

Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

# **“Bring History Alive”: Exploring the Evolution of Flying Apsaras in Mogao Caves.**

A thesis presented in partial fulfilment of the requirements for the degree of Master of Design at Massey University, Wellington, New Zealand.

**XINYUE DAI, 2019**

# Abstract

This research project explores a visualisation framework with an educational purpose for digital heritage, by using a digital story-telling format. It examines a visualisation that demonstrates the historical evolution of the flying Apsaras - one of the main characters of ancient grottoes in Mogao caves, located in Dunhuang province, China. Culture and religion merged in Dunhuang, an ancient city in the middle of the Silk Road. Dunhuang was influenced by multiple cultures - from the West and East, and it was in this context that the Mogao Caves was established. On the wall paintings, the flying Apsara was a vehicle through which cultural changes in a thousand years were shown, through changes in their appearance. Now due to the environmental problem and over-visiting of the Mogao Caves, visitors can only explore a limited number of caves and have difficulty understanding the stories in the faded and incomplete murals. This project thus examines art style transformation of the murals, extracted representative symbols, and patterns and colour sets of each dynasty reinterpreted in a digital narrative with a modern aesthetic. The methodologies used in this project encompassed historical analysis, character design, and experience design that includes information design. The design output provides an accessible framework for other designers engaging with a digital heritage like the Mogao Caves. Also, by extending this project, potential functionalities of digital narrative could be explored for educational purpose.

**Keywords:** the flying Apsara, digital story-telling, experience design, character design, digital heritage, Mogao Caves.

# Acknowledgements

I want to give a warm thank you to my supervisors, Tanya Marriott and Dr Jacqueline Naismith. Their support and insights have guided me throughout my master journey.

# Table of Contents.

Abstract.....	i
Acknowledgements .....	ii
Table of Contents.....	iii
Introduction .....	1
Research question .....	5
Digital Heritage in Museums and Exhibitions .....	5
Digital Storytelling for Educational Purpose. ....	7
Cultural Heritage, Storytelling and Design.....	8
Experience Design for educational purpose. ....	11
Precedent Analysis. ....	15
Methodology.....	20
The Project.....	21
Conclusion and Further Development. ....	34
Reference List.....	35
List of Illustrations. ....	38

---

# Introduction

This project is an exploration in both cultural heritage and digital storytelling realms. It designed a digital storytelling framework through analysing a group of ancient Buddhist caves – the story of the flying Apsaras begins from there.

There are many Buddhist caves in the world. Tracing the ancient Silk Road from West Asia to East Asia, the spread of Buddhism also brought about many Buddhist caves, which included the Mogao Caves, located in Dunhuang, a city with a long history.

Among the Chinese Buddhist caves, the Mogao Caves are undoubtedly well-known, contain a long history of Buddhist illustration, and have a unique status in Buddhist art (Fan, 2014). They contain 492 existing caves and 4,500 m<sup>2</sup> of grottoes, and over 2,000 painted clay sculptures (Ma, 1995). The art work in the caves encompasses more than ten significant genres which include architecture, sculptures, murals, textiles, printed images, dance and music (Centre, n.d.).

Another important aspect of the Mogao Caves is the unique art style. The Mogao Caves contain a great number of narrative paintings in two main subjects, *Jātaka*<sup>1</sup> stories and Sutra Paintings<sup>2</sup>. These paintings cover different art styles from East to West, spanned over a thousand years, which makes the Mogao Caves valued and different from other heritage caves.

On almost every narrative painting in the Mogao Caves, there are characters called the Apsara, or the flying Apsara (Feitian). They are flying gods or goddesses in Indian

---

<sup>1</sup> Stories of former lives of the Buddha, preserved in all branches of Buddhism. ('Jataka | Buddhist literature', n.d.)

<sup>2</sup> Paintings that illustrate an oral presentation of Buddhism. (Abe, 1990)

---

mythology, acting in roles such as spreading fragrance and music. When Buddhism came to China through the Silk Road, it brought the Apsara from India, and over time, it transformed from an Indian mythological figure to a Chinese woman figure. In the evolution of Apsara's appearance, its gender becomes more and more evident from the Indian to Chinese influence, and Chinese Apsara's typical long ribbons gradually evolved.

In 1990, a Chinese Taoist, Wang Yuanlu accidentally found the main cave of the Mogao Caves, also known as the Library Cave (Wang, 2012). After Dunhuang was abandoned by rulers in the Yuan Dynasty, the Mogao Caves had slept in the desert for approximately seven hundred years. Then, China came into a turbulent period where the Mogao Caves were severely damaged. However, since the 1940s, China has attempted to protect the caves from further damage (Tu, 2014).

Today, the two main issues the Mogao Caves face are environmental problems and over-visiting. These two issues are the direct causes of the murals going mouldy, exfoliating, and becoming detached from the wall (Fan, 2014).

Figure 1. *(Demas, 2014) Crowd at the Mogao Caves during peak visitation.*

---

The average number of visitors in 2014 was more than the caves could accommodate; this was over 6,000 per day and over 700,000 that year. The consequence of this level of over-visiting raises the temperature and moisture (caused by visitors exhalation) in the caves, indirectly causing irreparable damage to the grottoes (Tu, 2014).

To solve the problem of over-visiting, the Dunhuang Academy decided to open a limited number of caves (approximately 30) at a time, with careful monitoring to ensure long-term preservation of the caves (Tu, 2014). Also, the murals and statues are protected by glass panels, lit only by low intensity LED lights in most caves (Kenderdine, 2013). Simultaneously, the Dunhuang Academy started to build the Digital Centre base and online library Digital Centre database. During this time, there was also a reduction in the amount of time that visitors could spend in the caves. However, people were able to spend time visiting the digitalised version of the Mogao Caves.



Figure 2. *Visitors queuing in front of the digital centre of the Mogao Caves. Dai. 2018*



---

Now with the opening of Digital Dunhuang, the digitalisation data of about 30 caves have been put online for the public, but compared to the total of 492 caves and the speed of digitising 20 caves per year (Tu, 2014), it is still a long-time project. Also, due to environment problems and over-visiting, some caves are temporarily closed for protection and restoration, some even permanently. That means the real caves of some dynasties may never have a chance of opening again. Even visitors who can access the inside of the currently open caves often find that the visitation time of sixty minutes is insufficient. Even visitors have a chance of seeing each cave in isolation. They arguably cannot distinguish the difference and transitions of art styles from one dynasty to another, but by seeing a composition of symbols, colour sets and figure movements of the caves, side by side (which is what this project is trying to achieve), it can enhance the visitors understanding of the Mogao Caves art styles in a short time, simultaneously reducing the damage of caves caused by over-visiting.

In an historic site tour, especially one like the Mogao Caves which combines the visitation of a digital centre with that of the caves themselves, there are questions not only over how to collect and display digitalisation data or how to protect the cave from over-visiting, but also on how to enhance visitor's understanding of the heritage context. Furthermore, the description of these historic sites through representation and interpretation using digital media can raise people's interest in cultural heritage, especially for the educational and cultural institution such as a museum.

This research project sets out to produce an educational visualisation that demonstrates the historical evolution of the flying Apsaras in the Mogao Caves, as well as the art styles of paintings among different dynasties. As design research with educational purpose and Buddhist content, it involves many realms such as historical analysis, digital heritage, digital storytelling, experience design, and information design which are explored in the process of design.

---

The following sections discuss the use of digital heritage and digital storytelling in museums and exhibitions for educational purpose, the methods used in this project, and the process of design prototype.

## Research question

- How can digital storytelling express the uniqueness and transformative qualities of the flying Apsaras in the Mogao Caves?

## Digital Heritage in Museums and Exhibitions

This exegesis has a specific focus on storytelling design within a digital heritage framework; a new concept that emerged in the digital age. Digital heritage is a growing field of research for everyone to access knowledge about heritage and relics online, thereby making historical artefacts globally accessible. It has been widely used in museums, educational exhibitions, archaeological study, and the entertainment industry. The process of heritage digitalisation includes laser scanning sites or relics, and one-to-one scale modelling sites or relics after precise measurements to ensure that the architectural ratio is accurate. More than one type of digitalisation technique could be used to collect digitalised data from a historical site, due to the size difference and mobility of items. For example, in the digitalisation process of the Mogao Caves, a one-to-one scale site may be modelled with a 3D software first, then murals and sculptures may be laser scanned and placed in the site's model.

