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Vessel: A Cultural Heritage Game for Entertainment

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Abstract

Museums are digitizing their collections of 3D objects. Video games provide the technology to interact with these objects, but the educational goals of a museum are often at odds with the creative forces in a traditional game for entertainment. Efforts to bridge this gap have either settled on serious games with diminished entertainment value or have relied on historical fictions that blur the line between reality and fantasy. The Vessel *project is a 3D game designed around puzzle mechanics that remains a game for entertainment while realizing the benefits of incorporating digitized artifacts from a museum. We explore how the critical thinking present in solving puzzles can still encourage engagement of the story the artifacts have to tell without creating an historical fiction. Preliminary results show a preference for our in-game digital interaction over a traditional gallery and a desire to learn more about the artifacts after playing.*

Motivation

Museums are places where curators tell stories. They design galleries and carefully coordinate artifacts to connect their viewers to the history surrounding the artifact. These galleries engage not only the facts but also the cultural heritage context surrounding each object. Although museums have historically been physical locations, many institutions have recently gained interest in applying the technological advances of the 21st century to build "virtual galleries" that can be experienced on a computer or phone rather than in the physical building [1], [2]. The ongoing COVID-19 pandemic has rapidly increased awareness of the need to have cultural experiences available beyond a museum's physical walls.

Virtual galleries are an excellent way to increase access to a museum's collection for those who are unable to physically visit the institution, but can be much more than just a digital translation of a physical room. Some enhancements are immediately apparent, such as the ability to virtually "pick up" and move an object, which would be unacceptable with the physical object. Some virtual experiences have gone further, exploring serious games with concrete educational goals [3]–[9]. While an innovative application of 3D technology, these experiences often struggle to break free of the boundary between museum and game, remaining stuck in the rules of a gallery and not the limitless world of entertainment. At least one study has indicated that these experiences are less effective at engaging a younger audience [8].

In recent years, popular video games have demonstrated their ability to tell stories that educate the player with regard to history, art, or culture while simultaneously providing entertainment value. Examples of this include AAA games like the Assassin's Creed and Uncharted series as well as smaller games like "Never Alone", "Walden, a game," and "Heaven's Vault." [10] However, these games are typically narrative-driven and often mix real history with the game's internal mythology, creating a largely imagined historical fiction. This, along with a tendency to forget the sacredness of historical objects and spaces, limits the games' ability to truly educate the player through the entertainment [11], [12].

Figure 1. *The main hub space of Vessel, a puzzle game for entertainment that incorporates digitally scanned artifacts from a museum.*

Educational research has found that the more actively a person is engaged with an experience designed for learning, the more impactful and memorable that experience will be [13]–[16]. This suggests that the educational goals of a museum might be well served by breaking down the barrier between a "museum" for education and a "game" for entertainment. In fact, one can complement the other's weaknesses: the traditional aspects of a "museum" can fulfill a player's desire for more meaning and purpose when playing the game, while the components of a traditional "game" can allow the player to be more actively involved, making the museum experience more engaging and memorable.

The availability and nature of 3D content from museums has changed significantly in recent years. New efforts by major GLAM (galleries, libraries, archives, and museum) institutions worldwide are utilizing photogrammetry to scan and digitally preserve their physical collection. Research and standards have grown, and information has proliferated quickly as scanning becomes easier and more affordable. However, the industry has struggled to provide an effective means for the public to engage these artifacts in a way that is similar to the in-person, gallery experience. Many institutions keep this material under strict copyright, recognizing the significant cost and time involved in its generation.

