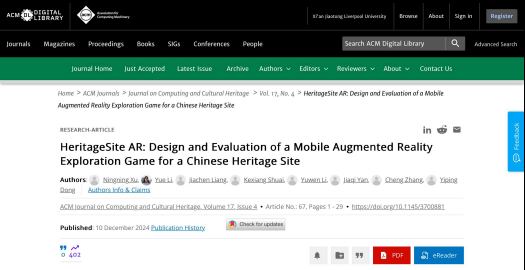


HeritageSite AR: An Exploration Game for Quality Education and Sustainable Cultural Heritage

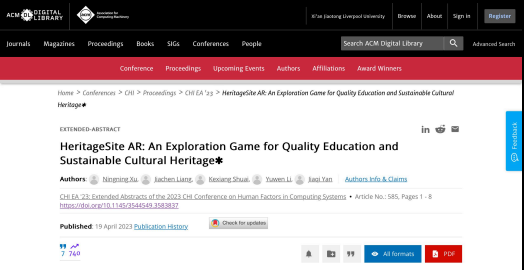
HeritageSite AR is an exploration game for onsite Cultural Heritage (CH) learning and visits with publics in Relics of Arhat Monastery and Twin Pagoda (also known as Shuangta).



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About Twin Pagoda (Shuangta)

Suzhou Twin Pagoda (Shuangta) was built in the Northern Song Dynasty, more than a thousand years ago.

This historical site preserves the Twin Pagoda, carved stone pillars of the Main Hall Relics of Arhat Monastery, a stone carving museum exhibiting historical stone statues, and inscriptions with over 1,000 years of history.

They are not only representatives of Buddhist architecture but also reflect the architectural art and religious beliefs of the time.



The value of Shuangta

History



As buildings from the Southern Dynasties, it reflected the society's religious beliefs and cultural features at that time.

Culture



It reflects the superb skills and aesthetics of ancient craftsmen, and also contains profound Buddhist cultural connotations.

Architecture



It has mainly influenced the development of later architecture in terms of its shape, decoration, and construction technology.

Education



It is an essential physical material for studying Buddhist history, architectural art and Southern Dynasties culture.

Pre Research

Expert Interview

To understand the feasibility of applying digital technology and gamification and the gap in background knowledge about the site between experts and the public, we invited three experts, one female and two males, and conducted in-depth interviews. They have professional insights into historical architecture, heritage conservation in Suzhou, and museum studies.

1. The meaning of cultural popularization
2. Factors to consider in cultural heritage experiences
3. The use of digital technology in CH learning.

“Visitors are particularly **interested in the stories behind Shuangta**. For example, ‘why were Shuangta built here? What happened during the building process?’ ”

“**The history of the Shuangta is not clearly presented in the ruins**. Therefore, some explanations are needed to avoid confusion among tourists. ”

“Factors such as **route setting and visual presentations should be considered** in the design of Shuangta guides. ”



Plan itineraries for visitors and use technology to create a coherent and immersive experience for visitors.



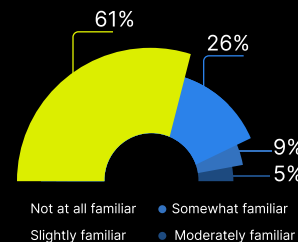
Using multimedia and multi-sensory functions can enhance people's touring experience and convey the cultural information of historical buildings more vividly.



With VR, AR, and other digital guides, users can have rich sensory experiences and better understand the site's history.

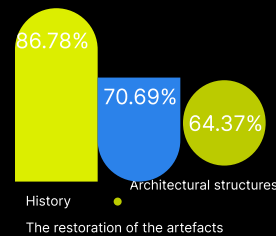
Questionnaire survey

We received **174 valid responses (94 females and 80 males), aged between 13 and 59**. The respondents' two primary occupations were students (62.64%) and clerical support workers (16.67%). We also received responses from professionals (11.49%), business people (1.72%) and freelancers (4.02%).