Digital heritage contains high-quality imagery and is convenient to access, which is significant given that visitors have limited time at the origin sites. Instead of visiting physical sites or museums in person, visitors can visit the digital heritage online libraries if they choose, and can zoom in to the picture to get more details. In Mogao

---

Caves' online library Digital Dunhuang run by Dunhuang Academy, visitors can get information about each cave including cave type, dynasty, high-quality mural pictures, and stories about the cave, by clicking in the cave number. Also, every digital cave provides a panorama view, which allows visitors to explore the cave's insides by click and drag or through virtual reality equipment, while the website provides an easy and accessible way for everyone to explore the murals inside the Mogao Caves. It only shows the caves' situation for now, which means the figures and symbols are illegible due to fading and detachment. Also, just as in visiting the site in person, each digital cave is isolated on the website; it requires people to click and see it one by one when they want to compare the art style between two caves.

Figure 3. *Dunhuang Academy. (2017) Mogao Grottoes Cave 285 Page*, retrieved from <https://www.e-dunhuang.com/cave/10.0001/0001.0001.0285>

Today, with more museums opening digital tours, taking heritage off the site is no longer a tricky thing. While some heritage elements, like ancient frescoes, can be easily found online in a digital version or the digital exhibition, some people are still not interested or find it difficult to understand the context, which is possible because they need some form of context or narrative to give the experience meaning. For example, Mogao Caves contain more than two hundred stories

---

painted on the wall, but only a few of these stories are now well-known.

## Digital Storytelling for Educational Purpose

To enhance people's understanding of ancient heritage, the digital narrative is an effective and efficient way to work with digital heritage data. The digital narrative is a way of story-telling that displays dynamic images via digital media, this way; core information can be extracted from frescoes and interpreted in a new narrative, then presented in front of audiences. For the visitors that only have limited time to access physical heritages sites, a condensed digital narrative can help them understand the basic framework of the story in murals in a short time, thereby helping them to gain more detailed information.

The framework of digital narratives for heritage like frescoes that include stories, highlight the points in these stories and use the main character to string these points together logically. This frame can condense the long stories of heritage into short narratives without losing core information, and effectively pass on heritage knowledge to visitors.

More than ever, people want to experience both “education” and “entertainment” when they are exposed to digital heritage. On the one hand, the traditional way of

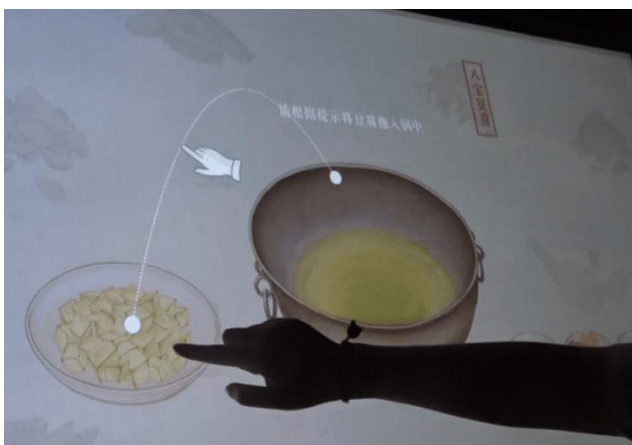


Figure 4. A visitor is experiencing an interactive game in the National Palace Museum, Dai, 2018

representing heritage, which is to focus more on education and interpretation, is hard to attract people's attention, on the other hand, too much emphasis on entertainment seems to make the heritage element subordinate. Finding the balance between “digital”

---

and “heritage” will be a growing issue with the development of technology.

## Cultural Heritage, Storytelling and Design

This project used research through design as the primary research method. It used historical research, precedent analysis, digital story design, and experience design. The historical research addresses the context of changes in the historical site and the narratives of the frescoes, focusing on one character of the frescoes. The precedent analysis explores the work related to digital story-telling in the heritage realm, discovers what they achieved, and identifies gaps in design innovation. The designer then designed a sequence of an experiment to test for the best way to represent digital stories for heritage.

the middle section of this document outlines the designer used digital story design to create a linear narrative for the characters in the Mogao Caves and design the physical space through experience design.

In the sections to follow the project discusses the research method used in this exegesis, the theories behind digital storytelling for cultural heritage, and the process of designing the prototype.

### ◇ Storytelling in the past and now

There are many different definitions of digital storytelling, but in simple terms, it means to use digital media to express a story or narrative. Multimedia such as video, audio, and images, can be used in digital storytelling (Robin, n.d.). While digital storytelling, unlike traditional storytelling, conveys a narrative through media, they still share the core thing – a story.

Traditional storytelling places more emphasis on engaging characters and exciting plots, comparatively, digital storytelling can integrate the elements of conventional

---

storytelling and address different learning styles (J, Borst Brazas, & Kajder, 2004). That is one reason why most museums now choose digital storytelling as a new way to represent collections and as a strategy to attract audiences, especially younger visitors.

Research on theme-based storytelling methods in museums shows there are three kinds of ingredients can deliver to audiences: 1) Cultural heritage information, 2) Authored stories about cultural heritage information, 3) Interactive experience (i.e. augmented reality games). (Dal Falco & Vassos, 2017).

Other research on using digital storytelling in cultural heritage institutions also points out some questions that need to be considered when putting storytelling in museums (Ioannidis et al., 2013). For instance, 1) how can it find the balance between providing rich information and telling the story effectively? 2) Should it target the entire audience or deeply satisfy some? 3) How can it create motivation and engagement for audiences? These questions provide a useful way for subsequent designers to build their criteria when they work on similar themes.

As shown above, authors produce general or specific criteria from different concerns. There are no standard criteria in the digital storytelling realm because the designer's purpose may vary. For example, a framework called "the modular structure" is often used to blend storytelling with teaching and training for educational purposes. This is outlined in Miller's book "Digital Storytelling, A Creator's Guide to Interactive Entertainment". There she states: "The structure of a digital narrative consists of big building blocks and small building blocks. In the modular structure, each module is like a big building block, it plays an independent role in the whole narrative, and contains its small blocks(information), which audiences can visit in any order." (Miller, 2014). For example, in this project, the

---

## **10 Step Checklist**

- Premise and purpose
- Audience and market
- Medium, platform, and genre
- Narrative elements
- User's role
- Characters
- Structure and interface
- Fictional world and settings
- User engagement
- Overall look and sound

flying Apsara figures are playing the role of “big blocks”, and the patterns and symbols are playing the role of “small blocks”. She also creates a 10 Step Checklist, along with the modular structure, to check if the information is well arranged into different blocks (as shown in Image 3).

Figure 5. *10 Step Checklist. Adopted from Miller H.C. (2014). Digital Storytelling, A Creator's Guide to Interactive Entertainment*

### ◇ **Digital Storytelling in Museums.**

The development of digital technology in museums enables static relics and artefacts to become highly involving and interactive, by making use of techniques such as holographic images, animatronic characters and immersive environment.

In recent years, museums and exhibitions have become a new home for mixed or augmented reality. Digital elements and physical objects are put together in the same space to create an immersive environment and may interact with each other (Miller, 2014).

Miller's discusses the use of large theatrical-sized movie screens in exhibitions to create an immersive environment. Compared with the V.R.(Virtual Reality) technique, the large screen can usually offer little or no opportunity for audiences interaction, but it still takes participants on a fictional journey, because of the size and shape of the screen(sometimes it is a wraparound curve), and it may have enhancements such as artificial smell and sound. Also, designing for a large screen is more comfortable than for V.R. equipment in some ways, because it draws upon

---

a cinematic narrative tool, which most designers are already familiar with.

## Experience Design for educational purpose

### ◇ **Physical Space.**

Depending on the scale of museums or exhibits, the range of physical space for visitors can be as big as a multi-story museum, or as small as a single installation, but whether designing for a big or small physical space, three factors require consideration are; 1) Scene setting, 2) Mapping and Routing, 3) Crowding density (Goulding, 2000). In a small exhibition, scene setting requires a clear theme and concise content to enhance visitor understanding and orientation. Prominent signs and pointers can act as a spatial controller to directly attract people's attention, guiding the direction of their visit. Also, sensory design can be a kind of sign, for example, a specific fragrance can attract people without engaging them visually, and by providing multi-sensory features, it can increase the richness of visitor experience, and make it more memorable (Eardley, Mineiro, Neves, & Ride, 2016). Crowding density may vary at different times. Therefore, the maximum number of visitors at peak time should be considered to avoid congestion.

### ◇ **Social Interaction**

Visitors often come to an exhibition or a museum as part of a social event, but social interaction is widely ignored by researchers (Heath & Vom Lehn, 2004). Social interaction does not only occur when people visit the physical space but also before and after it. According to Selvadurai & Rosenstand (2017), people find other people's pictures and comments about the exhibition online before their visit; this is called the "pre-visit". During their stay, they photograph the exhibition and upload it on social media and these comments and pictures can be found by others as the pre-visit. These three parts, pre-visit, visit, and post-visit combine to comprise the



---

whole process of visitors social interaction.

As stated above, visitors do not only attend exhibitions for leisure or education but often desire various types of shared experience with other attendees. They come with a purpose and prior knowledge, like looking for “goods” on a “shopping list”(Goulding, 2000). Once we understand this relationship, it becomes easier for designers to think about visitor motivation.

