



A Serious Game Design and Evaluation Approach to Enhance Cultural Heritage Understanding

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Abstract. One of the most promising means regarding the potential of supporting both, entertainment and learning, in cultural heritage sector are the Serious Games (SGs). During last decades, Cultural Heritage Serious Games (CHSGs) are being developed with the use of different technologies, in order to facilitate learning of cultural heritage via an entertaining manner. Although, there are evidences about CHSGs effects, there is the need of extracting more reliable results about their effectiveness, meaning the extent to which the initial intentions achieved their purpose. Regarding CHSGs, this purpose is twofold, which means the measurements are as much about entertainment as learning. Moreover, there is the need of increasing evidences on CHSGs' effectiveness regarding higher-cognitive processes in learning. The aim of the present paper is to describe a CHSG design and evaluation approach, which is oriented to the enhancement CHSGs effectiveness in terms of entertaining and learning, as well as the extraction of more reliable results. Regarding learning aspects, the proposed approach focuses on extracting results about cultural heritage understanding. The suggested approach will be applied in a CHSG for the understanding of the Roman Forum of Thessaloniki, Greece.

Keywords: Serious Games · Cultural Heritage · Game design

1 Introduction

In recent years, serious games are being used as means to communicate cultural heritage, through the use of various technologies such as AR, VR, projection-based applications, desktop and web applications [1–5]. CHSGs that take place in 3D virtual worlds offer the opportunity to the user not only to view the representations of the past, but also to interact with them. In addition, game mechanics allow the user to execute quests and earn rewards for completing activities that promote learning and thinking on the related cultural content. Such games promote the explorative behaviour, while the user is triggered by game mechanics to explore the virtual world [6]. During the exploration the user receives visual stimuli, which enhances the understanding of the past. The users also have higher motive to think about the past in order to make decisions to progress in the game. The other hand Although, CHSGs can be highly effective in communicating cultural heritage content, there is the need of more reliable

evidence on their effectiveness [1, 9]. Moreover, the results on their effectiveness regarding higher cognitive processes, are limited [1, 2, 4]. Thus, it is important to highlight the positive effects that serious games can have on cultural heritage cognition in a systematic and reliable way in order to create more high-level games and spread their use. Additionally, the integration of personalized experiences in CHSGs, can increase their effectiveness in terms of entertainment and learning, and reach wider audience [4].

This paper aims to present the early design phase of a CHSG approach that targets to enhance the understanding of cultural heritage. More specifically, the proposed approach aims to meet these objectives: (a) increase serious games effectiveness by design [1, 10], (b) contribute to the collection of more rigorous CHSGs research results [1, 2, 4, 9], (c) examine the CHSG's effectiveness on higher cognitive processes [1, 2, 4], (d) analyse log data and use artificial intelligence to increase SG effectiveness in terms of user experience and learning [1, 4, 11].

The rest of the paper is structured as follows. Next section, which consists of four sub-sections, presents the objectives of the CHSG research study. In the third section, the suggested design approach is presented, while in the fourth section, the progress and the upcoming work are being described. Finally, the last section presents the conclusions.

2 The Proposed CHSG Objectives

The proposed CHSG approach aims to meet the following four objectives defined on a literature review of the field:

2.1 Increase Serious Game Effectiveness by Design

One of the objectives of this work is to contribute to the serious game design methodology to enhance their effectiveness, through the definition of the targeted effectiveness goals, in early stages of SG design. Serious games are widely used in various fields, while there are evidences that they facilitate learning through an attractive and entertaining manner. Serious games aim by definition in entertaining and learning [13], while their effectiveness should be defined in terms of whether they achieved the initial goals in relation to these two parameters. In recent years, discussions on serious games focus on ways to increase the evidences in order to spread their use. In the last few decades, many design frameworks have been introduced as tools within the research community to ensure some level of effectiveness [10]. Although, evaluation frameworks have been also introduced, it is not common to take into account the evaluation process, during the design phase [10]. A different approach comes from the education field, where every educational process, in design phase has built-in mechanisms that will allow the measurement of the results according to the objectives set. Thus, to enhance effectiveness, is suggested to define from the very beginning in a specific verbal manner the expected outcomes of the gameplay (What will be measured?), as well as the way that these outcomes will be measured (How they will be measured?). Thereby, during final evaluation, it will be clear if the initial goals

