



Memorial Quest - A Location-based Serious Game for Cultural Heritage Preservation

Georg Volkmar

Digital Media Lab, TZI
University of Bremen
Bibliothekstraße, 1
28359 Bremen, Germany
gvolkmar@uni-bremen.de

Nina Wenig

Digital Media Lab, TZI
University of Bremen
Bibliothekstraße, 1
28359 Bremen, Germany
nwenig@tzi.de

Rainer Malaka

Digital Media Lab, TZI
University of Bremen
Bibliothekstraße, 1
28359 Bremen, Germany
malaka@tzi.de

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Abstract

This paper describes the design and evaluation process of a location-based serious game in a *heritage awareness* context. Conveying knowledge regarding tangible cultural heritage with the help of video games is a well-established concept. Though many applications in this domain have proven to be effective, they always rely on restrictions regarding time, place and usage of specific hardware. In contrast to previous approaches, we have developed *Memorial Quest*, a serious game with the objective to convey knowledge regarding cultural heritage objects accessible without aforementioned constraints. We examined educational effects by conducting a user study ($n = 40$) in which we compared our game to a common learning method in cultural heritage. Statistical analysis of the results revealed that learning effects were significantly larger when playing the game instead of perceiving the same contents in a traditional way. With the help of questionnaires and qualitative data, we identified possible flaws and elaborated potential improvements for future iterations.

CCS Concepts

•Applied computing → Computer games;

Author Keywords

Serious Games; Cultural Heritage Awareness; Game Design; Location-based Services; Embodiment

Introduction

Tangible cultural heritage (TCH), a concept first established by the *International Council on Monuments and Sites (ICOMOS)* [12], incorporates structures such as landscapes, historic places, sites and built environments [13]. Those objects, spread across a cityscape determine a city's unique character and thus, play a significant role in shaping a society's identity [25].

As Anderson et al. have summarized in an overview paper [1], serious games have been utilized to preserve and enhance knowledge regarding *TCH* by reconstructing ancient historical sites, virtual museums and commercial historical games. However, games that were developed within this context were bound to a specific place and in some cases custom-built hardware. Therefore, those applications were naturally limited in scope and required special circumstances to be played leading to a decreased accessibility. In contrast to this approach, we wanted to empower people all around the globe to learn about the historical background of their environment in a playful way. With this intention in mind, we developed *Memorial Quest (MQ)* - a mobile location-based *TCH* serious game that can be played anywhere only requiring internet access.

Since the learning effectiveness of this new approach hasn't been evaluated yet, we conducted a user study, in which the game was compared to a common learning approach in cultural heritage. Results show that *MQ* led to a significantly higher learning effect than its traditional counterpart while keeping mental workload to a similar level. Moreover, we collected qualitative and quantitative data on how to improve the game even further and implemented additional features based on subjects' feedback.

With this work, we contribute to the preservation and expansion of knowledge concerning *TCH* by presenting a functional gameful approach of tackling this objective with the help of embodied interaction.

Related Work

Serious games developed in the application area of cultural heritage fall into three different categories based on their specific learning objective: *cultural awareness*¹, *historical reconstruction*² and *heritage awareness*³ [18]. For each of those categories, previous projects have contributed substantial work.

The *GEIST* project provides a historic sightseeing tour through the old town of Heidelberg, enhanced by mobile, augmented reality technology [15, 17]. *VeGame* is a location-based application that aims to facilitate historical knowledge regarding the Italian city of Venice [3]. In *Frequency 1550* [24], a team of four players has to solve tasks that are spread over the city of Amsterdam. Playing *Virtual Egyptian Temple* [14], players learn about ancient Egyptian culture in a CAVE-like environment. *Revolution* [10] covers the everyday lives of citizens in Williamsburg during the 18th century. The *Ancient Pompeii Project* [16] and *Roma Nova* [21] are concerned with displaying avatar behavior as realistic as possible to immerse players and increase learning effects. In the *Media EVO Project* [7], players visit a recreation of the Italian city Otranto using a Nintendo Balance Board for navigation and a Wiimote for interaction. As for the *Priory Undercroft Game* [8], a treasure-hunt setting was utilized to motivate people to learn about the eponymous crypt in Coventry.

What all of the discussed previous projects share is that content is tied to a specific place or event. These games work fine for players who are particularly interested in the history of a city or a certain time period. However, for peo-

¹Games that cover intangible cultural heritage aspects such as norms, values, rites, beliefs and the overall society.