### ◇ **Information design.**

Information design has been widely used in many realms, which includes experience design for educational purpose. As the diagram below shows, the designer’s role is to convert data into information and convey that information to audiences. Raw data is easy to collect and is everywhere. Without organising and processing, the audience will feel overwhelmed by too much information, which is called “information overload” (Shedroff, 2011).

Shedroff notes that data can only be organised by seven principles into three groups, which are: 1) Time, Numbers, Alphabet, and Magnitude. 2) Category and Location. 3) Randomness. Besides the last one, randomness, which is often used in game design, the first two groups can effectively be used for the design of digital heritage storytelling, especially time and location, specific to the theme of historical sites.

For example, at a historical site like the Mogao Cave, different kinds of data can be sorted by different principles. The Mogao Caves can be divided into the Thousand Buddha Caves and West Thousand Buddha Caves by location. In the Thousand Buddha Caves, caves can be sorted by cave numbers, and cave numbers can be put together into groups by time range (dynasties). Also, items in each cave like murals, clay sculptures, silk paintings, and Buddhist scriptures can also be organised by either category or magnitude.

---

The benefit of organising data in this way is so that when extracting information from data, whatever for, representation or organisation, core information can be easily found from raw data by different principles and organised by their labels (e.g. Cave 256, murals), thereby making further exploration easier and more structured.

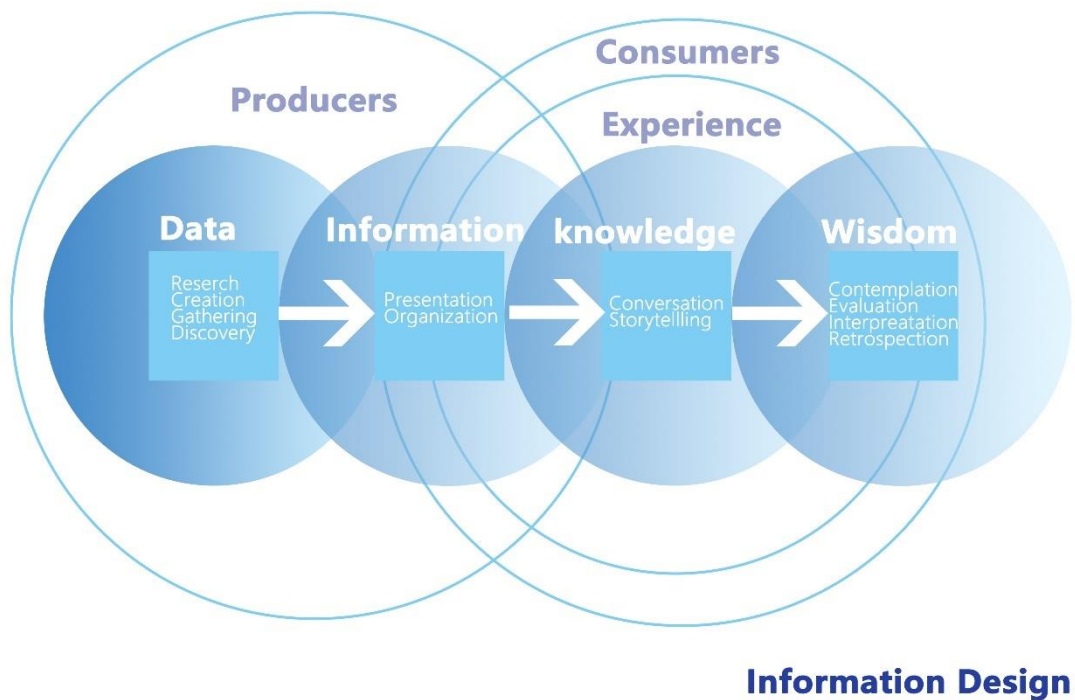


Figure 6. *Information Design Method. Adapted from Shedroff, (2011), Experience Design*

### ◇ **Character Storytelling for digital Heritage.**

Now, digital heritage is becoming an increasingly popular way to represent a cultural heritage site. Reconstructing a historical site in 3D software is no longer a hard task. However, there is an essential factor that is often missing in this virtual scenario - human presence (Machidon, Duguleana, & Carrozzino, 2018).

There is no doubt that most historical sites have no resident anymore in the present, but if tracing back, they must have some functions for human activities. That is why

---

a virtual character is important for a digital site. An appropriate virtual character can appeal to visitors to interact with the virtual environment; it can also enhance visitor's understanding of the site's function, the background story, and even the social environment in that time.

Just like visitors are keen to know the story of historical sites, so are they eager to know the story behind a virtual historical character – if the character is attractive enough to grab their attention. An effective way to make a virtual character interesting is to keep a sense of mystery, and throughout the narrative, audiences can dig out more stories about this character (Tillman, 2012). Tillman also points out that three factors need to be considered during character design: 1) Age group, 2) Genre, 3) Colour. The first two factors should be connected to the visitors who come to the site. For instance, if it is a historical site, who will watch that? Children or Adults? What genre do they belong? Are they cultural aficionados? For the third factor, a character's colour set can either link to the environment or its characteristics. On the other hand, a distinctive colour set can also help audiences distinguish the character from others, which is helpful in a virtual heritage site with more than one virtual character.

---

## Precedent Analysis

The following three precedents demonstrate an animation film adapted from a story on the murals in the Mogao Caves, an augmented reality exhibition of one cave in the Mogao Caves, and a digital restoration project about a historical site in China in sequence. The first two precedents show the existing explorations on the digital Mogao Caves, and the last precedent elaborates a framework of organising and representing digital data in a historical site on the same scale as the Mogao Caves.

### ◇ **A Deer of Nine Colours (Jiuselu)**

*A Deer of Nine Colours* is an animation produced by Shanghai Animation Film Studio in 1981. It was adapted from a story painted on the wall of the No. 257 Cave in the Mogao Caves.

This animation is the first time in Chinese animation history that cultural heritage was combined with digital storytelling and thanks to this animated film, the story of the nine-colour deer became well-known to that generation. Unfortunately, after this first attempt, no one in the Chinese animation industry seems to have produced another animation of this kind. Even though there are over a thousand stories in the Mogao Caves, the story of the nine-colour deer is still the only well-known one.



Figure 7. Shanghai Animation Film Studio, (1981) *The Deer of Nine Colours*, (Animation), Retrieved from <https://www.youtube.com/watch?v=5srXRIJ7yBw>

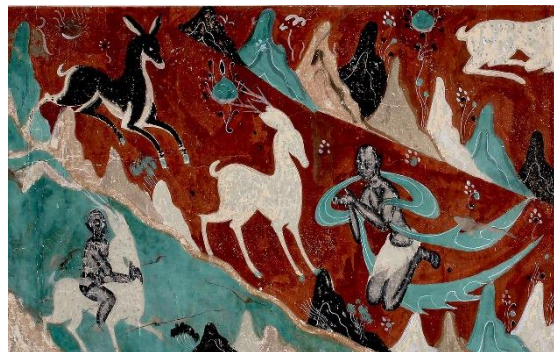


Figure 8. Dunhuang. (2014), *The Deer King Jataka*, (Murals) The Mural on No. 257 Caves in Mogao Caves

---

The character design of the deer almost keeps the original shape and style of the one on the fresco, as well as the background elements. Also, the aureole behind the deer's head references the aureole behind Buddhas and Bodhisattvas. The colour selection in this animation film tries as much as possible to keep the original taste of the mural in No. 257 cave; it allows audiences to imagine how the mural looked like when it was freshly painted, and also make visitors who have seen this animation film easily recognise this story on the wall.

While the Deer of Nine Colours has many shining points, it looks more like a “dynamic mural” than a reinterpreted digital narrative. Background and foreground don't have perspective – like a classic Chinese painting, cave painting style makes the images lack texture. Also, the success of this animation film to a large extent relies on the story itself – explicit characters with different characteristics, complete and straightforward story flow that means this storytelling framework cannot work on the other mural stories that do not have these features.

### ◇ “The Pure Land”

The exhibition “The Pure land,” by Sarah Kenderdine demonstrates the use of augmented reality with digital datasets to display the murals and relics in Mogao Caves. The project made a significant contribution to the digitalisation of Mogao Caves and built a bridge that connected digital heritage with traditional museum display. In the installations, due to the size of the cave, Kenderdine led a team of people, who conducted a laser scan of the permanently closed cave #220. This was done using augmented reality and 3D digital visualisations as layers on top of the murals. In the project, they used a multi-layered structure, to separate the original murals from the repaired (newer) layers so that the exhibition could represent an accurate and interactive exploration of the cave. Kenderdine's project does not only show the potential for digital display of the Mogao Caves, but also demonstrates the benefit of doing it.

