# *Blue-and-White:*

# Exploring Mixed Reality Technology for Representing and Facilitating Intercultural Dialogue in Museums

By

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# Abstract

Since the 1980s, museums have been viewed as being able to promote conversations between communities in multicultural societies. The shift from the idea of a museum-going public to museum-going publics has contributed to efforts on the part of institutions to aid in addressing the diversity of experiences and interests that mark the postmodern world. The development of digital technology, mixed reality (MR), for example, has transformed the shared understanding of communication and the perception of information. This thesis presents an argument that MR can be effectively utilized to create a platform in which cross-cultural links between artefacts can be represented dynamically and interactively, to formulate a more diverse narrative about the history and material life, for museum audiences. By augmenting the narrative, the museum space can become a powerful platform to help audiences raise awareness of intercultural dialogue. A mobile-based augmented reality (AR) prototype that uses the story of what is commonly known as “Blue-and-White pottery” [青花; pinyin: qīng-huā or blue patterns and flowers] as a case study was developed to demonstrate the argument. This thesis concludes with a discussion of the potential for emerging technologies to solve contemporary problems in museums.

**Keywords**

Mixed Reality, Augmented Reality, Virtual Reality, Museum, Intercultural Dialogue, Blue-and-White Pottery, Cross-cultural Links, Smart Device

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# 1. Introduction

## 1.1 Motivation

I was born and raised in a small city in north-central China. Like many cities in the northern region, it had an old Muslim neighbourhood at its centre. Three-minutes by foot from my house lay a mosque with a green, arabesque minaret. It was rebuilt from a traditional Chinese-style mosque after the Chinese economic reform of the late 1970s. The traditional neighbourhood near the mosque had also been demolished and replaced by a new apartment complex called “Eden”. It was mainly built for sale to the local Hui Muslims. However, I do not recall any of my Muslim friends, who grew up there, ever think of it as strange for a Muslim neighbourhood to have a Christian name. Confucianism, Islam, Buddhism, Communism and new Christian elements coexist harmoniously in these urban corners of China’s northern plains. It was this strong cultural mix which I was born and raised into. Eventually, I left hometown for high school and university, and soon began working for magazines and museums in several cities. In my experiences, I came across multiple centuries-old traditional Chinese mosques that adhere strictly to the teachings of Islam but are also the epitome of Confucian philosophy and classical Chinese architecture. These material existences fascinated me not only for their elegance but also as symbols of cultural integration and the dialogue between them.

My experience of museums, however, is different. I’ve often felt a sense of disconnection from a reality where cultures coexist and influence each other. Museums have the

entrusted responsibility to safeguard and display artefacts collected from around the world. Consequently, curatorial responsibilities include the development of permanent exhibitions of objects that tell stories about cultures, in the context of time and place. Museums, therefore, possess the opportunity to shape the perceptions and narratives of the audience with respect to societies, their present and their past. I have found that in many museums, collections are classified according to their cultural origins. For example, Buddhist sculptures from China are often never found in the same space as their predecessors from the Indian subcontinent. While the audiences know that both come from Buddhism, in museums they often pass them by and miss accessing these stories from their experience. This is unfortunate as Chinese and Indian cultures have been connected for millennia. This artefact organization in museums represents the material enactment of the assumption of cultural differences and does not present the fact that many artefacts are, in fact, the products of cultural exchange. This museological tendency of museums to keep artefacts of places, regions and nations separate, undermines the possibility of the museum space as a platform for intercultural dialogue.

I often imagine the future of the museum as one where objects are connected based on shared histories which includes trade, migration and more. The audience does not need to walk from one gallery to another to observe the similarities and differences, as well as the stories, between Buddhist sculptures from China and India. All they have to do is stand in front of a single sculpture and electronically view all the Buddhist sculptures in the museum, including those from other museums and national collections. “Rather than thinking of the museum collection as a storehouse of treasures,” as Claire Bishop suggests about the museum’s future: “it can be re-imagined as an archive of the commons.” (56)

Meanwhile, the development of digital technology, such as mixed reality (MR), has transformed the ways of communication as well as the perception of information. One of the most popular MR technologies, augmented reality (AR), allows rich media content such as images, text and videos to be layered upon real environments through smart devices. Borders of the real-world can easily be invaded by virtual images. AR can present information about artefacts and places that are difficult to install in the space or are too fragile for the public to view. By taking advantage of these characteristics, AR can provide a powerful tool for museums to bring more information about the exhibit and enhance storytelling for visitors. (Harrington, 180) Many museums are embracing this technology. (Ding, 1) For example, ArtLens 2.0 by Cleveland Museum of Art is an AR application that uses image-recognition to detect the art pieces and show the interpretive content to the visitors. This application also provides the function to customize tours and interactive real-time maps. (ArtLens App)

## 1.2 Research Questions

This thesis will explore a theoretical foundation and process to develop an MR experience which represents the dialogue of cultures and creates opportunities for intercultural dialogue for museum audiences. In particular, this thesis seeks to address the following questions:

- How can mixed reality help to represent cross-cultural links between artefacts and facilitate intercultural dialogue for the visitor at the museum?
- How can the mixed reality experience be used to represent cultural links between artefacts in the museum to audiences?

- How might mixed reality be used as a mechanism for encouraging visitors to consider the relationships between cultures in the museum?

## 1.3 Chapter Overview

This thesis is composed of seven themed chapters, including this introduction. Chapter 2 presents a literature review by laying out the relationship between intercultural dialogue, artefacts and curatorial practice in the museum as well as the potential of mixed reality technology to explore possible intersections and approaches for these fields. The story of Blue-and-White pottery is presented to illustrate this complex relationship. Chapter 3 provides an overview of the use of Research Through Critical Design as a methodology for thesis research. Chapter 4 details a series of iterative prototypes and how each of them contributes to the final prototype, “Blue-and-White”. The user testing of the project is also presented in the same chapter. Finally, Chapter 5 concludes the thesis with a discussion of the work and avenues for future research.

# 2. Literature Review

The representation and facilitation of the dialogue of cultures through the employment of digital technology in the museum space is a complex concept. This chapter will present an overview of the scholarly-literature related to my research as well as consider practices devoted to this interdisciplinary subject. First, the definitions of culture and intercultural dialogue that emerge from the literature will be offered. It will lead to the concept that cultures are not impermeable and that what can be called the processes of cultural formation and activity are about the incorporation of shared information into shared activities. It is the result of the influences and exchanges with each other. To further explore this concept, I will talk about the history of Blue-and-White pottery, an example of long-term multilateral cultural exchanges. I will then introduce my argument that museums should make known the cross-cultural links between artefacts to encourage museum visitors to consider the relationships between cultures. The ability of the mixed reality technology, especially augmented reality, to assist this approach will be discussed.

## 2.1 The Dialogue of Cultures

In this section, I will present the discussion of culture, intercultural dialogue and show the relationship between artefacts and intercultural dialogue by using Blue-and-White pottery as a case study.

### 2.1.1 The Concept of Culture and Intercultural Dialogue

‘Culture’ is a fuzzy, challenging term that has long been discussed and used in daily life. It is a difficult concept to define. Stuart Hall argues this word can be used to describe the “shared values” of a group or of a society. (2)  He further explains that: “To say that two people belong to the same culture is to say that they interpret the world in roughly the same ways and can express themselves, their thoughts and feelings about the world, in ways which will be understood by each other.”(2) From the anthropological perspective, Clifford Geertz defines culture as webs of significance. For Geertz, culture is "a system of inherited conceptions expressed in symbolic forms by means of which men communicate, perpetuate, and develop their knowledge about and attitudes toward life."(5) From all of these definitions about culture, we can see that the human is the most basic element constituting the so-called culture. As Prown explains, “culture is a single community that was formed by a group of interdependent persons who have a set of beliefs.” (5)

This led to the dialogue between different cultures, known as ‘intercultural dialogue’. In recent years, the concept of ‘intercultural dialogue’ has attracted considerable attention in many public fields, such as schools, governments, and museums. (Bodo et al. 14) The

European Union defines it as “a process that comprises an open and respectful exchange or interaction between individuals, groups and organizations with different cultural backgrounds or worldviews.” (Council of Europe 17). Many people see this process as a meaningful mediation for the current world, where localism, populism and the far-right are on the rise, as it brings people from different cultures together and aims to exchange diverse perspectives and practices. (Bodo et al. 6)

Appreciating the strength of diversity is the essential characteristic of intercultural dialogue. However, it is crucial for different groups to realize and recognize the similarities that they share. All cultures are the results of influences and exchanges with one another. Human society is not made by isolated cultures but formed through exchanges and interconnections between different cultures. The Director of the British Museum, Neil MacGregor, rejected seeing ancient Greece as a separate world, because all cultures only make sense in the context of other cultures, although individual cultures do have their own histories. (O’Neill 192) As the UN Alliance for Civilization claims, intercultural dialogue “gives people a chance to understand the origin of their differences, but also to appreciate the similarities they share. [It therefore constitutes] an important step in overcoming the boundaries that separate people and groups.” (Ratzmann 20). Unfortunately, the traditional worldview and mainstream narrative prefer to show the world as a result of isolated development and overlook the exchange of religious, technological and artistic knowledge across continents, such as the cultural and material exchanges around the Mediterranean region and the Silk Road for thousands of years. José María Gil-Robles, for example, argues that culture itself is the outcome of

intercultural dialogue, and considers intercultural dialogue as “a tautological expression because culture essentially is interchange and dialogue.” (Doron 4)

### 2.1.2 Artefacts as Agents for Intercultural Dialogue

These concepts and definitions of intercultural dialogue are mostly developed from the intellectual dimension of culture. However, there is another important dimension of culture - material culture. According to Prown, material culture is the study through artefacts of the beliefs - values, ideas, attitudes, and assumptions - of a particular community or society at a given time. (1) The investigation of a material object is one of the best methods to understand culture because human-made and human-modified objects are expressive of the circumstances and cultures that produced them. These entities are the tangible incarnations of social relationships embodying the attitudes and behaviours of the past (Beaudry et al 272). People can also engage the other culture in the first instance not with the subjective minds, the seat of our cultural biases, but with the senses, by implementing cultural interpretation through artefacts. (Prown 5)

Artefacts help society to record human activities, recall the past and form collective identities. Meanwhile, many artefacts have emerged in situations of ‘cross-cultural contact’ in human history. Blue-and-White pottery is one of the most significant examples because this object developed as a long-term consequence of the multicultural impact of the Chinese realm and other parts of the world.

For centuries, Chinese porcelain played an important role in global trade and cultural exchange. Its tradition has inspired a wide variety of potteries in many cultures until the

modern time. Blue-and-White pottery is an iconic example of this. Some evidence suggests the birth of Blue-and-White pottery was impacted by the adoption of Persian production techniques, especially the use of cobalt pigment for the making of surface decoration. (Finlay 151) More recently, this pottery has been fostered by many countries in the Islamic world following economic activities. Numerous traditional Chinese motif designs blended into the Islamic world in the process. These two seemingly isolated cultures learned from each other and then shaped these inconspicuous artefacts that are still deeply engaged in our contemporary life. Some scholars such as Anne Gerritsen and Stephen McDowall go so far as to characterize and praise Blue-and-White pottery as the first truly global commodity. “By tracing these Blue-and-White porcelains from their origins in Jingdezhen during the Yuan dynasty to their consumers in Japan and Southeast Asia, throughout Eurasia, and into the Americas," explained Gerritsen, "the mercantile connections of the early modern world and the 'influence' of porcelain are revealed.” (4)

Meanwhile, from Southeast Asia and the Middle East to Europe and America, Blue-and-White pottery does not exist just as an exotic product, but also inspires some of the important imitators, so as to facilitate many major ceramic traditions in different cultures. For example, Safavid Iran played a key role in intercontinental maritime trade during the sixteenth and seventeenth centuries and produced excellent Blue-and-White pottery that adopted both Chinese and Persian traditions. (Golombek, 57)

Therefore, the analysis and interpretation of Blue-and-White ceramics can help audiences in museums perceive the intercultural links between the two cultures. By

excavating the cultural expression of artefacts, the story of cultural exchange can be presented in critical ways to diverse groups.