²Games that were developed with the intention to portray a specific period of time, event or place.

³Games that provide representations of current real structures and aim to motivate players to engage with their environment.



Figure 1: Welcome screen that is presented after launching the game with the historian on the left and an introductory text on the right.

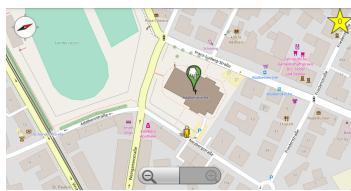


Figure 2: Standard view showing map layout, player, compass, points, zoom options and *POI* in the vicinity.



Figure 3: Learning set of a single *POI* (text retrieved from *Wikipedia*).

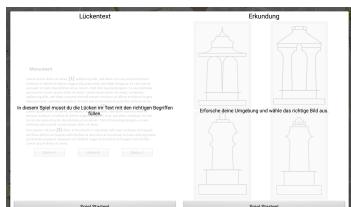


Figure 4: Menu showing minigame choices: *Fill-in-the-blanks* (left) & *Exploration* (right)

ple who would like to gain knowledge regarding cultural heritage of their surroundings, these applications don't provide a viable solution.

In the following section, we will depict the design of the location-based serious game *Memorial Quest* which tackles this problem.

Game Design

As stated above, *MQ* is constructed as a location-based game that can be played anywhere as long as an internet connection is available. The overall objective of *MQ* is to convey historical data by providing a playful interaction technique. The game can be played on a mobile device such as smartphones or tablets. The user's position is tracked via GPS or, if not available, a position-estimation algorithm based on the network connection. Information regarding culturally relevant objects is obtained with the help of *OpenStreetMap (OSM)* [19]. Since *OSM* only includes very basic information in regards to these structures (object's position & type), we used *Wikipedia* [26] which provided more detailed information. Data from *OSM* and *Wikipedia* is merged and integrated into *MQ*.

In terms of what gameplay elements should be integrated into the game, this work relied on the *Serious Game Model for Cultural Heritage* [2]. This model offers various *task templates* based on different gameplay mechanics. For *MQ* the *Manuscript* template, which lets players insert missing words in a text document was implemented. For a second minigame, we made use of another template called *VisualQuiz*, that requires players to choose the correct image representing a specific object. Furthermore, the game is set in a treasure-hunt scenario in which the player has to collect *TCH* objects to proceed.

As a method to increase motivation, a story-context has been implemented in the game. The approach of having

a fictional character introduce the story has been used in other serious games from the domain on cultural heritage with promising results [4, 5, 11]. In *MQ*, this idea was adopted by having a virtual historian tell the player that they need to collect historical data.

Technical Basics

Information regarding location and object type are obtained with the use of *OSM*. The application reads the player's position which is then transmitted to *OSM*. Within a specific bounding box (radius of about 50 meters around the player) objects of cultural relevance are retrieved. A query contains key-value pairs which determine what kind of point of interest (*POI*) is requested. For *MQ*, the query consists of a *historic* key and *values* such as *memorial*, *monument* or *archaeological_site*. Based on the object's kind, a specific marker icon is displayed on the map (e.g. an abstract statue for memorials).

After selecting a *POI*, the game sends another request to *Wikipedia* using the name that was retrieved via *OSM* before. If an entry could be found, the application obtains the general descriptive text that is used as a learning set and material for the *Fill-in-the-blanks* minigame later on. An image of the object is also stored for the *Exploration* game. In case no entry was found on *Wikipedia*, a small dialog appears telling the player that there is no information at the moment.

Gameplay

When launching the game for the first time, a virtual historian greets new players explaining their task and thus, the story-context of the game (see figure 1). He introduces himself as the *Preserver of Knowledge* and states that his task is to explore and document cultures of the past, summarizing information for an encyclopedia that he's currently writing. In the introductory text, the historian assigns the role of

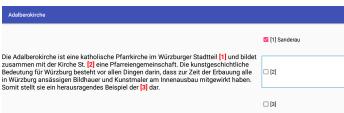


Figure 5: *Fill-in-the-blanks* minigame: incomplete text on top and 3 options for each blank below.



Figure 6: Feedback dialog after *Fill-in-the-blanks* showing received score & correct answers.



Figure 7: Layout of the *Exploration* game displaying four images including the correct picture.