One notable exception is the large collection of scanned artifacts at the Minneapolis Institute of Art (Mia). When the photographers at Mia first proposed scanning their artifacts into 3D models, internal debate occurred over how to license this new

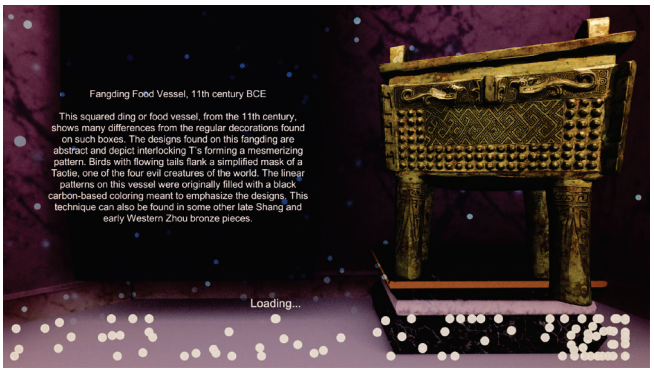

***Figure 2**. Artifacts are interactive and contain historical background information. (Left: Zen Zone; Right: loading screen).*

media. The photographers argued that it should be licensed in the same way as their photographs: free and open under a Creative Commons Zero license. [17] While this was a risky decision for the museum, it means that there is a *large* collection of high quality, 3D models available for both commercial and non-commercial use without concerns about attribution or copy-left clauses. A game that could leverage these assets effectively would further help the mission of the museum while instantly gaining a library of models and assets.

It is at the intersection of all these concerns that the *Vessel* project came into existence.

Problem

Existing tools for viewing captured 3D objects (like Sketchfab [18] and 3DHOP [19]) focus on simple interaction and often do not provide an environment that engages the mind at a deeper level. While they provide access to a visual depiction of a museum object, their storytelling ability is limited compared to the potential demonstrated by games for entertainment. They also use shading models originally designed for depicting artist-generated models, rather than accurately reproducing the appearance of artifacts from the real world using the mountains of information available in the photographs. While these tools do "remove the plexiglass" and bring you closer to an object, they also lose the reflective properties of the object and present the materials as static and unwavering, forever baked in the exact lighting and position in which they were captured.

The *Vessel* project seeks to address these problems:

- Improve engagement of the "story" of a digital artifact's culture and heritage.
- Overcome the sometimes-difficult experience of engaging art in a museum by connecting to the world of video games.
- Engage the desire for meaning and purpose while playing interactive 3D games.
- Encourage critical thinking in the context of this engagement with digital museum artifacts.
- Leverage video game technologies to render more accurate material properties in real-time.

Approach

Vessel is an undergraduate capstone project that set out to build a game for entertainment around a variety of digitally scanned artifacts from the Minneapolis Institute of Art (Mia). The student team was responsible for all aspects of the game's design and premise. They worked to develop an experience that would both stand on its own as a game for entertainment, but also address the problems outlined above. One key part of this was to build experiences that encouraged critical thinking while working with the artifacts. In addition, there was a desire to integrate opportunities to interact with the artifacts in a high-fidelity environment. The artifacts were present in three key game modes (see **Figure 2**):

- A primary puzzle game mode where gameplay is most important, but the artifacts are present with their context and story conveyed through text descriptions.
- A museum-influenced mode (called the Zen Zone) where artifacts can be interacted with in a more traditional way without the distractions of puzzles or other game mechanics.
- A loading screen between areas in the primary game mode which provides an interactive view of an artifact alongside a description of its historical background.

Artifact Acquisition and Rendering

As noted earlier, Mia has adopted a philosophy of open sharing of all 3D reconstructions of objects in their collection for which the original is itself in the public domain. Most of the museum artifacts used in Vessel are represented using a 3D model that Mia has published on their Sketchfab page (https://sketchfab.com/artsmia) and released into the public domain. The availability of so many public domain models from Mia contributed to the ease with which the Vessel development team was able to integrate these objects into the game.