### 2.1.3. Blue-and-White Pottery

In the coming sections, I will talk about the connections between the Blue-and-White pottery from Ming China (1368-1644) and Safavid Iran (1501-1736) as the case study to formulate the role of this artefact in the conversation of two cultures.

From the rare and delicate vase in the antique shop to the objects in a case in a museum to the ubiquitous utensils such as dishes and bowls in dollar stores, Blue-and-White pottery is one of the most common decorative forms or typologies in ceramics that we see in daily life. This white porcelain is decorated under a transparent glaze with blue pigment, generally cobalt oxide, and fired at high temperatures. Flowering plants like Lotus scrolls, dragons and clouds are the most common motifs on them. (Christie's)

Blue-and-White pottery was first developed in China during the Tang dynasty. (Li et al. 358) However, the mass production of fine Blue-and-White pottery did not start until the fourteenth century. During the Yuan dynasty (1271-1368) under the Mongols rule, China became more tightly linked overseas, especially with the Islamic world. Jingdezhen (which was called the capital of porcelains) became the center of the porcelain industry since that time. Significantly, most of the Blue-and-White pottery was made for export to the Middle East and Southeast Asia until the last part of the fourteenth century, as a significant part of the bigger vibrant trade. (Finlay 156) Many

scholars believe the reason Blue-and-White porcelain was developed was to satisfy the Middle Eastern market. (Finlay 150)

Visually, cobalt blue is the key element of Blue-and-White pottery. The cobalt oxide that is used for painting on the pottery was imported from Persia to China by the merchants in substantial quantities for many decades, known as Huihui qing (Muslim blue) or Sumali qing (from the Arabic samawi, 'sky-coloured'). (Finlay 155) It was pretty common to use cobalt to colour glaze as well as to paint over for Persian artisans since the ninth century C.E. At some time in the twelfth century, they began painting in cobalt blue on the white background of tin-glazed products. (Finlay 153)

Additionally, Song whitewares and greenwares were still mainstream in the Chinese domestic market. It was unusual for the Chinese consumers to accept this kind of fully decorated porcelain at that time. The growth of Chinese seaborne commerce since the twelfth century brought massive whiteware and greenware to the Islamic world. Compared to the local pottery, Chinese porcelain seemed to have a jewellike, magical quality. (Finlay 152) In terms of the exchanges about aesthetics and technology, also the stimulation of trade, the craftsmen at Jingdezhen started to make Blue-and-White wares with a new formula to fulfill the desire of the Islamic world.

At the same time, the Chinese aesthetic was also transferred into middle eastern culture following the massive import of Blue-and-White utensils from China, such as plant forms (including the lotus, camellia, and morning glory), animal forms (such as the

phoenix, dragon, heron, and peacock), and scores of auspicious emblems from Buddhism and Daoism. (Finlay 157)

Although Chinese artistic style has dominated Persian ceramic since the fifteenth century, Persian potters didn't attempt to imitate the Chinese porcelains until the seventeenth century. Many historical changes affected this huge shift, such as the political turmoil in China (the fall of Ming dynasty in 1644, for example), the influx of Chinese porcelain because of the establishment of the Dutch and English East Indies companies, the improvement of the techniques, etc. (Golombek et al. 2) Subsequently, the craftsmen in Safavid Iran started to follow the Chinese model to produce Blue-and-White pottery massively, such as the workshops in Kerman, a city located in southeastern Iran. Kerman became a centre to produce Chinese style porcelain in the early 17th century. (Golombek et al. 57)

Among all the Persian potteries, the lotus motif appeared most frequently. Owing to its Buddhist influence, the lotus is important in Chinese symbolism. As one of the eight Buddhist precious things, lotus "is associated with purity because it rises unsullied from the mud." Also, in Chinese language, the word for lotus (荷 he) is a "homophone for the word for 'harmony' (和)." (Christie's)

The Blue-and-White dish based on a Chinese model (Figure 1) from the Aga Khan Museum collection is an excellent example to portray this history. It was created in the 17th century in Kerman, Iran. However, the Chinese model for this dish was from the

early Ming period (ca. 1410). In the center of the dish is a lotus-bouquet with a ribbon. The inner walls and the exterior walls are painted with the lotus scroll, just as we've seen in much Chinese Blue-and-White pottery. According to Lisa Golombek, the Persian painter followed the Chinese model very closely, and even used the dark and light variation in the cobalt pigment. (Aga Khan Museum) Figure 2 is a dish with a lotus scroll made in the Late Ming period. It has a similar lotus scroll decoration in the middle and exterior walls as Figure 1. The Lotus design that originated and was commonly found in Chinese pottery design blended into Persian pottery and became a favourite among Kerman potters. The combination of the Chinese idiom and the local techniques for making the dish, adopted by the craftsman, demonstrates the dialogue between Ming China and Safavid Iran.

*Figure 1 Blue-and-white dish based on a Chinese model*

*Accession Number: AKM588*

*Creator: Black square potter's mark on base*

*Place: Iran, Kerman*

*Dimensions: diameter - 46.6 cm*

*Date: ca. 1640*

*Materials and Technique: Stonepaste body, underglaze-painted with cobalt and thin black lines*


*Figure 2 Dish with Lotus Scroll Ming dynasty, Jiajing period and mark (1522-66)*

*© Gardiner Museum, Toronto.*

*The Robert Murray Bell and Ann Walker Bell Collection of Chinese Blue and White Porcelain, G01.2.7*

## 2.2 The Current Practice of Intercultural Dialogue in the Museum

In this section, I will show why museums are important in the work of cultural stewardship, research, education and social engagement. In addition, I will talk about the relationship between intercultural conversations and museums, and how given the unprecedented demographic and digital social changes, there needs to be new modes of engagement. Furthermore, I will show the limitations of museums that try to become spaces for intercultural dialogue.

### 2.2.1 Intercultural Dialogue in Museums

Traditionally, the museum is a space for the collection, preservation and display of cultural objects. In addition, museums, with their collections, must function as public sites of education and engagement. However, increasingly, museums are being perceived as spaces that might aid in the fostering of respect for cultural differences and promote inter-group dialogue. (Bodo 181) This trend has come up with one sign of the museum, which, as Bodo notes, is able to "unfold narratives and suggest inferences allows it to act as a platform for reflection on knowledge systems, beliefs, values and attitudes." (8) The museum space also has the privilege to trigger reflections, to suggest alternative ways of looking at the cultural heritage it preserves. (9)

Institutions and scholars try to position cross-cultural conversation in the museum in different ways. One significant way is to support a platform to help audiences from different backgrounds develop new narratives for the existing space and collections. Bodo has noted that “some institutions are actively engaging mixed groups in the development of new, shared narratives around collections through storytelling, theatre techniques and other mediation methodologies, starting from the premise that project participants can provide a significant contribution to the knowledge, understanding and interpretation of museum objects.” (Bodo 186) For example, the British Museum developed a learning program called “Talking Objects”. It brings young people from different backgrounds together to discover the history of the objects. Participants can handle the real objects and discuss relevant issues by using creative methods like drama and dance. (Bodo 17)

### 2.2.2 Current Limitation of the Museum as an Intercultural Dialogue Space

While many museums are trying to promote intercultural dialogue (such as workshops bringing different cultural groups together), some current museological approaches are not often seen as the obstacle for intercultural dialogue. Mark O’Neill argues that traditional museological practices “tend to overemphasize the distinctiveness and separateness of cultures.” (197) He analyses the current museological model of the museum in general - “They focus on a narrow definition of authenticity which constantly tends towards an essentialist view of cultures and the relationship between objects and cultures (qtd. in Errington 1998). They minimize the impact of interactions between people and of change over time.” (197)

Many museums use text and audio tours to help audiences understand the connections and the stories behind the artefacts from different cultures that always sit in divided galleries. Special exhibitions about cultural exchange is another common way for audiences to learn shared stories. However, these efforts are often temporary or subtle because of the many limitations that have affected museums for a long time, such as physical space, financial problems and other related issues.

### 2.2.3 Louvre Abu Dhabi

As mentioned in chapter 2.1.2, the artefacts in the museum hold a significant role in intercultural dialogue. The knowledge and the interpretations about the objects that museums provide deeply affect the perception of its audiences and the communities they belong to. Therefore, a new institution has started to make a new museological model to redefine the artefacts and their display.

The Louvre Abu Dhabi, opened in 2018, is an outstanding example of this new approach. Disavowing the organizational model of its namesake, the institution housed in a Jean Nouvel-designed structure modelled on regional architectural forms, has no geographically-designated exhibitions. The galleries are organized thematically around twelve themes that present a globalized historical perspective of world history and cultures, which begin in pre-history and end in the present day. In undertaking this bold experiment, the museum emphasizes the connections between cultures as opposed to

perpetuating siloed models. All the objects are presented based on the similarity of their history, not on a nation or geographic region. Audiences in the Louvre Abu Dhabi can walk into an extraordinary scene in which statues of deities from the Hindu, Christian and Buddhist traditions are displayed side by side. Everyone can easily investigate the various ways in which different cultures visualized the divine, in the same space, without needing to go to different departments. (Leech 6)

The Louvre Abu Dhabi shows the parallel developments of different cultures and emphasizes the cross-cultural links. It creates a narrative that "values all civilizations equally, and emphasizes moments of contact and connection between cultures, displaying their artefacts in dialogue, side-by-side, rather than emphasizing their differences." (Leech 16) This unique approach shows a new angle of intercultural dialogue, which is focused on presenting common characteristics among artefacts from different cultures. It tells audiences the shared narratives of all civilizations to reinforce the intercultural dialogue.

## 2.3 Mixed Reality (MR) Platforms

As discussed in the previous chapter, it is not realistic for museums to reinterpret all artefacts and display connections between cultures. It will cost considerable human and financial resources to facilitate such radical change. However, digital technology such as mixed reality (MR), could be used as a powerful tool to assist this approach. In the following sections, I will introduce the concept of MR and focus on augmented reality (AR), which is a widely used subclass of MR. Furthermore, I will discuss how the museum industry can potentially utilize the characteristics of AR technology to represent the cross-cultural links between artefacts to facilitate intercultural dialogue.