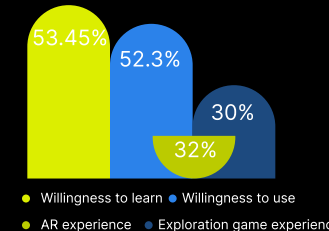
Knowledge of Shuangta

However, most respondents (78.74%) had not visited the Shuangta, and 60.92% of respondents were not familiar with it at all.



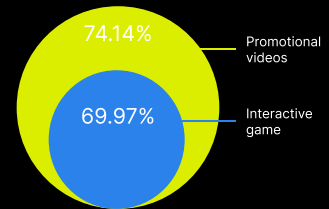
Interest in CH

The majority of respondents were willing to learn about history (86.78%), the restoration of the artefacts (70.69%), and architectural structures (64.37%) during their CH visit.



Attitude to new technologies

The results showed that more than half (52.3%) of the respondents are willing to experience new technologies. 53.45% of people are willing to spend time on learning activities through new technologies.



The ways of learning CH

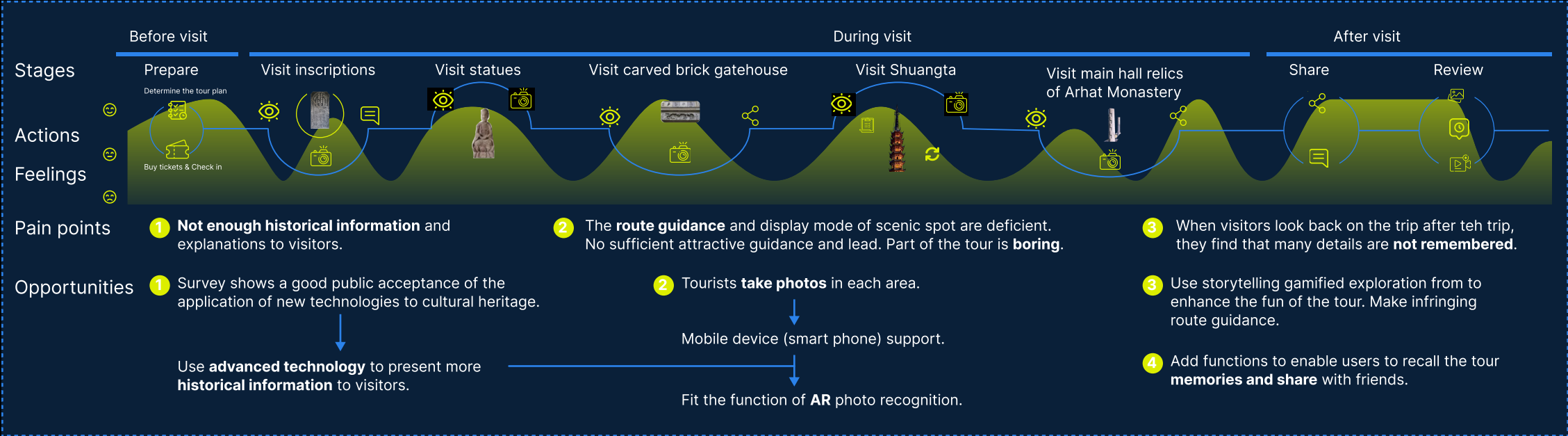
Watching promotional videos containing history and culture was the most popular choice (74.14%), followed by experiencing the interactive game with cultural characteristics (69.97%).

● People generally have some knowledge of AR technology and exploration games and most people are willing to use new technologies for learning.

● People have an intense interest in CH visits with rich content of social activities and entertainment experiences.

● Learning is an intrinsic activity for CH visits, and there is strong potential for the use of AR in CH learning.

User journey Map



Design Goals

Goal 1 Trigger: Provide an informative guide to support knowledge acquisition.

We try to avoid the misunderstandings caused by the lack of the information provided. We will help visitors access the content of the Shuangta's inscriptions by providing the modern Chinese translations in context using new technologies.

