
explorAR: A Collaborative Artifact-based Mixed Reality Game

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Abstract

explorAR is a project that provides a new experience to learn the world of the past by exploring mixed reality with your phone. In this interactive experience, users engage with the museum and with each other by collecting artifacts which include fossils, paintings, statues, and other historical objects. Users will learn how to preserve historical objects by extracting fragments of artifacts, how to collaborate with each other by combining fragments of missing artifacts, how to express their creativity by designing their own virtual gallery, and how to participate in a crowdsourced research. We developed the concept using human-centered design approaches which includes interviews, personas, prototypes, and user testing.

Author Keywords

Mixed reality; game design; learning technology; gamification; digitization; collaborative learning.

ACM Classification Keywords

H.5.1 Multimedia Information Systems
H.5.2 User Interfaces
K.3.1 Computer Uses in Education
K.8.0 General (Games)



Figure 1: The main screen of the game which shows an interface of functional buttons, a generated rock, and a map of the user's environment.

Introduction

Museums are places where both adults and children can spend their leisure time. They provide reliable, authentic, and understandable information where the public can find meaning and connection [5]. In this era of digital information where there are more alternatives to leisure activities, museums have a decline in interest as a result from lack of social participation [8]. As reported by the New Media Consortium, major museums & institutions start digitizing their collection by 3D scanning and exporting them into 3D models which helps museums expand their audience. There is a need for museums to engage their visitors, increase participatory experience through new media, and create a crowdsourcing environment [10]. Our solution is explorAR, a collaborative artifact-based mixed reality exploration game can offer a new learning experience.

This game is played through an immersive experience, which allows users to conceptualize key concepts and representations easier, enhance user experience, and increase engagement [6]. According to Falk, motivation, expectations, group social interaction, and exhibition design strongly affect learning [5]. Studies have shown that immersive experiences can improve education [2]. Augmented Reality for education enables users to interact with digital information within the physical environment [4]. Unlike other virtual reality museum tours and audio guided museum tours that have been existed, mixed reality gamification is the main aspect of this approach.

Our goal is to create a mixed reality game that demonstrates a new gamified learning experience based on exploration which supports public learning and empowers the engagement between users and museums.

Background Research

We identified 2 targeted main stakeholders of the game: high school & college level students who are motivated to learn subjects outside of their curriculum and museum curators who want to try new platforms to engage and attract more customers.

We interviewed two experienced museum curators who both have spent at least a decade in curating a museum. Based on the interviews, we learned that:

- Even though they come from different departments, they feature some objects in common in their exhibits, such as fossils, artifacts, and art.
- They stated that museums seem to be overshadowed by other modern entertainment media.
- They thought the newer generation is not entirely interested in museums, because they are more exposed to modern entertainment media in their free time.
- They believed that creating a mixed reality game based on museum artifacts would make people, especially the newer generation, experience the sense of exploration that traditional museums could not offer which might also increase more visitors.
- They were currently 3D scanning their artifacts collection as a part of their digitization program, but had no clue how to utilize them.
- They stated a problem where there are some artifacts that have very little information, which would be difficult to be presented in the game because they need to have accurate information.

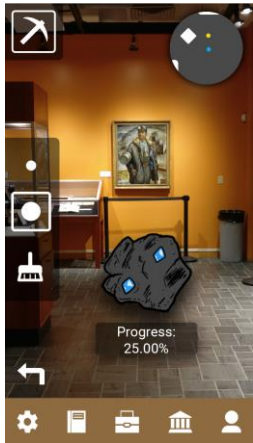


Figure 4: Excavation mode showing a rock to be extracted using a set of different tools.

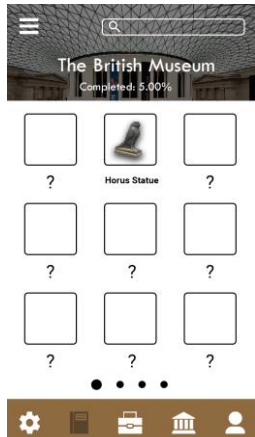


Figure 5: The encyclopedia which shows a completed artifact in a collection from a museum.

residues from the rocks. However, if users are not careful with their tools, they could damage the fragment and it can be destroyed. (Figure 4)

This game can be played both inside and outside of the museum. This does not mean that playing the game inside and outside of the museum have the same experience. Users outside of the museum have normal spawn rate of generated fragments, but users around the museum have increased spawn rate of generated fragments, exclusive geotagged content from the corresponding museum, and higher chance to encounter players to engage with. The gallery and encyclopedia features are accessible in both locations.

Encyclopedia

The user's phone acts as an adventurer's log book & mini encyclopedia that tracks all of their discovered artifacts. (Figure 5) The encyclopedia can be sorted into different museums. It can also be filtered in terms of types of objects, such as statues, monuments, fossils, and paintings. Users can read interesting facts about their findings and observe the 3D model by rotating and zooming the object. Incomplete artifacts have small hints about what the whole artifact would be like. After the completion of an artifact, it will show the whole information about the artifact including facts and its history. (Figure 7)

Virtual Gallery

Users can create their own virtual gallery where the virtual gallery is decorated by their collection of discovered items. (Figure 8) Users can also visit another user's gallery and give ratings. This feature allows users to express themselves by presenting their most rewarded completed artifacts in their gallery.