### 2.3.1 The Definition of Mixed Reality (MR) and Augmented Reality (AR)

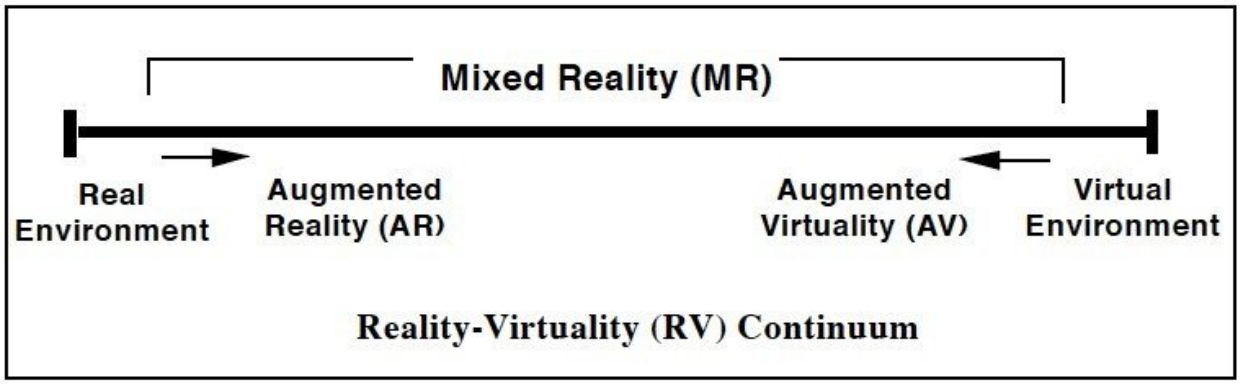


*Figure 3 Reality-Virtuality (RV) Continuum from Milgram and Kishino. (3)*

Mixed Reality (MR) is a general term for various visual display technologies that involve the merging of real and virtual worlds. More specifically, MR can be shown in the "virtuality continuum" as Figure 3, which is in between the completely real environments to completely virtual environments (VR). (Milgram and Kishino 3) VR is a 3D computer-based immersive system that simulates the environment. Unlike the traditional user interface, VR places the user in a fully synthetic and interactable 3D world that is fully immersive. (Milgram and Kishino 2)

Apart from VR, augmented reality (AR) is the best-known type of mixed reality; it refers to all cases in which the display of an otherwise real environment is augmented by means of virtual (computer graphic) objects. (Milgram and Kishino 2). One of the most comprehensive summaries about the characteristics of AR is from Ron Azuma - "it combines real and virtual content; it is interactive in real-time; it is registered in 3D." (Billinghurst et al. 9) Different from VR which transfers the user into a completely virtual world without perceiving the visual information of the current world, AR augments the real environment by adding a layer of computer graphics on top of the current world. Accordingly, AR is a hybrid display environment that brings virtual imagery into the real environment. Although the first prototype AR system was created in 1968, this technology has recently become popular. (Billinghurst et al. 85) The development of the combination of tracking technology and display technology has brought its application into a never-before-seen level of stability and user experience.

### 2.3.2 Augmented reality (AR) in the museum

Traditionally, museums have used interpretative tools such as descriptive labels, brochures, audio guides, websites and mobile applications to facilitate the engagement and education of the public. Recently, a growing number of museums are embracing AR for enhancing public comprehension and engagement. (Billock)

Primarily, AR is an excellent tool to break the physical limitations of space by reconfiguring the 'location' or spatial proximity of the artefacts, thus revealing a completely new dimension for museum visiting. Museums can make 3D information for the artefacts and present them in any space; therefore, audiences can make their "surrounding spaces a stage for endless extra layers of information." (Ding 3) In other words, the viewer is able to achieve a much closer examination of an artefact by using AR that simulates the actual physical object on the digital device. It is different from the experience when they observe the real artefact in a museum where objects sit within glass cases.

Moreover, AR can animate exhibits and artefacts. Most museums tend to present static exhibitions. By adding digital augmentations over real objects, museums can provide detailed access to artefacts from multiple perspectives. For example, the Skin and Bones application developed by the Smithsonian National Museum of Natural History (Washington, DC) allows audiences to overlay skin and movements onto the animal skeletons in an anatomy exhibition. (Bone Hall)

Additionally, AR is a powerful tool to increase engagement. Audiences in museums can gain comprehensive information about the displayed artefacts by interacting with the physical artefacts through AR tools. (Billock) It closes the gap between audiences and the museum because AR can help users to inspect the details, to explore, even create new content in the augmented space. AR can turn knowledge sharing into entertainment by displaying crafted stories or interactive AR gaming experiences for young visitors. And the augmented content can be very diverse, such as video, 3D augmentations, audio, text, games and more. Among the increasing examples, visitors in the Mauritshuis Museum (The Hague, Netherlands) can use a smartphone to experience Rembrandt van Rijn's *The Anatomy Lesson of Dr. Nicolaes Tulp* (1632) in an AR app. Users can interact with virtual holographic 3D objects to reconstruct the painting by simply using devices compatible with Apple's ARKit or ARCore for Google. (Hitti 1)

Most importantly, the smartphone, which every audience has, is the easiest tool of engagement. AR allows digital elements to be displayed on top of a visitor's view of the real environment through handheld devices, such as tablets and smartphones. Any device that facilitates augmented reality adds another dimension of interactivity, engagement and personalization, and at the same time functions in unobtrusive ways. In addition, the appearance of ARKit [1] and ARCore [2] by Apple and Google made AR application development become economic and accessible for digital departments in museums.

[1] Apple Developers, "ARKit." http://www.developer.apple.com/augmented-reality. (accessed March 9, 2020).
[2] Google Developers, "ARCore." http://www.developers.google.com/ar. (accessed March 9, 2020).

In July 2017, the Art Gallery of Ontario (AGO) in Toronto, Ontario, Canada worked with digital artist Alex Mayhew to develop a successful museum AR application 'ReBlink'. Audiences could use their smartphones to scan the 2D paintings and see the subjects come alive and be transported to 3D rendering animations in a 21st-century content. For example, viewers can see the lady in the painting holds a selfie stick when they use the AR app to scan *The Marchesa Casati*[3], one of AGO's most famous portraits. By using this AR application as an intervention for traditional museum exhibitions, smartphones become the means to attract audiences to focus on the exhibits, not a distraction. According to the AGO's Interpretive Planner Shiralee Hudson Hill, 84% of visitors to this exhibition reported feeling engaged with the art. 39% looked at the images again after using the app. (Zhang)

Another successful example of such an application is called "WWF Free Rivers" that was developed by the World Wildlife Fund (WWF). Users can display the realistic 3D river ecosystem, such as a river basin in any space, by pointing the phone camera towards a flat surface in the application. Users can learn why free flowing rivers are so important by damming the river to see what happens in the experience. Also, users can try different navigations and narrations to keep the river healthy and flowing. According to WWF, the AR technology is second nature for the new generation, with even children under 12 using it. (George 4)

[3] Art Gallery of Ontario, "The Marchesa Casati." https://ago.ca/collection/object/2164. (accessed March 15, 2020).

## 2.4 Summary

Overall, the intercultural dialogue, museum artefacts and mobile-based augmented reality technology are the fields I dug into in the literature review, to support my argument that MR technology, especially AR can facilitate museums to make known the cross-cultural links between artefacts for audiences. This can encourage visitors to consider the relationships between cultures and further, encourage intercultural dialogue. In addition, through researching and analyzing the story of the Blue-and-White pottery, the design of my final prototype is getting into shape and is clearer in my mind.

# 3. Methodology

The methodology selected for this project employs a mixed-method approach called research through critical design. It is inspired by Critical Design to help me explore my research questions; it also deploys Research Through Design (RTD) to design my thesis prototype.

## 3.1 Critical Design

Anthony Dunne and Fiona Raby define 'critical design' (CD) as "... more of an attitude than anything else, a position rather than a method." (34) They concluded a principle of CD from the industrial design perspective - "to challenge narrow assumptions, preconceptions and givens about the role products play in everyday life." These definitions do not depict the framework of the CD in practice. Therefore, many scholars such as Leon Karlsen Johannessen summarize the goal of CD as to challenge what is given by society, and thus affect how the world develops. (3) To achieve this, designers should provoke "the public to think critically about norms and values. CD practice strives to encourage public debate." (3)

For my thesis research, I use critical design as the main part of the research process. It follows parts of the process codified by Leon Karlsen Johannessen. (8) First, I define the context for debate by asking questions like "How can museums do better to represent

the cross-cultural links of artefacts?" and "How can museums be changed by technology in the future?". Second, I ideate and find problems by asking "what if?" questions. For example - "What would the museum look like today if the cross-cultural links between the artefacts from disparate cultures can be highlighted through the use of AR technology?" I then create a scenario by designing an alternative present of the visiting experience of the museum. Eventually, I will create a scenario to provoke public debate, which will be an MR experience.

## 3.2 Research Through Design

After using critical design to develop the theoretical framework, I started to create the new scenarios of the visiting experience in the museum to provoke public debate, which will be an MR experience. I choose to follow the research through design (RTD) methodology to develop the new scenarios. RTD is a research methodology that the construction of a design artefact is to answer the research question. It emphasizes the artefact-led, practice-based research and experiential, hands-on prototyping. (Gaver 945) Prototype making is an essential method in every stage of this methodology.

In terms of the nature of my prototype that is designed for museum visitors, interaction design is an orientation of the prototypes for my thesis research. As Zimmerman argues, the model of RTD allows interaction design researchers to study the world and then to make things intended to affect change. The first step of the model is to integrate true

knowledge (the models and theories) with how knowledge (the technical opportunities). Then researchers ground their explorations in knowledge produced by design researchers performing the upfront research for a design project. Finally, going through an active process of ideating, iterating, and critiquing potential solutions, researchers continually reframe the problem as they attempt to make the right thing. (313)

## 3.3 Research Through Critical Design Methodology

Both CD and RTD methodologies align with my research goals. To develop my prototype, I will assemble the appropriate components of both methodologies to form a hybrid approach. This methodology merges critical design as the core position into the structure of research through the design model. The “what if?” questions are the core of the research to design an alternative present of the current visiting experience of the museum. The alternative present becomes the object of research and evaluation by using iteration design and user testing.

By using the research through critical design methodology, I developed a diagram to show my research process (Figure 4). First, I developed the theoretical model that artefacts can be used as important agents for representing the intercultural links, by analyzing the literature and case study. Then, I used iterative prototyping and user testing as methods to develop the technological solution to facilitate the theoretical model I developed.

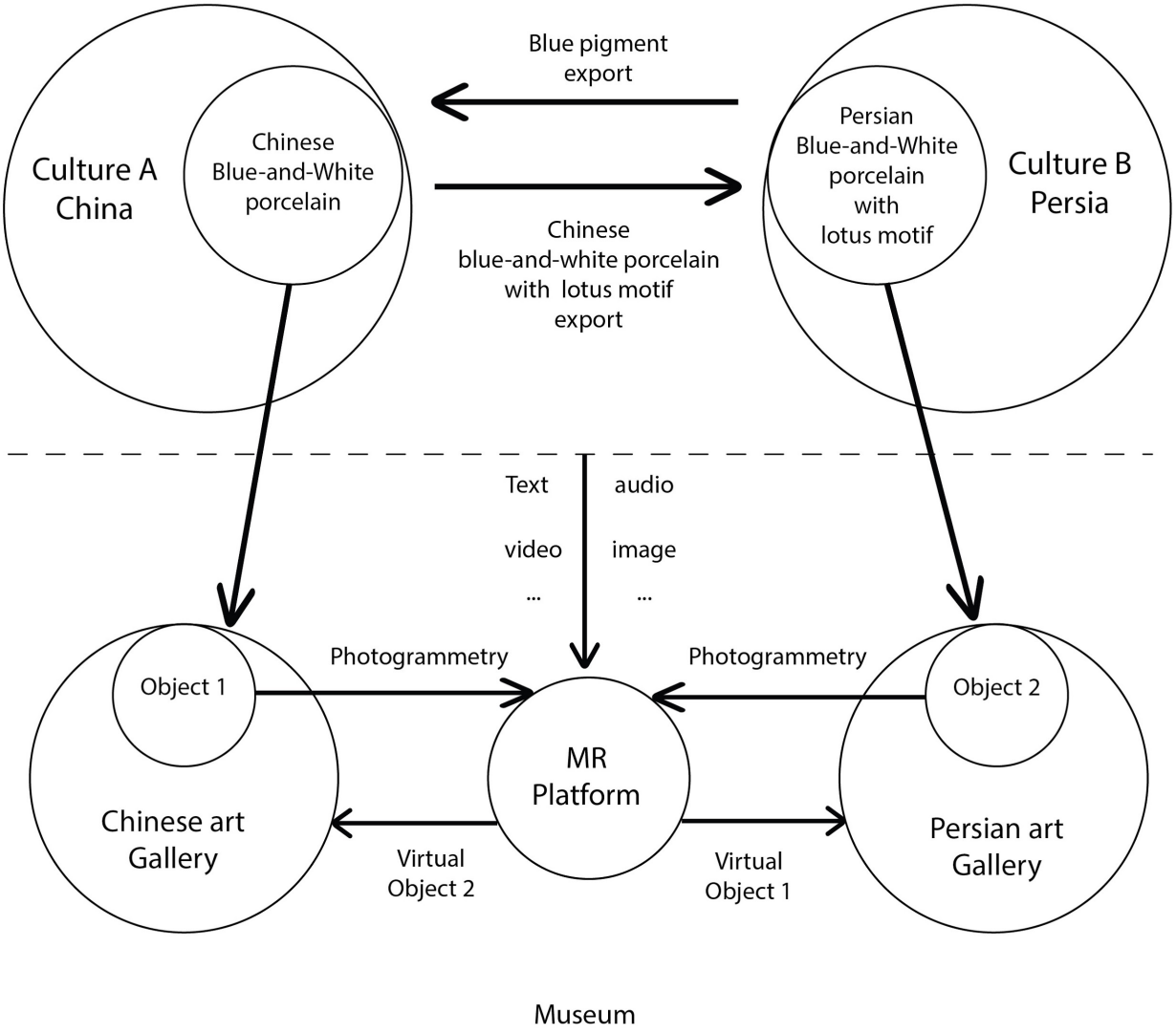


*Figure 4 The diagram to show the role of the MR platform in the process of intercultural dialogue in museum spaces*

# 4. Iterative Prototyping

Following the methodological approach, the prototype-making has consisted of two early prototypes and one final prototype. The first prototype examines the virtual reality (VR) technology to develop a digital experience for intercultural dialogue, the second utilizes one type of mixed reality (MR), augmented reality (AR) technology, based on the mobile device. After exploring VR and AR technology from the first two prototypes, the final prototype focuses on representing the history of Blue-and-White pottery, summarized in the literature review, to museum audiences to facilitate the dialogues between China and Iran.

