ARCHIVING A MUSEUM WITH AN INTERACTIVE EXHIBIT

A report to detail the process of creating an interactive, virtual reality exhibit for the Hönnunarsafn Íslands Museum of Design and Applied Art.

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By:
Lauren Herchenroder
Nathan Jackson
Emma Lowry
Lewis Guy

Sponsored by:
Sigridur Sigurjonsdottir, Director of The Hönnunarsafn Íslands Museum of Design and Applied Art

Archiving a Museum with an Interactive Exhibit

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Authors:

Emma Lowry
Nathan Jackson
Lauren Herchenroder
Lewis Guy

Sponsors:

Sigridur Sigurjonsdottir
Director of The Hönnunarsafn Íslands
Museum of Design and Applied Art

Advisors:

Professor Fred Looft
Professor Ingrid Shockey
Worcester Polytechnic Institute

Abstract

The goal of this project was to work with The Hönnunarsafn Íslands Museum of Design and Applied Art to design and develop an interactive VR exhibit that could showcase museum artifacts not physically on display. We researched digital interactive exhibits in other museums, identified the best practices for developing them, and surveyed the interests of museum visitors. We used this information to develop a user-friendly VR exhibit prototype. After analyzing visitor feedback and our post-interaction prototype results, we drafted recommendations for how the museum could improve and maintain the prototype we put in place.

Authorship

Section	*Author(s)*	*Main Editor*
Title pages	Lauren	
Abstract	Emma	
Authorship	Lauren	
Acknowledgements	Lauren	Emma
Executive summary	Emma	
Table of contents	Lauren	
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Executive Summary

Introduction

The only thing better than viewing a painting might be stepping into one. In fact, developments in interactive technology and, in particular, virtual reality, have given art a whole new dimension – one that masters like Michelangelo never could have imagined. The immersive effect of virtual reality (VR), augmented reality (AR), and other digital interactive media technologies has changed how we interact with art, and museums are now interested in testing this new technological climate (Erlic, 2017).

The Hönnunarsafn Íslands Museum of Design and Applied Art is located in Gardabaer, just outside of Reykjavik. The Museum focuses on design artifacts that showcase Icelandic culture throughout history. The museum moved their previous permanent exhibits to storage to make room for rotating exhibitions, generating an increase in visitor numbers. However, the large collection that was moved to storage is inaccessible to the public. Therefore, the goal of this project was to research and develop a prototype of an exhibit that would allow for a digital and immersive way to view collections not physically on display (About the Museum, n.d.).

Icelandic Design and the Role of Museums

Iceland has a rich history of art and design built upon its Nordic roots and a long-standing spirit of self-reliance (Icelandic Art & Design, n.d.). Icelandic art and culture are preserved and celebrated in its many museums. The country's many reputable museums attract tourists from all over the world, and they are a significant part of tourist activities in Iceland. Between 37-52% of tourists of Iceland respond to surveys that they visited museums during their vacations (Maskína, 2017).

Leveraging Interactive Media

Researchers have found that interactive digital experiences increase immersion and thus involvement in the learning experience (Christopoulos et al., 2018). Virtual Reality (VR) is a relatively new and popular form of interactive media. Its versatility and attractiveness have led to its widespread adoption by educational organizations, including museums (Coates, n.d.).

Virtual reality provides a way for visitors to interact with an exhibit while being immersed in a way that traditional exhibits could never offer (Song, 2017). Well known museums including The Smithsonian have all begun to implement virtual reality exhibits and have found great success (Coates, n.d.). Despite beliefs that cultural appreciation and technology do not mix, combining the two in VR leads to better understanding of the exhibits (Song, 2017). The primary issue that has limited the adaptation of virtual reality in museums is cost. Fortunately, rapidly evolving technology has expanded the accessibility of VR to these institutions. Artists using VR see the potential for the exciting medium to create pieces that can truly immerse the viewer in an experience they envisioned.

VR Background

The two kinds of hardware we researched were 360° Cameras and VR Headsets. 360° cameras are devices used to capture photos in a full 360-degree field of view across both the horizontal and vertical planes (Scaramuzza, n. d.). This type of camera has recently gained popularity in the last decade thanks to the 360° photo viewing support on social media sites. Virtual Reality, or VR, is defined as the implementation of digital technology to create a simulated environment which places the user in an immersive experience (Bardi, 2019). VR equipment, which was once expensive and inaccessible to most of the public, is widely available on the market today. Mobile VR, a branch of VR technology, requires only a smartphone, making it an inexpensive VR experience accessible to large audiences. The user can look around and experience a 360-degree photo or video (Snyder, 2018).

Objectives and Methods

The goal of this project was to provide the Hönnunarsafn Íslands Museum with a framework for a user-friendly VR exhibit of artifacts. The museum wanted a means to display artifacts and create exhibits in an interactive format that also occupied minimal physical space. Therefore, our objectives were to:

- Determine the best practices for implementing VR exhibits that showcase museum artifacts
- Understand the interest in VR and VR exhibits within the museum's potential audience
- Design, test, and pilot a virtual reality exhibit prototype to solicit feedback
- Develop recommendations and implementation plans, budgets, and other supporting documentation that museum staff can use to implement a successful VR exhibit

To achieve our objectives, our team reached out to museums within Iceland in order to determine the best practices for creating and using VR in limited spaces. We conducted open-ended interviews that inquired about the successes and problems of their past virtual reality exhibits.

We also conducted a survey of museum attendees to understand the level of interest of our potential VR exhibit audience as well as any background they may have in using virtual reality. We gathered this information using a short survey that asked the attendee questions focused about their interest in VR and different design genres.

We then photographed selected exhibits and artifacts with a 360° camera. We created an account for the museum with Momento360, a site meant for sharing and viewing 360° photos. The prototype was designed so that users could follow a QR code with their smartphones and view 360° pictures of museum artifacts online. We also acquired and Oculus Go, a standalone VR headset that we uploaded our 360° pictures to.

To evaluate the success of the prototype exhibit we implemented, we surveyed visitors that used the prototype. The survey we used contained questions assessing the topics of how the

user felt about the experience, what they'd like to see from it, and their additional thoughts on the exhibit.

Results

When we visited Aurora Reykjavik, a museum with a VR experience, we learned about their set up and the hardware that they used for their VR exhibit. Our team reached out to the photographers and directors of the museum via email. The photographers provided recommendations for how to take and edit our photos. The directors told us about their decision-making process for different aspects of the VR experience.

Interviewing our museum's director, Sigridur Sigurjonsdottir, revealed that most of the museum's visitors were attendees of special events. We did most of our surveying at museum events as a result of this trend. The multiple-choice questions revealed that the majority of visitors at the special events both had a smartphone and were familiar with QR codes. The interest in a virtual reality display was overwhelming, regardless of whether they had used one or not before. Architecture was the most popular genre of design among those who took the survey.

Prototype testing revealed that users were engaged when wearing the VR headset and exploring the pictures available to them. Our visitor surveys, prototyping, and post interaction surveys revealed that a virtual reality exhibit of museum artifacts has great potential for growth and visitor interest. The variety of visitor interests in design genres suggest that expansion of this exhibit will allow the museum to appeal to all current visitors as well as attract new visitors.

Recommendations

To allow Hönnunarsafn Íslands to continue to update the exhibit, we wrote a manual detailing how to take 360° photos, upload them to the headsets and Momento360 account, set up QR codes, and properly set up an Oculus Go headset for daily use.

To continue to add to the exhibit, Hönnunarsafn Íslands will need to obtain their own 360° camera to continue to photograph pieces. We recommended several cameras of varying price and functionality. We also recommended the museum purchase at least one additional Oculus Go to provide the VR experience to multiple guests at once.

Because of the success of the architectural models in VR and the significant portion of users who preferred them over other items, we recommend they photograph additional architectural models they have in storage.

We also recommend using the 360° camera to photograph rotating exhibits and make them available for viewing inside the new virtual reality exhibit. This would allow visitors to view rotating exhibits no longer on display and also give artists further exposure after their exhibit is no longer on display.

Conclusion

This project sought to bring art and technology together in a way that would benefit the Museum of Design and Applied Art and the local design community as a whole. We laid the groundwork for a VR exhibit with potential to expand and develop over time and hope that its presence in the museum will foster an appreciation for artifacts that cannot be on display in the exhibition hall, increased interest and attendance, and further assert technology's positive role in the world of art appreciation. Finding ways to combine art and technology into new profound experiences is an essential step towards preserving art and design and ensuring that it continues to enlighten our culture and communities.

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1. Introduction

The only thing better than viewing a painting might be stepping into one. In fact, developments in interactive technology and, in particular, virtual reality, have given art a whole new dimension – one that masters like Michelangelo never could have imagined. The immersive effect of virtual reality, augmented reality, and other digital interactive media technologies has changed how we interact with art, and museums are now interested in testing this new technological climate (Erlic, 2017). By using virtual reality and online exhibits, museums can modernize and revitalize visitors' interests and attendance numbers (Song, 2017).

The Hönnunarsafn Íslands Museum of Design and Applied Art, located in Gardabaer, just outside of Reykjavik. The Museum focuses on design artifacts that showcase Icelandic culture throughout history, and it houses the works of Icelandic designers, ranging in subject from furniture, ceramics, textiles, to unique exhibitions. When the Museum was founded in 1998, its primary features were permanent exhibits that displayed the most prominent pieces in its collection at the cost of over half of the space in the museum. This meant that visitors to the museum once had already seen most of what it had to offer and were less likely to return again, leading to stagnated attendance rates. To address this issue, the museum staff moved the permanent exhibits to storage to make room for rotating exhibitions, resulting in an increase in visitor numbers. However, the large collection that was moved to storage became inaccessible to the public, meaning visitors were unable to enjoy a wealth of Icelandic culture. To resolve this, the museum wanted to consider developing an exhibit that would allow for a digital and immersive way to view collections not physically on display (About the Museum, n.d.).

The purpose of this project was to assess and test the feasibility of using interactive exhibits to digitally showcase artifacts for the Museum of Design and Applied Art and to prototype a Virtual Reality exhibit of that achieves this outcome. In preparation for the project, our team reviewed literature on digital technologies, compared virtual reality and digital applications in museums such as the National Museum of Finland, The Smithsonian, and The Tate Modern. We then designed and tested scenarios that could showcase the Museum of Design and Applied Art's collection and created a VR exhibit prototype that could be expanded upon by museum staff.

2. Background

This chapter explores the changing role of museums and highlights various digital and interactive platforms that make stored collections available to the public and increase public interest.

2.1. The Value of Museums

Museums were not always public institutions. Originally, artists were hired by the upper classes, such as royalty and clergy, to decorate homes or buildings which only few could access (Günay, 2012). Fortunately, this trend indirectly preserved cultural and historical perspectives that were representative of cultures and moments in history. The collections were valued by the public and later became a way to showcase artwork in a way that would educate local citizens (Günay, 2012).

