on all fronts to create the final editions, showcased in Figure 12 above. All menus and content panels needed the information necessary for the exhibit to educate and contextualize what is being looked at. As per typical museum expectations, a view/object name, description, known artist, object IDs, material information, and provenience are listed by default in the content panel of each view. Then, beyond "Item Information," other content can be accessed via other tabs in the secondary menu such as "Associated Documents" which has any photos, receipts, drawings, or correspondence related to the miniatures, "Animations" for the items with movement that is playable, "Detail View" has a texture-less version of the model and text to highlight interesting details of the scan, and "Modeling Process" which contains the scanner and scanning information as well as any changes made to the model after the scanning process to finalize the model. A final

button that allows the viewer to return to the main menu was added to the top right corner. Once the exhibit was functioning, and all the information had been loaded in, the exhibit was ready for presentation to the public.

Chapter 5

Results and Discussion

The goals of the final virtual exhibit was to use and highlight unique offerings of the virtual platform in order to encourage a different type of relationship between the miniatures of the collection and the gallery's visitors. The affordances that were prioritized were interaction, versatility, scalability, preservation, and minimal space requirements. The use of a game engine allowed for point-and-click or touch screen based navigation through the exhibit. Additionally, the models included in the exhibit were able to be rotated and zoomed as the user pleased to view specific details. Models were able to be utilized multiple times to allow for multiple uses across the exhibit. The laser scanning of the models created a digital 3D version of 10 miniatures, several of which were never previously cataloged in any previous digitization efforts. Six additional items were built digitally due to them not being located during the project. Four items were able to have animation added to the final program. The final exhibit was first unveiled to students who were working with the collection for a class at the University of Nebraska, Lincoln. The class was working in groups to produce a series of miniature exhibits for the gallery. The virtual exhibit is accessible online via this link. In order to continually update the link as needed, if any changes were to be made that alters the URL, the current URL will be updated to this website, where process images to record

the project in the event of its loss also live. The public display of the virtual exhibition will occur on May 3rd, as part of a public opening of the gallery and the student's work for the semester. The exhibit will be available to the public on a touch screen near the entrance to the gallery.

5.1 Discussion

This case study had a goal of producing a virtual exhibit showcasing a portion of the Eloise Kruger Collection of Miniatures while trying to utilize the unique affordances of digital tools in order to facilitate a new type of relationship between audiences and the collection materials. As recapped above, interaction, versatility, scalability, preservation, and minimal space needs were specific goals of the project. In order to assess the success of their implementation, a comparison of the in-person miniature exhibits available for view in the Eloise Kruger Gallery of Miniatures and similar collections under the same criteria will be reviewed. Interaction was implemented via the discussed click and drag mechanics in the final exhibit that allows personal control to the viewer. The in-person exhibitions, like so many traditional museum exhibits, do not allow any physical interaction. Miniatures in general, especially the many handcrafted pieces featured in miniature collections around the nation, require careful handling. It is not feasible to allow free handling of many of the pieces on display in these collections. The digital interaction, via a screen, is by no means the same as handling a real piece, so it is not a one-to-one experience, but it allows for an element of interaction that is nonexistent in the Kruger Collection's other exhibits currently available to view. Versatility was implemented by having several different views and orientations in the exhibit using the

same models. As they are digital, the miniatures in the virtual exhibit can be repeatedly applied to different content. Since this exhibit benefitted from multiple views, this was a successful implementation. Two views that benefited from the versatility are the scale view and the individual views. The scale view was necessary to give the viewers a sense of scale - a feature often missing from other digital exhibitions of miniatures. There are certainly various ways of doing this, but having the miniatures next to their full scale version was an entertaining version, and was exceptionally easy to implement. The individual views allowed visitors to zoom in and see finer details of the miniatures that are difficult to see in the in-person displays of the furniture. Preservation and minimal space requirements were arguably hit and miss in their success. The exhibit does require less space in the sense that, if on display in a gallery, only one screen is needed for the exhibit to be fully experienced. In the case of miniatures, however, this is not the craziest of space saves. Considering that the screen needs to be connected to a computer or server that houses all the data for the exhibit. Though the "space" the exhibit is taking up is not the same, it would not be truthful to claim this exhibit is really taking up less space compared to a traditional exhibit.