## 4.1 Early Prototype 1: Virtual Museum for Intercultural Dialogue

When I started exploring how to build a digital platform for the promotion of intercultural dialogue in museums, the first digital medium that came to my mind was virtual reality (VR). It is because VR is a computer-based technology that replaces reality and creates an immersive environment, (Billinghurst et al. 79) and can be compared to MR.

I began brainstorming and creating sketches for potential plans to design a digital space for intercultural dialogue using VR.

### 4.1.1 Inspiration

During the summer of 2019, I learned how to build scenarios in Unity and use C Sharp to implement interactive functionality. Unity is a cross-platform game engine that can be used to develop two-dimensional, three-dimensional, virtual reality and augmented reality games. C Sharp is a programming language which is used for building functions in Unity. Meanwhile, many museums released scans of artefacts for the public to access online. (Flynn) For example, the British Museum is working in collaboration with Sketchfab, an online platform to download 3D scans. It has created over 250 3D models of statues, busts and pieces of jewelry from its collection across ancient Egypt, ancient Rome, ancient India and so on. Anyone can download them, and even print out by using a 3D printer. (Fig. 5)

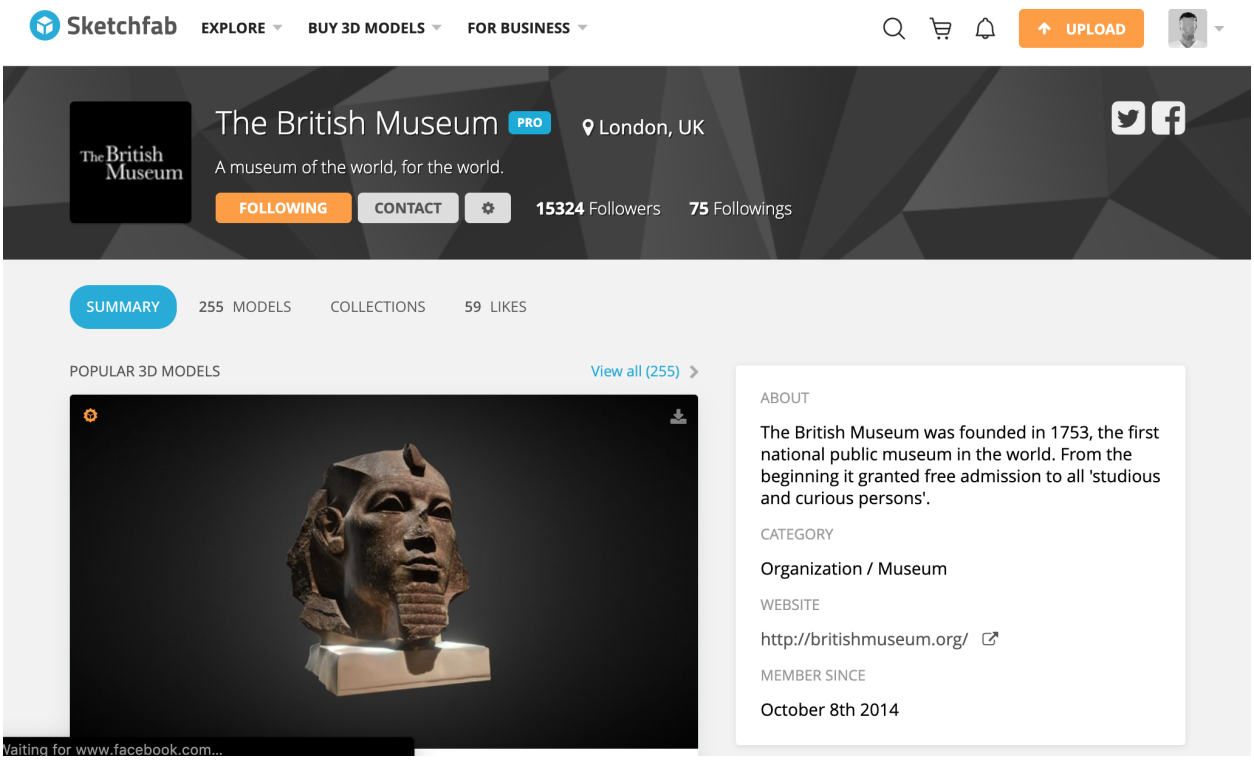

*Figure 5 Screenshot from The British Museum webpage on Sketchfab. (C) Sketchfab. Retrieved from https://sketchfab.com/britishmuseum/models*

Furthermore, the popularization of 360° video makes the production of immersive video more convenient. These pocket-sized cameras can be used to film a 360° video without any professional background. Anyone can just simply plug it into a smartphone and record the environment. More and more museums are working with technology firms to produce 360° videos for remote audiences. For example, The Metropolitan Museum of Art, in New York City, (The Met) created a series of such videos by using spherical 360° technology. (The Met 360° Project) Users can use smartphone, computer or VR headset to be part of a virtual tour in the galleries with a 360° view. By providing these experiences, people can visit the museums without travelling and enjoy an empty gallery environment.

### 4.1.2 Design Consideration

As mentioned before, the democratization of 3D scans and the development of the 360° camera makes the museum resources more accessible than ever before. Therefore, I came up with the idea to utilize these public resources from different museums around the world, to create a virtual exhibition space by bringing the real-time exhibition and virtual 3D artefacts together. The intention is that the dialogue of cultures can be presented and transmitted to audiences in this virtual space because the gallery does not follow the usual museum approach to organize and display artefacts chronologically by culture. It brings all artefacts from different civilizations and museums into the same space for audiences to compare and appreciate. Museums can also use this platform to curate special cultural

exchange-themed exhibitions for the audiences. The limitations of physical space and display no longer exist in the immersive virtual space.

I named this prototype the Virtual Museum for Intercultural Dialogue. Figure 1 presents one typical scene of the virtual gallery. I created the virtual gallery space in the Unity game engine, where visitors can walk through three different exhibition spaces, each consisting of a 360° video. In the center of the exhibition galleries, there are virtual exhibits corresponding to the content of the exhibition of each 360° video. Through this new experience and display of exhibits, the prototype gives audiences the opportunity to appreciate artefacts from different historical periods and cultural backgrounds in the same space.

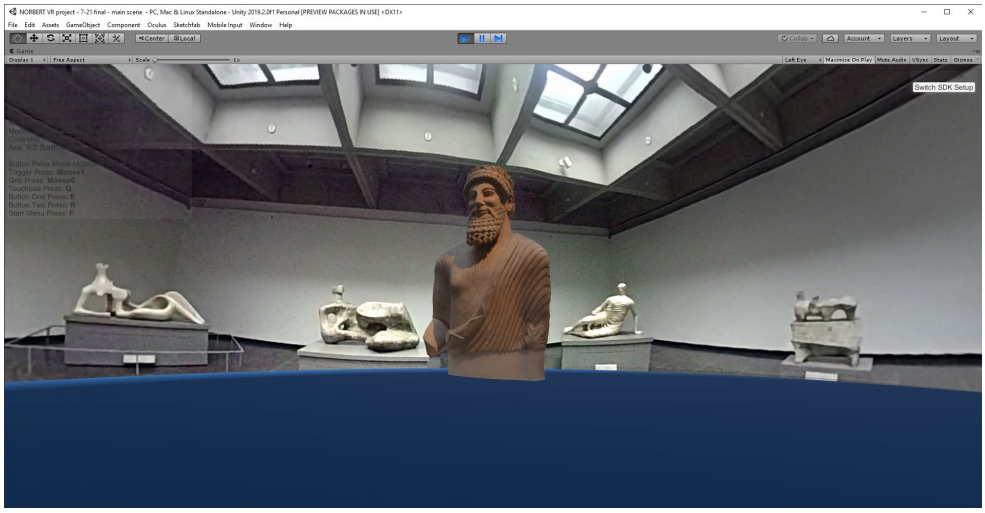


*Figure 6 Image from Virtual Museum for Intercultural Dialogue. This scene shows a publicly available 3D artifact4 (under creative commons license CC By-NC 4.0, via the Trustees of the British Museum).*

[4] https://sketchfab.com/3d-models/statue-neo-assyrian-temple-of-nabu-5b0fcce6567a4bccae578aa09681ab80

### 4.1.3 Development

The development of this experiment started in June 2019. By using a 360° camera called insta360, I took three 360° videos from three galleries in the Art Gallery of Ontario (AGO): the Canadian painting gallery, the Henry Moore Sculpture gallery and a special exhibition titled Brian Jungen: Friendship Centre. (The personal use of photography is allowed in the AGO.)

In Unity, I built three spheres to show 360° videos, because the sphere is the best shape to show these videos; it is more immersive than other shapes.

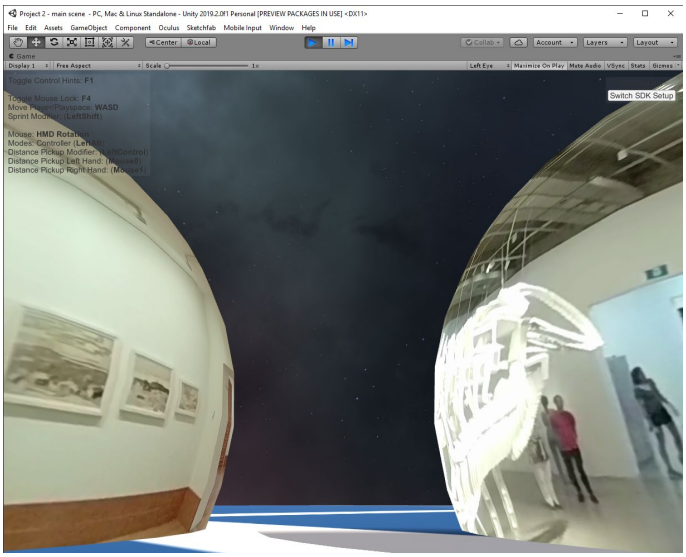


*Figure 7 Image from the virtual museum for intercultural dialogue*

Meanwhile, I added 3D scans into different galleries and tried to create a new parallel display of the real exhibition and the virtual artefacts. I put three virtual objects from the British Museum into each virtual gallery. In the gallery of the Henry Moore Sculpture Centre, I installed a statue of a priest from Cyprus (fifth century B.C.) in the

middle. By putting them beside each other, I tried to create a conversation between this ancient statue and the semi-abstract sculptures from Henry Moore. This interference allows users to compare and appreciate the similarity, differences and connection between the artefacts which are separated in different spaces, in the real world. In the rest of the galleries, I also installed virtual objects with a similar theme but from a different historical period.