Goal 2 Engage: Engage visitors in active onsite explorations.

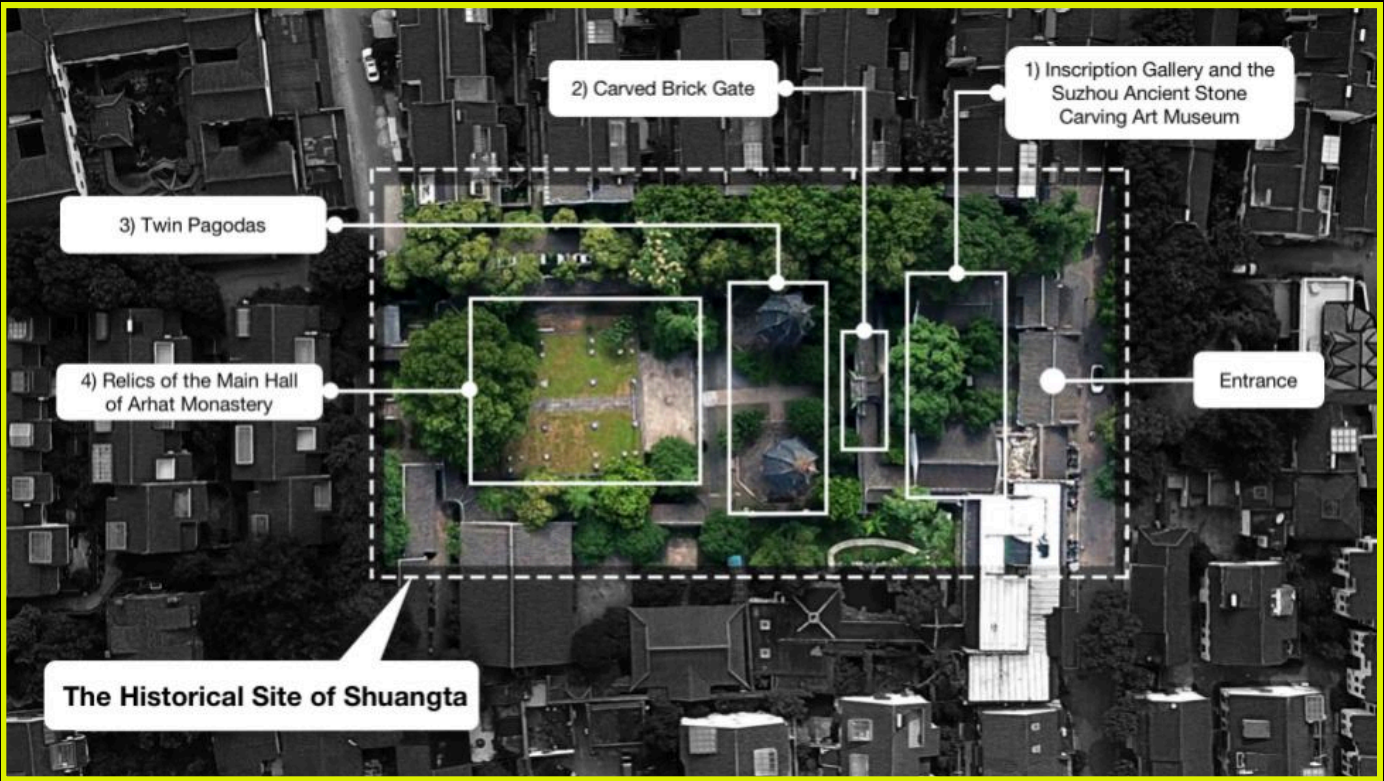
Existed researches proved that users are more likely to engage in learning if greater interactivity is supported. Therefore, we intend to integrate game features into onsite CH visits such as collection and clues.

Goal 3 Consolidate: Facilitate personal meaning-making and user memory.

Visitors acting in different roles with different purposes in CH visits supports the personal context of learning and visitors' meaning-making of their visits. We aim to construct the emotional link between the visit and their daily life to capture the memory and relate with families and friends

Goal 4 Relate: Develop relevance through social interactions.