of the game achieved and to what extent (see Fig. 1). The initial measurable goals and their evaluation should concern parameters related to (a) the users' experience, including entertainment and (b) learning. These parameters could be evaluated using a framework for a systematic evaluation of educational games, such as MEEGA+ model [14]. This framework provides quality factors that can be used to evaluate a SG in terms of user experience (focused attention, fun, challenge, social interaction, relevance, satisfaction, usability) and learning (knowledge, skills, attitude).

2.2 Extract Rigorous Results About CHSGs, Through the Use of Log Data

This work also aims to contribute to the CHSGs research with more rigorous results about their effectiveness, through the use of log data. The effectiveness of the CHSGs is related not only with the results themselves, but also with the reliability of the measurement process to extract the results. According to [1], most of the recent studies on CHSGs, conducted non-experimental methods with one intervention group and lack of comparison group, making difficult to draw conclusions about what would happen without the game session. Moreover, most of the non-experimental studies did not use a pre-test in order to compare the intervention group before and after the session. In addition, only few studies utilized the ability to observe user's behaviour through log data. Taking into account the additional small size of the participants in most of the studies, it is evident that more rigorous results need to be extracted to promote CHSGs potentials. The parameters that will be defined as effectiveness factors should be measured during gameplay, by integrating the collection of log data in the game architecture. These data, in combination with the results from other evaluation tools (questionnaires, pre-test, post-tests), is expected to enhance the reliability of the results (see Fig. 1).

2.3 Examine the Effectiveness of CHSG on Facilitating Higher Cognitive Processes

Another goal of this work is to examine the effectiveness of CHSGs on facilitating higher-level cognitive processes. The entertainment factor is included in user's experience parameters and can be evaluated among other factors that contribute to a pleasant experience [14]. On the other hand, learning may concern cognitive (knowledge), affective (emotions - attitude) and psychomotor (actions - skills) domains [7, 8, 14]. Cognitive domain refers to different levels. The understanding level of cognition targets higher learning objectives than the first remember level, which usually is being examined. The remember level concerns the information retention and recalling, while the next levels concern the understanding, applying, analysing, evaluating and creating [7, 8]. Although, the goal of the serious games is twofold: entertainment and learning, recent studies focus more in the users' experience and examine less or not at all the learning outcomes of the games. Furthermore, most of the evidence are limited to the cognitive level of remembering, while there is a little effort on enhancing higher level cognitive processes, and by extension there are few relevant results [1]. This work will examine the three first levels of Bloom's taxonomy (remember, understand, apply)

focusing on understanding level of cognition. According to needs, and measurement tools available it is possible to include parameters regarding higher levels (analysing, evaluating, creating). It is expected to contribute to the evidence that exists on whether a digital CHSG is able to enhance the understanding of cultural heritage.

2.4 Increase CHSG’s Effectiveness Through the Use of Data Analysis and Artificial Intelligence

Last but not least, current study aims to improve the effectiveness of CHSG regarding user’s experience and learning by using data analysis and artificial intelligence (AI). The data collection during gameplay, can inform us about the users’ behaviour inside the virtual world [11]. Some of the collected data can be exploited not only for the final evaluation, but also for the formative evaluation, during game session (see Fig. 1). Those data can be analysed and part of them can be used as input to the artificial intelligence module, which will configure part of the game. In this way, the CHSG can offer a more personalised experience, that is more satisfying in terms of entertainment and learning. Thus, the data that will be collected will be defined, as well as the types of analyses, the input parameters for the AI and the output parameterized content of the game. Moreover, the data analysis can provide more reliable results in final evaluation in combination with the rest of the log data. Finally, through data analysis is possible to extract results not only for users’ experience but also for the learning process.

