

# A study on metaverse of China's Dunhuang Frescoes through COSPACES EDU

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## COSPACES EDU를 통한 중국 둔황 원시벽화 메타버스 연구

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**Abstract** Due to natural and human factors, dunhuang frescoes in China have gradually degenerated. China has conducted digital transformation of frescoes since 1990. However, it requires expensive research costs. Most of the visitors passively accept transformation contents and lack subjective participation. The paper focuses on produces a prototype of Dunhuang frescoes on the CoSpaces EDU. It was implemented as a metaverse through procedures such as transforming the cave into 3D, mapping images to the cave model and developing CoBlocks. The research puts forward a more specific methodology without expensive costs of development. The paper makes it easier to realize the immersive and interactive virtual Dunhuang frescoes world, to improve the tourism contents and educational effect. This research carries on the statistics to the product result which develops according to the user experience of 100 different ages, has obtained the good feedback. The research results need to be improved is to strengthen the processing of graphic details. Therefore, Optimization and improvement of the result will be carried out in the future research.

**Key Words** : Dunhuang frescoes, Metaverse, CoSpaces EDU, CoBlocks, Digital transformation

**요약** 중국의 둔황 벽화는 자연과 인위적인 요소로 인하여 점점 퇴화되고 있으며 중국 둔황 벽화에 대한 보호연구는 1990년부터 벽화의 디지털 트랜스포메이션을 실시하였다. 그러나 값비싼 연구비용이 필요하고 대부분 관람객들은 디지털미디어에서 관람을 수동적으로 받아들이며 메타버스형 참여가 부족했다고 판단된다. 본 연구는 둔황 고굴 벽화를 연구범위로 정하고, 메타버스를 위해 COSPACES EDU 플랫폼에서 프로토타입을 제작하였다. 둔황벽화를 3차원으로 변환시키고 동굴모형에 이미지를 매핑하여 관광과 교육을 위한 코블록스 블록을 개발하는 등의 절차를 통하여 구현하였다. 또한 사례 연구를 통해 비싼 개발비용을 사용하지 않는 구체적인 방법론을 제시하여 몰입형 둔황벽화 세계를 쉽게 구축하고 관광 콘텐츠와 교육효과를 높이기 위한 프로세스를 개발 제안하였다. 그리고 100개의 유저 체험 설문 피드백을 기준으로 개선해야 할 연구 방향은 문화재 디테일에 대한 퀄리티를 강화하는 것으로 나타났다. 향후 연구를 통해 이를 보완, 최적화해야 할 것으로 판단된다.

**주제어** : 둔황 벽화, 메타버스, 코스페이스스 에듀, 코블록스, 디지털 트랜스포메이션

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## 1. Introduction

Potential Problems of Current Tourism are obvious in China. China's protection to cultural heritage relics is insufficient, especially for some cultural relics with large areas and multiple types. Due to the large number of cultural relics and the shortage of professional technicians for the restoration of cultural relics, China's protection to cultural relics can not keep up with the speed of artificial destruction of cultural relics or their own damage. As the following figure, the palace frescoes at XianYang Palace<sup>1)</sup> ruins cracked again after restoration in China[1].



Fig. 1. The Frescoes of Xianyang Palace

In addition, the contradiction between tourism development and cultural heritage protection has intensified, and it is hard to balance tourism development and protection of cultural sites. The influx of tourists into the attractions in tourism industry has put great pressure on some fragile relics or historical sites that have been damaged and made them overwhelmed. The Leshan Buddha<sup>2)</sup> of Sichuan Province in China has an average annual visitors of 70 million[2].



Fig. 2. Leshan Buddha in China

Therefore, it is a problem to be resolved on how to ensure the development of cultural and tourism industry on the premise of protecting cultural artifacts and historical heritages. In this paper, writer set the Dunhuang frescoes in China for Metaverse<sup>3)</sup> as the research scope and aim to produce a prototype using CoSpaces as a solution.