---

Figure 9. Kenderdine, S. (2013) *"The Pure Land" – An exhibition project* (Digital Photograph). *"Pure Land": Inhabiting the Mogao Caves at Dunhuang.*

In this exhibition, three black screens make an open space for simulating the spatial distribution of the Cave #220; visitors can see the picture of real caves in the corresponding position on the black screen through the mobile devices in their hands. This method allows visitors to explore the cave their way, and compared to non-interactive installation, can enhance visitor's feeling of participation and engagement. While this method is not suitable for a large number of visitors as problems may occur in the arrangement and maintenance of mobile equipment, this visiting mode is still a good model in the digital heritage exhibition realm.

In many digital cultural heritage precedents, visitors may have felt immobile when they experienced a virtual tour with head-mounted equipment or engaged augmented reality with mobile devices. Visitor's pathways are not only designed for physical exhibits but also for digital content (Choi & Kim, 2017). Instead of arranging for digital content to be viewed when a visitor is immobile, it could be arranged on a pathway in the physical space to give them more options and a feeling of "fun."

---

Figure 10. Kenderdine, S. (2013). Visitors watching murals through an iPad in "The Pure Land" Exhibition. (Digital Photograph). "Pure Land": Inhabiting the Mogao Caves at Dunhuang

### ◇ Digital Yuanmingyuan (The Old Summer Palace)-Tsinghua Heritage Institute for Digitization.

Tsinghua Heritage Institute for Digitization completed a digital preservation team project based on the Old Summer Palace in 2017. Over a decade they have restored 60% of the area of Yuanmingyuan digitally, built four databases on Chinese architecture, Western building, plant material, and indoor material, and also developed more than thirty digital products which include V.R. (Virtual Reality), A.R. (Augmented Reality), A.R.G. (Augmented Reality Game), and 3D technologies. A company called "Beijing Re-Yuanmingyuan Co.Ltd." was also established to maintain collected data.

Digital preservation of the Old Summer Palace is more difficult than for other historical sites as it covers more than 800 acres and was destroyed in the Second Opium War ('The loot from China's old Summer Palace in Beijing that still rankles | Oxford Today,' n.d.). The digital reconstruction of this project is divided into four parts: 1) Data collection, 2) Historical research, 3) 3D construction, 4) Publication and maintenance.

---

In the data collection stage, the researchers primarily used chrono-spatial units to deduce the historical evolution of the site. This was because many historical sites in China including the Mogao Caves have changed over thousands of years and when persevering these sites, classifying relics and texts in chronological order, and geographical order is of equal importance. In the case of the Old Summer Palace, because it was built comparatively recently in the Qing Dynasty (1736-second half of the 20th century), researchers split the historical evolution time into six periods and named them by the emperors that ruled at that time. The other historical sites like the Mogao Caves were built over 13 dynasties; with some frescoes that are difficult to discern what dynasty they belonged, thus it is more appropriate to divide them by their stage of development (i.e., early period, late period).

On the other hand, spatial classification is also essential for historical sites that need to be preserved digitally. Generally, architectural structure is the first stage of digitalization in a historical site. It can be modelled with 3D software by using figures that are measured on the physical site. Then the second stage digitalizes the moveable relics (i.e., vase) and unmoveable relics (frescoes) in the site, which can use a laser scan technique and so on. After these two stages, the final step focuses on details such as colours and textures.

When facing these kinds of historical sites which have a long history and rich content, having both chronological classification and spatial classification is not conflict, but helps a lot when using the digitalization data that is recorded for representation or interpretation. Also, distinctive components are worth to privilege after digitalization work in these historical sites. Like with Yuanmingyuan and the Mogao Caves, it is hard to represent every garden and cave in detail without compromise due to the scale of the sites, then some of them with characteristics and stories (i.e., contain more information) are good samples to be present first.



# Methodology

This exegesis outlines an interactive storytelling project for the cultural heritage context that uses the method of research through design. Research through design is specifically suitable for the design that explores both theory and realization. In this exegesis, the interrelation is a pathway to create the prototype, which contains animation to show the historical evolution of the flying Apsara, and a Silk Road map to explain the cultural and artistic change in Dunhuang.

In this digital storytelling, the “storytelling” part comprises an analysis of the historical background and the context design of the storytelling and the “digital” part places more emphasis on technique preparation and experience design for physical space.

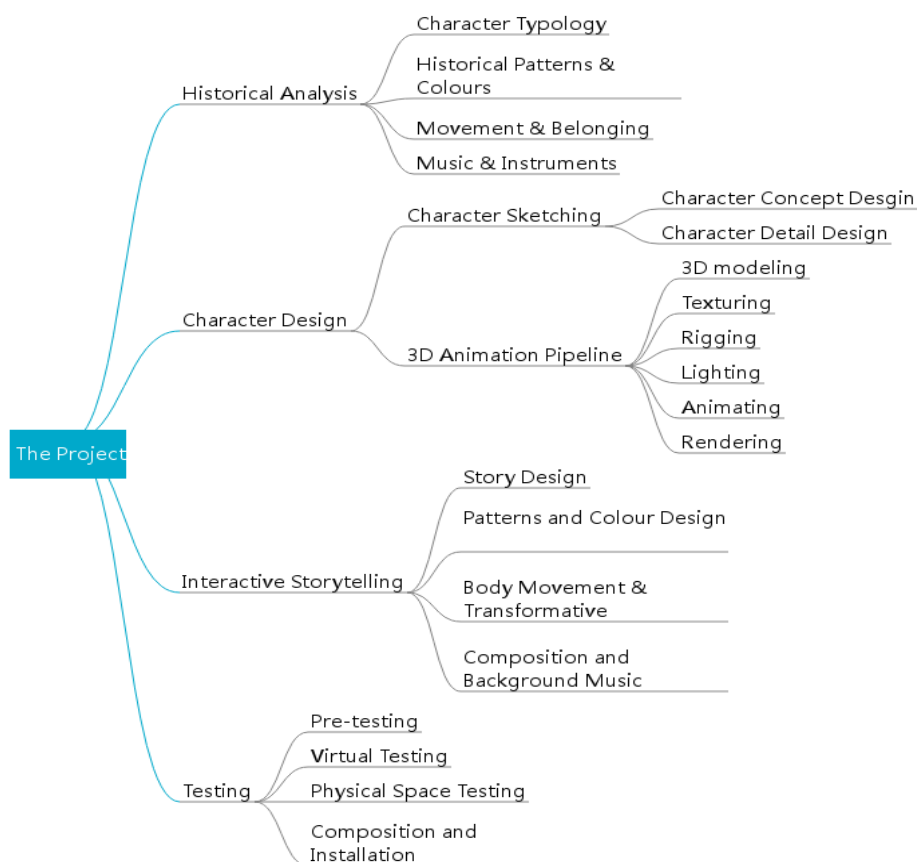


Figure 11. Flow of the 'Bring History Alive' Project.

---

# The Project

## ◇ Historical analysis

The first step before character design is historical analysis. Compared to designing a character for a film or a game which starts from zero, designing a character for a historical site begins with analysing the existing archetype. This project aimed to design four Apsaras for each period in line with the Mogao Caves' development time, hence, defining each Apsara character's genre is important in the early stage.

Due to the historical change and cultural transmission, the Mogao Caves' art styles are varied. The artistic styles influenced by many countries and cultures include Indian, Greek, Tibetan and Mongolian. Furthermore, when an artist from different cultures work in the Mogao Caves, they add elements from their cultural background which includes instruments, costumes, patterns, and so on. A distinct Apsara character can express its dominant art style or culture, while, a simplified Silk Road map can tell us where this culture and art style belongs. In my installation, the flying Apsara animation works together with 2D cultural elements, to approach the goal of digital heritage representation and interpretation. Because the Apsara character adapted from original murals, the Apsara animation takes the role of "representation," and, because the 2D cultural elements transform from one dynasty's art style to another, it will show a process of "evolution."

Figure 12 demonstrates four typical Apsara characters in the Mogao Caves from different dynasties in chronological order. In each frame, the right side is the original frescoes. Meanwhile, the left side is the character sketch outlined according to the source.