Museums truly emerged in the 18th and 19th centuries alongside industrialization and growing city populations. These institutions exclusively showcased fine art and science. However, a new type of museum emerged during the industrial era that filled the gap that art and science museums left open. New Design and Applied Art museums focused on the changes in crafts and design caused by the evolving artistic approach to production (Dimaki & Dimakis, 2006). One of the unique aspects of these museums was that the items they displayed were typically from the current era and could often be touched by visitors (Maroevic, 1998). The first design museum was the Deutches Gewerbemuseum, founded in Germany in 1827. The Victoria and Albert museum then opened in England in 1852 (Dimaki & Dimakis, 2006). After the establishment of these first design museums, many more appeared in major cities around the world.

2.1.1. Understanding Design Museums

Design museums are unique because they highlight not only the art of the artifact but also address the quality and functionality in relation to the needs of society. During an interview with The Vitra Design Museum, designer Konstantin Grcic describes the nature of design by saying:

> *My designs do not immediately reveal themselves. They do what they are designed to do, are functional, but at the same time, they question their own functionality and call upon the user to do likewise. (Grcic, 2013)*

The genre of design is diverse, including fashion, furniture, ceramics, architecture and many others. As a result of the design genre's depth and range, the audience that visits design museums like The Hönnunarsafn Íslands Museum of Design and Applied Art has specific interests and backgrounds. The atmosphere of a design museum and the artistic content it provides caters more to art students, designers, archivists, history students, architects and those with a passion for design in its many forms. Design museums offer their appreciators a rich understanding of diverse artistic processes due to the wide range of disciplines and skills their artifacts represent. Items in design museums showcase craftsmanship and creativity unique to the design genre, and the artifacts in their collections are often representative of a time period's artistic evolution. The in-depth understanding that they offer about a culture and its history is incredibly valuable to the surrounding artistic community.

2.1.2. Icelandic Art and Design

Iceland has a rich history of art and design tied to its Nordic roots and a long-standing spirit of self-reliance (Icelandic Art & Design, n.d.). In addition, an appreciation for design within Icelandic culture is strong and celebrated. For example, the city of Reykjavik is home to a festival known as DesignMarch, hosted by the Iceland University of the Arts, that celebrates the four primary fields of design taught at the school: fashion, industrial, graphic, and architectural design. The festival itself is a showcase that spans the entirety of Reykjavik, transforming the city "into one big venue for design," (About DesignMarch, 2019). Furthermore, the Iceland University of the Arts also offers a course titled "Heritage" that prompts design students to learn about their art and design history (Icelandic heritage pattern, 2010). This appreciation for art and design is promoted to visitors of Iceland through museums and exhibitions that honor Iceland's artistic identity.

Museums are a fundamental source of cultural education and artistic inspiration in Iceland. In just the greater Reykjavik area alone, there are over 30 museums (Visit Reykjavik, n.d.). These museums cover a wide range of subjects including 2D art, photography, culture, wildlife, sculptures, and history, and they attract the attention of many. Between 37-52% of tourists responded that they visited museums during their vacations in Iceland (Maskína, 2017). However, among all of the museums in Iceland, there is only one design museum.

2.2. The Evolution of the Museum Experience

The internet has enabled mankind to experience museums in several new ways. Online exhibits can stimulate interest in potential visitors and are often more accessible to people with certain disabilities. Utilizing social media to advertise new museum exhibits, especially digital interactive exhibits, encourages people to visit the museum and experience the exhibit for themselves. Carter Cleveland, the founder and CEO of the world's largest online collection of art, relates the online exhibit experience to modern love: "Ultimately, the physical experience of art is more just like online dating. We want to meet someone physically in the end, but it's spurred with online platforms" (Song, 2017, para. 6).

Recognizable museums, such as The Smithsonian Museums and Metropolitan Museum of Art (Met), offer great examples of how museums have modernized to work with the internet. On each of the Smithsonian museums' websites, they dedicate a section to previous and current exhibits they have displayed, as well as digitally archived pieces.

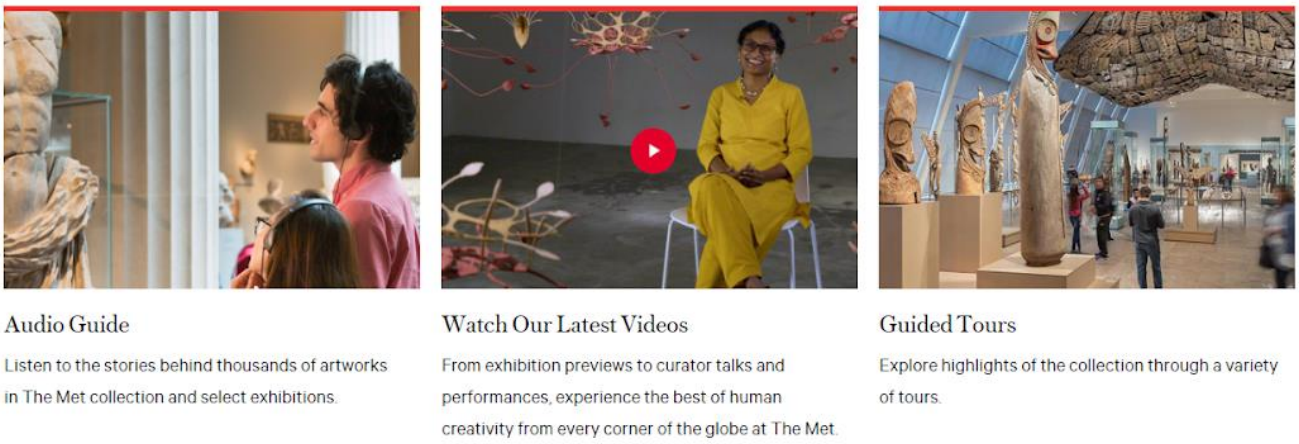

Figure 1: A portion of online features from the Metropolitan Museum of Art's webpage (www.metmuseum.org, 2019).

As seen in the figure above, The Met also began to improve their online presence by adding preview videos for new exhibits, guided tours of current exhibits, and several 360° video experiences that showcase the museum on their website in an immersive way. Overall, a museum's active online presence generates more online visitation, which can interest in visitors and convince them to attend the exhibit in person (Coates, n.d.).

In addition to encouraging physical attendance, online exhibits make museum experiences available to those who cannot visit the museum physically. For example, it can be difficult and expensive to modernize older institutions to make the building handicap accessible. Therefore, online exhibits that utilize modern technology such as at-home virtual reality, text to speech

capabilities, and printable artifact guides make museums accessible to a more diverse group of visitors (Germak, Lupetti, Giuliano, & Kaouk, 2015).

Another factor that can motivate museum attendance is the installation of virtual reality and other interactive exhibits directly within the museum. The Met in New York City has integrated interactive exhibits in recent years and has since seen a rise in attendance. Ken Weine, the chief communications officer of the Met, said that attendance is "stronger than ever," there being "more than 7 million visitors in 2016" (Song, 2017, para. 15). This increase in attendance has been partially attributed to the digitization of hundreds of thousands of artifacts in the museum's possession.

2.3. Leveraging Interactive Media

The technical domain of digital engagement is a specialty in itself. Interactive media is generally understood to be a category of entertainment defined by its responsive relationship with the user. Video games, digital simulations, augmented realities, and virtual realities fall under this term because they interact directly with their users and respond to user inputs (Dhir, 2019). Interactive media has not only become more popular because of its role in mainstream culture (video games, interactive films such as Netflix's *Bandersnatch)* but also because of its growing role in education (Christopoulos et al., 2018). In particular, researchers have found that interactive digital experiences increase immersion and thus involvement in the learning experience, especially if students are properly introduced to the medium beforehand (Christopoulos et al., 2018). The immersion that defines interactive media is what draws people to it. Virtual Reality (VR) is a relatively new and popular form of interactive media, and its particularly immersive applications are undergoing extensive research and feasibility testing. Its versatility and attractiveness have led to its widespread adoption by educational organizations including museums (Coates, n.d.). With a reasonably affordable investment, these technologies can be incorporated into education settings such as classrooms and museums. Some of the most important hardware is described in detail below.

2.3.1. 360° Cameras

360° cameras, also known as omnidirectional cameras, are devices used to capture photos in a full 360-degree field of view across both the horizontal and vertical planes, creating an entire scene captured around a single point (Scaramuzza, n.d.). Originally limited to complicated and stationary film cameras in the early to mid 1900s, the technology has advanced significantly in the past 20 years. Modern 360° cameras are now generally handheld, fully digital, and capable

of high resolution (Spinner 360 History, n.d.). This type of camera and the photos they take have recently gained popularity in the last decade thanks to support from social media sites such as Facebook. In mid 2016, Facebook began supporting 360° photos and made them viewable in a user's home feed. After just one year, over 70 million of these photos had been uploaded by users (Facebook Engineering, 2017). Facebook's platform granted 360° photos significant exposure, bringing them into mainstream culture and supporting an increase in their usage by individuals and institutions.

Modern 360° cameras typically fall under two categories, either having two lenses or more than two lenses, the former being the most common. Dual-lense cameras have lenses that face outward, opposite of each other, each capable of capturing over 180° of vision. Figure 2 below shows a popular example of a dual-lensed camera.

Figure 2: Ricoh Theta z1 360° camera (www.theta360.com, 2019).

These lenses create two overlapping hemispherical photos, taken by each lens, that are then stitched together into one spherical image by the camera's built-in software (Scaramuzza, n.d.).

2.3.2. Virtual Reality

Virtual Reality, or VR, is defined as the implementation of digital technology to create a simulated environment which places the user in an immersive experience (Bardi, 2019). Games are a platform where VR truly shines technically and artistically, but VR is finding a role in

immersive educational experiences and digitized exploration as well (Christopoulos, 2018). A typical VR headset designed for gaming is shown below in Figure 3.

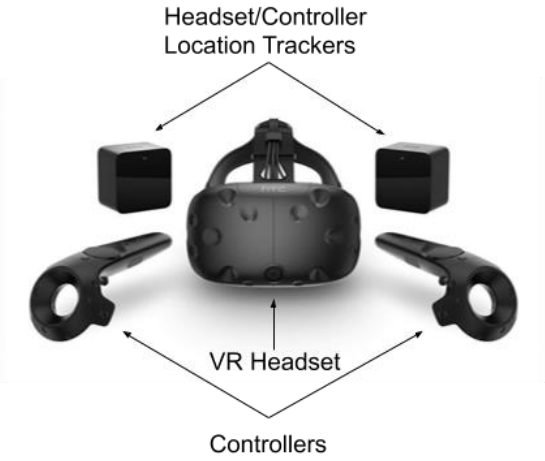

Figure 3: The HTC Vive VR Headset (www.bestbuy.com, 2019).

VR makes use of specialized headsets that transmit both visuals and audio to their users, creating a simulated world space that can be explored and interacted with (Bardi, 2019). This VR equipment, which was once expensive and inaccessible to most of the public, is widely available on the market today.