Figure 8: Page of the virtual encyclopedia that holds information for collected *POI*.

a collector of knowledge to the player who in turn embodies this role physically by aggregating the desired information in the real world.

After the introduction has been given, the standard view of *MQ* is displayed. This screen contains the user's position (visualized with a distinct icon), a compass, a map showing basic information such as streets or buildings and certain *POI* that carry cultural relevance (see figure 2).

By pressing a *POI* via touch, a learning text is presented on screen (see figure 3). When they are finished reading the text, players can press the *Choose Game* button which gives them the opportunity to select either the *Fill-in-the-blanks* or *Exploration* minigame (see figure 4).

For *Fill-in-the-blanks*, players have to assign specific expressions to blanks in the text by applying the information they learned while reading the text (see figure 5). For each blank, two false alternatives are presented. After all three blanks have been filled, *MQ* gives a feedback dialog showing how many answers were correct (see figure 6). Points are assigned for each right answer.

When playing *Exploration*, the correct image representing the object has to be selected (see figure 7). To solve this task, players have to engage with their environment, exploring and thus learning cultural heritage in their vicinity. Just as in the other minigame, points are rewarded if the task was completed successfully.

The encyclopedia was integrated in the game as a treasure-hunt scenario to foster motivation. For each visited *POI*, a new entry is created that can be perceived later on (see figure 8).

To enrich the score that can be increased by collecting *POI* with meaning for the player, we implemented badges that are unlocked for a number of points (see figure 9). As of now, the first badge unlocks *Exploration* whereas *Fill-in-the-blanks* is available from the start.

Comparative Study

The application's educational effectiveness was evaluated by conducting a study in which the game was compared to a traditional learning approach in cultural heritage (e.g. information on brochures in the tourism sector). This traditional counterpart is based on mere texts and images, a method that common cultural heritage education used to rely on [20]. The evaluation was performed in the form of a between-subjects design consisting of two conditions. In the experimental condition participants played the game whereas in the control group they perceived the learning set in the form of text and images.

Material

The experiment was conducted using a mobile device (10.1 inches Android tablet). For evaluation purposes, a prototype that only included basic functionality was developed. This version didn't contain a story-driven introduction, badges or treasure-hunt mechanics. Moreover, since the study was conducted in a laboratory setting, *Exploration* couldn't be played sufficiently. Therefore, we focused solely on the *Fill-in-the-blanks* minigame.

For the study, five specific *POI* were created with simulated historical data (no linkage to *Wikipedia* for reasons of robustness during the experiment). Additional materials used in the study were instructional documents, a multiple-choice quiz for the examination of learning effects and questionnaires (SEA-Scale for mental exhaustion [9], ISONORM 9241/10 for overall software quality [23]).

Procedure

Before the actual session began, participants signed a statement of agreement (collection and use of personal data) and read the instruction paper. In the experimental condition, subjects played the game "visiting" five *POI* in random order (see figure 10). Afterwards, they filled out the



Figure 9: Dialog showing a medal as an achievement (bronze in the example) after reaching a specific score.



Figure 10: Adjustments for the evaluation study: random order of *POI* determined by a red number.

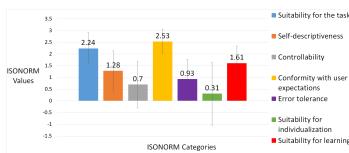


Figure 11: Values for each category of the ISONORM 9241/10 questionnaire with one standard deviation as error bars.

SEA-Scale, self-reporting their mental exhaustion. Finally, the ISONORM 9241/10 was completed and demographic as well as qualitative data was gathered. In the control group, a PowerPoint presentation covering the same *POI* as in the experimental one was presented in random order as well. The rest of the procedure was the same with the only exception that no ISONORM 9241/10 questionnaire had to be completed.

Participants

Overall, 40 subjects (18 female, 22 male) took part in the study. Their ages ranged between 19 and 31 years ($M = 22.23$, $SD = 2.83$). Most participants (97.5%) stated to be students of either Media and Communication (B.A.), Human-Computer-Systems (B.Sc.) or Human-Computer Interaction (M.Sc.).

Results

For learning effects and mental workload, t-tests for independent samples ($\alpha = .05$) between control and experimental condition were conducted. Effect sizes were calculated according to the formulas reported by Cohen [6].