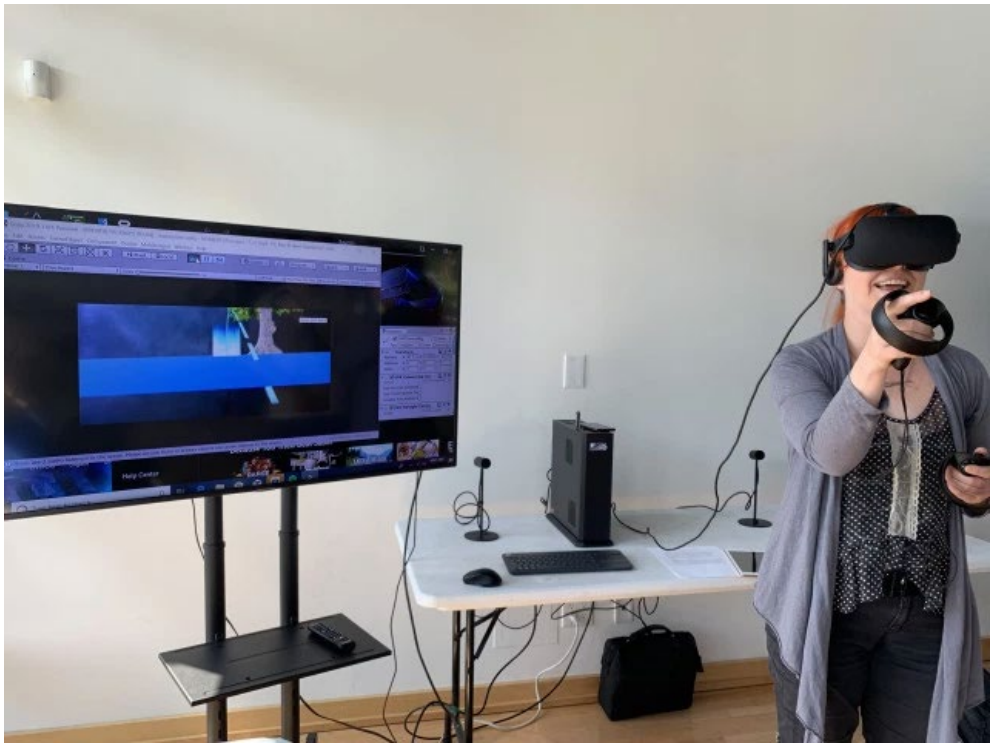

*Figure 8 User testing for the prototype.*

### 4.1.4 Evaluation

After creating the three virtual galleries, I brought the project to the CFC intensive workshop to get feedback from more people.  In this VR experiment, users need to wear a headset to experience the complete immersive environment that allows the user to be intimate with the museum artefacts and environment. I received positive feedback from

this workshop. Most testers agreed that the prototype provided a new perspective to see the current role of the artefacts displayed in the museum. The remix of the virtual objects from different museums and historical periods in a virtual experience gives them access to appreciate the dialogue between different cultures as well as the conversation between historical objects and contemporary exhibits. In terms of scene design and interaction design, many users mentioned that the three virtual galleries are far apart, and that most users don't have the patience to spend time navigating the scene. Some users also felt my virtual galleries could be bigger as they wanted to see more art objects in the galleries and not just 360° videos. I therefore changed my scene design by bringing the three sphere galleries closer, and deleting the tree and the rigid body of galleries. I made the spheres bigger so users could navigate in the scene easily.

However, I got some questions about whether this technology is accessible enough for museum visitors. VR is fully immersive and divides users with the physical environment. VR also requires the headset as the digital tool, which is unaffordable and inaccessible for a majority of people and museums. Although VR is not the perfect technological tool to represent the intercultural dialogue in museum visits, users had very positive feedback about the mixture of 360° videos and the virtual artefacts, and the parallel display of artefacts from different cultures during the informal user testing. It has proved that extended reality can be used as a valuable tool to enhance the current museum experience. I then started to explore the possibility of using MR for my research to determine whether an AR application based on the mobile device could be a good solution for it.

## 4.2 Early prototype 2: Interactive map for museum visiting

Unlike VR, AR does not require a headset or a certain space. AR is portable for most smartphones nowadays. It can also overlay information over the surrounding space and track the user's physical space. These characteristics make AR a more feasible tool for my analysis as my research question is about finding how to best represent and facilitate the dialogue of cultures in the museum space.

Immediately after the first prototype, I started to learn how to use AR technology to build a mobile device-based experience. This prototype was more like the preparatory work for my final project, so I made an AR map to learn the skill of image tracking by using the Vuforia augmented reality software development kit (SDK).

When the user scans the map with the built-in camera on their phone, a 3D virtual image of the artwork will be displayed in the corresponding gallery space on the map. It utilizes the image target function of Vuforia augmented reality SDK. Through this map, visitors have a more intuitive and three-dimensional understanding of the information of the artefacts, especially the display model, that artefacts are presented in different spaces based on cultural origins. To break the conventional visiting approach, the museum can show the dialogues of cultures on this AR map by visualizing the links between artefacts on the interactive map. Therefore, the museum audiences can use the map to customize their visiting plan based on collections that have intercultural links. This was an early attempt to combine the physical information of the museum (the paper map) with

augmented information, and further explore how to use MR display technology to provide more possibilities for representing and reinforcing the dialogue of cultures in the museum-visiting experience.

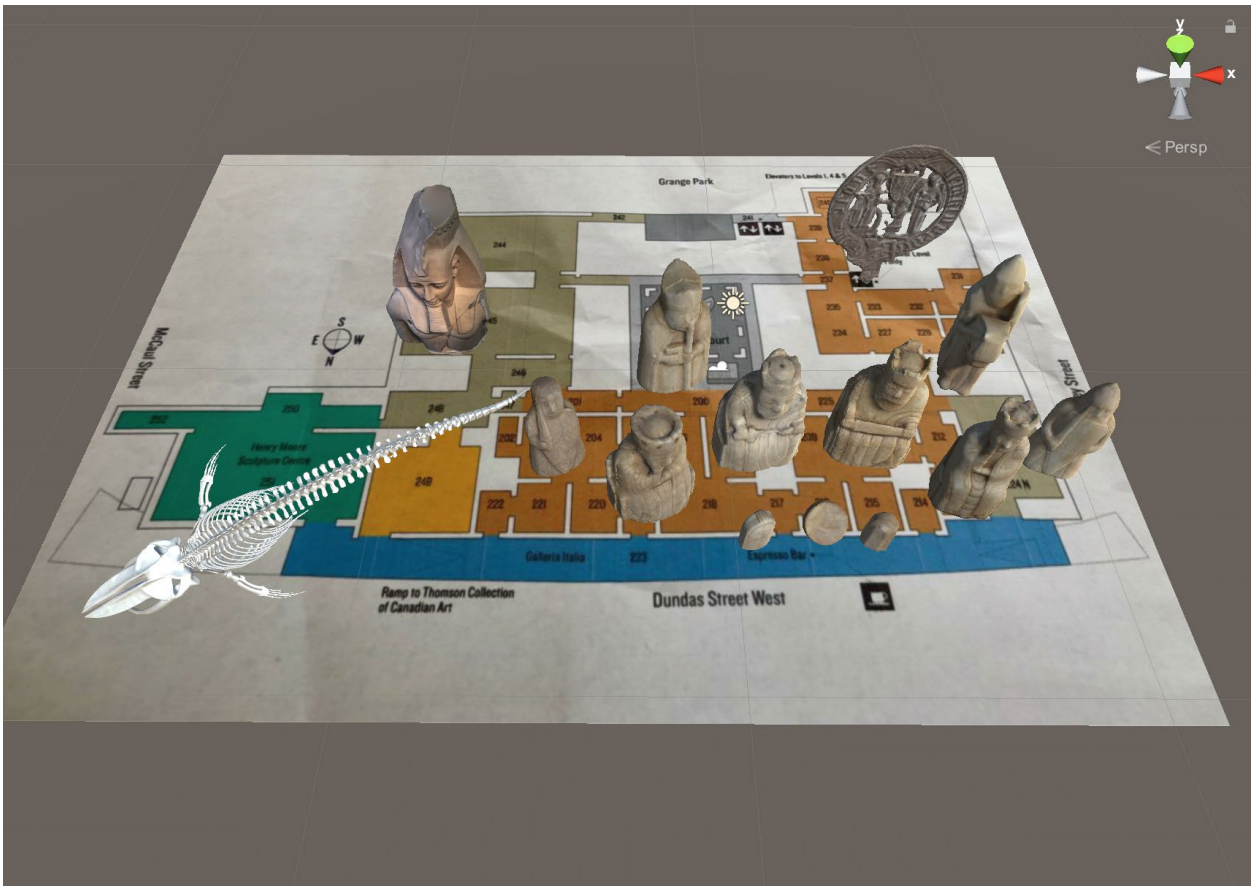


*Figure 9 Screenshot from AR interactive map[5] that shows publicly available 3D artifacts[6] (under creative commons license CC By-NC 4.0) from different resources.*

[5] Gallery map. (C) Art Gallery of Ontario (AGO). Retrieved from https://ago.ca/visit/gallery-map
[6] https://sketchfab.com/britishmuseum/models
https://sketchfab.com/3d-models/blue-whale-skeleton-8502dbef80ed4aa688c13c90cb14de73

# 4.3 Final Prototype: Blue-and-White

## 4.3.1 Ideation

With the last prototype, I learned the technology for developing an AR application with image tracking. I started to examine how to employ this technology, to show connections between the artefacts to the museum audience.

As mentioned in chapter 2.1.3, many artefacts such as Blue-and-White pottery are the result of cross-cultural conversation. However, the stories between these artefacts are not displayed to the audience in a comprehensive way in the museum because of the conventional curatorial practice that displays artefacts based on culture, as well as technical and financial constraints. At the same time, not all museums, like the Louvre Abu Dhabi, have the ability to remix museum exhibits to represent the cross-cultural links; it is an exception. My final prototype, Blue-and-White, demonstrates how AR can be used to present the story of how the historical knowledge exchange between Ming China and Safavid Iran shaped the Blue-and-White pottery.

To present these connections between the artefacts, I first started research what the cross-cultural links between them are. In chapter 2.1.3, I introduced the historical connections between the Chinese and Persian Blue-and-White porcelain, in which blue pigment and lotus motif are two representative intersections. I visualized this information into the diagram below.

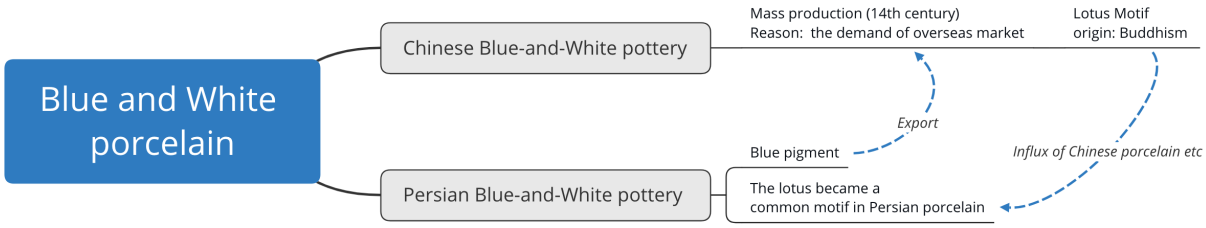


*Figure 10 The visualization of the story of Chinese and Persian Blue-and-White porcelain*

### 4.3.2 Development

After determining the narrative that the prototype needed to present, I started looking for appropriate Chinese and Persian Blue-and-White porcelains to be the protagonists of the story in the prototype. First, I contacted the Aga Khan Museum, because this Islamic art Museum owns a huge collection of Blue-and-White pottery from the Middle East. From its online collection, I found the Blue-and-White dish based on a Chinese model (Figure 1). As mentioned in chapter 2.1.3, this dish uses typical Chinese style art, particularly the lotus scrolls around the lotus bouquet. This is an excellent example to show the linked history of the lotus motif between Chinese culture and Persian culture through the movement of Blue-and-White pottery. However, the Aga Khan Museum doesn't have 3D scans of this object, so I chose to use photogrammetry technology to produce the 3D model. After getting permission from the museum, I used the SLR camera to take photos of the artefact. I got over 100 pictures of this artefact from all angles.