Mia's large collection of digitally archived 3D objects consists primarily of objects scanned using a turntable photogrammetry pipeline. The turntable is programmed to move automatically in increments of 10 degrees, and a robotic arm is used to automate captures at different elevations (again, using increments of about 10 degrees). When safe to do so, an artifact may be turned upside down to photograph both the top and bottom of the object. This process produces between 200 and 500 photographs of each artifact. For each object, a photograph of the object with an X-Rite ColorChecker chart [20] is also included to perform color calibration. Agisoft Metashape [21] is used to perform photogrammetry, producing a 3D textured model of each artifact.

Most objects in Vessel were reconstructed from photographs taken on a white background using studio lighting. This results in a high-quality diffuse texture map, which is sufficient for objects that do not exhibit much specularity. However, certain objects were photographed against a black background using a single on-axis flash mounted onto the camera for backscattering illumination. This

Figure 3. *An artifact in the Zen Zone (Warrior Prince, Guan Yu; in the collection of the Minneapolis Institute of Art) rendered using a custom shader that more accurately reproduces the specular appearance of the object.*

method has been shown to better capture the specular properties of an object [22], [23]. As observed in prior work [23], [24], the offset from the position of the light source to the camera can be determined using a manual calibration step where the user moves a virtual camera until shadows disappear; at that point, the viewpoint will be at the same position as the light source in the photograph. As in the same prior work, to obtain linear reflectance measurements and thus ensure accurate specular reproduction, representative values from each grayscale square on the ColorChecker chart were obtained and interpolated to reverse the tonemapping that was applied to the photographs. An iterative process modelled after Nam et al. [25] was used to fit the flash images to a model that can be efficiently evaluated in real time using a custom shader in the Unity game engine (see **Figure 3**). The custom shader produces a more accurate depiction of the object's specular properties than the default Unity shaders, with little to no impact on performance.

Performance

One major technical concern for the *Vessel* project was rendering the artifacts in the primary game mode while maintaining a high framerate on an average computer. The game must carefully balance resources for game mechanics and rendering of the full environment in addition to displaying the museum artifacts in a way that maintains their fidelity. To address this, all artifacts used in the game were decimated to a lower polygon count, while maintaining a proper mesh structure. We then used this lower-polygon model in-game to support having more of them in the virtual space along with other shaders and visual effects.

This decimation process is straightforward as Autodesk Maya provides a robust automated system for mesh decimation. Meshes were first imported into Maya, where the automated reduce tool was used to eliminate some polygons. This method did have some issues, the primary one being that the objects were already textured. Maya does not adapt the texture for the lower polygon count, so in some cases the texture appeared stretched after decimation. Although this meant that we were not able to use the reduced versions in some cases, the technique could be very useful in future projects where more time could be spent developing a workflow to properly retexture the mesh after decimation.

Gameplay and Interaction

The history of the artifacts is largely absent in the story of the primary game mode, providing only hints for puzzle solving (see **Figure 4 Left**). This helped avoid the temptation to construct a historical fiction or blur the lines between history and fantasy. Instead, the game developers worked to build mechanics and a narrative that afforded critical thinking of the kind desired in a museum. The primary gameplay mechanic revolves around two "vessels" that the player can occupy, one youthful and naïve, the other older and wiser. The youthful vessel has more mobility (they can jump) while the other vessel has knowledge the younger one does not (they can see solutions to puzzles) (See **Figure 6 Right**). Through line-of-sight (either direct or via reflections in a mirror) the player can freely swap between vessels and work to connect the old and young's abilities just like we desire them to connect the past and the present in a museum gallery.

To help draw additional attention to the artifacts within the game and create a drive for players to look more closely at the artifacts themselves we added in a visual effects (VFX) system which outlined the artifact in glowing particles. This VFX system was only given while playing as the older character to help provide a hint system to find the artifacts more easily, while also tying in these artifacts into the game's aesthetic with particle-based characters, and the ethereal mind-museum theme the game was targeting (see **Figure 4 Right**).