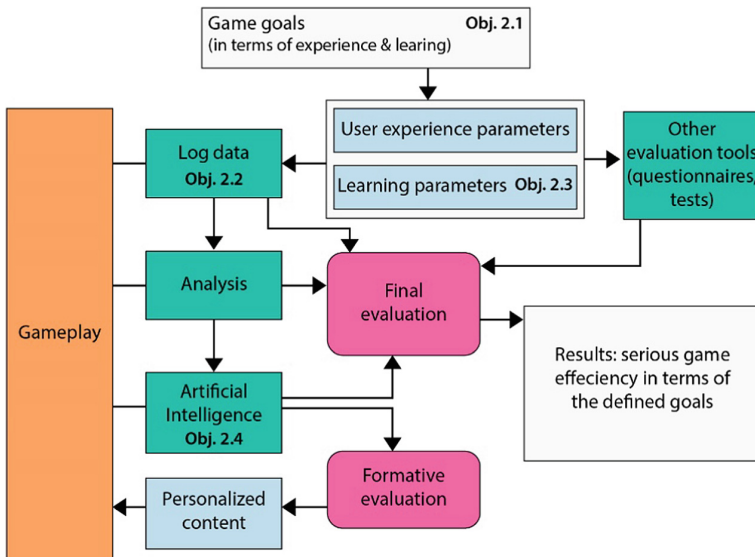


Fig. 1. Visual representation of the proposed CHSG evaluation process

3 CHSG Design Approach to Enhance Understanding of Cultural Heritage

The visual representation of the CHSG design is presented in Fig. 2. The main subject of the CHSG emerges from tangible or intangible cultural heritage that is intended to be disseminated to the public. The main subject may vary from an emblematic museum exhibit, to a monument or an archaeological site. Interesting to communicate with a 3D CHSG is a historical theme or a whole era, due to the fact that a whole virtual world can be created in the game, as well as myths and traditions, where imaginary creatures can get alive and heroes can revive. An interesting aspect is to create CHSGs for monuments, or cultural heritage objects, that are difficult or even impossible to reach the wide public. Often monuments are accessible only for researchers (e.g. tombs), or it is impossible for the public to reach them, due the restrictions of the physical space (e.g. underwater). Additionally, important cultural heritage objects that cannot be exhibited because of their fragile materials can reach the wide public through CHSGs delivered via web.

Fortunately, for cultural heritage sites, objects or monuments, there is at least one institution or utility that is responsible for its protection and communication. The same goes for the intangible cultural heritage, which is widely being digitized in recent years. Regarding historical themes and myths there are also the responsible organizations or specialists (universities, research teams etc.). The collaboration with the experts, facilitates the identification of the scientific knowledge that exists for the cultural heritage subject. Additionally, the experts may have supportive role during the development process of the game, to ensure the reliability of the CHSG content.

The information about the CHSG subject may come from different sectors such as archaeology, history, architecture and many others. This material is being filter with storytelling techniques, to be transformed into scenarios. Additional, material such as similar projects or related representations, mood boards, and inspirational sources can feed the visual representation of the virtual world. In any level of fidelity that have been selected for the game graphics, this process is a highly artistic work with challenges regarding meeting the users' needs. With the integration of the game mechanics, the scenarios are being interactive in order for the users to progress in the story, while playing. This means that the scenarios are being transformed to missions, quests, levels, non-playing characters, virtual agents, rewards etc., according to the game genre that has been selected as the most appropriate in earlier stages of the CHSG design. Thus, the virtual environment is being transformed to a game.