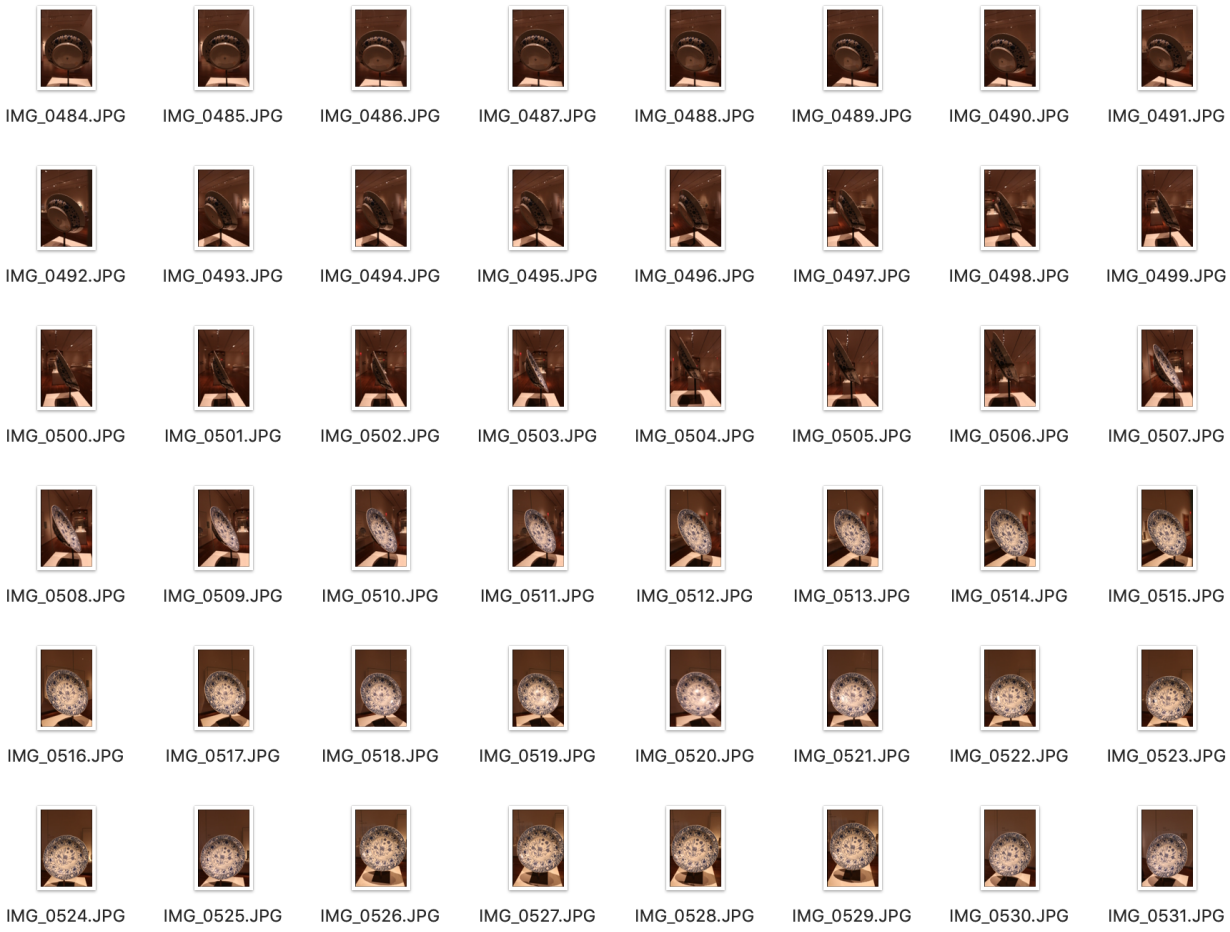


*Figure 11 The pictures of the Blue-and-White dish (Figure 1) that were taken in Aga Khan Museum*

The next step was to import all of these pictures into a software called Agisoft Metashape, which is a 3D reconstruction tool. This software can align all photos automatically and render the photos into a 3D model by building a Mesh texture. The 3D model can be exported as an obj file for game engines such as Unity.

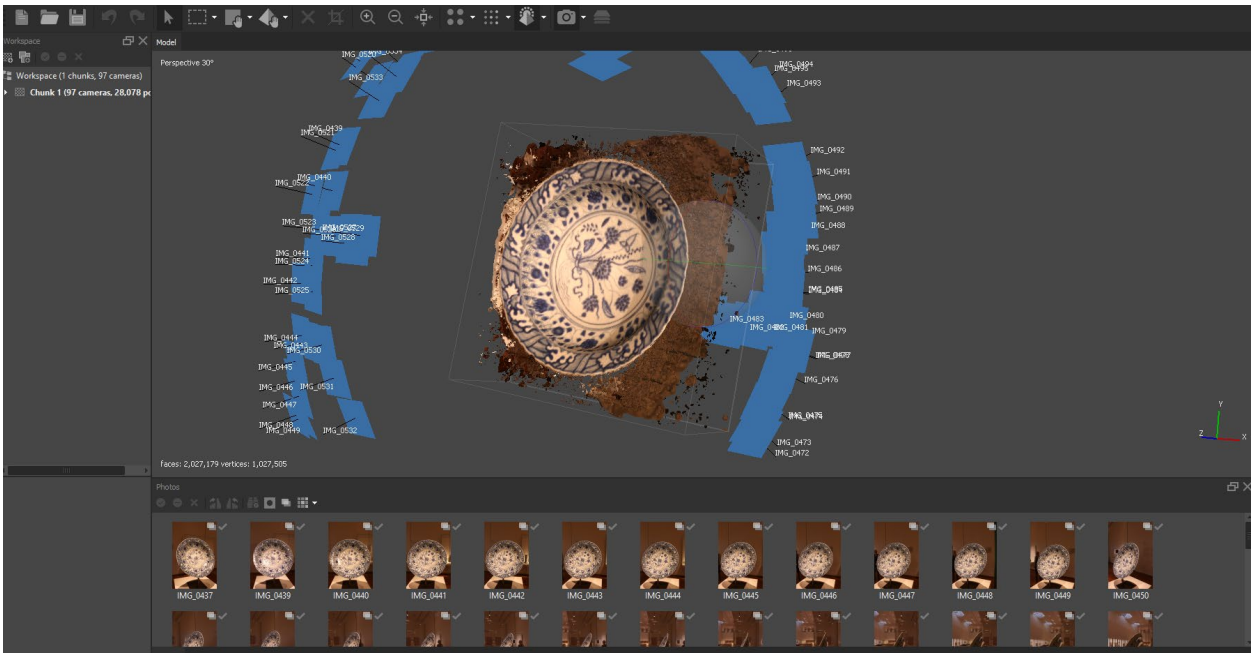

*Figure 12 Building the 3D model of the Blue-and-White dish (Figure 1) in Agisoft*

The representation of the shared history between artefacts coming from seemingly isolated cultures is a powerful way to show the dialogue between the cultures. Therefore, I looked up the Ming Chinese Blue-and-White pottery that also has a similar lotus motif design. I decided to get in touch with the Gardiner Museum in Toronto. As luck would have it, it is the only institution that specializes in global ceramics in Canada. From the museum's rich collection of Chinese Blue-and-White porcelain, I found many Ming Chinese pieces that also are painted with a classical lotus motif design. Among them, I chose the dish with the lotus scroll (Figure 2) as an example to represent the Blue-and-White porcelain from Ming dynasty.

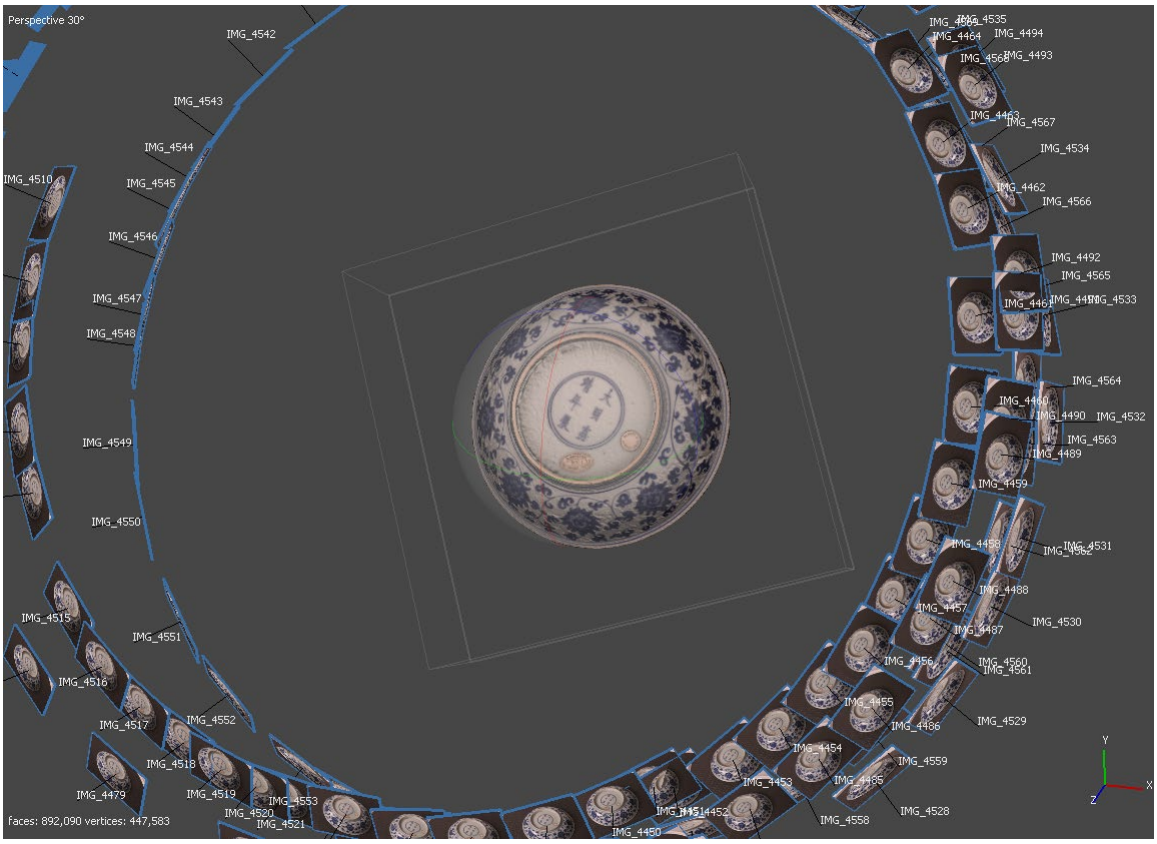


*Figure 13 Building the 3D model of dish with lotus scroll (Figure 2) in Agisoft*

To simulate the experience of visiting a museum for the prototype, I bought a Blue-and-White dish from Home Sense that is common in daily life, as an entry point of the experience. I set the picture of this utensil as image target in Unity. Two 3D models that were built before are imported into Unity as a subset of this image target. In other words, when the image target is sensed by the camera, these two 3D models will also appear in the lens.