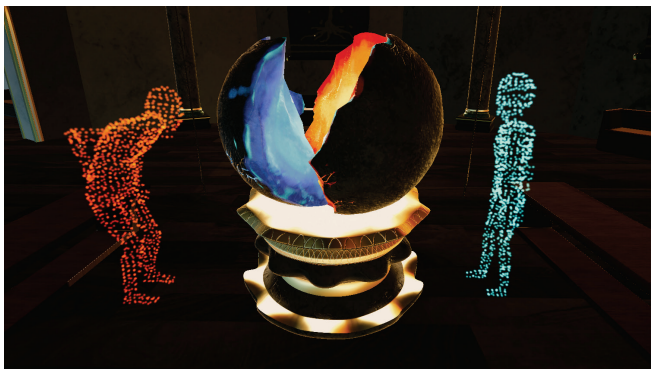

Figure 4. **Left***: Gameplay often involves interacting with artifacts and placing them in their proper location (such as on these pedestals).*
Right*: The two 'Vessel' characters rendered with particles. Vessel made use of many such visual effects to enhance player engagement.*

Figure 5. *The central garden of the Zen Zone emphasizing an ethereal and calm environment more indicative of a museum.*

Both the Zen Zone and the loading screens were developed to allow the player to engage more directly with the history of the artifacts in the game, apart from any gameplay requirements. In the Zen Zone (**Figure 5**), the player can view a large collection of artifacts, including quite a few that were not used in the main game. These artifacts can be rotated and zoomed to see details. This mode allows the artifacts to be enjoyed at any time, and most importantly, with no barriers between the viewer and the artifact. The Zen Zone is set up like a traditional museum exhibit, without the fantastical elements of the standard gameplay.

In the Zen Zone, when a player wants to investigate a specific artifact, they approach it and pick it up (See **Figure 6 Left**). Once they have picked it up, the information about the piece appears on screen. The title, time-period, and historical background of the object are all included in the text. On-screen text was chosen over the traditional wall placard, as it makes it much harder for the player to ignore or miss the information. The focus of the Zen Zone is for players to learn about and interact with objects, so we wanted them to see both the information and the artifact at the same time.

The loading screens function similarly to the Zen Zone, allowing the player to interact with and learn about the objects. However, whereas the Zen Zone puts these objects within a greater museum environment where players can spend as much time as they want, the loading screens provide the same function without the environment in the brief loading times between puzzle levels. Loading screens tend to be the less interesting parts of a game, so the goal was to use these times to further engage the player. This gives the player an opportunity to learn more about the artifacts whether they choose to go through the Zen Zone or not.

The loading screens only use artifacts that were also featured in the puzzle levels. In contrast, the Zen Zone contains new objects for the player to interact with, beyond those they already encountered in the levels or the loading screens. These extra artifacts provide additional motivation for the player to explore the Zen Zone. In fact, one of the motivations for creating the Zen Zone was to display additional artifacts from Mia that did not have a place in the puzzle levels. Since there were many artifacts to choose from, deciding which to showcase in levels was difficult. The Zen Zone also served as a place to experiment with the custom specular shaders to evaluate the performance when rendering both the artifacts and the environment on different computers.

Results

The first version of Vessel was released on May 5th, 2021 as part of the virtual Stout Game Expo. It can be downloaded and played on modern Windows PCs (https://bissellb3521.itch.io/vessel). Since the project did not have concrete educational goals as many other cultural heritage games do, we decided to approach evaluation qualitatively. Individuals were asked to play the game and fill out a post-play survey giving their impressions of traditional games-for-entertainment concerns like enjoyment and engagement, as well as UI and UX concerns like ease of use and difficulty. They were also asked about their general impressions of the different roles that scanned artifacts played and the different modes for engaging them.