Multiplayer Collaboration

In creating an engaging learning experience, users can collaborate with each other. Collaborative learning is a

learning strategy that involves small groups that have shared goals of learning [7]. By having a common goal to collect and combine artifact fragments, users will collaborate with each other. By collaborating with each other, users can combine missing fragments into a complete artifact. To combine fragments into an artifact, users can select which fragment in their inventory they want to combine and simply drag and drop the piece into the main play area. (Figure 6) Both users acquire the completed artifact which they can see the artifact in the encyclopedia and use the artifact to decorate their gallery. Apart from completing artifacts together, users can visit and rate another user's gallery. Using a mixed reality gamified learning environment increase social engagement and collaboration. It also increases motivation and healthy competition between other users [3].

Based on the five essential elements of collaborative learning by Johnson & Johnson, this is how our game design would fit [9]:

1. *Positive Interdependence*: In scavenger hunt, users need each other's contribution of missing fragments to complete an artifact for their collection.
2. *Promotive interaction*: Users support each other by helping in excavation mode, completing an artifact, and visiting each other's galleries.
3. *Individual accountability*: Each user can check their progress of their collection using their encyclopedia.
4. *Interpersonal and small group skills*: Users will develop their teamwork skills in collecting all of the artifacts;
5. *Group processing*: By visiting each other's galleries, users can discuss each other's progress in completing the encyclopedia of artifacts.

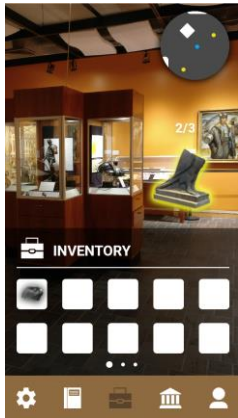


Figure 6: A fragment in a user's inventory is ready to be combined.

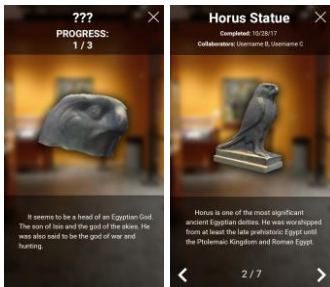


Figure 7:

Left: A fragment of an artifact which shows a hint of the whole artifact.

Right: A completed artifact which shows the completed information about the artifact.

Interactive Learning

Research has shown that students find interactive augmented reality educational platforms easy, practical, and useful in learning [11]. In fact, an augmented reality mobile guide for art appreciation in a

museum has been proven to make their users more engaged in the learning experience. Therefore, users give positive responses and acceptance attitudes to the platform [1].

Motivation

In explorAR, users are motivated both intrinsically and extrinsically. The game incentivizes users to collect artifacts, which will be their main source of intrinsic motivation. While collecting the artifacts, users will learn factual information and the history of the artifacts. Extrinsic motivation of the users can be shown when users visit each other's gallery, which creates a healthy competitive environment for users to collect and learn more about the artifacts. By showing the completion percentage of a museum collection at a museum, users can be rewarded a souvenir from the corresponding museum.

Crowdsourced Research

Based on the interviews with the museum curators, some of the museum artifacts in their collection are unknown and have little information. The game can feature lesser known artifacts from a museum collection, which lets users to provide factual information about the artifact through crowdsourcing. Users may come from different cultural backgrounds which would be beneficial for the museum if they could provide information about the artifact. Users can check the encyclopedia entry of a lesser known artifact where there is a section that need more information, write the known information, and submit it to the museum moderators to confirm if the information is valid.

(Figure 9) With this feature, museums can engage with not just their current visitors, but people around the world who are users of the game.

User Testing

We conducted user testing to observe how users operate the application and how users evaluate the usability of the game. We asked five students to test the application prototype. Before they were tested, they were explained the main idea and the objectives of the game. After user testing, we asked some questions about the main features of the game and suggested the users to give feedback of each feature. From the users' feedback, we discovered:

- Users found the interactable objects in the environment and the navigation map immersive.
- Users felt more curious about the artifact after they got a fragment of an artifact which showed a hint about the whole artifact.
- Although some users were lost when combining a fragment, they loved the idea of collaborating with each other.
- Users enjoyed the concept of collecting artifacts and motivated to learn more about the history and factual information of the artifacts.
- Users were interested in the virtual gallery where they can create their own gallery and visit another user's gallery.
- Although the tested users admitted they don't know much about artifacts, they believed crowdsourcing unknown artifacts through users' insights can benefit museums' research.



Figure 8: A virtual gallery of a user where it is decorated by the user's completed artifacts.

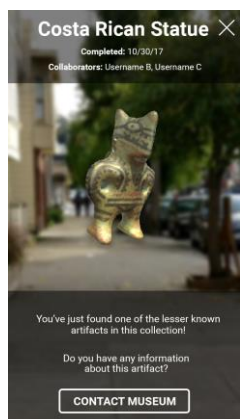


Figure 9: A lesser known artifact that users can contribute information about it.

Conclusion

We have designed a collaborative artifact-based mixed reality game using human centered design methods. Based on the user testing, users have a lot of interest in the game and the goal of the concept is fulfilled, to create a new gamified learning experience based on exploration that supports public learning and empowers the engagement between users and museums. After minor design tweaks in the future, explorAR can be developed into a working game and can be used as a platform for museums as a part of the digitization movement.

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