## 2. Theoretical background

### 2.1 A brief introduction of the Dunhuang frescoes and its damaged situation at present

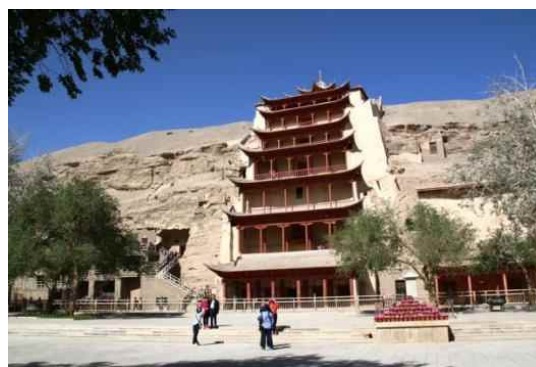


Fig. 3. The exterior of Dunhuang Mogao Caves

The Mogao Caves at Dunhuang, inscribed on the World Heritage List in December 1987, are the world's largest repository of Buddhist art, with 492 surviving caves, 45,000 square meters of frescoes and over 2,400 painted sculptures. The

1) The political center of the ancient Qin Dynasty, and now, It is an important site of cultural relic protection in China.

2) Located in Leshan City, Sichuan Province, China, with a height of 71 meters. It is the largest cliff stone statue in China.

3) <https://baike.so.com/doc/7222932-7447706.html>

frescoes cover social life, music and dance painted with mineral pigments[3].

At present, 40% of the frescoes in Dunhuang Mogao Caves are destructed[4].

First, the Dunhuang Mogao Caves are damaged in several ways: destruction by extreme natural disasters (earthquakes, typhoons), natural erosion over time (efflorescence, acid washout, strong saline, lightning, smoke erosion), man-made damage (damage by people living around the ruins or by tourists)[5].



Fig. 4. Dunhuang frescoes are damaged

Second, the Dunhuang frescoes are damaged to different degrees: complete destruction, large-scale destruction and small area of destruction[6].

People have made great efforts to protect precious frescoes. From the spring of 1941 to 1943, the painter Zhang Daqian<sup>4)</sup> led his team to the Dunhuang Caves to paint copies with the hope of preserving the fading Dunhuang frescoes. Since 1990, the Dunhuang Research Institute<sup>5)</sup> of China has carried out a series of digital transformation projects of Dunhuang frescoes[7]. But these digital transformations are limited by high equipment cost and research fund.

4) A painter and calligrapher in China. (1899–1983)

5) The Scientific Research Institute of Dunhuang Studies, designated by the Chinese Government for protection of Dunhuang Mogao caves and frescoes. It was established in 1984.

## 2.2 Digital Restoration of Cultural Heritages

Many countries in the world are carry out digital transformation projects. Since there are lots of perishable artifacts among cultural relics, which are prone to decoloration, and flaking, and are still difficult for long-term research and display after manual restoration[8]. Through digital restoration, the cultural relics can be displayed completely and preserved in a tighter environment[9], which is conducive to protect cultural relics.



Fig. 5. The digital restoration of the Terracotta Warriors, 2011

The vast majority of the more than 8,000 terracotta figurines from the Terracotta Warriors<sup>6)</sup> of China's Qin Shi Huang Mausoleum were broken when they were unearthed, and most of what people saw were the results of the restorers of cultural relics.

The utilization of information and scientific technology like graphic image processing has completed many cultural relics digitization and virtual restoration of cultural relics restoration projects, opening up new ways for the researches of cultural relics conservation, archaeology[10].

## 2.3 Digital Transformation of Cultural Heritage

Visitors can obtain background knowledge

6) A lot of stone sculptures of an ancient tomb. These sculptures were used for the burial with the dead king of Shihuang.

through app about the Terracotta Warriors in the museum. The applications of augmented reality achieves the purpose of education[11].

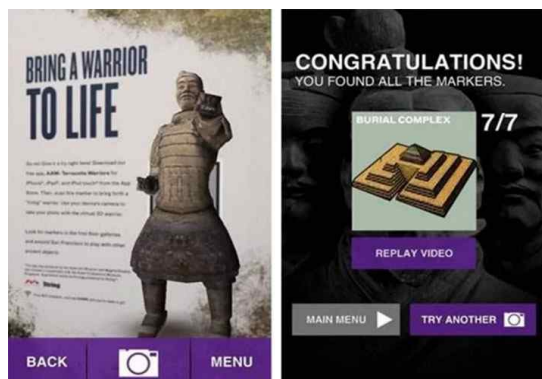


Fig. 6. The Digital Museum of San Francisco, 2014

It extends the exhibition site to other, specific virtual realms by using virtual reality(VR)<sup>7)</sup>, for example, the exhibition in the interstices of the Los Angeles Museum of Art fills museum's courtyard and hallways with colorful digital funnels and lecture videos, allowing visitors to see these Terracotta Warriors that do not exist in the real world through their smart phones.