Learning Effect

Overall, the amount of achievable points ranged between 0 and 15. Subjects who played the game answered significantly more questions correctly ($M = 13.50$, $SD = 1.43$) than subjects in the control group ($M = 12.20$, $SD = 2.38$), $t(38) = 2.10$, $p = .043$, $d = .68$.

Mental Exhaustion

Values for self-reported mental workload measured by the SEA-Scale could vary between 0 and 220. No significant differences could be identified between subjects playing the game ($M = 59.60$, $SD = 31.60$) and subjects who were part of the control condition ($M = 60.40$, $SD = 31.69$), $t(38) = -.08$, $p = .937$.

Software Quality

In the study, the German version of the ISONORM 9241/10 was used. For this paper, we refer to its scales by the translation provided in the international version [22]. Values for each scale can vary between -3 and 3. Excellent results were received for *Suitability for the task* (2.24), and *Conformity with user expectations* (2.53). Promising ratings were also received for *Suitability for learning* (1.61) and *Self-descriptiveness* (1.28). In terms of *Controllability* (0.7) and *Suitability for individualization* (0.31), there is still room for improvement (see figure 11).

For the experimental condition, subjects were given the opportunity to express their opinions concerning the game's quality and content. Many participants stated that they missed context information on why they would play the game in the first place and keep playing over a prolonged period. Moreover, players criticized that awarded points didn't carry any meaning at all.

Discussion & Future Work

As the results indicate, *MQ* has proven to be an effective tool for conveying cultural heritage knowledge in a playful manner. In comparison to traditional learning methods, *MQ* achieved a significantly higher educational effect. Considering mental workload, both the serious game and the common approach caused a similar level of exhaustion. Taking data from the ISONORM 9241/10 questionnaire into account, the game was seen fit for the task at hand, it was capable of describing its own functionality rather well and it behaved according to players' expectations.

Since *Controllability* received such low scores, we want to address this issue in the future. Certainly, low ratings for *Controllability* can be attributed to the nature of our study. Subjects were given a distinct task and were not able to use *MQ* in its entirety, features such as collecting *POI* or exploring were not integrated in the study prototype after all.

Nevertheless, we want to increase the feeling of *Controllability* further by providing players more options and thus freedom when interacting with the software. For instance, allowing them to pause or abort a game session would be imaginable. Generally, options for playing the game are quite limited since there are basically only two minigames provided so far. Giving people the feeling of more control could be enhanced even further by adding more mechanics in various ways. *MQ* offers stages that can be unlocked by playing the game and collecting points. However, only the first level-up (= bronze badge) actually impacts the gameplay by unlocking the new minigame *Exploration*. For future iterations of the software it would be advisable to provide additional game fragments which become available when the player has reached a new stage.

Suitability for individualization obtained the lowest ratings since it wasn't in the focus of development up to this point. In the future, we want to enhance this quality by implementing ways for customization. Potential changes would be the integration of a personal avatar for the player, different tile sets for the map screen and color schemes.

Based on qualitative data, participants of the study have criticized the lack of purpose and motivational factors. These problems have already been tackled by the full version of *MQ* that wasn't playable in the evaluation study. We embedded the game in a story-context with the use of a virtual agent to give meaning to gameplay mechanics and added a treasure-hunt setting while giving players the feeling of contributing something to the problem established in the story-introduction.

With the current version of *MQ*, we have delivered an effective serious game that isn't restricted to a specific location as previous projects have been.

However, in our first experiment, we only investigated short-term effects regarding motivation and learning progress.

It is still unknown whether these effects will prevail over a

longer period of time. Thus, we can't say if *MQ* will motivate players to stay engaged in the long run and hence achieve a long-term learning effect. In the future, we would like to conduct an experiment over an extended time span to examine this issue.

Furthermore, we have evaluated the game in a laboratory setting so far. Since *MQ* is meant to be played in a mobile context, we will conduct a study in the wild in the future. It is worth noting that all subjects of the first study presented here had a media and/or computer science background. As a consequence, it can be assumed that most of them had prior knowledge in terms of using mobile devices and interacting with touch-based applications similar to *MQ*. None of the participants were in need of an extensive introduction on how to operate the tablet device or how touch inputs worked. Being able to interact with the game intuitively for reasons of familiarity may have impacted the results regarding mental exhaustion and software quality. In the future, we aim to address a more heterogeneous audience with our game. Therefore, we plan to include a larger variety of subjects regarding age and educational background in the proposed field study.

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