There are two distinguishable kinds of VR present today. Firstly, there is VR that allows for the exploration of simulated, 3D-modeled and rendered environments, which will be referred to as 6-Direction VR (6-D). This is the most common kind of VR in games and immersive simulations. 6-D VR allows for both 3 axes of rotation - looking up, down, and to the sides - and 3 directions of physical movement. Headsets such as the HTC Vive (Figure 3), Facebook's Oculus Rift, and Sony's Playstation VR are the most popular consumer 6-D Virtual Reality devices (Bardi, 2019). However, numerous tech companies have designed and sold their own headsets, all varying in price and quality. At common technology retail stores like Best Buy, for example, the HTC Vive is available for USD$499 (ISK 61.890), the Oculus Go is priced at USD$249 (ISK 30.883), and Sony's Playstation VR is sold at USD$349 (ISK 43.286). However, other types of VR headsets, such as those that use smartphones for Mobile VR, are available for as low as USD$9.99 (ISK 1.239). This is because Mobile VR headsets rely on the screen of a consumer's personal smartphone rather than generating their own visuals. Examples of Mobile VR headsets include Google Cardboard and Samsung GearVR (Snyder, 2018). Because of the wide availability of virtual reality devices of both kinds, VR has soared in popularity; 2016 was deemed "the year of

VR" (Coates, n.d.). At that time, the VR market was worth USD1.8 billion, and it's grown significantly since: in 2019 it hit USD6.2 billion and is predicted to reach a value of USD16.3 billion by 2022 (Superdata Research, n.d.). This projected upward trend is shown in Figure 4.

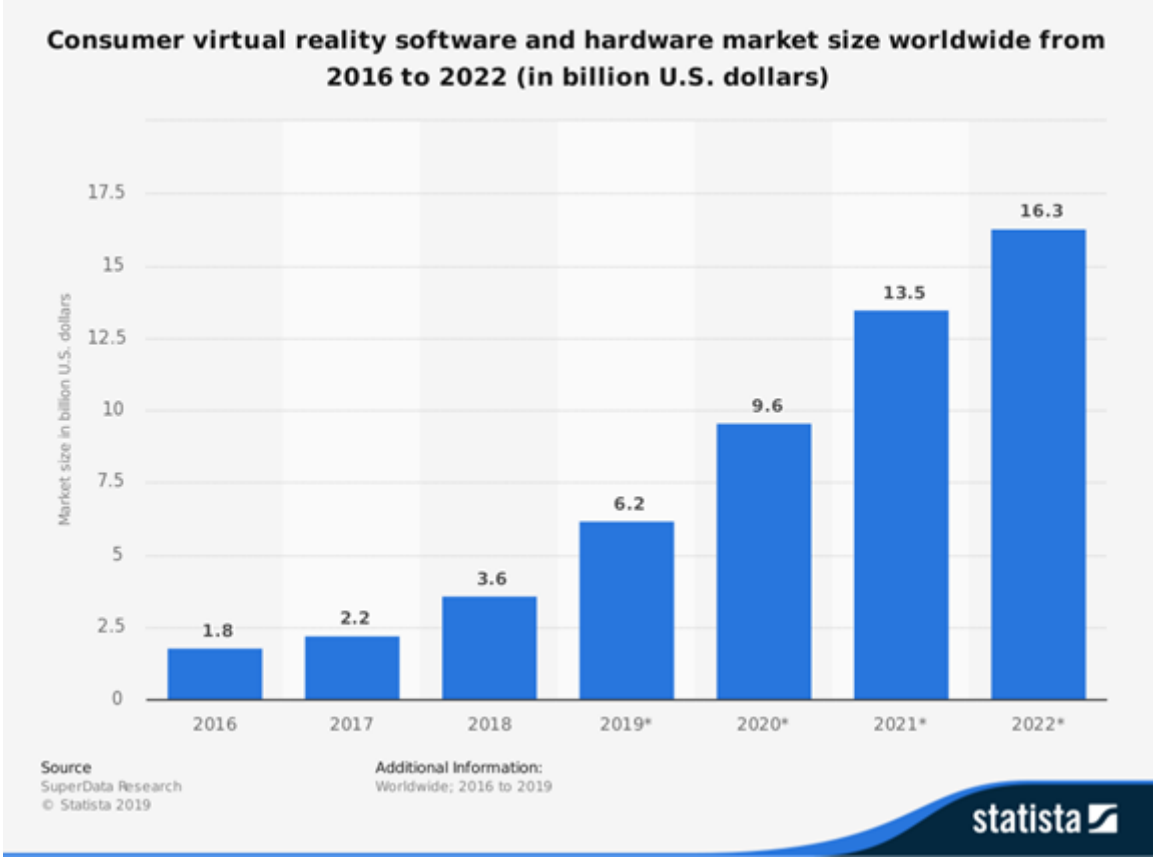

Figure 4: Depicts VR growth as an industry (Superdata Research, n.d.).

While both 6-D and mobile VR provide interactive experiences, there are several notable differences between the two. Mobile VR viewing requires only a smartphone, making it an inexpensive VR experience accessible to large audiences. The user can look around and experience a 360-degree photo or video (Snyder, 2018). However, despite its accessibility and low cost when compared to 6-D VR, Mobile VR faces disadvantages as well. Mobile VR users often can only rotate and cannot move within a scene, for this imagery is all pre-captured and unmalleable, and thus can do little exploring inside each image. The quality of the image users see is also lower than that of 6-D VR. This is because the lenses built into a mobile VR headset must be focused on a phone screen and are sometimes not adjustable.

6-D VR involves the creation of artificial 3D environments which are rendered with game engines or similar programs. This means that the environments are fully developed and

detailed and are being rendered in real time by the computer that the headset is connected to. The user can explore every corner of them by either moving around their bodies or using controllers. Below, Figure 5 is an example of a rendered 3D environment built for a VR game currently in development by Labrodex Studios (Tokarev, 2017). Within this virtual space, a player can explore and interact with their surroundings.

Figure 5: A VR game environment (Tokarev, 2017).

However, 6-D VR set ups, which involve headsets and other equipment such as computers with powerful graphics capabilities, are often complex and tethered by wires to computers or gaming systems. This makes them immobile, complicated to install, and in need of regular maintenance. Both the hardware and software involved often experience system errors and other problems (Snyder, 2018). These advantages and disadvantages affect where each kind of Virtual Reality experience can succeed. When addressing the role of this kind of technology in the context of learning establishments such as museums, it is critical to consider how each kind of system's interactive value, cost, and overall experience impacts its viability.

2.4. Bringing VR to Museums

Virtual reality can have applications in nearly every industry, and museums are certainly no exception. Virtual reality provides a way for visitors to interact with an exhibit while being immersed in a way that traditional exhibits could never offer (Song, 2017). Museums such as the National Museum of Finland, The Smithsonian, The Tate Modern, and the National Museum of Natural History in Paris have all begun to implement virtual reality exhibits and have found

great success (Coates, n.d.). Experts say that it is because a physical interaction with the pieces creates a longer lasting impression. Despite critics' claims that cultural appreciation and technology do not mix, combining the two in a comprehensive and well implemented VR display actually leads to a greater understanding of the exhibits (Song, 2017). For example, pictured below is a VR exhibit implemented by the National Museum of Finland. It allows users to enter R.W. Ekman's painting, *The Opening of the Diet 1863*, where they can interact with characters and the environment. By exploring the virtual space and speaking with figures such as the Russian Emperor, audiences of this exhibit can learn more about this moment in history (Coates, n.d.).

Figure 6: The National Museum of Finland VR exhibit (Coates, n.d.).

Another example of how virtual reality can revitalize museums is the case of the Palazzo Ducale in Venice, which sought ways to separate itself from its competitors. The museum installed two virtual reality stations that featured a tour of a series of famous paintings. After interviewing 3000 visitors, they found the stations had an overall excellent rating of satisfaction, and visitors were able to successfully relay information learned from the experience. The trial run went so well that the museum then quadrupled the number of stations (Izzo, 2017).

The primary issue that has limited museums adapting virtual reality has been cost. Early systems were several thousand dollars, and the labor-intensive nature of creating and updating the programs to run on them leads to high development costs (Coates, n.d.). Fortunately, the rapid evolution of virtual reality technology has led to a wide array of options for headsets, devices with different features ranging from 10 to 800 dollars (Morozov, n.d.). Another concern is sanitation. The high number of users per day can lead to hygiene issues if the headsets are

not cleaned. To address this, museums have to task staff with cleaning the headsets or applying disposable, single use covers for each user. The final issue is that some people may experience motion sickness while using a virtual reality system. However, most users will find a short five-minute guided tour brief enough to handle without side effects (Coates, n.d.).

Despite the existence of the entirely virtual Kremer Museum, the future of virtual reality in museums is one focusing on cooperation rather than domination (Coates, n.d.). Bruno David, the president of the National Museum of Natural History in Paris, believes virtual reality will complement physical museums rather than replace them. He stated, “People are coming to a museum to see real objects because real objects are emotional” (Coates, n.d., para. 29). The perceived artistic shortcomings of virtual reality can be avoided by implementing the technology in a thoughtful manner, giving creators of these displays a great opportunity to connect with visitors (Coates, n.d.).

Artists using VR see the potential this exciting medium has to create experiences that can truly immerse viewers in their artistic visions. Two great examples of groundbreaking VR pieces include View of Harbor by artist Jon Rafman for the Institute of Contemporary Art in Boston, and The Chalk Room by artist Laurie Anderson for the Massachusetts Museum of Contemporary Arts.

Figure 7: Image depicting the immersive environment

of Laurie Anderson's *The Chalk Room* (Shea, 2018).

Eva Respini, the chief curator of ICA, was excited by the new presentation capabilities that VR brings to art. After personally experiencing Rafman's piece, which puts the viewer in front of an oncoming tidal wave, she describes VR saying:

> *It leaves a physical sensation that your whole body experiences it -- as opposed to just a cerebral or visual experience, the way we might think about a painting or a sculpture. So in that sense, it really engages all senses in a way that no other work does. (Shea, 2018)*

On the other hand, Joe Thompson, the director of Mass MoCA, really had to be sold on Anderson's VR piece. Her VR artwork puts the viewer in a space where they can experience the making of a story in an immersive way. Initially, Thompson thought that "high tech devices and gizmos" were getting in the way of the connection between viewers and artwork. After seeing Anderson's work, his view changed dramatically: "Her pieces are probing, thought-provoking and break down the barriers between the adept artist and her viewers" (Shea, 2018). Both exhibits received positive reviews from the general audience. To artist Jon Rafman, Virtual Reality could be "one of the most important mediums of our era" (Shea, 2018).

2.5. Summary

Museums are important houses of cultural preservation in every region and subject imaginable, but they are struggling to stay relevant in the digital age. Digital exhibits are a great way for museums to showcase pieces without taking up physical space while also reaching out to a much wider audience. Virtual reality, with its endless potential for immersive, interactive displays, is another key technology in making museums popular attractions once again. After doing this research, we understood that firstly, new technologies have brought in new audiences to museums, and that VR has been adapted by museums in order to complement art and explore history. The literature we reviewed suggested that VR has proven successful for many museums if implemented well. Secondly, we took away information that aided us in choosing which kind of VR our on-site surveying and prototype development would focus on. Our research suggested that Mobile VR would be the most cost effective and practical choice for our project. It was the focus of our project to examine these various forms of interactive media in the context of museums and find the best way to display the artifacts and exhibits the Museum of Design and Applied Art has available.