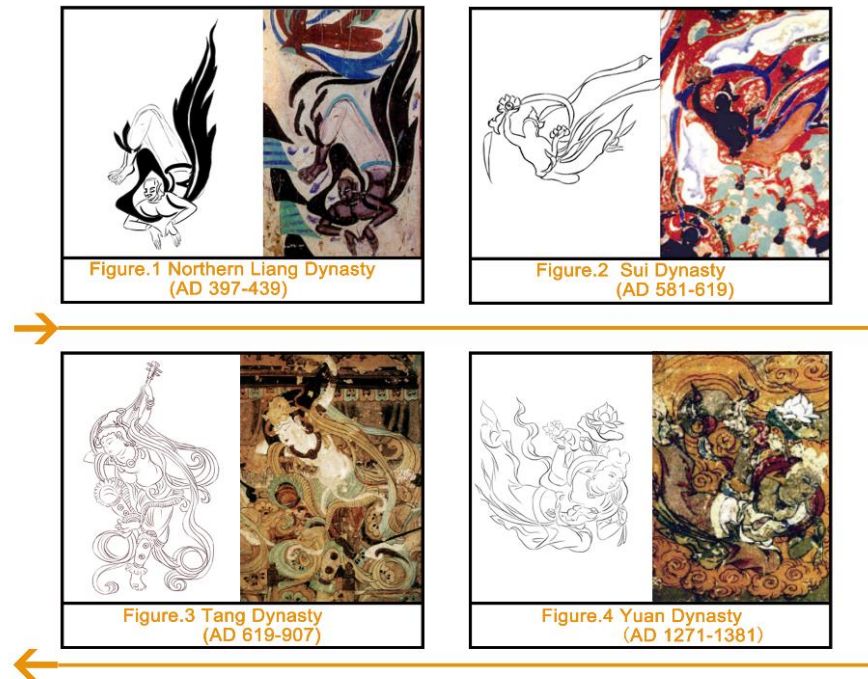


Figure 12. *The Apsara appearance in different dynasties.*

The first image in Figure 12 shows the early period of Mogao Caves' building (i.e., Northern Liang Dynasty and Western Wei Dynasty). During the painting process of the flying Apsaras, the Apsara appeared to have an Indian style of artistry with a male appearance in a "V" shaped pose. Though, in the Northern Wei Dynasty, the Apsara had a more female appearance and began to sinicise (transform the Apsara into Chinese appearance) (Dunhuang Academy, 2014).

In the second image in Figure 12, The Sui Dynasty (AD581-618) is a short-time dynasty which only lasted for 37 years. While the dynasty did not exist for a long period, it managed to build over a hundred caves and created many murals containing different religions, including Buddhism. As such, it is often said that the Sui Dynasty is the most creative dynasty among all of the Mogao grottoes.

The art of Mogao Caves reached its zenith in the Tang Dynasty, as showed in the third image in Figure 12. There are still existing caves from the Tang Dynasty, which make up almost half of all caves. During the Tang Dynasty, the flying Apsaras no

---

longer take on a western face, and no longer resemble a goddess. Instead, the Apsara is becoming more of regular Chinese women while dancing and playing. The flying Apsaras are highly secular in the Tang dynasty (Dunhuang Academy, 2014).

In the Yuan Dynasty (the last image in Figure 12), Dunhuang was conquered by Mongols, and during the time, the flying Apsaras' faces change to western appearance again, and they even appeared with blond hair. Also, the paintings have been created to look closer to a Taoist style, rather than a Buddhist style.

## ◇ Character Design

- **Prototype**

Character design is an important part of the process of interactive storytelling. Figure 13 shows the four Apsara characters sketch from four different periods. From left to right, the Apsara derived from an early period, middle period, peak period and late period. Following the historical analysis above, each Apsara has been equipped with a ribbon, skirt, headwear and accessories. Most of the original Apsara painted in the Mogao Caves resembles a god or goddess with complicated lines and patterns. In contrast, I decided to keep the Apsara's appearance as simple as possible by removing the unnecessary extra patterns and lines, and abstain the key features. Also, the project is presented in a short animation (around 2 minutes). The extra details make it harder for the audience to focus within a short time. Therefore, for each body part, I selected only the key features from their dynasties and combined them together. This will allow the audience enough time to comprehend each design details within the animation time length.

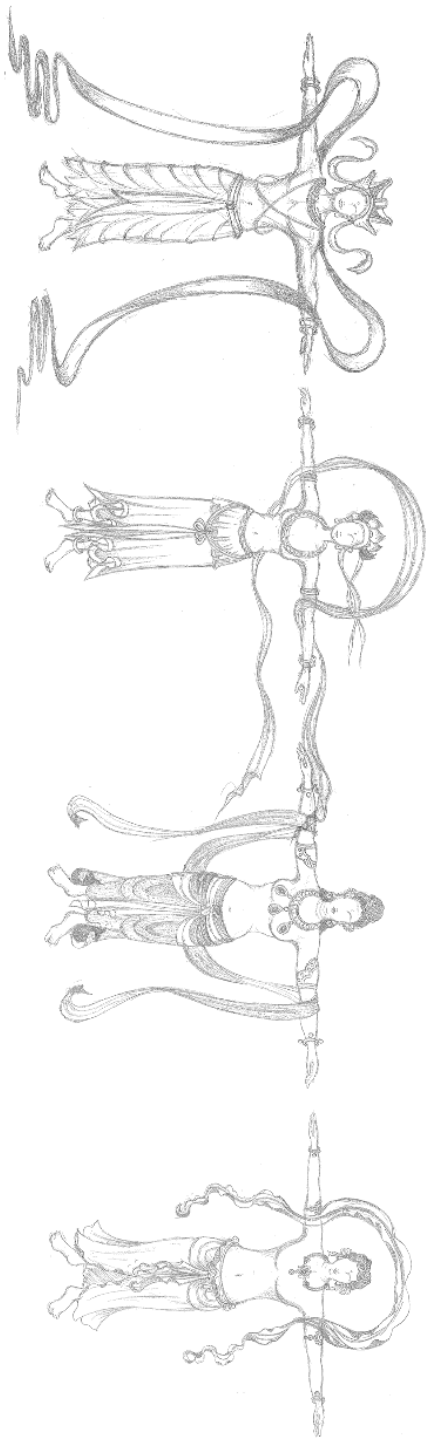


Figure 13. Sketch of the four Apsaras from the early period to the late period, left to right.

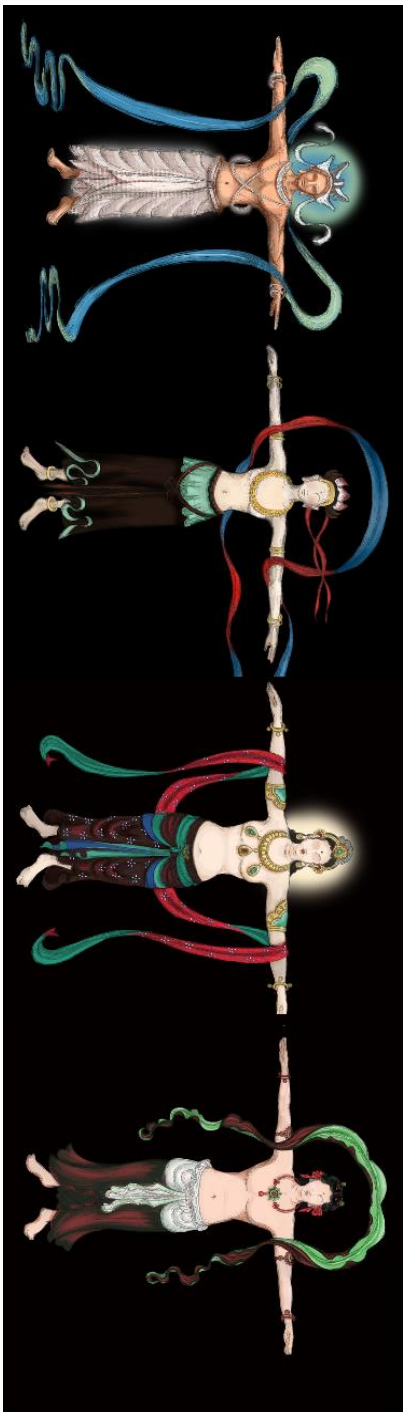


Figure 14. Coloured sketch of the four Apsaras from the early period to the late period, left to right.

---

The colours of all the Apsaras are chosen from the Mogao Cave painting pigments. And for every two adjacent Apsaras, the Apsara share at least one identical colour. In return, the identical colour creates a link between the Apsaras in a loop, as well as keep their characteristic. In addition, colours also represent the aesthetics of different dynasties, like in the early period (from Northern Liang dynasty until Sui Dynasty), the colours of Apsara looks dim and dark. While in the peak period (Tang Dynasty), a flourishing age, the Apsara contains more colours. Most colours are bright and vivid compared to the early period.

- **Face Details**

The face design is another important part used to distinguish the four Apsaras. According to the historical analysis discovered from the early period to the last period, the gender and racial features are different. The first Apsara appears to resemble a male with Indian feature because Buddhism was first spread in China from India. The second Apsara shows the transition between first one and the third one – which is the Chinese plump female features, and the last Apsara has a Mongolian feature because the ruler in that period was Yuan Dynasty<sup>3</sup>.