We are still gathering this feedback and analysis is ongoing, however initial trends indicate that users find interacting with the artifacts in Vessel very enjoyable, both in the loading screens and in the Zen Zone. They also indicated that this interaction stimulated their desire to learn more about the artifacts and that they preferred interacting with the objects in Vessel over a traditional museum gallery. One of the more critical responses indicated that while they found the overall idea "masterful," and enjoyed interacting with the artifacts, there were some criticisms about usability and clarity in the gameplay mechanics: specifically, a desire to be able to traverse the Zen Zone more easily and some confusion about how certain puzzle objectives were presented. Initial respondents have not been a representative sample. They all identify as gamers and game designers. We hope to diversify the pool of respondents to see if the positive feedback holds for those that do not play games regularly.

Video game development is known for having a very tight feedback loop from user testing back to the design of the game. Due to social distancing concerns during the SARS-CoV-2 outbreak, the team was not able to hold public playtests as frequently as desired. To alleviate this, Mia has offered to playtest the game and solicit feedback with groups of interest in their own organization. Through community outreach, they hope to engage a younger audience by having them playtest Vessel and helping to generate more feedback for improving the overall game design and evaluating the success of recreating the full, immersive experience of a museum gallery.

Conclusions

While the goals of Vessel are not as quantitative as in serious games, preliminary feedback does show that the continual engagement afforded by the high-quality scanned objects enhances engagement of these artifacts and stimulates interest. Players enjoy interacting with the artifacts and express a desire to know more about their history.

We do not have feedback to support it yet, but we expect that the game will appeal to a wider audience than games that are either purely for entertainment or for education. We also have some evidence that players of a certain background (gamers) prefer the interaction with artifacts in Vessel over a traditional gallery.

Lastly, the Vessel development team reported a very favorable experience working on the game. They found the scanned artifacts to be a source of inspiration that shaped the entire development process. We speculate that avoiding concrete educational goals helped with this, allowing the team to play to their strengths and stick to what they know for Vessel.

Countless experiments in creating games-for-education around historical information and artifacts seem to have fallen short, being

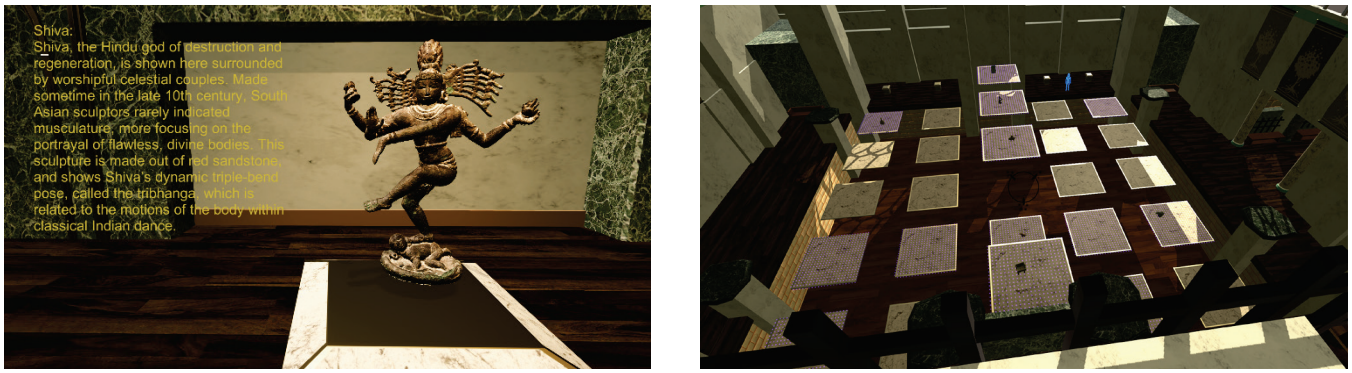

***Figure 6. Left**: Close interaction in the Zen Zone with information about the artifact displayed next to the object.*
***Right**: A puzzle from the main game where the older vessel can see information that the younger vessel cannot.*

judged harshly by traditional game critics and players. This seems to be indicative of most games that desire to teach more than entertain. Vessel shows some promise in closing that gap and engaging the world of video game developers and players more favorably while still achieving some fundamental educational goals.

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