3. Methodology

The goal of this project was to provide the Hönnunarsafn Íslands Museum with a framework for a user-friendly virtual reality (VR) exhibit of artifacts. The museum wanted a means to display artifacts and create exhibits in an interactive format that also occupied minimal physical space. To achieve our goal, our objectives were to:

- Determine the best practices for implementing VR exhibits that showcase museum artifacts
- Understand the interest in VR and VR exhibits within the museum's potential audience
- Design, test, and pilot a virtual reality exhibit prototype to solicit feedback
- Develop recommendations and implementation plans, budgets, and other supporting documentation that museum staff can use to implement a successful VR exhibit

The primary strategies used to conduct our research are outlined in detail below.

3.1. Objective 1: Determine the best practices for a virtual reality exhibit

3.1.1. Open-ended Interviews

Our team reached out to museums of similar scale and focus within Iceland in order to determine the best practices for creating and using VR in limited spaces. We found two locations offering VR experiences, Aurora Reykjavik and Battle of Iceland 1238 and contacted their directors and those involved in the development of their VR exhibits. We conducted open-ended interviews that inquired about the successes and problems of their past virtual reality exhibits. We asked about how they made development decisions, how they advertised the VR exhibit, the difference in attendance they saw, and what demographics the exhibit brought in.

3.1.2. Participant Observation

We visited a virtual reality experience in Reykjavík known as Aurora Reykjavik to assess the practices that were successful and to understand issues visitors faced. We tried the experience for ourselves and took notes on what features we enjoyed and things that could be beneficial to a museum exhibit. We observed the reactions of other participants to get an idea of how visitors engaged with the devices and felt about the experience.

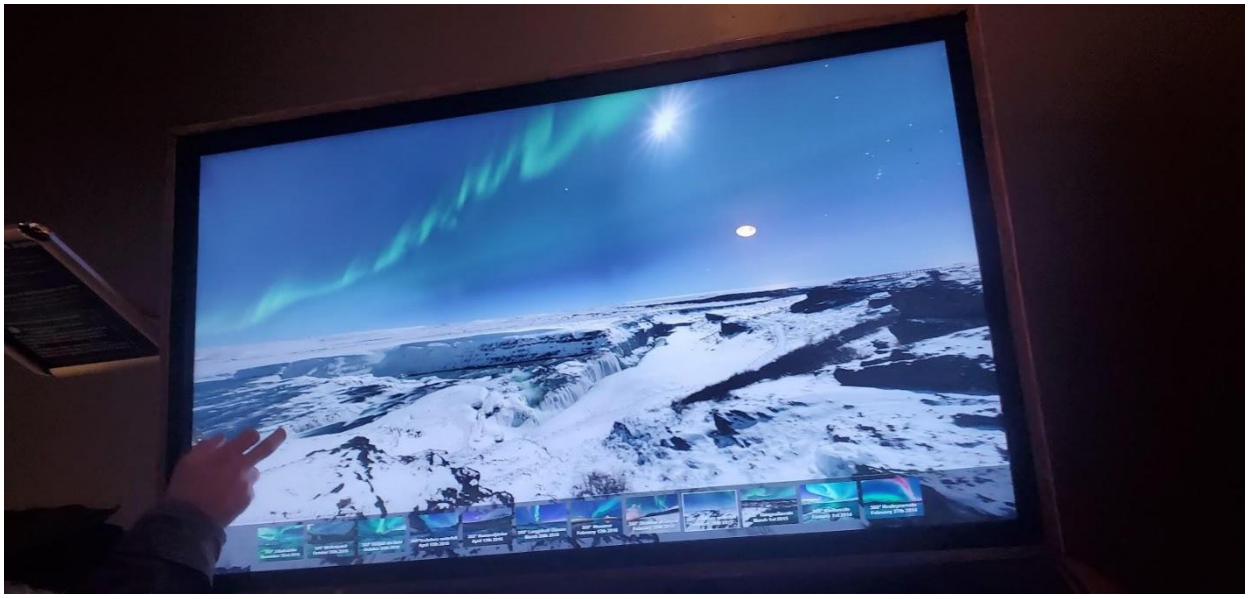

Figure 8: Image of interactive display featured at Aurora Reykjavik (2019).

3.2. Objective 2: Understand the knowledge of and interest in VR and VR exhibits within the museum's potential audience

3.2.1. Open-ended Interviews

Informal and open-ended interviews with the Design museum staff about attendees helped us better understand the potential audience of our VR exhibit. This information also determined which days or times were best to survey attendees. We discussed with the museum director and staff about their mission, history, and vision for events as well.

3.2.2. Survey

We conducted a survey of museum attendees to understand the level of interest of our potential VR exhibit audience as well as any experience they had with virtual reality and interactive exhibits in museums. For example, the level of interest in virtual reality headsets helped us determine if it was necessary for the museum to purchase headsets for use with the exhibit. In addition, the feedback also helped us select specific artifacts to focus our prototype exhibit on so we could gauge the exhibit towards the most common interests among visitors. We gathered this information using a short survey that asked the attendee questions about:

- Their knowledge of VR/Interactive technology
- Their knowledge of interactive exhibits
- Their reasons for attending this museum
- Common demographic questions that are useful to our project

The full survey is provided in Appendix A.

3.2.3. Observations

We observed museum event attendees and visitors at The Museum of Design and Applied Art to better understand their interests and how they spent their time at the museum. We took notes of our observations, keeping track of how much time they spent in the exhibit, their dwell time at specific locations within the exhibit, and mapping their movement through the museum.

3.3. Objective 3: To create, test, and collect feedback on a prototype exhibit

3.3.1. Develop Prototype Exhibit

To develop our VR prototype exhibit, we took found ways to take 360° photos, host these pictures online, and connect users to these photographs. We created an account for the museum with Momento360, a site meant for sharing and viewing 360° photos. After photographing artifacts and exhibits from multiple angles, we uploaded the 360° pictures to our Momento360 account to evaluate image quality.

By keeping the Momento360 account private, we avoided online copyright issues. This site claimed no rights to the pictures, so copyright was not a problem. We then generated QR codes that would link directly to the images when scanned. These codes were available to visitors in the museum space and linked directly to different VR exhibits. With the different technological choices established, the VR prototype was designed to function as follows: Visitors could approach the VR exhibit's physical display (a board with QR codes, descriptions, and sample pictures), scan a selected QR code with their smartphone, and be linked instantly to 360° photos of the exhibit they chose. The smartphone could then be placed inside a Mobile VR headset or be held on its own. They could rotate themselves and their device to see the entirety of the exhibit and click through different viewpoints to gain a complete visual understanding of the exhibit and artifacts photographed.

We worked with the museum staff to choose items to photograph for our VR exhibit prototype. We decided to photograph seven artifacts in storage that had never been on display in the museum before. This included five different geodesic dome sculptures by Einar Thorsteinn and a wooden architectural model of The Bakkaflöt House, designed by Högna Sigurðardóttir. This model is shown in Figure 9 below. In addition, we photographed the inside of a plywood house gifted to our sponsor by a former student. While this final piece was not part of a stored collection, we believed it would provide for an interesting VR experience and a valuable way to test the prototype.

Figure 9: The architectural model of The Bakkaflöt House with its roof removed.

The museum staff also purchased a standalone Oculus Go headset. The Oculus Go headset requires no smartphone, and we pre-loaded it with all of the 360° pictures we took of the seven artifacts. Before being used by a guest, this headset would be switched on and navigated to its photo gallery. Upon being given the headset and its corresponding controller, its user could scroll through the headset's preloaded 360° pictures. This headset was available alongside the QR code printouts so that those who did not have a smartphone could still view the VR exhibit.

Figure 10: Our team preparing the prototype exhibit with the Oculus Go.

In preparation for testing, we created three different QR code stations. These stations each consisted of a colored poster card that had a QR code linking to a set of 360° pictures. One set consisted of pictures of The Bakkaflöt House model, one of the pictures of the plywood house, and one consisted of all of Thorsteinn's geodesic domes that we photographed. We wrote instructions detailing which apps users could scan the QR codes with and how to adjust phone settings to allow for the best mobile VR experience. We also included a step-by-step guide for using the Oculus Go headset.

3.3.2. Test the VR Prototype and Post Interaction Survey

To evaluate the success of the prototype exhibit we implemented, we invited a group of college students to visit the museum and test out the prototype. We distributed a post-interaction survey after they used the VR prototype. This survey, outlined in Appendix B, contained multiple rating scale questions and short open-ended questions. These questions assessed the topics of:

- The visual quality of the experience and ease of use
- Which pictures were most preferred by respondents
- Respondents' favorite and least favorite aspects of the experience
- What items respondents would hope to see displayed in the future

- Thoughts on other ways to enhance the experience

We also invited a group of students from the nearby middle school and hosted a special event for them to test the VR prototype. 24 students were brought in and introduced to both the QR codes and the Oculus Go headset. We took observational notes on how they interacted with the exhibit and each other. Once they had all experienced each QR code station and tried on the headset, we came together as a group and hosted a voluntary discussion. During this discussion, asked the students:

- How many of them had previous experience with virtual reality?
- How many of them had previous experience with QR codes?
- Which images were their favorites?
- How easy was the prototype to use?
- Issues they came across when scanning the QR codes
- Their impressions of the prototype experience and if they enjoyed it

3.3.3. Data Analysis Tools

We chose to use response coding methods in order to analyze the answers to our open-ended survey questions. Our coding process involved selecting key terms and ideas and recording their frequency, thus turning qualitative responses into quantitative data that could be analyzed and applied to future planning. Alongside this coding, we calculated the averages of the responses to our post-interaction survey's scaled rating questions and observed trends in the answers. These questions were designed to assess the overall visual quality of the VR experience, how user friendly the VR headset and prototype design were, and how satisfied users were with the artifacts on display in the prototype.

3.4. Objective 4: Develop Recommendations and Implementation Plans

3.4.1. Documentation

Throughout the process of designing the prototype, we documented the tools we used and how we used them. This included recording all of the online profiles we created for the VR exhibit, such as the email account associated with the Momento360 account and its password. We also recorded information about the camera we used to take the 360 photos, our methods of enhancing and prepping these photos for use in the prototype, and how we posted them to the Momento360 account and created QR codes for each.

3.4.2. Budgets and Maintenance

Using the information we gathered from email interviews with the staff of museums that run successful VR exhibits and what we learned from our visits to nearby VR exhibits, we developed a manual outlining the potential maintenance costs associated with expanding the VR exhibit we prototyped. This budget and maintenance manual addressed the funding required to purchase new headsets, upgrade to better headsets, and the necessary cleaning supplies and work required to keep the headsets in a functional and sanitary condition.

3.4.3. Recommendations

Finally, we created recommendations for the future development of the VR exhibit prototype. We used the information we collected about successful VR exhibits to comprise a list of developmental steps that Design Museum's staff could follow to fine-tune the VR prototype and expand upon it. Possible expansion routes outlined in the document include the implementation of different features that were successful at other museums, advertising methods recommended by contacts we interviewed, and other notes that could help the Museum of Design and Applied Art support a successful VR exhibit.

4. Results and Discussion

This chapter covers the results of our interviews, surveys, and prototyping at the Hönnunarsafn Íslands.