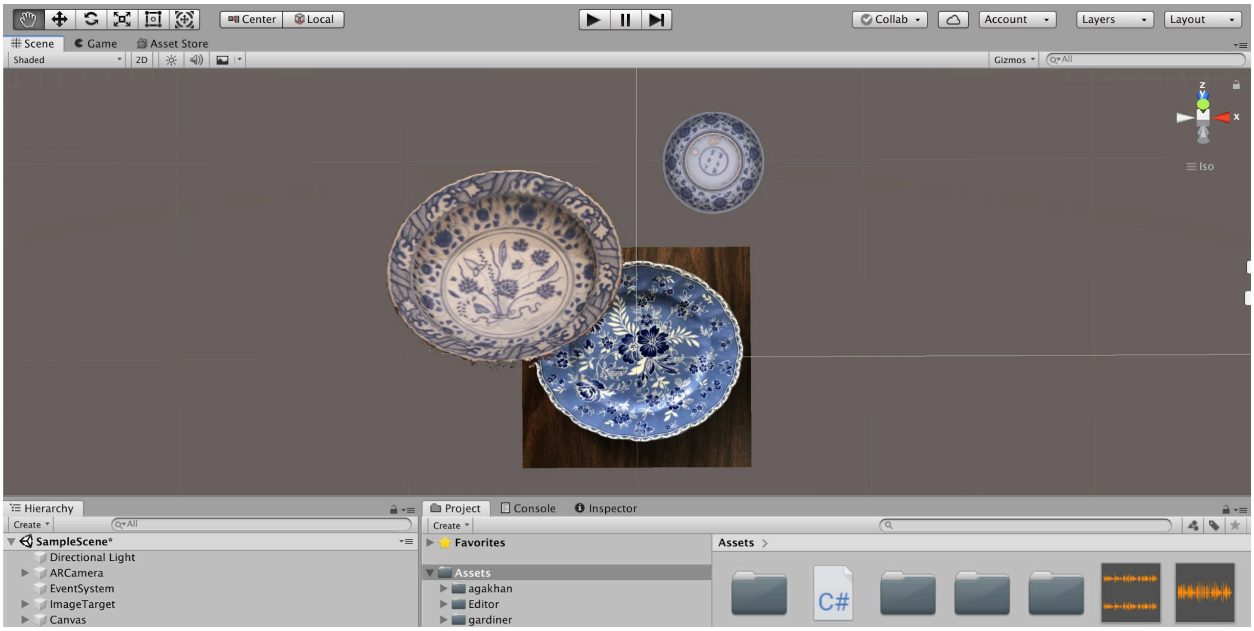


*Figure 14 Setting the image target in Unity.*

In this way, Blue-and-White porcelain from different cultures, which are usually displayed in different spaces, are displayed together directly to convey a message to the audiences - these objects and the two cultures behind them have many similarities. In addition, to break the limitations of physical space, I needed to present the story explaining why they have many similarities, in the experience. Specifically, the two representative intersections - blue pigment and lotus motif.

The user journey of this prototype is like this -

First, the users can use the AR application on the iPad to scan the Blue-and-White dish in the gallery to get 3D virtual models of the Chinese dish and the Persian dish. There are also descriptions of the artefacts, such as country of origin, date and size.

Then, on the virtual objects presented, highlighted hotpoints probe the users to click. (Figure 15) The one on the Persian dish is about the blue pigment. The user can click on the hotspot and get an audio introduction about the blue pigment that was produced in Persia and exported to China on a large-scale. In turn, this material transfer and trading needs stimulated the mass production of Chinese Blue-and-White porcelain. The hotspot on the Chinese dish is about the lotus motif. After clicking it, users will get an audio introduction about the transfer of the lotus motif from China to Persia through Blue-and-White porcelain trading. The lotus motif was originally derived from Buddhism. Eventually, it became a common decorative element in Persian porcelain because of the Chinese influence.

For the current prototype, I used audio to display the narrative. There are many opportunities here for future designs, such as image, video, interactive animation and more. I will talk about the future works plan and potentials in the upcoming chapters.


*Figure 15 Screenshot of the prototype "Blue-and-White". Users can click the dialog icon to get audio about the relationship between these two artifacts through the story of the blue pigment and the lotus motif.*

### 4.3.3 User Testing

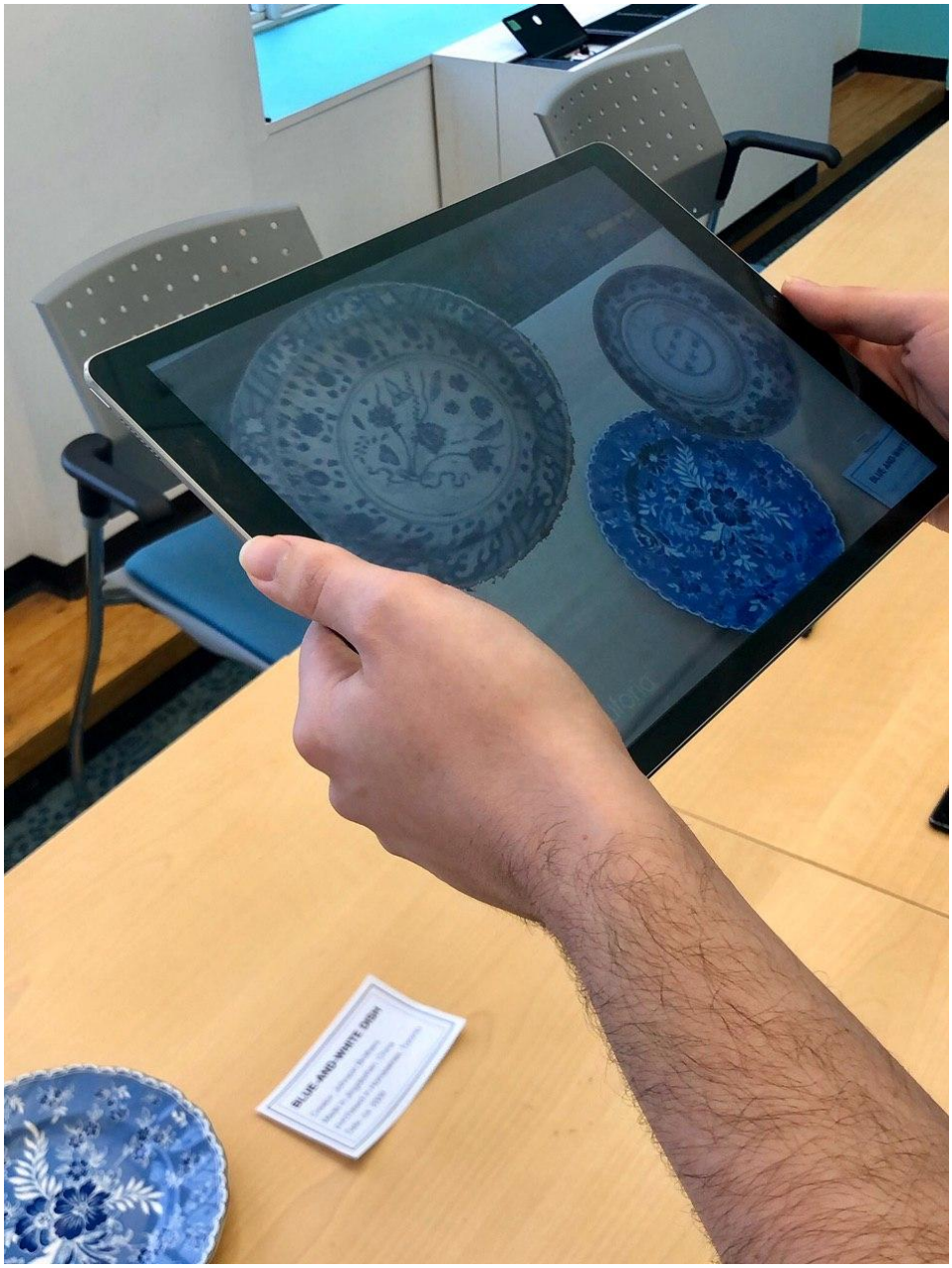


*Figure 16 User testing of the prototype "Blue-and-White".*

To evaluate the overall design and experience of the prototype, and to get suggestions about future work, I recruited ten anonymous participants in total to playtest this application. These participants are all undergraduate and graduate students from OCAD University. There was one participant per test. After signing the consent forms,

participants began using the prototype on the iPad to interact with the Blue-and-White dish on the table. Then each tester was asked to complete the questionnaire. This user testing mainly focused on exploring whether the narrative effectively transfers the description about the historical links between these two artefacts, whether the design of the interface is reasonable, and whether the augmented reality experience helps raise awareness about the dialogues between cultures.

### 4.3.4 Results and Reflections

According to the responses from the participants in the questionnaire, this prototype can be used to meet my research goals. To begin with, all participants thought it would be a promising prototype in a museum space. (Figure. 17) Many of them believed it was a rare experience, one they haven't observed in a traditional museum.

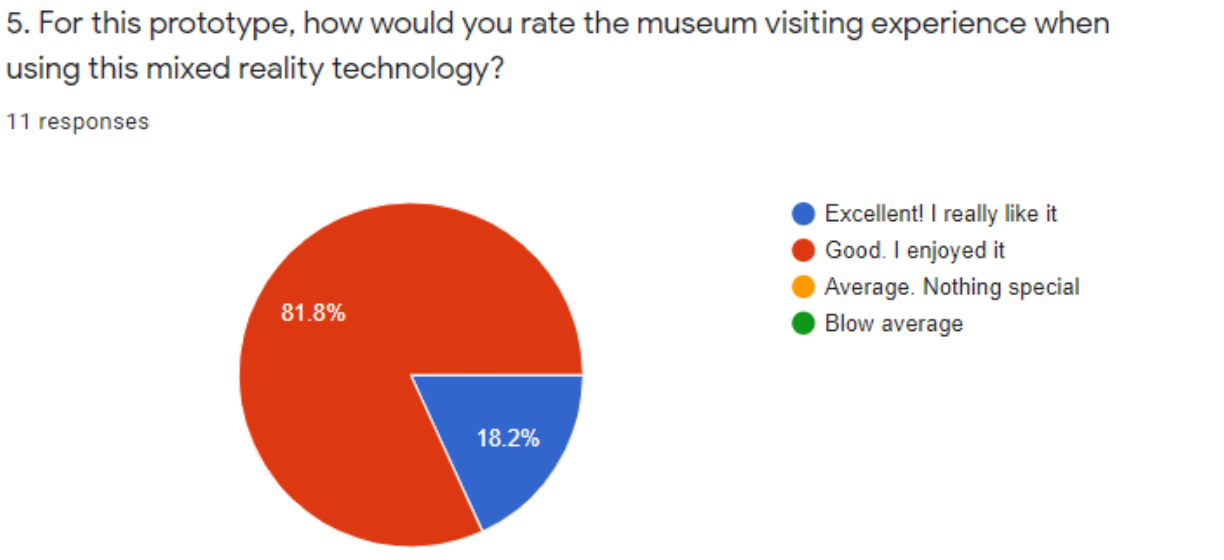


*Figure 17 Response from participants regarding their experience.*

Additionally, most of the participants said they had not realized the similarities between the artefacts, and the audio story in the prototype made them rethink the connections between cultures. All the participants agreed that the prototype helped them learn about the connections between Chinese Blue-and-White porcelain and Persian Blue-and-White porcelain. 91.7% of participants grade at least 3 in 5. (Figure. 18) The positive feedback proves that the prototype can be effectively used to encourage visitors to consider the relationships between cultures in the museum space.