Figure 15. *The face design of the four Apsaras from the early period to the late period, left to right.*

---

<sup>3</sup> Yuan Dynasty, the ruling dynasty in China during 1271 AD- 1368 AD, established by Kublai Khan, leader of the Mongolian Borjigin clan (Mote, 1994)

---

After the body and facial designs were all completed, the characters were modelled in Maya, flowing in the 3D animation pipeline, and output was in a virtual character format.

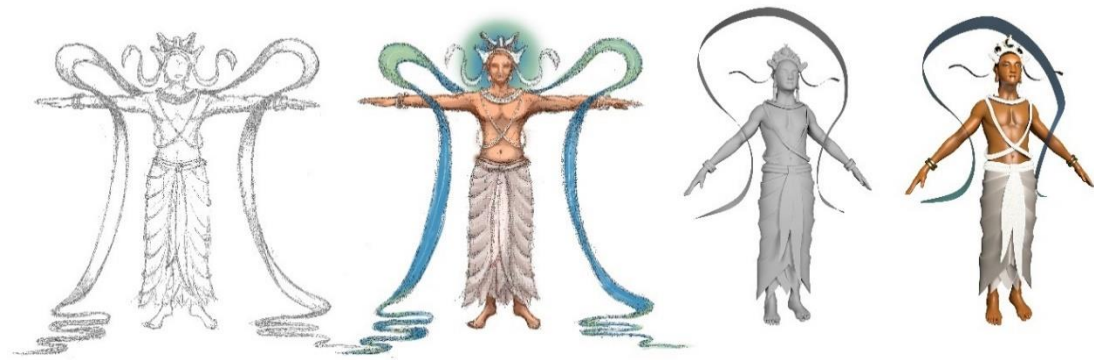


Figure 16. *Apsara 1 in sketch, coloured draft, Ambient Occlusion model and textured model, from left to right.*

### ◇ Interactive Storytelling

A successful character always contains rich information, even a static sculpture can tell a story about character despite its lack of movement. For example, when people look at an exquisite sculpture, its clothes, decorations, facial expression, and position can provide plenty of information.

The facial features and skin colour of an Apsara indicate the origin. Most Apsaras on the wall of the Mogao Caves do not have any records of their origin or the creator's details, but the portrait from a dynasty to some extent can reflect the appearance of the society and culture at the time. Similarly, different textures of clothes such as linen, cotton and silk, hair, dress styles, jewellery, and belongings, constitute a complete character, and there is no redundant component. Each one holds a significant role.

Many characters in Buddhist stories have specific belongings in their hands or on

---

their bodies, and so does the flying Apsaras. The roles of the flying Apsara are generally split into four aspects: 1) Playing instruments, 2) Praying, 3) Flowering and spreading fragrance, 4) Dancing.

To express the multiple roles of the flying Apsara, each Apsara in this project will take one. Also, each Apsara has at least one belonging to enhance the richness of the character and create more options for the 2D and 3D elements to interact with and transform. For instance, when the character is holding a china bottle, the 2D elements can fly in and out of the bottle rather than just circulating the character.

Body movement is a vital part of Chinese traditional animation, especially for characters resembling fairies and gods. Characters in traditional Chinese animation prefer to move in a soft, smooth, and elegant way. Choosing a proper movement for the characters can glue the story of the four characters together.

Pattern transformation in this project will act on the layer between the solid black background and characters as a 2D animation. The whole animation consisted of four screens, and each screen had three layers from front to back; character layer, pattern layer, and the background layer. The background layer and pattern layer are combined to emulate the environment of original murals. The idea is to replicate the Mogao Cave environment while the 3D Apsaras fly around the psychical space. This elevates the audience sentiment and connects them with the original murals.





Figure 17. Patterns extracted from the murals in the Mogao Caves.

---

## ◇ Music

The animation in this project portrays a visual story, while the background music conveys an aural narrative. A song or music could directly connect the audience to a specific sense or culture. Because the four Apsara characters belong to different cultures, music from their religion is a bonus for the development of the characters. Also, music represents the sound of featured instruments for a specific culture and adjust the emotion and rhythm of the animation.

Figure 18 demonstrates how background music works together with animation. Each period has an instrument played to represent an emotion, excluding the late period. This is because, in the late period, the Mogao Caves was an abandoned city that got gradually covered by sand, so the last part of the music only has the sound of wind blowing sand in the desert. The background music is a 2 minutes 30 seconds loop, which matches the length of the animation.

The music starts with the swing of camel bells representing the birth of the Mogao Caves and the image of people riding camels at the desert to build the Mogao Caves. Then follows the flute and Tabla (a traditional Indian drum), referring to the first period of Apsaras, when Buddhism first came to China from India, with Dunhuang being the first stop. The middle section of background music is played with Pipa, a Chinese folk instrument, representing the third period; the influence of Chinese Society in Buddhism for a few centuries. In the last section, the sound of the Pipa fades away and is gradually replaced with the sound of wind, indicating the last period; Dunhuang was occupied by Mongolia and Buddhism was no longer the main religion. Mongolian rulers gave up on the city, including the Mogao Caves, which eventually got covered by sand and wind.

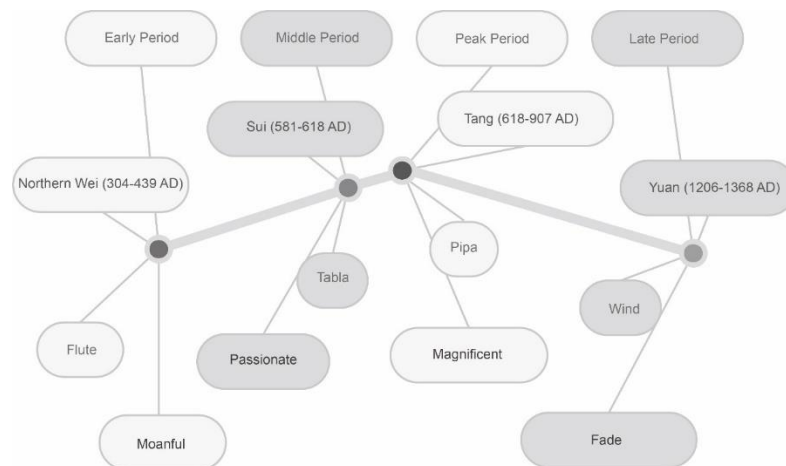


Figure 18. The flow chart of background music in 'Bring History Alive' project.

## ◇ Testing

### • Preparation

Before the creation of the prototype, several kinds of technology were tested for digital storytelling, including Pepper Ghost, holographic effect projection, and projection mapping. Since the installation is designed for an open space located in the digital centre of the Mogao Caves, and the maximum visiting number is 6,000 people in one day, the installation should be a middle scale which allows about 20 people to experience it at the same time.

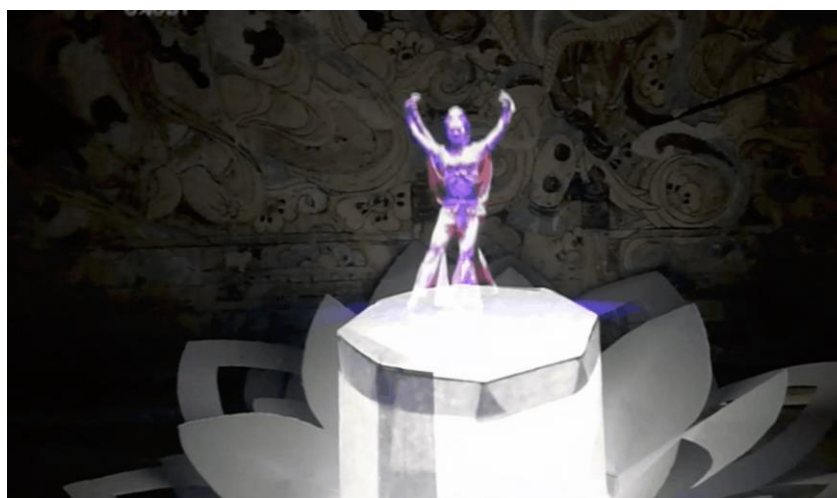


Figure 19. The Pepper Ghost testing.

---

A sequence of background images has been tested by projections for a better result, including abstract colour strip, wall texture, and solid black background. After a series of testing, the solid black background was found to have presented the best result. Because during the animation projecting and the environment is pitch black, a solid black background makes the 3D Apsara characters and the 2D cultural elements look as if floating in the air. Meanwhile, the other background images constrain the 3D Apsara characters and the 2D cultural elements within a 2D space.