Museum's displaying ways have evolved from the most traditional static displays of objects, panel pictures, and films, to emphasizing hands operation, audience participation, to digital multimedia and human-computer interaction[12]. This evolution shows that digital museums are increasingly accepted by audiences, and that digital technology allows users to interact on both virtual and real levels.

### 3. Developing prototype of China's Dunhuang Frescoes through CoSpaces Edu for Metaverse

Metaverse is an internet world that is detached

7) Virtual Reality(VR), a computer simulation system that can create and experience virtual world.

from the real world but parallel to it, a virtual reality network world supported by VR, 3D and other digital technologies.[13] Disadvantages of China's tourism culture include destruction of originals, loss of originals, and protection from various spectators. Therefore, digital transformation of important cultural properties is necessary in the coming Metaverse era.

#### 3.1 Introduction of the cave 112 and CoSpaces Edu



Fig. 7. A photo of Cave 112 in the Dunhuang Mogao Grottoes

This paper introduces Metaverse and transforms the frescoes of Dunhuang Mogao Cave 112 through digital transformation on the CoSpaces Edu<sup>8)</sup> platform. Because Cave 112 has the most basic structure among those caves, and its internal frescoes are also very complex. As a research prototype, this cave can represent the situation of other caves.

Through the case study method and comparative research approach, a more comprehensive and active participatory methodology of digital transformation content production is proposed without using expensive digital transformation equipment, which easily presents an immersive and virtual Dunhuang Fresco World to realize greater communication and educational effects.

8) A platform called CoSpace. Developed by a German startup is also an interesting educational platform. Existing VR content requires students to experience it passively, but Cospaces offers students the opportunity to create virtual reality 3D content on their own. (<https://cospaces.io>)

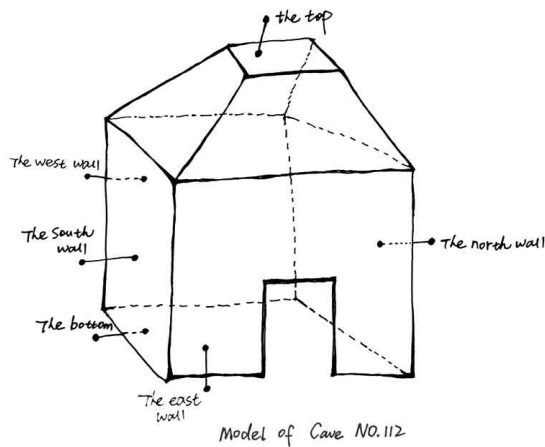


Fig. 8. The Perspective of Cave 112

The CoSpaces Edu platform offers creation tools that allow for customization of environments, and creators can design contents in scenes for different themes. Because of its interactive feature, it also allows for a wider range of uses for the digitalized product. The using of CoSpaces Edu can achieve a more popular, more active participation in digital contents. This Prototype is more participatory and interactive than the traditional method of digital transformation[14].

Next, the digital transformation of cave 112 is carried out through steps like processing the original fresco photos, building a cave model, setting up tour coding blocks, scene transformation and detail demonstration.

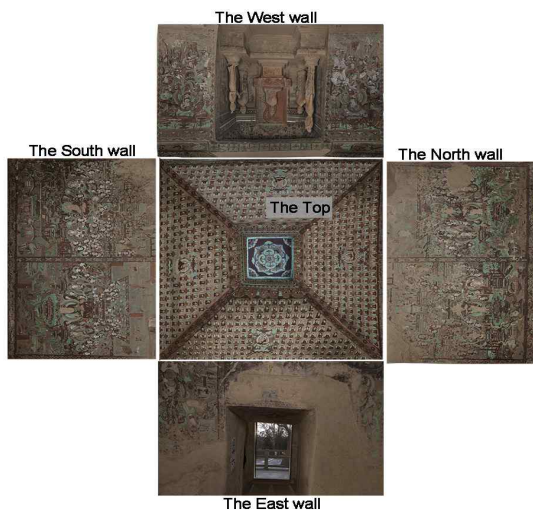


Fig. 9. Splitting Pictures of Inner Walls of Cave 112

### 3.2 Steps of the digital transformation of frescoes in Cave 112

First, The writ process the photo footages of the original frescoes to ensure that the images match the cave deconstruction, and create 3D scenes to facilitate presentation of the top and bottom content). Then, the writer import the Dunhuang frescoes unfolding images into the CoSpaces Edu platform separately to build virtual cave models.