In order to facilitate learning, the structure of the game activities, as well as their learning content, is formed not only by the game attributes but also by the contribution of learning theories. The user plays the game by using the selected input devices. During the game session, data are being collected regarding the user's actions inside the virtual world. These data are being analysed and, through the use of artificial intelligence, part of the experience is being personalized to the behaviour of the user. At the same time these data, are used to evaluate the game, enhancing the reliability of the evidences CHSGs' effectiveness in terms of entertainment and learning.

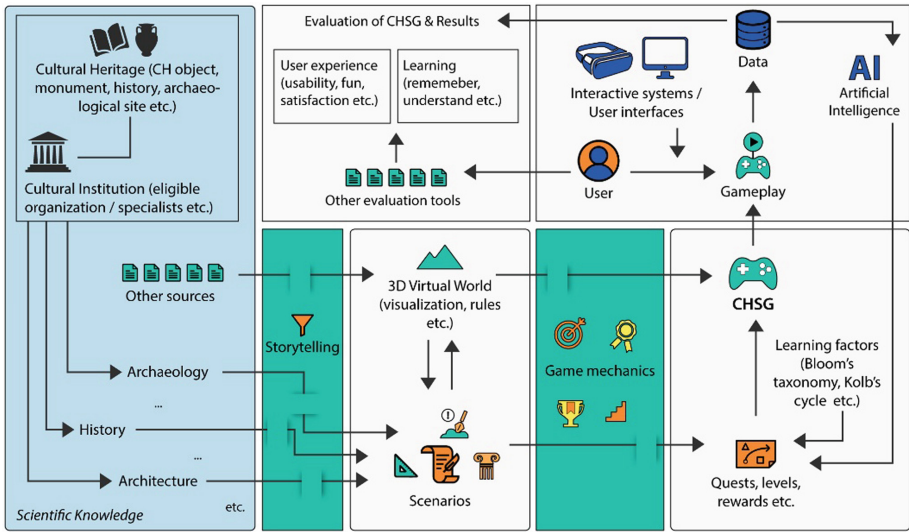


Fig. 2. Visual representation of the proposed CHSG design

4 Current and Future Work

The aforementioned approach is intended to be applied for the creation of a CHSG for the Roman Forum of Thessaloniki¹, Greece. The monument was the administrative centre of the ancient city. Its construction began at the end of the second century A.D. on the site of an older forum dating from early Imperial times. The complex of the forum was arranged around a rectangular paved square. There were stoas on the three sides, each of which consisted of a double row of columns and provided access to a surrounding zone of public buildings. The southern stoa stood on a vaulted substructure (cryptoporticus) – an impressive double arcade which was partly underground, making use of the natural slope of the land. To the south, along the cryptoporticus, there was a row of shops fronting the ancient shopping street. There is also a building for public performances that must have functioned as an odeon. The Roman Forum Museum (Ancient Agora)² is underground and is located inside the archaeological site. The exhibition of the museum includes mainly informative material and emphasis is given to the clarity of the information and the comprehensive way of presentation, with the goal to make the content easy to understand for everyone.

The organization that research and protects the archaeological site is the Ephorate of Antiquities of Thessaloniki City (EATC), which under the Hellenic Ministry of Culture and Sports. In collaboration with the EATC, we decided to develop a serious game to enhance the understanding of the Roman Forum. The understanding of cultural

¹ In Thessaloniki page, <http://inthessaloniki.com/item/roman-forum-museum-ancient-agora/>, last accessed 2019/6/15.

² In Odysseus page, http://odysseus.culture.gr/h/3/eh351.jsp?obj_id=2457, last accessed 2019/6/15.

heritage is expected to be reinforced by implementing the game in a 3D virtual world, which offers visual stimuli and enhances the sense of presence. Firstly, a 3D representation will be developed, based on the existing archaeological material, in order to consist our 3D Virtual World. The same material is being processed, at this time, to extract the scenarios of the game.