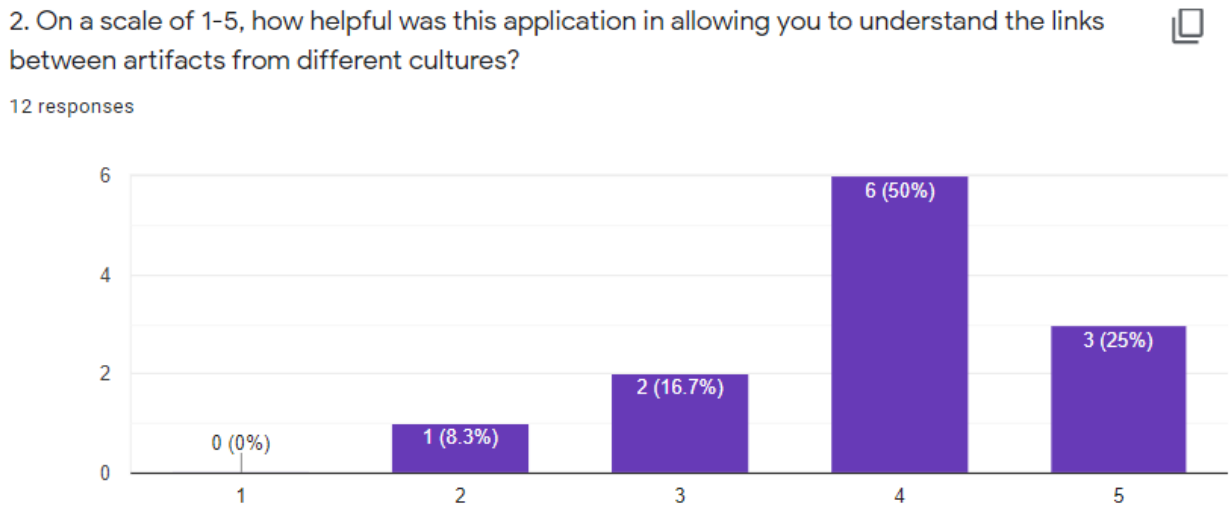


*Figure 18 Response from participants regarding the representation of the links between two cultures.*

At the same time, I also received a lot of constructive feedback from the users which could be used to improve the prototype in the future. 50% of the participants thought the interaction design needs to be improved. Many of them wanted more interaction with the virtual artefact, such as scale up and down, rotation, reposition, clicking to see details and more. 16.7% of the participants thought the information visualization could be better, although most of them felt positive about the audio. Many of them suggested adding more content to the virtual objects, like images, videos and timelines. While 16.7% of the participants believed that the interface design could be more refined. Some

of them believed it would be clearer if the lotus motif and blue pigment could be highlighted when the audio is playing. (Figure. 19) Besides, testers also mentioned adding guidelines and making the hotspots more attractive.

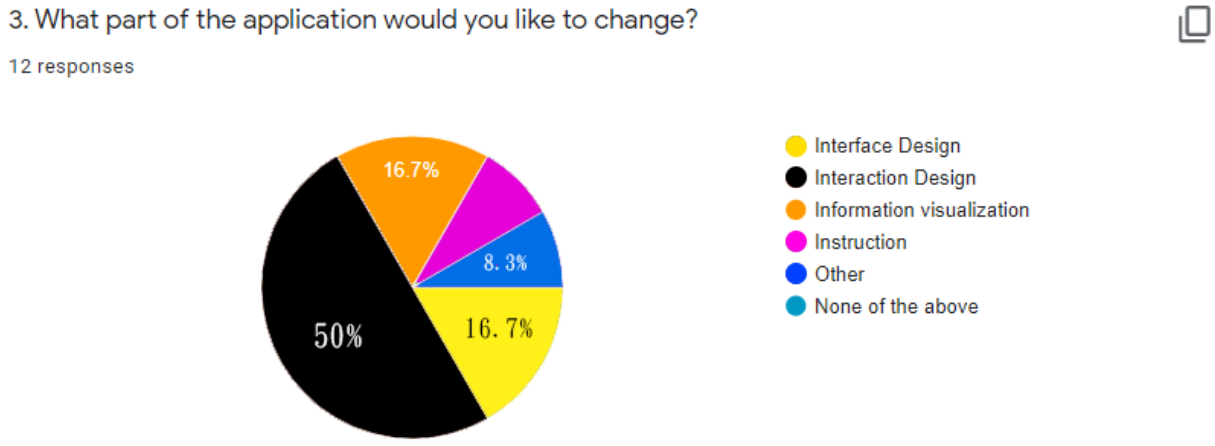


*Figure 19 Response from participants regarding future changes of the prototype*

My observations on the participants from the user testing are as follows:

- Most users need a guideline to learn how to use the prototype
- Audio is an effective and interesting way to tell the story, but both audio stories are a bit long
- For non-native English speakers, the existing audio makes it more difficult to learn
- The current virtual objects are too close to the physical objects
- In general, participants will want to try to magnify virtual objects
- Most participants are surprised by the similarity of artefacts from different cultures
- The iPad Pro used in the testing is heavy for many participants

Through the analysis of user test results and self-reflection, I found this prototype effectively conveyed the cross-cultural connections between the two cultures through artefacts and inspired the thinking of the participants. However, I underestimated the importance of diverse interaction design and information visualization. Compared to other MR tools for museum visits, such as those mentioned in section 2.3.2, the visualized information of the prototype Blue-and-White should be more diversified. Users should get more interactive functions with the artefacts as well.

# 5. Conclusion and Future Orientation

## 5.1 Revisiting Thesis Goals

The goal of this thesis is to explore the relationship between museum artefacts, intercultural dialogue and mixed reality. The main goal of this research is to develop an MR tool, Blue-and-White, by taking Blue-and-White pottery from China and Iran as a case study to answer the following research questions:

- How can mixed reality help to represent cross-cultural links between artefacts and facilitate intercultural dialogue for the visitor at the museum?
- How can the mixed reality experience be used to represent cultural links between the artefacts in the museum to audiences?
- How might mixed reality be used as a mechanism for encouraging visitors to consider the relationships between cultures in the museum?

The Literature review chapter introduces the relationship between intercultural dialogues, artefacts, museums and mixed reality. It examines my argument that artefacts in museums can be served as a powerful vehicle for promoting cross-cultural conversation, especially by presenting the similarities and historical links between artefacts from different cultures to visitors. The historical connections between the Ming Chinese Blue-and-White porcelain and the Safavid Iranian Blue-and-White porcelain are used as a case study to further explain this argument. Meanwhile, mixed reality, especially augmented reality, is introduced as a powerful technical means to realize this process.

A series of prototypes were built in the research process. An immersive VR experience was initially developed by remixing museum exhibits in virtual spaces to explore how changing the presentation of artefacts can push visitors to rethink the relationship between different cultures. Subsequently, an interactive museum map using AR technology was developed to examine the impact of mobile-based AR technology on visitors' access to information. Finally, a mobile-based AR application was designed, called Blue-and-White. This application brings the Safavid Persian Blue-and-White porcelain and Chinese Blue-and-White porcelain that come from different physical spaces together through augmented reality technology, and tells the historical relationship between them to the users through audio.

Also, the prototype examined the role of mixed reality (MR) for intercultural dialogue in museums and its potentials. According to the usability criteria for expert and guideline-based evaluations summarized by Andreas Dünser and Mark Billinghurst. (294) I developed this table:

| MR features | visual output | interaction | engagement |
|---|---|---|---|
| **Utilization in prototype Blue-and-White** | Display the 3D models of the artefacts from two different cultures and multiple locations in one space. | Click the virtual buttons to learn the stories between artefacts through audio. | Enhance visitor's interest and experience to explore the intercultural connections between the artifacts. |
| **Future potential in museums** | Display any artefact from the museum collection in any location of the museum based on the intercultural connections. | The stories between artefacts can be shown in countless visual ways, such as images, videos, text, etc. | Visitors from different backgrounds can input their interpretation about the artefact and form the intercultural dialogue with others. |

*Figure 20 The role of mixed reality (MR) in Blue-and-White and its potentials in museums.*

## 5.2 Contributions and Limitations

Based on the results of the user testing of Blue-and-White, MR technology, especially AR, in this case, can be used as an effective means to represent the intercultural links between artefacts from different cultures, and stimulate visitors to reassess the relationship between these cultures. Also, a thorough literature review at the intersection of museum artefact, intercultural dialogue and mixed reality was displayed. Currently, many museums and institutions are using MR to improve the presentation of information and increase the engagement of visitors. However, it is rare for the technology to be used to demonstrate the connections of exhibits to facilitate cross-cultural conversation.

The research also has some limitations. First, it's still only available on a small scale. The museum's digital staff can only use the tool to customize the artefacts and the narrative to visitors. It is unable to identify all museum objects and then display the intercultural links automatically. However, this research promises to raise awareness about the importance of artefacts as agents for promoting intercultural dialogue. Mixed reality can be used as a strategic possible technology to facilitate this process. To achieve the larger picture of this idea in the future, the further development of mixed reality, artificial intelligence and mass databases for the museum collections are necessary.

## 5.3 Future Works

The current prototype Blue-and-White needs to be more polished. For my future work on this research, I choose to follow the feedback I received in the user testing. Many testers think the prototype's interface design and interaction design need further improvement. I will, therefore, focus on optimizing the user interface and interaction design by adding instructions at the beginning of the application, more interactive features to the virtual objects such as zooming in to see details and rotation function, place the information buttons in a more prominent position, and explore more possible visual ways to replace and facilitate the audio information, such as images, videos, text, etc.

Beyond this prototype, I am excited about the future of this research topic. MR technology, especially AR, has been widely used in museums, such as wayfinding, tour, entertainment and educational activities. However, it is rare to see the cross-cultural relationship between artefacts being displayed through MR technology. I imagine that

museum collections will be classified in the mass database in the future. All the artifacts, no matter wherever they are, are interconnected through the historical relationships. Museum visitors can use a mobile device with the MR function to scan any artefact for its intercultural connections with the rest of the artifacts. As a result, MR brought the potential to decentralize the museum: the visitors can be free from the constraints of the space in which the artifact is placed, resulting in a more diverse understanding of the museum's artifacts. Furthermore, visitors from different backgrounds can take part in the interpretation of artifacts and share their stories with others. Therefore, the traditional curatorial practice and the hieratical order in the museum might be challenged.

## 5.4 Final Thoughts

As a case study example, this research is just the beginning of the combination of museum artefacts, intercultural dialogue and mixed reality. I want to encourage other researchers, designers and institutions to consider the potential that digital technology brings to the museum for intercultural dialogue. As I mentioned in the introduction of this document, I hope museum collections can become free, connected, dynamic and accessible archives of human existence across time and place which will serve the societies that support them.

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# 7. Appendices

### Appendix A: REB Approval Statement

This project has been reviewed and received ethics clearance through the Research Ethics Board at OCAD University.

# Appendix B. Questionnaire

**Questionnaire**

Participant number
Date
Time
Place

1. On a scale of 1-5, how much did you find current visiting experience in museums help you understand the links between artifacts from different cultures?

1 2 3 4 5

1a. Follow-up: What makes you choose that score?

_____

2. On a scale of 1-5, how helpful was this application in allowing you to understand the links between artifacts from different cultures?

1 2 3 4 5

2a. Follow-up: What makes you choose that score?

_____

3. What part of the application would you like to change?

- Interface Design
- Interaction Design
- Information visualization
- Instructions
- Other_____
- None of the above

3a. Follow-up: What makes you choose that?

_____

4. Have you experienced mixed reality applications in museums before?

- Once
- A few times
- Regularly

- Never

4a. Follow-up: How does that experience compare to this experience in the testing?

_____

5. For this prototype, how would you rate the museum visiting experience when using this mixed reality technology?

- Excellent! I really like it
- Good. I enjoyed it
- Average. Nothing special
- Below average.

5a. Follow-up: What makes you choose that?

_____

6, What is your least favorite part of using mixed reality technology in this museum visiting experience?

_____

7. What did you think of using this application as a learning tool in the museum?

_____

8. What other functions would you like to see in this application?

_____