Fig. 10. The Construction of Cave 112

The writer set the position, scale, angle and other parameters to keep the frescoes content in the best viewing clarity. CoSpaces Edu's camera view can ensure a 360-degree immersive viewing and audio-visual experience for viewers.

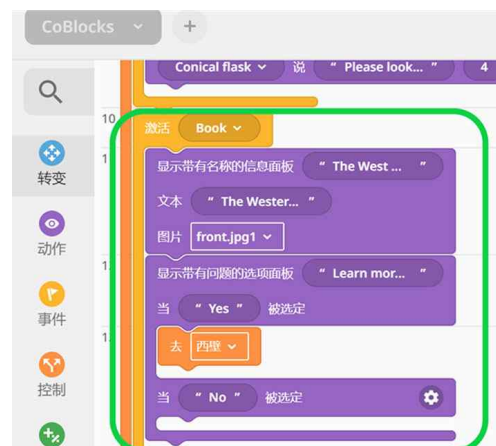


Fig. 11. Editing Mode in CoBlocks

Second, allowing visitors to directly control the subjective point of view on top of this will make a more active experience possible. Using

CoBlocks<sup>9)</sup> to set up four code blocks to create interactive tour modes that enable the following interaction methods: buttons, menus, hot words, conditional judgments, text input, moving object target areas, limited time, limited number of times and key activation. The arrangement of CoBlocks programming development allows users to freely choose in order to diversify and customize their personal viewing methods. These logical codes help the spectators to interact and participate in the process of appreciating the Dunhuang frescoes.

Meanwhile, the spectators can choose the contents and details of the cave frescoes that they want to watch, and actively participate in the dissemination of the Dunhuang frescoes through the sharing function of CoSpaces.

Third, establish the scene transition and detail demo. In order to ensure the spectators to browse freely and smoothly in the main cave scenes, setting the scene transition and code commands of detail demonstration in CoBlocks. When spectators activate the preset fixed button in front of walls in the main caves, the system dialog box automatically pops up to ask, waiting to get the viewer's command to realize the feedback screen. If it receives a new command, switch to a new scene, and read more comparative inner stories and details.

Ultimately, the results of the digital transformation of Dunhuang frescoes will be completed.<sup>10)</sup> According to the new travel policy<sup>11)</sup> for the Mogao Caves in Dunhuang, viewers can only stay on a cave site for up to 15 minutes and must leave in some endangered caves[15]. Actually, they have minimal access to information

9) CoBlocks are visual block-based programming language in cospaces, to Code while having fun creating virtually anything. CoBlocks can also be programmed to create interactive links, narratives, and games. (<https://cospaces.io/edu/coding.html>)

10) <https://edu.cospaces.io/RYN-LDX>

11) <http://public.dha.ac.cn/>

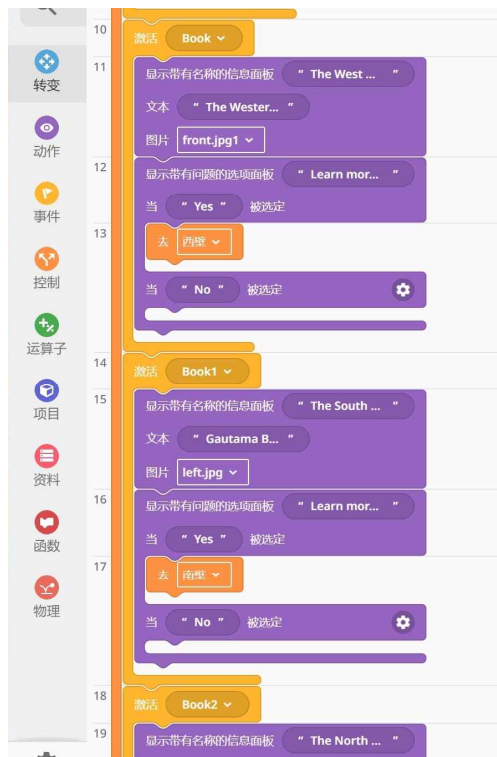


Fig. 12. Building scenes with CoBlocks

about the caves. But, The development of this study break the boundaries of space and time, allowing for a shared experience of viewing Dunhuang frescoes any where in the world.