4.1. Results

Objective 1: Determine the best practices for implementing VR exhibits that showcase museum artifacts

Visiting Aurora Reykjavik provided our team with firsthand experience of a virtual reality exhibit at an Icelandic museum. The VR exhibit was comprised of two Oculus Gear headsets as shown below in Figure 11, a set of simple instructions on how to use the goggles, and a seating area. The exhibit is located within the gift store so that museum staff can answer questions, monitor the exhibit, and restart the device when necessary. The exhibit included instructions that required headset users to remain seated throughout the entire experience.

Figure 11: Aurora Reykjavik headset.

After visiting Aurora Reykjavik, our team reached out to the photographers and directors of the museum via email. The technical director and main photographer, Ólafur Haraldsson, provided images of their customized camera setup, shown below in Figure 12. He offered us advice on taking quality interior 360 photos, suggesting that lighting was the key to taking good still pictures. To answer our question about faulty image stitching, he told us that they developed their own customized software modules to use alongside products such as Nuke X, Cara VR, and PTGui.

Figure 12: Personal camera setup for Aurora Reykjavik photographers (Haraldsson, 2019).

Grétar Jónsson, the CFO of Aurora Reykjavik, told us about their decision-making process for choosing a headset. He stated that they chose the Oculus Gear because it was the only wireless headset that would suit their needs that was available at the time. He said that they had faced difficulties with broken headsets and headset components, such as straps, cords, and the phones they kept in each headset. When asked about trends in the VR exhibit's audience age demographic, Grétar Jónsson stated that he hadn't noticed one.

We also reached out to Ingvi Jökull Logason, who was involved in the development of the Battle of Iceland 1238. When asked about how they selected headsets for the project, he replied that accessibility, durability scores, how easily they could be cleaned, price, image quality, comfort, and ease of use were all major factors in the decision-making process. He described that the action-oriented nature of VR meant that there was a high risk for broken equipment, and that they dealt with this by "design[ing] the area around it to minimize that risk". When asked about the greatest challenge the exhibit faced, Ingvi Jökull Logason stated that it was cost and making a VR experience that would appeal to various demographics.

Objective 2: Understand the interest in VR and VR exhibits within the museum's potential audience

Our open-ended interview with Sigridur Sigurjonsdottir, the director of The Museum of Design and Applied Art, revealed that most of the museum's visitors were there to attend special events. Similarly, most guests that visited during normal hours primarily did so to see the

current in-house artist or the museum store. In addition, she revealed that there was no particular trend in when during the day guests visited the museum more often.

We also learned that one of the most important issues the museum faces is lack of physical space, for they have several thousand pieces in storage but only have a few rooms for displays. Sigridur revealed that the museum was working to purchase an additional room that would expand the museum, but this new space would still not be nearly enough to display the entire storage collection. Another issue she brought to our attention was that there are several architecturally significant houses near the museum that they have organized tours through before, but they have had difficulty establishing a regular schedule.

To learn about the virtual reality experience and interests of museum visitors, we created a survey and distributed it at museum events and left additional copies at the front desk. We received 21 responses from two scheduled museum events, and 13 responses from visitors who took the survey at the front desk during regular museum hours throughout the week. Two additional categories of interest, graphic design and fashion, were added to the survey available to visitors at the front desk as a result of a suggestion made by Sigridur. These categories were not available as an option at the events, and therefore we analyzed this data separately as a percent of visitors that selected it when it was available.

Portions of the survey results are shown in Figures 13-16 below. Full data can be viewed in appendix C. The majority of visitors at the special events had a smartphone and were familiar with QR codes. The interest in a virtual reality display was significant, regardless of whether or not respondents had used a VR exhibit before. In fact, 91% of respondents stated that they were interested in a virtual reality exhibit, despite the fact that only 64% had experienced an interactive exhibit before. The comparison of experience to interest is depicted in Figure 13 below.

Architecture was the most popular genre of design: 65% of visitors selected it as an interest. The second most popular was Graphic Design, selected by 54% of visitors. The rest of the categories were not as popular but were still selected by several respondents. The respondents at the museum events were generally older, most attendees being over 40. With the front desk survey data added, the average age range was 40-50.

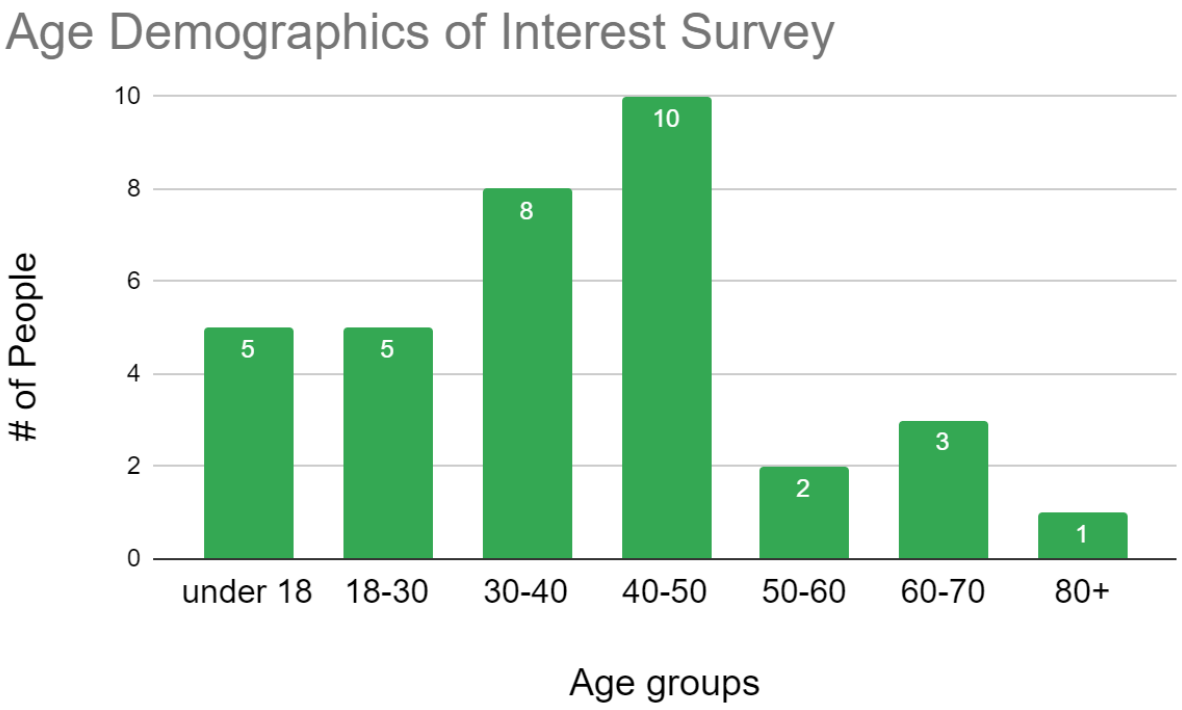

Figure 13: Results from a section of the survey assessing age group of the visitors.

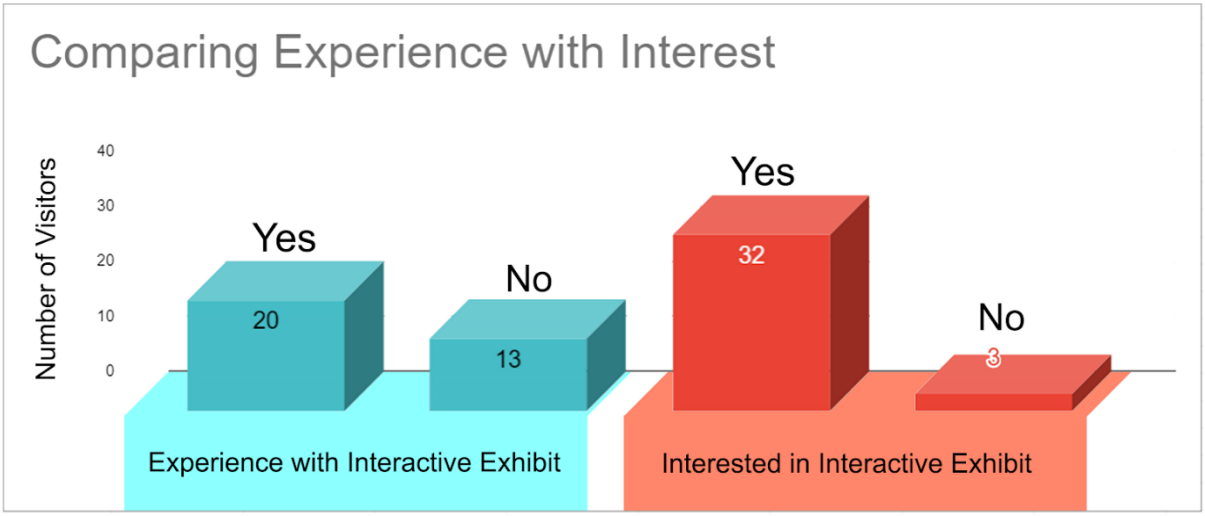

Figure 14: Results from a section of the survey assessing experience with interactive exhibits compared to interest in an interactive exhibit at Hönnunarsafn Íslands.

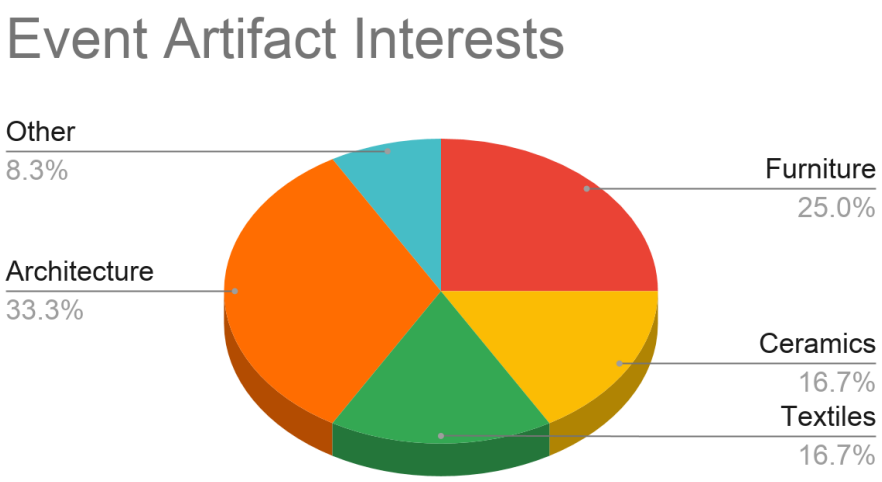

Figure 15: Results from survey distributed at museum events, assessing visitor interest in design genres.