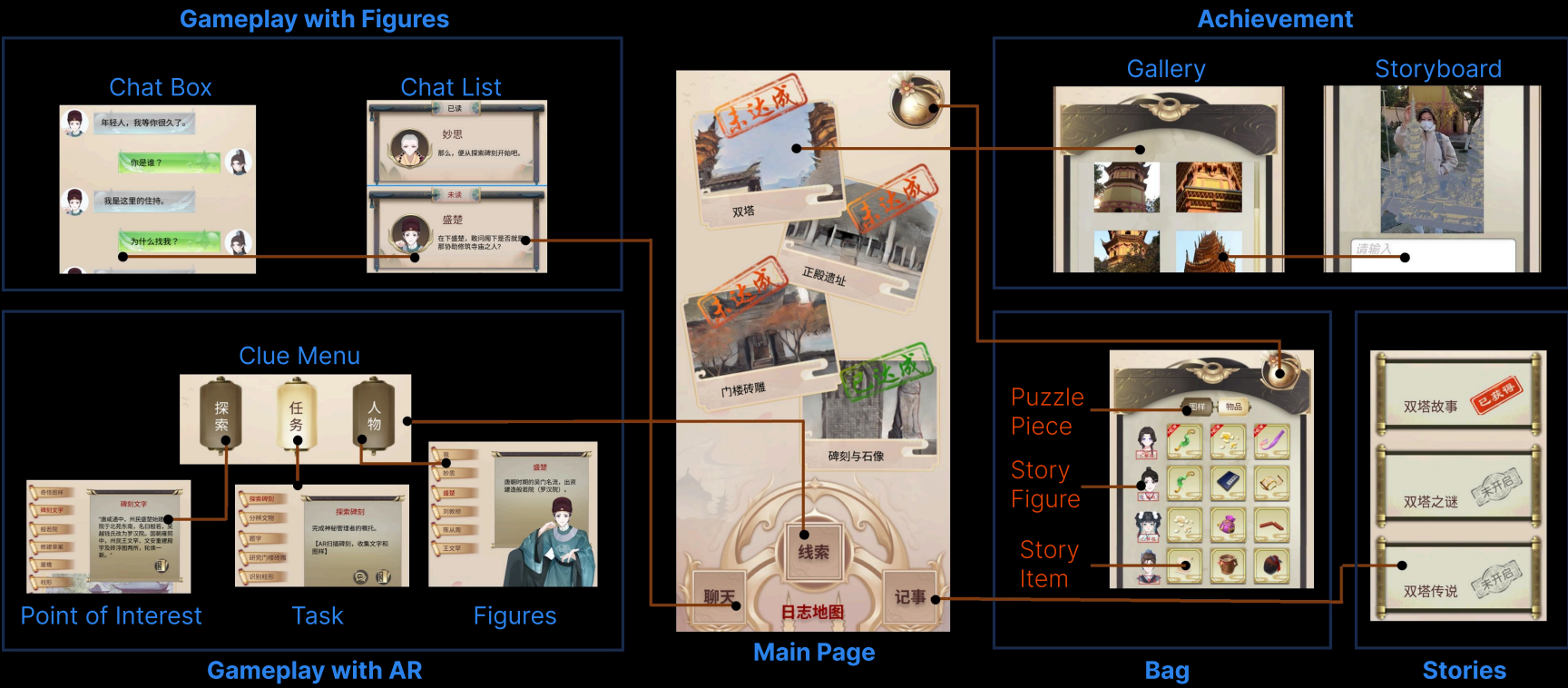
CH experience is a trajectory that could be extended after visiting. Users expect to have social activities and entertainment in CH visits. Thus, we try to satisfy this preference to encourage social activities (e.g., photo-taking, social sharing).