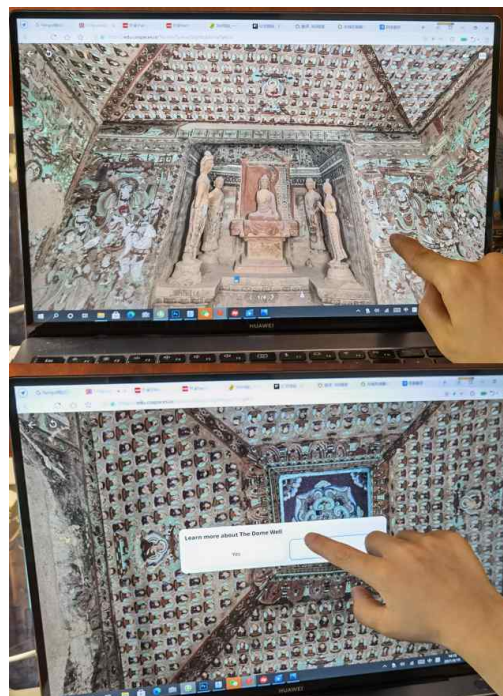
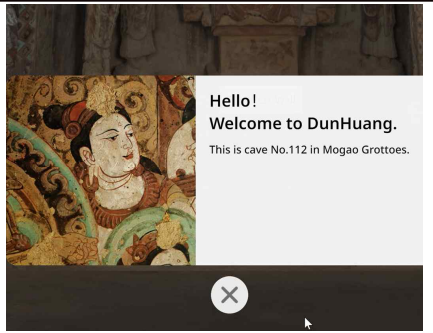
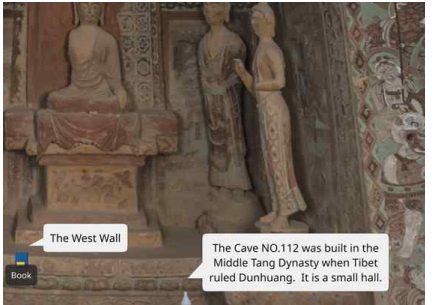
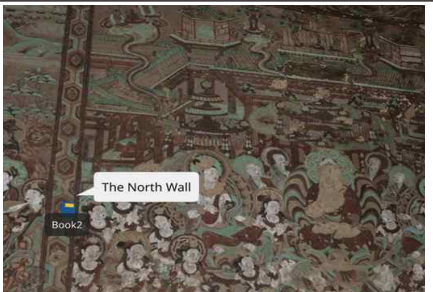


Fig. 13. Player Mode Using CoSpaces

### 4. Conclusion

The significance of this paper is to increase the communication and education of Dunhuang frescoes, increase the interaction of immersive on-site visit, and deeply excavate and present the connotation and significance of Dunhuang murals. Instead of using expensive equipment, we propose a more popular and active participatory method to easily present interactive virtual Dunhuang frescoes world.

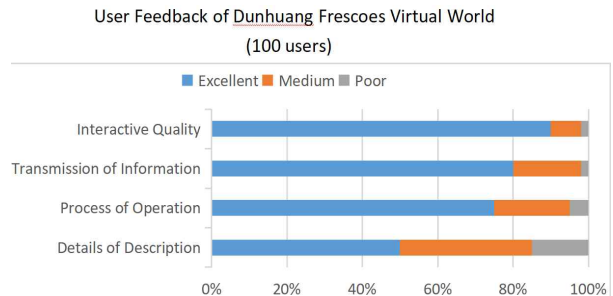
Table 1. Screenshot of the Digital Transformation Results of Frescoes in Cave 112

Welcome interface	
Guided tour	
Active participation	

In this paper, 100 users of different ages were invited to experience the product results of research and vote on the following indicators as follows. The 100 users ranged from 6 to 70 years

old, so the result of votes can reflect the experience feelings of most people.

Table 2. Feedback from 100 users on the research result



By collecting the user experience of the research results, it can be summarized as follows: Unified interface style, simple operation mode and clear information transmission. But the research results need to be improved is to strengthen the details of Description. Therefore, we will continue to optimize and improve it in the following research.

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