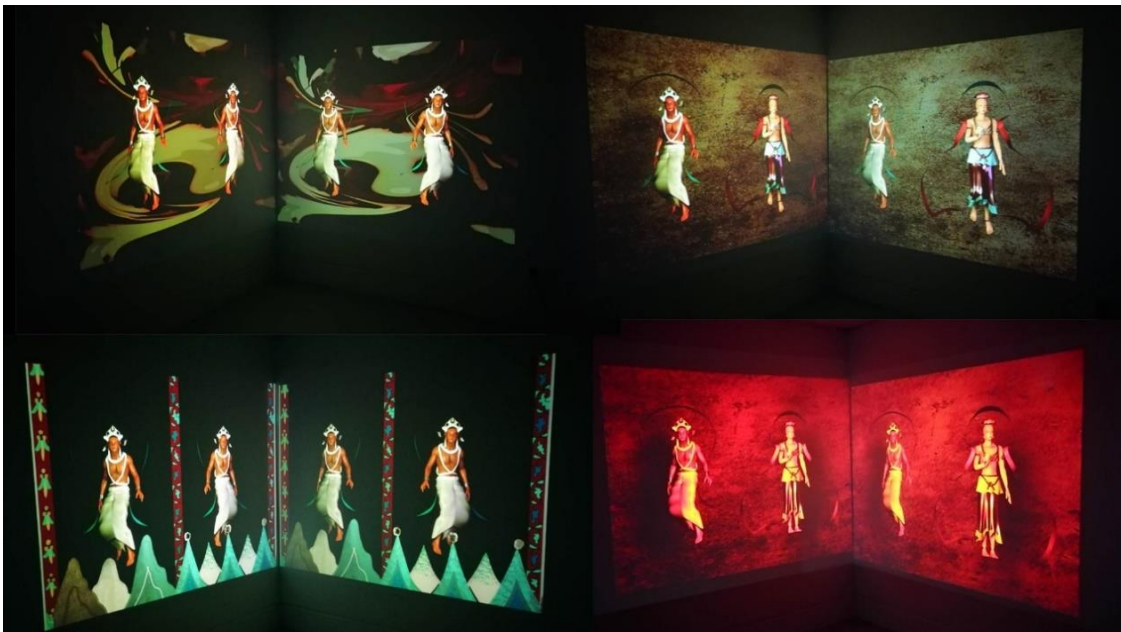


Figure 20. *Testing of the Apsaras with different background images.*

Experience design for installation in this project is targeted at audiences of Mogao Caves with a fundamental knowledge of the Silk Road culture. The knowledge provides a clear pathway for the installation while guiding the audiences to follow the orientation of visiting. The plan is to maximise the audience interaction through the project installation and enhance their visitation experience.

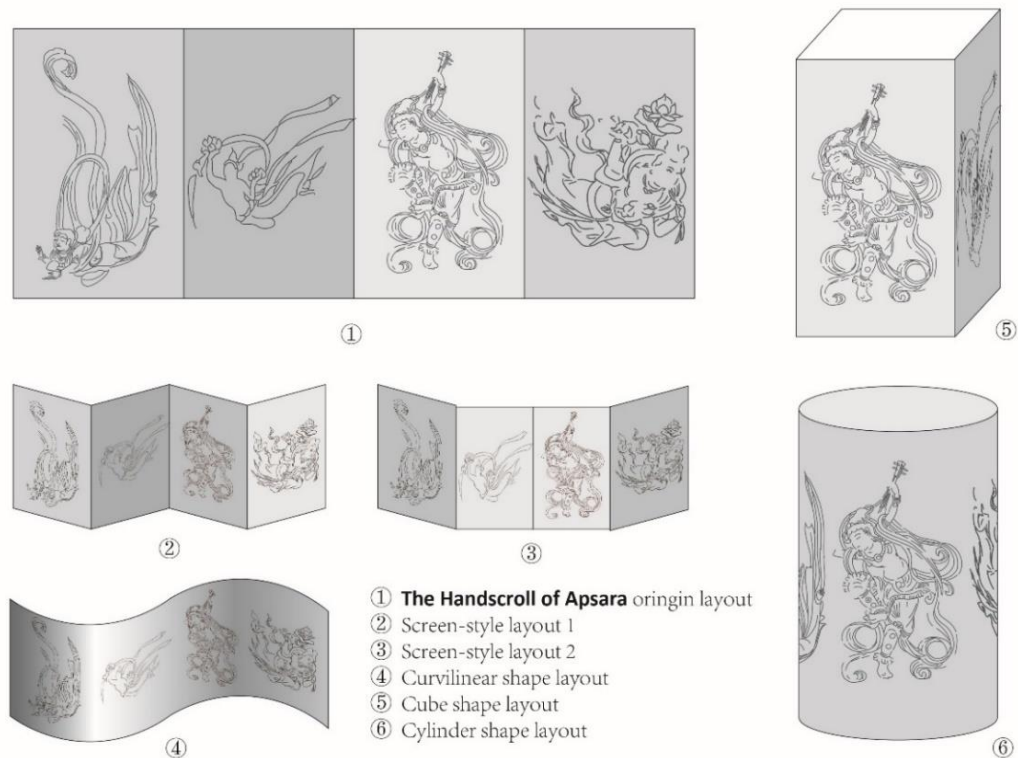


Figure 21. *The layout of prototype 'The Hand Scroll'.*

The prototype resembles a long handscroll picture; four animations are presented on it in chronological order. The handscroll picture is a painting format from East Asia; it allows artists to depict a continuous narrative or journey and is suitable to represent the historical evolution of the flying Apsaras in my project.

The first picture in the diagram below shows the initial layout of the Apsara animation; the screen is equally divided into four parts, and each Apsara from different dynasties performs in the middle of each screen. Based on this origin layout, there can be a variety of derived layouts depending on the installation environment.

Each Apsara animation unit has its background, which consists of a static illustration and a group of animated 2D elements. The background changes slightly from one unit to another, depending on the layout. In picture two, three and five, because each animation unit has clear boundaries on both sides, each background



illustration can be independent and have boundaries, though the 2D animated elements are free to travel from one unit to another. On the other hand, in layouts such as picture 4 and 6, the four animation parts are not isolated from each other and the background illustration is more appropriate to consider.

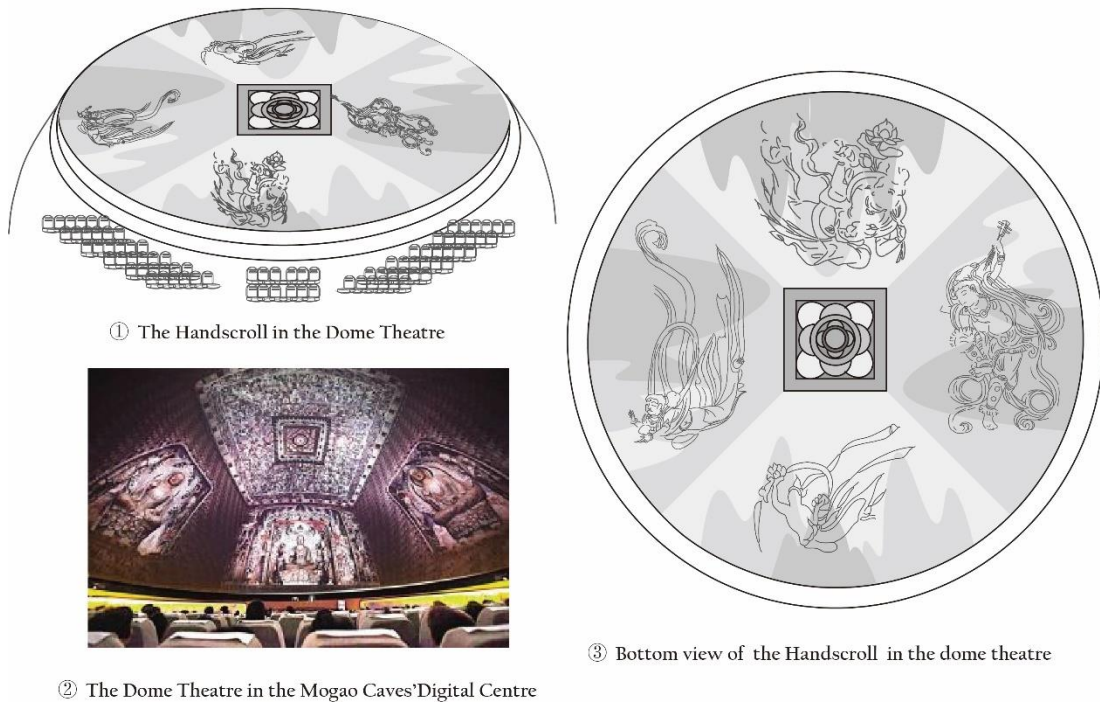


Figure 22. The design prototype for presenting in the digital centre in the Mogao Caves.

Figure 22 shows how the animation is going to be represented in the Mogao Caves' digital centre. In the digital centre, there is a dome theatre which has a huge dome screen. The screen's centre in image 2, is showing the ceiling of a cave. It is a special ceiling from the Mogao Caves called 'Zaojing' (藻井), the shape is like a pyramid with a square centre plate with four Apsaras flying on each ceiling piece, and when audiences look up to the dome screen, it looks like four Apsaras are flying on the ceiling of one cave in the Mogao Caves.