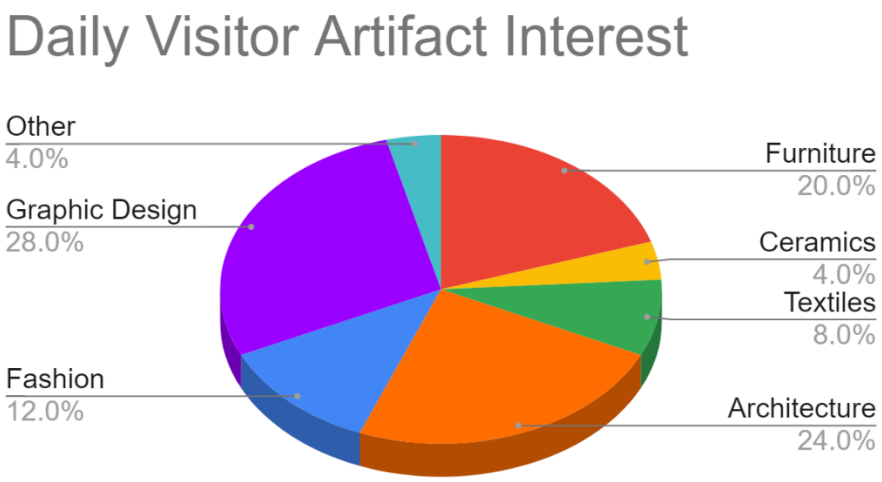

Figure 16: Results from survey available at the front desk, assessing visitor interest in design genres.

Objective 3: Design, test, and pilot a virtual reality exhibit prototype to solicit feedback

Twelve college students tested our prototype and filled out the post-interaction survey we created. The full data can be found in Appendix D. The prototype received positive responses, with the average rating for enjoyment being slightly higher than 9 out of 10. Most people found the instructions easy to follow, for the ease of use average rating was 8.3 out of 10. As shown below in Figure 17, the wooden house was the most popular set of pictures, half of the students selecting it as their favorite. Many prototype users enjoyed the viewpoint of being

inside a small model that felt life-sized, with “favorite aspect” responses including “the tiny viewpoint” and “feeling like I was in the exhibit”. A complaint that surfaced was picture quality, with responses to “least favorite aspect” including “quality was a little blurry” and “the lighting in the photos”.

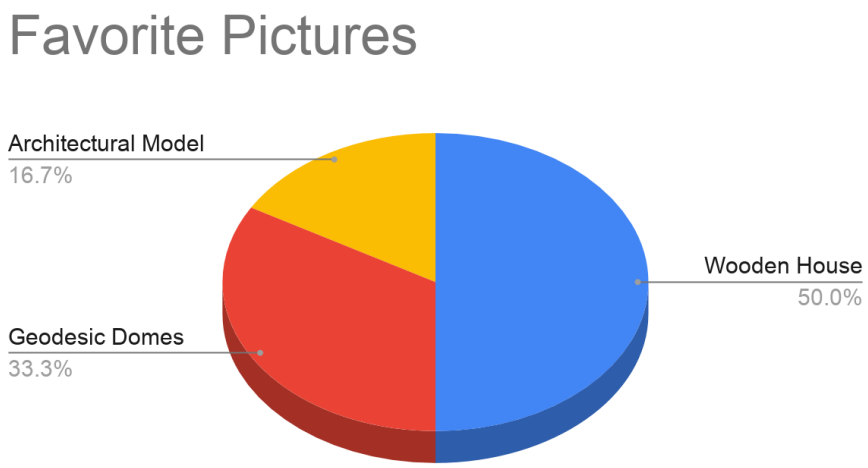

Figure 17: Results from the survey assessing favorite group of pictures in the prototype.

In addition to testing the prototype with college students, we reached out to a local middle school and organized for a group of them to visit the museum and test the prototype. While taking observational notes of the 24 middle school students interacting with the prototype, we found the following: a significant portion of students had difficulty initially finding a way to open the QR code link we provided. Many of them had phones that didn’t have built in QR scanners or encountered issues when trying to use other apps with QR capability such as Snapchat. However, most of those who encountered issues resolved them by fixing phone settings or installing QR reader apps.

While we had split the group up so one third of the students would each be at each of the three QR stations, we observed the students wandering between stations. We observed that the QR code station with the lowest dwell time was the geodesic dome station. The station that attracted the largest number of students for the longest time was the plywood house. Because the plywood house was the only item included in our prototype that wasn’t down in storage, we wheeled it out and placed it beside its corresponding QR station. The students were immediately fascinated by the house shown below in Figure 18, and several made comments suggesting that they enjoyed the fact that the pictures made the house feel life-sized.

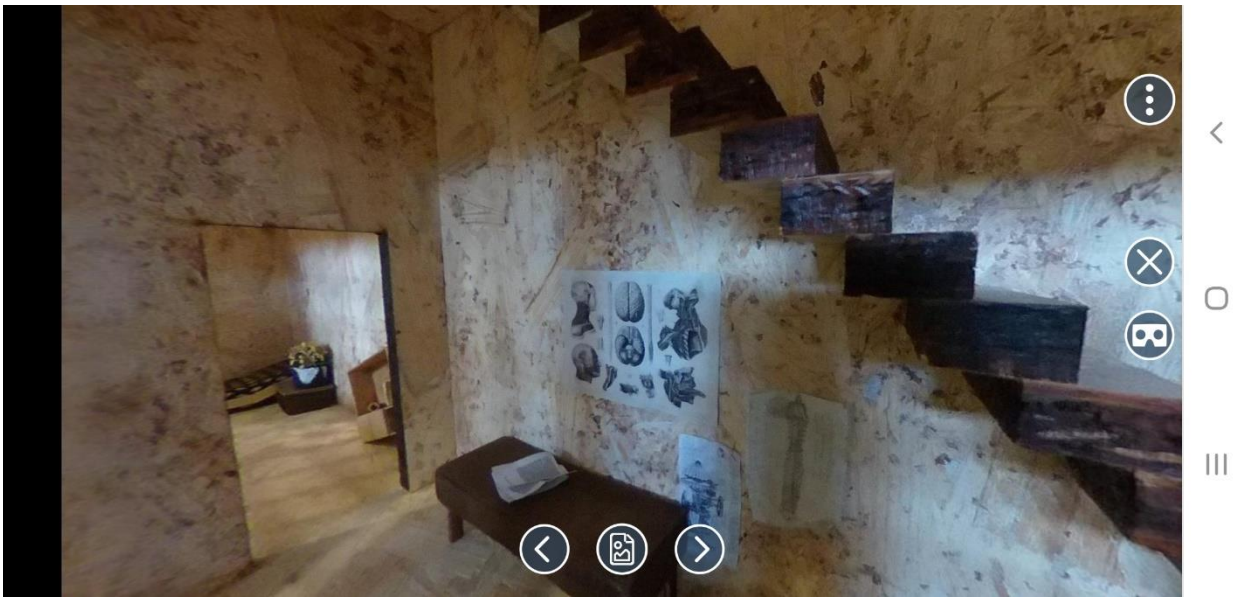

Figure 18: Screenshot of 360° photo experience on mobile device of the model house.

Interestingly, a group of students wandered over to the Oculus Go Headset before we introduced it to them. They started using it on their own and later told us that they had used VR in the past and thus knew how it worked. Once we introduced the rest of the group to the headset, there were signs of significant interest and engagement. Students lined themselves up and waited for their turn, talked to each other enthusiastically while using the headset, and several students asked if they could get back in line to use the headset again. On several occasions, users accidentally hit the wrong button on the controller, returning them to the Oculus home screen. When this occurred, the user had to remove the headset and give it back to us so we could reopen the 360° photo gallery.

Figure 19: Nathan using the Oculus Go and 360° photo viewing app.

When we came together afterwards for a brief open discussion about their experience, we asked the group to tell us about their experience. When asked about their favorite artifact, a significant portion of the group agreed that they preferred the plywood house over the other two photo sets. They were in general very enthusiastic about their experiences with the headset.

Objective 4: Develop recommendations and implementation plans, budgets, and other supporting documentation that museum staff can use to implement a successful VR exhibit

We created a set of recommendations and instructions based on our findings that we gave to the museum after we completed the prototype testing process. These documents contain clear and detailed directions about how to follow the process we used to create the VR exhibit prototype so that the Design Museum's staff and following project teams can follow and build upon it. These documents are included in Appendix E.

4.2. Discussion

Best Practices and Factors Leading to Successful VR Exhibits

Our interviews with Grétar Jónsson and Ingvi Jökull Logason led us to draw several conclusions about best practices when developing a VR exhibit that influenced how we created our prototype. Firstly, the interview responses suggested that an important detail was the implementation of safety measures. After analyzing our observations at Aurora Reykjavik and

interview responses about broken equipment, we concluded that instructions to remain seated in a designated area were valuable to a successful and low-risk VR exhibit. We applied this information to how we designed our own prototype's instructions and guidelines and found that during testing this helped reduce the risk for both personal injury and equipment damage.

Analyzing Grétar Jónsson and Ingvi Jökull Logason's responses about the physical maintenance of headsets, including sanitation and possible damages, suggested that these would be issues facing any VR exhibit and thus needed to be considered in the context of our prototype as well. The long-term success of the VR exhibit will rely on cost-effective equipment maintenance and preventative measures to reduce the damage done to headsets by users.

Prototype Accessibility and Usability

Upon analyzing survey responses, we came to several conclusions. Firstly, the general user familiarity with QR codes suggested that users would be able to successfully scan and interact with them. During our prototype tests, the middle school group lacked familiarity with the tools for scanning QR codes but quickly adapted and learned from the instructions given to them. The college students who participated in the prototype testing had little difficulty with the codes and responded that the prototype was overall easy to use. These findings suggest that the QR codes, while subject to some code interpretation difficulties depending on phone model, have the potential to be an accessible way to view the exhibit's 360° photos. However, more detailed printed instructions that contain extra troubleshooting suggestions may be required to improve the user experience.

Our observations of users interacting with the Oculus Go headset suggested that it was easy to put on and use. However, the complications that arose once a user accidentally clicked a menu button and exited the 360° picture gallery required that we constantly be available to assist them and return the headset to the pictures. This broke the immersion of the experience and appeared to be detrimental to the prototype's success in this area. This issue was consistent throughout tests with both college students and middle school aged students, and thus should be addressed in future development. The prototype should be modified in a way that ensures that users remain in the photo gallery.

Prototype Content

Post-interaction survey responses revealed that the plywood house was the most popular among users. We determined that the architectural items and pictures were the most successful because they generated the most interest and activity. Interest survey responses

support this conclusion. These results led us to determine that a VR exhibit that showcases architectural items such as building models has great potential to interest a large audience and encourage discussion and exploration.

The complaint about fuzziness and low visual quality led us to analyze the way we took the 360° pictures for the prototype. While we spent time editing the pictures in photo editing software to increase contrast, balance lighting, and resolve other issues, our actual photographing process was rushed. Due to the time sensitivity of our project, we did not have the opportunity to put extra time into perfecting lighting, retaking photographs, and additional photo editing processes. We believe that these factors impacted the quality of the pictures we were able to take for the prototype.

Potential Audience

The overwhelming interest in a VR exhibit showcasing museum artifacts indicated by survey responses and the results of our prototype observations suggest that the exhibit could generate enthusiasm among guests and attract new visitors. The age range represented in these positive survey responses and the consistent engagement of both college-age and younger students, along with Grétar Jónsson's observations of Aurora Reykjavik's demographics, suggest that age is not a limiting factor in VR exhibit usage.