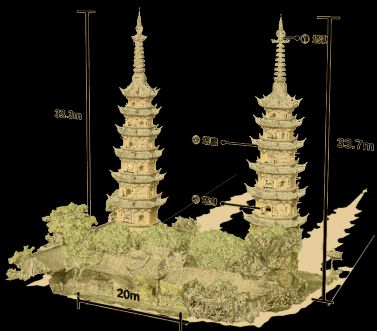
Prototype Development

Design Goals' Implementation

- Goal 1 - Trigger Stage: storytelling, avatar, and map for guide.**
An informative guide is designed to support knowledge acquisition, using storytelling with avatars to present the historical event about Shuangta.
- Goal 2 - Engage Stage: storytelling, avatar, and map for guide.**
Visitors in the game collect items and puzzle pieces to obtain items related to the legend of the Twin Towers to understand the complete plot.
- Goal 3 - Consolidate stage: gallery and storyboard for memory.**
Via the AR camera, visitors not merely record the scenery shots but also the interaction moments with the site.
- Goal 4 - Relate stage: creation and sharing for social interaction.**
Functions such as AR photo-taking and inscription writing that attach visitors' personal values to CH visits.



3D reconstruction



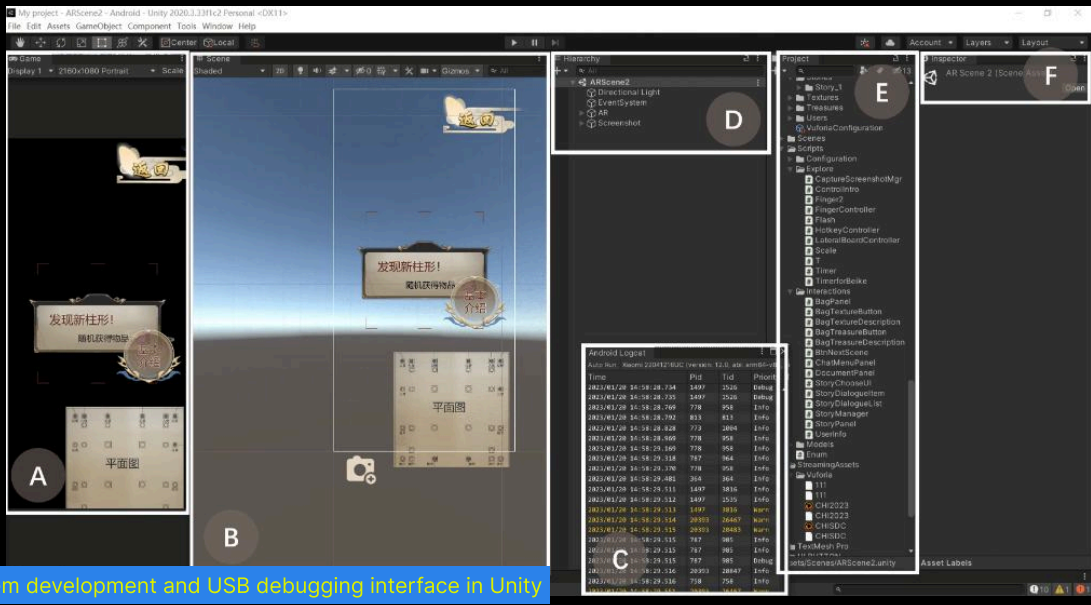
Prior to the development of the AR game application, we conducted several field surveys at Shuangta to collect data for 3D reconstruction. The Twin Pagodas and the carved brick gate were scanned and reconstructed in RealityCapture using images captured from drones and cameras. The model was edited using Rhino, with annotation of dimensions added to enrich the AR information display

AR game development

We used Unity and the Vuforia Software Development Kit (SDK) for the AR game development. Vuforia offers support for a range of features, including 2D and 3D image target recognition, as well as markerless and multi-target tracking. It is compatible with native development for both iOS and Android platforms and seamlessly integrates with the Unity for AR application development.