---

## Conclusion and Further Development

This project is an examination of how digital storytelling can understand the uniqueness and transformative qualities of the flying Apsara in the Mogao Caves. During the project, historical analysis has explored the evolution of the Mogao Caves across a thousand years. Character design, experience design and information design were used in the design process of animation, and the animation was presented by projection mapping after a series of testing.

Designing a character in a digital storytelling for cultural heritage is shown as an effective way, in this project, to enhance a visitor's understanding of the cultural heritage content. Also, by designing a character, many potential outcomes of digital heritage production could be explored further after this research. This may include, for example, teaching and training (Educational Purpose), promotion and advertising (Business Purpose), games and lifelike robots (Entertainment Purpose).

This project moves to encourage designers to understand the importance of story in digital heritage interpretation and representation and inspire them to explore further on the other stories in the Mogao Caves. While digital preservation is vital for historical sites in now, how to delivery these digitalised heritage to the public should not be neglected. Furthermore, that is one of the ultimate goals of preserving cultural heritage in a digital way.

---

## Reference List

Abe, S. (1990). Art and Practice in a Fifth-Century Chinese Buddhist Cave Temple. *Ars Orientalis*, 20, 1–31.

Centre, U. W. H. (n.d.). Mogao Caves. Retrieved 18 February 2019, from <http://whc.unesco.org/en/list/440/>

Choi, H., & Kim, S. (2017). A content service deployment plan for metaverse museum exhibitions—Centering on the combination of beacons and HMDs. *International Journal of Information Management*, 37(1), 1519–1527. <https://doi.org/10.1016/j.ijinfomgt.2016.04.017>

Dal Falco, F., & Vassos, S. (2017). Museum Experience Design: A Modern Storytelling Methodology. *The Design Journal*, 20(sup1), S3975–S3983. <https://doi.org/10.1080/14606925.2017.1352900>

Demas, M. (2014). Strategies for sustainable tourism at the Mogao Grottoes of Dunhuang, China. New York: Springer.

Eardley, A. F., Mineiro, C., Neves, J., & Ride, P. (2016). Redefining Access: Embracing multimodality, memorability and shared experience in Museums. *Curator: The Museum Journal*, 59(3), 263–286. <https://doi.org/10.1111/cura.12163>

Fan, J. (2014). The Preservation of the Mogao Caves in Dunhuang, China.

Goulding, C. (2000). The museum environment and the visitor experience. *European Journal of Marketing*, 34(3/4), 261–278. <https://doi.org/10.1108/03090560010311849>

Heath, C., & vom Lehn, D. (2004). Configuring Reception: (Dis-)Regarding the ‘Spectator’ in Museums and Galleries. *Theory, Culture & Society*, 21(6), 43–65.



---

<https://doi.org/10.1177/0263276404047415>

Ioannidis, Y., Raheb, K. E., Toli, E., Katifori, A., Boile, M., & Mazura, M. (2013). One object many stories: Introducing ICT in museums and collections through digital storytelling. In 2013 Digital Heritage International Congress (DigitalHeritage) (pp. 421–424). Marseille, France: IEEE.  
<https://doi.org/10.1109/DigitalHeritage.2013.6743772>

J, S., Borst Brazas, J., & Kajder, S. (2004). Digital Storytelling at the National Gallery of Art. Archives & Museum Informatics. Retrieved from <http://www.archimuse.com/mw2004/papers/springer/springer.html>

Jataka | Buddhist literature. (n.d.). Retrieved 18 February 2019, from <https://www.britannica.com/topic/Jataka>

Kenderdine, S. (2013). “Pure Land”: Inhabiting the Mogao Caves at Dunhuang. Curator: The Museum Journal, 56(2), 199–218.

Machidon, O. M., Duguleana, M., & Carrozzino, M. (2018). Virtual humans in cultural heritage ICT applications: A review. Journal of Cultural Heritage, 33, 249–260. <https://doi.org/10.1016/j.culher.2018.01.007>

Miller, C. H. (2014). Digital storytelling: a creator’s guide to interactive entertainment (Third edition). New York: Focal Press, Taylor & Francis Group.

Mote, F. (1994). Chinese society under Mongol rule, 1215–1368. In H. Franke & D. Twitchett (Eds.), The Cambridge History of China (The Cambridge History of China, pp. 616-664).

Robin, B. R. (n.d.). The Educational Uses of Digital Storytelling, 9.

Selvadurai, V., & Andreas Foss Rosenstand, C. (2017). A Heuristic for Improving Transmedia Exhibition Experience. The Design Journal, 20(sup1), S3669–S3682.

---

<https://doi.org/10.1080/14606925.2017.1352873>

Shedroff, N. (2011). *Experience Design*.

Shichang, M. (1995). Buddhist Cave-Temples and the Cao Family at Mogao Ku, Dunhuang. *World Archaeology*, 27(2), 303–317.

The Art of Dunhuang. (n.d.). Retrieved 30 January 2018, from <http://public.dha.ac.cn/content.aspx?id=185436748917>

The loot from China's old Summer Palace in Beijing that still rankles | Oxford Today. (n.d.). Retrieved 24 September 2018, from <http://www.oxfordtoday.ox.ac.uk/opinion/loot-chinas-old-summer-palace-beijing-still-rankles>

Tillman, B. (2012). *Creative Character Design*. Routledge. <https://doi.org/10.4324/9780240814964>

Tu, Y. (2014). The digital Mogao Caves - *ConfuciusMag*, V(34). Retrieved from <http://confuciusmag.com/digital-mogao-grottoes>

Wang, J. (2012). Aurel Stein's Dealings with Wang Yuanlu and Chinese Officials in Dunhuang in 1907, 6.

## List of Illustrations

Figure 1. ( <i>Demas, 2014</i> ) Crowd at the Mogao Caves during peak visitation. ....	2
Figure 2. Visitors queuing in front of the digital centre of the Mogao Caves. Dai. 2018. ....	3
Figure 3. Dunhuang Academy. (2017) Mogao Grottoes Cave 285 Page, Retrieved from <a href="https://www.e-dunhuang.com/cave/10.0001/0001.0001.0285">https://www.e-dunhuang.com/cave/10.0001/0001.0001.0285</a> .....	6
Figure 4. A visitor is experiencing interactive game in the National Palace Museum, Dai, 2018. ....	7
Figure 5. 10 Step Checklist. Adopted from Miller H.C. (2014). Digital Storytelling, A Creator's Guide to Interactive Entertainment .....	10
Figure 6. Information Design Method. Adapted from Shedroff, (2011), Experience Design .....	13
Figure 7. Shanghai Animation Film Studio, (1981) The Deer of Nine Colours, (Animation), Retrieved from <a href="https://www.youtube.com/watch?v=5srXRIJ7yBw">https://www.youtube.com/watch?v=5srXRIJ7yBw</a> .....	15
Figure 8. Dunhuang. (2014), The Deer King Jataka, (Murals) The Mural on No. 257 Caves in Mogao Caves.....	15
Figure 9. Kenderdine, S. (2013) "The Pure Land" – An exhibition project (Digital Photograph). "Pure Land": Inhabiting the Mogao Caves at Dunhuang. ....	17
Figure 10. Kenderdine, S. (2013). Visitors watching murals through an iPad in "The Pure Land" Exhibition. (Digital Photograph). "Pure Land": Inhabiting the Mogao Caves at Dunhuang. ....	18
Figure 11. Flow of the 'Bring History Alive' Project. Dai, 2018. ....	20
Figure 12. The Apsara appearance in different dynasties. Dai, 2018. ....	22
Figure 13. Sketch of the four Apsaras from the early period to the late period, left to right. Dai, 2018. ....	24
Figure 14. Coloured sketch of the four Apsaras from the early period to the late period, left to right. Dai, 2018. ....	24
Figure 15. The face design of the four Apsaras from the early period to the late period, left	

---

to right. Dai, 2018. ....	25
Figure 16. Apsara 1 in sketch, coloured draft, Ambient Occlusion model and textured model, from left to right. Dai, 2018. ....	26
Figure 17. Patterns extracted from the murals in the Mogao Caves. Dai, 2018. ....	28
Figure 18. The flow chart of background music in 'Bring History Alive' project. Dai, 2018. .....	30
Figure 19. The Pepper Ghost testing. Dai, 2018. ....	30
Figure 30. Testing of the Apsaras with different background images. Dai, 2018.....	31
Figure 21. The layout of prototype 'The Hand Scroll'. Dai, 2018. ....	32
Figure 22. The design prototype for presenting in the digital centre in the Mogao Caves. Dai, 2018. ....	33