5. Recommendations and Conclusion

5.1. Recommendations

Based on the results from our prototype testing and the visitor interest surveys, we created some recommendations to guide the future of the virtual reality exhibit. Since we considered visitor interests when creating these suggestions, following this path to expand the exhibit will allow the museum to appeal to as many visitors as possible. We are also recommending ways to make the physical implementation of the exhibit in the museum as efficient as possible.

Distribute Post-interaction surveys to users interacting with the museum's VR exhibit.

It was clear from our own survey results that collecting survey data after a user interacted with the VR prototype provided valuable information about the quality of their experience. Continuing to provide the opportunity for museum visitors to offer feedback will help the museum staff keep the VR exhibit relevant, address any technical problems the visitors face, and decide on how to expand the exhibit in the future. It is very important to consider the audience's preferences when deciding what to add to the display. Engaging with the exhibit's audience throughout its development will ensure that its content caters to visitor interests and that the overall experience remains enjoyable.

Purchase a 360° camera.

To continue to add to the exhibit, Hönnunarsafn Íslands will need to obtain their own 360° camera to continue to photograph pieces. We recommend they purchase the Ricoh Theta V because of its relatively low cost (USD$376.95; ISK 46,775.73) and because of its user friendly features. If the exhibit is successful and the museum wishes to expand and to purchase a higher quality camera, we recommend the Ricoh Theta Z1, which is available for USD$999.95 (ISK 124,023.80). Additionally, if the museum would like a smaller camera for taking pictures inside artifacts that a Ricoh camera would not fit in, we recommend the Insta360 EVO. This camera is significantly smaller than the Ricoh Theta V and Z1 and costs $399.00 (ISK 49,479.99).

Purchase additional headsets for the VR exhibit.

While developing our prototype, one headset was all we needed to test out the features of the exhibit. However, we recommend the museum purchase at least one additional Oculus Go once the VR prototype is a permanent exhibit so that multiple guests can experience VR at a time.

This is especially relevant for events where larger groups are interacting with the exhibit. Additionally, as the number of artifacts included in the VR experience increases, users will likely spend more time using the headset. Additional headsets will become critical for keeping multiple guests engaged and for maintaining the flow of users through the exhibit. To avoid excessive spending, we believe two headsets should be adequate for the exhibit's debut, but further expansion is recommended over the following years.

Design an area in the museum that can showcase a permanent VR exhibit display.

The museum should dedicate an area to the VR exhibit in order to follow the best practices we determined. This area should include comfortable seating, a desk or table, and an outlet to recharge the headset when it is not in use. The seating available in this space should allow a user to fully rotate without hitting a wall or other object. Based on the current layout of the museum, we recommended two spaces to them that we believe fit these criteria. These include the near corner of the main exhibition hall and an enclosed space connected to the museum store that is currently outfitted as a children's area.

Create virtual reality tours of important Icelandic houses to highlight architectural design.

Based on the surveys regarding visitor interest in genres of design, architecture was the most popular by a significant amount. Combining this finding with the knowledge that the museum has attempted to organize tours of architecturally important houses nearby, we believe it would be beneficial to use the virtual reality exhibit to provide tours of these houses. Using the museum's 360° camera to photograph the interior of these houses would create permanent tours of these houses, requiring no visitor travel or planning. It would also provide visitors who are interested in architecture with a virtual reality tour that would fit their interests.

5.2. Conclusion

In conclusion, this project sought to bring art and technology together in a way that would benefit the Museum of Design and Applied Art and the local design community as a whole. We laid the groundwork for a VR exhibit with potential to expand and develop over time and hope that its presence in the museum will foster an appreciation for artifacts that cannot be on display in the exhibition hall, increased interest and attendance, and further assert technology's positive role in the world of art appreciation.

VR has the potential to bring audiences closer to art and design than ever before. It allows for visitors to explore small yet intricate architectural models and enjoy immersive viewpoints that they could not experience otherwise. VR headsets offers immersion into an environment that images alone will not be able to portray, making them a valuable new part of the museum experience. The VR experience provides insight and understanding of an artifact's inner workings and story.

Technologies like VR draw new audiences and provide an exciting place for visitors, students, and practitioners to learn and explore art, design, and the histories behind each. The future of interactive technologies in museums and other places of education and culture is one worth watching. As the world changes and society evolves, art and design remain a vital part of humanity's identity. Finding ways to combine art and technology into new profound experiences is an essential step towards preserving art and design and ensuring that it continues to enlighten our culture and communities.

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Appendices

Appendix A: **Visitor Interviews**

Events Draft (English Version)

THIS IS A FULLY ANONYMOUS AND VOLUNTARY SURVEY.
If you choose to take part, please fill out as many questions as possible. We appreciate the time taken to complete the survey as it helps us in our project. Thank you!
ÞETTA ER NAFNLAUS KÖNNUN.
Ef þú velur að taka þátt, vinsamlegast fylltu út eins margar spurningar og mögulegt er. Við þökkum tímann sem gefinn er til að ljúka könnuninni þar sem hún hjálpar okkur með skolaverkefni sem við erum að vinna. Bestu þakkir!

Nemendur við Worcester Polytechnic Institute

What country are you from?

Which age group do you belong to?
☐18-30 ☐30-40 ☐40-50 ☐50-60 ☐60-70 ☐70-80 ☐80+

What genre of design interests you most? (Check all that apply)
☐Furniture ☐Ceramics ☐Textiles ☐Architecture ☐Other: _____

Have you ever used an interactive digital museum exhibit (such as virtual reality, 360 views, simulations, games, etc.) before?
☐Yes ☐No

Do you use a smartphone?
☐Yes ☐No

Have you ever used or scanned a QR code? Example:
☐Yes ☐No

Would a virtual reality display of exhibits at Hönnunarsafn Íslands interest you?
☐Yes ☐No

What would you hope to see on display in a virtual reality exhibit at Hönnunarsafn Íslands? (Please answer in English if possible)

Please leave any additional thoughts about virtual reality exhibits below (Please answer in English if possible):

Events Draft (Icelandic Version)

THIS IS A FULLY ANONYMOUS AND VOLUNTARY SURVEY.
If you choose to take part, please fill out as many questions as possible. We appreciate the time taken to complete the survey as it helps us in our project. Thank you!
ÞETTA ER NAFNLAUS KÖNNUN.
Ef þú velur að taka þátt, vinsamlegast fylltu út eins margar spurningar og mögulegt er. Við þökkum tímann sem gefinn er til að ljúka könnuninni þar sem hún hjálpar okkur með skolaverkefni sem við erum að vinna. Bestu Þakkir!

Nemendur við Worcester Polytechnic Institute

Hvaða landi ertu frá?

Hvaða aldurshópur tilheyrir þú?
☐18-30 ☐30-40 ☐40-50 ☐50-60 ☐60-70 ☐70-80 ☐80+

Hvaða tegund hönnunar vekur áhuga þinn mest? (Athugaðu allt sem við á)
☐Húsgögn ☐Keramik ☐Vefnaður ☐Arkitektúr ☐Annað: _____

Hefur þú einhvern tíma notað gagnvirka sýningu á stafrænu safni (svo sem sýndarveruleika, 360 skoðanir, uppgerð, leiki osfrv.) áður?
☐Já ☐Nei

Notar þú snjallsíma?
☐Já ☐Nei

Hefur þú einhvern tíma notað eða skannað QR kóða? Dæmi:
☐Já ☐Nei

Myndi sýndarveruleikasýning á sýningum í Hönnunarsafni Íslands vekja áhuga þinn?
☐Já ☐Nei

Hvað myndir þú vonast til að sjá til sýnis í sýndarveruleikasýningu í Hönnunarsafni Íslands? (Vinsamlegast svarið á ensku ef mögulegt er)

Vinsamlegast skildu allar hugsanir um sýndarveruleika sýningar hér að neðan (Vinsamlegast svarið á ensku ef mögulegt er):

Front Desk Draft (English Version)

THIS IS A FULLY ANONYMOUS AND VOLUNTARY SURVEY.
If you choose to take part, please fill out as many questions as possible. We appreciate the time taken to complete the survey as it helps us in our project. Thank you!
ÞETTA ER NAFNLAUS KÖNNUN.
Ef þú velur að taka þátt, vinsamlegast fylltu út eins margar spurningar og mögulegt er. Við þökkum tímann sem gefinn er til að ljúka könnuninni þar sem hún hjálpar okkur með skolaverkefni sem við erum að vinna. Bestu Þakkir!

Nemendur við Worcester Polytechnic Institute

What country are you from?

Which age group do you belong to?
☐18-30 ☐30-40 ☐40-50 ☐50-60 ☐60-70 ☐70-80 ☐80+

What genre of design interests you most? (Check all that apply)
☐Furniture ☐Ceramics ☐Textiles ☐Architecture ☐Fashion ☐Graphic Design ☐Other:_____

Have you ever used an interactive digital museum exhibit (such as virtual reality, 360 views, simulations, games, etc.) before?
☐Yes ☐No

Do you use a smartphone?
☐Yes ☐No

Have you ever used or scanned a QR code? Example:
☐Yes ☐No

Would a virtual reality display of exhibits at Hönnunarsafn Íslands interest you?
☐Yes ☐No

What would you hope to see on display in a virtual reality exhibit at Hönnunarsafn Íslands? (Please answer in English if possible)

Please leave any additional thoughts about virtual reality exhibits below (Please answer in English if possible):

Front Desk Draft (Icelandic Version)

THIS IS A FULLY ANONYMOUS AND VOLUNTARY SURVEY.
If you choose to take part, please fill out as many questions as possible. We appreciate the time taken to complete the survey as it helps us in our project. Thank you!
ÞETTA ER NAFNLAUS KÖNNUN.
Ef þú velur að taka þátt, vinsamlegast fylltu út eins margar spurningar og mögulegt er. Við þökkum tímann sem gefinn er til að ljúka könnuninni þar sem hún hjálpar okkur með skolaverkefni sem við erum að vinna. Bestu Þakkir!

Nemendur við Worcester Polytechnic Institute

Hvaða landi ertu frá?

Hvaða aldurshópur tilheyrir þú?
☐18-30 ☐30-40 ☐40-50 ☐50-60 ☐60-70 ☐70-80 ☐80+

Hvaða tegund hönnunar vekur áhuga þinn mest? (Athugaðu allt sem við á)
☐Húsgögn ☐Keramik ☐Vefnaður ☐Arkitektúr ☐Fatahönnun ☐Grafísk Hönnun ☐Annað: _____

Hefur þú einhvern tíma notað gagnvirka sýningu á stafrænu safni (svo sem sýndarveruleika, 360 skoðanir, uppgerð, leiki osfrv.) áður?
☐Já ☐Nei

Notar þú snjallsíma?
☐Já ☐Nei

Hefur þú einhvern tíma notað eða skannað QR kóða? Dæmi:
☐Já ☐Nei

Myndi sýndarveruleikasýning á sýningum í Hönnunarsafni Íslands vekja áhuga þinn?
☐Já ☐Nei

Hvað myndir þú vonast til að sjá til sýnis í sýndarveruleikasýningu í Hönnunarsafni Íslands? (Vinsamlegast svarið á ensku ef mögulegt er)

Vinsamlegast skildu allar hugsanir um sýndarveruleika sýningar hér að neðan (Vinsamlegast svarið á ensku ef mögulegt er):

Appendix B: **Post Interaction Survey**

THIS IS A FULLY ANONYMOUS AND VOLUNTARY SURVEY.
If you choose to take part, please fill out as many questions as possible. We appreciate the time taken to complete the survey as it helps us in our project. Thank you!
*****_VR Prototype refers to both the headset and the mobile phone QR scanning experience_

Please rate the visual quality of your experience with the VR prototype on a scale of 1-10 (circle one)

Very Poor 1 2 3 4 5 6 7 8 9 10 Very Good

Please rate how easy it was to use the VR prototype on a scale of 1-10 (circle one)

Very Hard 1 2 3 4 5 6 7 8 9 10 Very Easy

Please rate how much you enjoyed the items you viewed in VR on a scale of 1-10 (circle one)

Didn't Enjoy 1 2 3 4 5 6 7 8 9 10 Enjoyed a Lot

Which pictures were your favorite to view?