In our case, we decided to follow the adventure genre and corresponding game mechanics, as the most appropriate genre to enhance cultural heritage understanding. The proposed serious game will place the cultural objects in their original context of use and will enhance the explorative behaviour of the users. The combination of the experiential approach with the digital 3D representation in a virtual world can enhance the educational value of the experience, while the user could be able not only to observe the environment but also to interact with its content [6]. The explorative behaviour in the virtual world is being enhanced by transforming the interactive experience in a serious game, by implementing game mechanics and pedagogical approaches. More specifically, when the game mechanics follow the adventure type of game the user explores the virtual environment, collects objects and clues related to their context and forms hypotheses about their use. Then the user tests the hypotheses by using the objects in the environment, in order to solve game's puzzles and executes the missions to progress in the game. This approach leads itself to the use of Kolb's theory and application of the experiential cycle of learning, where the user thinks about how to solve a task and experiments to the point that the approach tested leads to the solution of the riddle [12]. Additional to the experimentation activities, Vygotsky's scaffolding [15] (hints, help on demand, etc.) will be used, among other facilitating learning factors [10].

During gameplay log data will be collected in order to export more rigorous results on users' experience. Moreover, by analysing those data it will be possible to offer a more personalized experience to the users, while part of them will be used as input to the Artificial Intelligence (AI) module, which will adjust part of the game, based on the users' behaviour. The interaction will be offered in lower (desktop) and higher (virtual reality system) level of immersion. The log data will be used for formative evaluation (during gameplay) and the final evaluation, combined with other tools (pre-tests, post-test, questionnaires). This CHSG will be evaluated in terms of the cognitive level, and more specifically in understanding and higher-level processes. In terms of user experience fun, satisfaction, usability and other factors will be measured.

The collection of the related scientific material has been completed, meaning the archaeological research that have been published by the EATC. The scenarios are work in progress, as well as the design of the virtual world rules and environment. In parallel, decisions are being made in more detail regarding game user experience and learning intentions, as well as other factors, based on our previous work [10]. According to the intentions, the metrics will be defined, as well as the corresponding parameters for the log data, the type of analysis and the input/output of the artificial intelligence module, aligned with the game activities.

5 Conclusions

The results of this study are expected to contribute to the creation of experiences with high educational and entertaining value in the CH field. It is evident that SGs are able to offer such experiences, while existing studies have highlighted their potential for enhancing learning and entertainment. However, the results of CHSGs that have been extracted with systematic ways are limited. Many of the studies, evaluate the user's experience, which includes the entertainment factor, and do not evaluate the learning aspects of the game, while most of them evaluate the first cognitive level (remember) [7, 8]. The evidence regarding the effectiveness of the CHSGs in terms of higher cognitive levels are limited [1]. This study proposes that the CHSGs effectiveness can be enhanced by defining the game goals in terms of user experience and learning, along with the tools that will be used to measure the results, from the early stages of the design process. Thus, it is possible to integrate evaluation mechanisms in the architecture of the game, in order to collect data regarding the behaviour of the users, during gameplay. Additionally, those data will be analysed to extract more rigorous results. Moreover, part of the data will be used as input to the artificial intelligence module in order to adapt a part of the game content to the user's behaviour and offer a more personalized experience. The goal is to extract evidence of CHSGs effectiveness with more systematic ways, and provide rigorous results regarding their potential to offer a pleasant experience (entertainment) and to support cultural awareness and understanding of cultural heritage (learning), in order to spread their use. The use of 3D environment and immersive technologies will support the communication of cultural heritage, and is expected to trigger the participants' interest on the cultural heritage content of the game.

Main aspects of the proposed CHSG approach are (a) the use of log data and the data analytics to increase the reliability of the evaluation and the extraction of more reliable results, (b) the use of artificial intelligence to adapt content of the game based on user's behaviour, (c) the use of 3D virtual world to facilitate cultural heritage understanding, (d) the indication of the adventure games as suitable game genre for the understanding of cultural heritage, and for the support of higher-level cognitive processes.

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