Lastly, there was absolutely digitization and preservation happening during this project. Now that these models exist, the gallery is free to use them as desired. They are preserved, but the level of investment used in this particular project is very high if 3D preservation is the goal. The digitization process offered a degree of learning curve, which could be a common experience for museums interested in starting 3D digitization. The scanner that is owned by the School of Global Integrated Studies was purchased with

a goal to balance price, ability, and investment. Given that it was not on the highest end in regards to scanners that can be acquired, it was fairly successful at scanning without major hurdles. Many of the scanning struggles that arose during the process were completely expectable from most scanners, as discussed. It would be important, if the process were to be replicated with another exhibit or collection, to evaluate a scanner that fits the specific needs of the collection and the materials therein. If extensive digitization is desired, a heftier and more detail oriented scanner would be necessary to minimize problems that could slow down the process. The middle of the road scanners are fully capable of making scans that need no additional work, but there were just as many instances of poor scan quality or odd deformities in the end models that had to be fixed later on in the process. This was acceptable only due to the pre-existing skills available to the process. Without that, fixing the issues might not be a sufficient plan for all projects. On the other end of the scale, a project that just wishes to produce 3D models that can exist independently and be viewed by guests could be very easily done with phone apps that can make 3D models from a series of photographs. The use of the scanner for this project allowed for the highly detailed models that are in the final exhibit, as well as easy transport into the various programs that were used for the development.

An element of this project that perhaps makes it infeasible for any team interested in something similar is the need to have preexisting knowledge or skills for a series of programs. For the production of this exhibit, three different programs were needed to get the end product, one for the scanning, one for the edits of the models, and one for the development of the interactable exhibit. There was most certainly a degree of learning

involved - as experience in the exact three programs utilized was not had - but experience in similar programs or programs that used elements of the utilized programs was had during development. Without a degree of familiarity in 3D model creation/editing or coding of some sort would create a fairly massive learning curve. The degree of success of a virtual exhibit such as this one would be heavily dependent on the level of investment that varies based on preexisting knowledge and skills as much as if the exhibit successfully fulfills the needs of the collection. Given that there were available skills to ease the development process, the amount of investment was of a reasonable proportion to the end product. This exhibit was able to be created and all the relevant collection materials were able to be digitized in less than a year by an individual student. So, with the right programs and knowledge, it seems to be a feasible investment.

Chapter 6

Conclusion and Future Considerations

In order to examine potential ways of implementing 3D modeling and digitization into museum exhibits in a way that adds to the personal relationship of the visitors to the collections, a case study was conducted on the development of a digital exhibit. The exhibit utilized a portion of the Eloise Kruger Collection of Miniatures managed by the University of Nebraska - Lincoln to produce an end product that has heightened interaction, versatility, and scalability as tools to build a connection between collection and viewer. The exhibit housed 3D models of the miniatures to display in a series of interactable views. Overall, the resulting exhibit was successful in its goals for this specific collection, but is not entirely feasible for all projects, teams, or collections. It is

very important to interrogate the nature and purpose of an individual collection before deciding to take on such a project at this point. Prior to more user friendly, pre-built exhibition software being produced, the amount of time, labor, and funding involved in producing any similar exhibits is high enough to necessitate such interrogation. Not all collections would benefit from increased interaction, versatility, or any other discussed affordances of digital tools. The Kruger Collection of Miniatures, very specifically, did benefit from those additions, which allowed for the overall success of the exhibit.

Moving forward, there are some interesting considerations and possibilities for 3D technology use in the future. For this case study, the extent of interaction was limited to zooming and rotation due to the time frame. However, there is absolutely a wonderful opportunity to build upon this interaction into something very unique. The limited interaction is already more than replicable with the in-person exhibits, and visitors can see more detail than is typical. But, with more time and coding skills, the creation of an exhibit with a "sandbox" type object interaction, that allows visitors to place and design their own miniature rooms would be a fantastic long term use of digital tools to benefit such a collection. As this type of collection specifically brings to mind haptic interaction - playing with dollhouses, building and designing miniatures, and so on - a sandbox design style exhibit would lean much further into that relationship. As the Kruger Collection develops and grows with student investment, such an exhibit could be created down the line. Beyond future developments for this specific collection, the procurement of 3D models of museum materials such as the miniatures offer a potential alternative use beyond preservation of exhibit use. Once a more robust library of these scans exists, it

would be possible to allow the use of the scans for educational purposes. In the case of the miniatures, opening a library of scanned, scalable miniature furniture to interested architecture or interior design students might be a wonderful alternative use for these models beyond letting them live in a computer untouched except for exhibit use. While it would be wonderful (and would set up the most success for museums and galleries interested in creating interactable 3D model based exhibits) for a program to exist that a museum could just plug their 3D models and exhibit information into and produce a fully functional exhibit - at this time, no such program exists. Until then, an array of skills are needed to produce a custom exhibit that meets the needs of a specific collection. However, as long as the interested parties, who know their collection and its needs the best, are intentionally seeking out digital tools that implement 3D models and program design in a way that builds upon existing exhibits and in-person information, there is great possibility for the future of 3D model use in museum exhibits.

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