We also considered some factors such as the available resources, hardware requirements, and the usability of the implemented game design. For example, we made some efforts to simplify the 3D models to make them suitable for low-end mobile devices without causing noticeable delays. We also assessed the size and quality of the image targets used for AR, ensuring that they were under 2 MB in size and achieved a minimum recognition rating of three stars (out of a total of five). During testing, we addressed some issues caused by the overlapping positions of the models on the mobile interface and issues related to lighting and rendering effects.

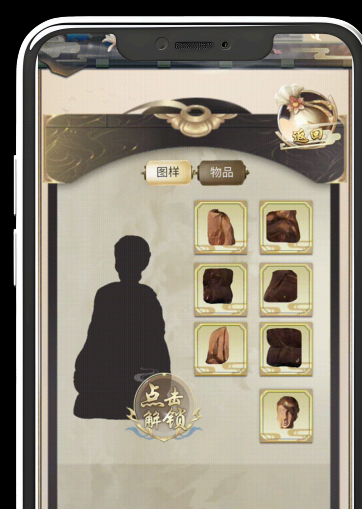
- A Game view**
- B Scene**
- C Android Logcat**
- D Scene Hierarchy**
- E Project Asset**
- F Inspector**



System development and USB debugging interface in Unity

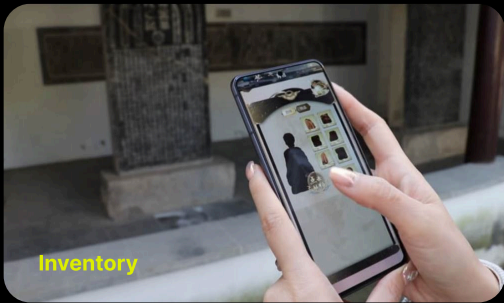
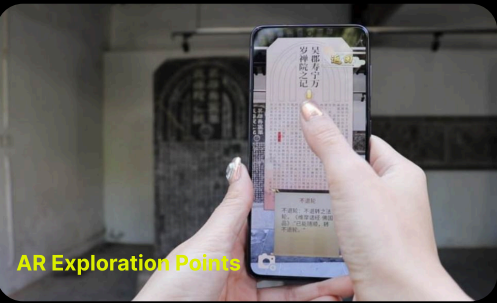
Final Prototype

HeritageSite AR is a location-based exploration game for CH visit and learning. Visitors can follow the dialogues with five historical figures represented as NPCs to explore the map and historical events about Shuangta. Visitors can start the conversations based on the clues they found, and visitors will be guided to the corresponding places for exploration. Visitors can trigger the augmented images and text information to interact with the relics, unlocking new clues or items for further exploration. Collecting items throughout the visits provides a sustainable experience with social activities, such as photo-taking and sharing.