☐Architectural Model (Bakkaflöt 1) ☐Wooden House ☐Geodesic Domes ☐Other:_____

What was your favorite aspect of the experience?

What was your least favorite aspect of the experience?

What items would you like to see added to this VR prototype in the future?

Was there information would you like to have known before trying the prototype? If so, what?

Additional thoughts:

Appendix C: **Complete Survey Results from Interest Surveys**

Question	Responses
What country are you from?	30 - Iceland 3 - Poland 1 - Germany
Which age group do you belong to?	5 - under 18 5 - 18-30 8 - 30-40 10 - 40-50 2 - 50-60 3 - 60-70 1 - 80+
What genre of design interests you most?	64.7%- Architecture 53.8% - Graphic Design 50.0% - Furniture 29.4% - Textiles 26.5% - Ceramics 23.1% - Fashion 14.7% - Other
Have you ever used an interactive digital museum exhibit (such as virtual reality, 360 views, simulations, games, etc.) before	20 - Yes 13 - No
Do you use a smartphone?	32 - Yes 2 - No
Have you ever used or scanned a QR code?	28 - Yes 6 - No
Would a virtual reality display of exhibits at Hönnunarsafn Íslands interest you?	32 - Yes 3 - No

Question	Responses
What would you hope to see on display in a virtual reality exhibit at Hönnunarsafn Íslands?	"Go into the design process." "I don't know, maybe something special from Iceland." "Anything virtual would be of interest" "Birds, urban spaces, natural development (shrinking glaciers because of climate change)" "Maybe different architecture over time" "Icelandic / Nordic furniture" "Seeing artists/designers working in their field" "Historical and cultural references in design history etc." "For the urban shape it would be nice to have some videos sequences for the cities" "Architecture" "Modern Art" "Whatever" "?" "Icelandic or scandinavian" "Possibly something to do with history that is too big to display, featuring homes from the past…" "Natural scenery of Japan" "Icelandic woodland" "Icelandic design objects" "Satirical property that is otherwise unavailable" "Spiderman" "Space" "Design games/ programs that man can roam in 3D" "All" "Design games and exhibition"
Please leave any additional thoughts about virtual reality exhibits below	"I believe the future lies in mixing virtual reality and traditional form" "Check out stulungaseter in sandarkrakur" "I like virtual reality on demand, in example things I can select/choose to see (not something I must see because its very dominant)." "Fun and interesting" "Interesting to make something for children to broaden their view on design. They are so quick with digital devices." "Maybe something that is sassy and ruinous"

Appendix D: **Complete Survey Results from Post-Interaction Surveys**

Visual Quality (1-10)	Ease of Use (1-10)	Enjoyment (1-10)	Which pictures were your favorite to view?	What was your favorite aspect of the experience?	What was your least favorite aspect of the experience?
6	8	8	Wooden House	It was really cool!	None
8	8	8	Geodesic Domes	Looking around	The lighting in the photos
9	10	10	Wooden House	Feeling like the pieces were life size	a bar with a play button kept popping up and disrupting the view
8	8	9	Geodesic Domes	I liked wearing the VR headset, it was really cool to look around.	I didn't have a QR reader on my phone or a Snapchat so I had to go and download an app. After that everything was easy to use.
9	8	10	Geodesic Domes	Being able to browse the different categories	Not realizing there were different categories
8	8	9	Wooden House	The scale perspective from inside the models was much more interesting than it would have been looking from the outside	On snapchat, it is difficult to look up without exiting the viewer. On the headset, I didn’t realize the slideshow wrapped around.
8	9	10	Wooden House	the immersion into the exhibit	The headset didn't fit my head super well so some of the images were blurry and I had to keep adjusting the headset
7	8	9	Wooden House	Seeing details in the house	Slightly blurry? I might not have focused it well / my glasses always cause problems with VR stuff

8	10	8	Architectural Model (Bakkaflöt 1)	The tiny viewpoint	Pictures were very similar to each other (seemed to be some repeats)
10	8	10	Architectural Model (Bakkaflöt 1)	The VR	I couldn't move around in the VR
8	8	10	Geodesic Domes	Feeling like I was in the exhibit	Quality was a little blurry
9	7	10	Wooden House	It was really neat feeling like you're inside the exhibit.	Some of the vr pictures/areas felt too empty.

What items would you like to see added to this VR prototype in the future?	**Was there information would you like to have known before trying the prototype? If so, what?**	**Additional thoughts:**
More houses	No	
Small models	What each picture was	
i would love if there was text descriptions added to some items to talk more about them	No	
Can't think of anything	That you might have to focus the headset. It was a bit blurry and I've never used one before so I didn't know you might have to move it to adjust focus.	
Should start at the menu	That there was a menu	
An audio/text guide as you look around would be cool so i know more about what I'm looking at	It would be cool to see the models themselves first so the VR scale is even cooler	Very cool
Anything that is too small or too big to be displayed in an actual museum	What all the buttons did on the remote	Cool project :)
The tiny car house	No, it was all in the instructions	Really cool! Great job guys
Space stuff?	No	
Labels of where you are	didn't read instructions so I can't answer	
Higher quality	The history of the exhibit	

I'd like some sort of way to see a description of what I'm currently viewing.	I would have liked to know how the controller worked before putting on the headset.	Overall that was a really cool experience!

Appendix E: **User Manual**

VR Prototype Exhibit User Manual

This manual outlines the process our team used to develop the VR Exhibit Prototype. It describes the step-by-step process of using the Ricoh Theta V, the 360 camera we used to take the pictures in the prototype. It also describes how to upload pictures to the Oculus Go, use the Momento360 account, generate QR codes for picture galleries, and how to set up the headset itself. This manual was given to the Hönnunarsafn Íslands Museum of Design and Applied art so that museum staff can follow the process we used and continue developing the VR exhibit prototype.

Using the Ricoh Theta V

The Ricoh Theta V is the 360 camera we used to take all of our pictures. We recommended that the museum purchase one of their own. After they have done so, they can follow these steps to take 360 photographs that can then be added to the VR exhibit prototype.

1. Download the RICOH THETA app on a smartphone
2. Turn on the Theta (a blue light will turn on) and then hold the wireless button until the wireless symbol begins flashing on the front of the camera
3. Connect your phone to the camera's WIFI (Network name should be "THETA…..") using the serial number on the bottom of the camera (Do not include the YL at the beginning)
4. Open the Theta App and tap the Theta logo button in the bottom right
5. On the "Select access point" screen, select the theta from the list of cameras
6. Once the preview of the camera's view appears you may now use your phone to control the camera
7. To take a picture, press the white circle button at the bottom of the screen
8. To change settings, tap the bottom right button that defaults to "Auto" and select "Manual", this will allow you to adjust shutter speed, iso, and white balance.
9. To transfer photos, connect the camera to your computer with a USB to Micro-USB cable
10. Navigate to the RICOH Theta on file explorer (This PC -> RICOH THETA V)
11. Open the "Fixed storage" folder, then the "DCIM" folder, and finally the "100RICOH" folder
12. Pictures may then be selected and copied (Ctrl + C) and then pasted (Ctrl + V) to the location of your choice on your computer

Uploading to the Oculus Go

The Oculus Go is a standalone VR headset that operates without the use of a mobile phone. It comes with a simple controller and internal software and storage. We uploaded the 360 photos we took to the headset so that they could be viewed in VR. The following are the steps we took to upload pictures.

1. Connect the Oculus Go to a computer with the provided USB to Micro-USB cable
2. Turn on the Oculus Go and use the controller to select "Allow" when asked if you would like to "Allow access to data' on the Oculus Go
3. Note that photos will be ordered in REVERSE alphabetical order in Oculus 360 Viewer. Therefore, we recommend a naming scheme based on letters with the first picture

being the last alphabetically. Ex: Photo 1 would be named Z, Photo 2 would be named Y, Photo 3 would be named X…

4. Locate the pictures you wish to transfer from your computer in the file explorer, select all of the pictures and copy (Ctrl + C)
5. Navigate to the Oculus Go on file explorer (This PC -> VR-Headset)
6. Open the “Internal Shared Storage” folder then the “Pictures” folder
7. Paste the pictures (Ctrl + V)

Uploading to the Momento360 Account

Momento360 is a 360 photograph hosting website that allows for the creation of custom collections of photographs that can be made private and accessible only by a link.
We created both a gmail account and Momento360 account for the museum that they can use to host their pictures. We gave them the username and password for these accounts in a private document.

1. Open https://www.momento360.com/
2. Login
3. Select “My Media” at the top of the webpage and then click the “Upload Files” button on the right side of the screen
4. In the popup, select all of the pictures to be uploaded and then click “Open”
5. Once the files are uploaded, click “Collections” at the top of the webpage
6. Click “Create New” to start a new collection
7. Fill out the collection name and description (optional)
8. Click “Create”
9. Click the “Add 360s” button under the newly created collection
10. Select all pictures to add to the collection, then click the  dropdown and select “Add to: (collection name)”
11. To add more 360s later, simply navigate to the collection and use the “Add 360s” button

Setting up QR codes

QR codes are used to allow easy access to the links for Momento360 collections created in the previous section. Scanning the QR codes created in this section will open to the collection used, offering an easy way to make these collections accessible only to people in the museum.

1. Open https://www.momento360.com/
2. Login
3. Select “Collections” at the top of the webpage
4. Click on the name of the collection that you wish to create a QR code for
5. Click the share dropdown  and select “Share or Embed Link…”
6. Click the “Copy” button
7. Open https://www.qr-code-generator.com/
8. Paste (Ctrl + V) the link into the textbox and the QR code will automatically generate
9. Click the “Download JPG” and allow a few seconds for the image to download
10. The image will download in a few seconds

11. This image will be the QR code that can then be posted or printed to then be scanned, linking directly to the collection selected in step 4

Headset Setup

This section details the daily setup to prepare the Oculus Go for use by guests throughout the day.

1. Put on the Oculus Go and hold the controller
2. Press and hold the power button (on top of the Oculus Go) until the Oculus logo appears on screen
3. Once the home screen is displayed, select “Library” from the toolbar on the bottom
4. Select the “Oculus 360 Photos” app
5. On the left side, select the “My Photos” tab
6. Select the “A to Z” tab at the top
7. Select the first photo
8. The headset is now ready to be used by the visitors