Using Process

Inscription gallery and Suzhou ancient stone carving art museum

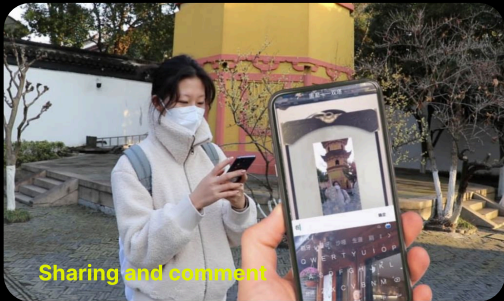


Shuangta

Craved brick gate

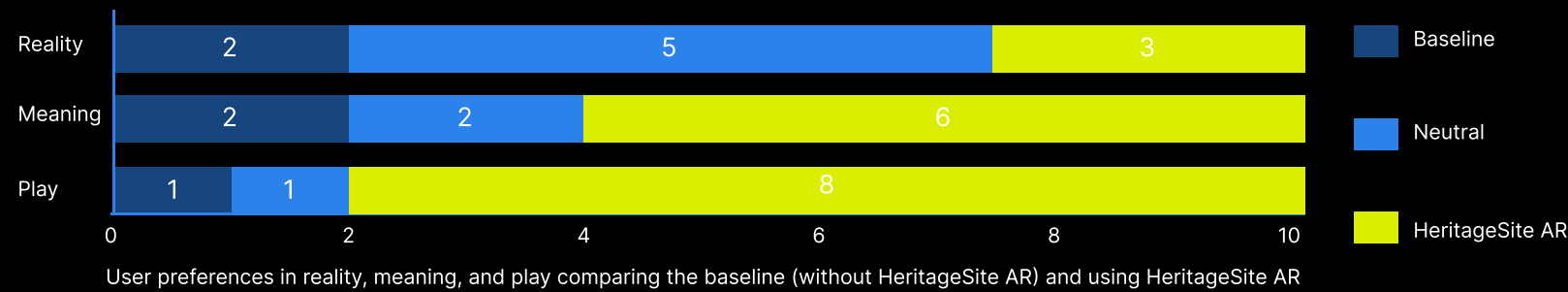


Relics of the Main Hall of Arhat Monastery



Evaluation And Reflection

Our evaluation study involved seven volunteers and three domain experts, a total of 6 females and 4 males. A semi-structured interview was conducted and analyzed using themes-based content analysis. For experts, we further ask their attitudes about the HeritageSite AR from the perspective of its potential values. The results showed that HeritageSite AR has a neutral performance in the reality dimension, but users found it to have made the CH visits more meaningful and playful.



Evaluation Following Triadic Game Design

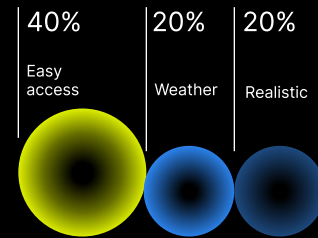
Reality

We identified three themes for this dimension.

Easy access: Acquiring heritage information using a mobile phone is convenient because users don't need a guide.

Weather: The user experience will be affected by the weather.

Realistic: Through AR exploration, users can get more information and are willing to recommend it to others.

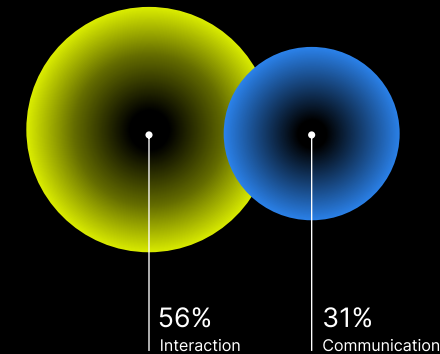


Play

Participant evaluations on this dimension were positive.

Interaction: Users' favorite part is the 3D model of the Twin Towers, which allows visitors to observe the model from all angles and take photos with it.

Communication: Visitors were often immersed in conversations with NPCs, and people felt obligated to help them solve their problems. However, one participant pointed out issues in AR recognition, saying that AR is affected by lighting and weather, and recognition is sometimes slower than expected.



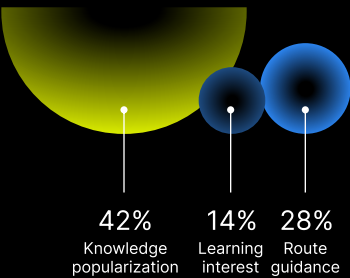
Meaning

All participants acknowledged the meaning of HeritageSite AR in terms of CH knowledge popularization.

Knowledge popularization: This app has allowed me to better read inscriptions and annotations that I once could not understand.

Learning interest: It makes the visit interesting and inspires users to explore the stories behind the attractions further.

Route guidance: The map gave users a clear guided tour and overview of the visit.



Reflection

- *Our current prototype design has placed limited concern on onsite social interactions to support CH learning. Incorporating a combination of social play and team collaboration could potentially enhance the overall visiting experience and improve learning efficiency.*
- *Users are very interested in experiencing CH restoration. However, creating visual representations of historical architectures demands extensive domain knowledge and technical expertise.*
- *Our evaluation results do not represent the views of all members of the public. A possible approach is using wearable devices and sensors in future system evaluations to obtain objective measures of sentiment and engagement.*