Interactive Game Development to Assist Cultural Heritage

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Abstract. Serious educational games provide a novel way to transfer knowledge on cultural heritage, which can especially attract young people by using interactive multimedia technology. The paper presents a new flexible tool for developing, managing and presenting games. This server-based solution can facilitate the game development by applying game templates, layout styles and question pools. It also supports the development of game packages for multiple languages and multiple platforms (Web and mobile). The games can easily be customised for various learning domains. Complex games can be composed from several so-called minigames (e.g. puzzle, multiple choice, memory game, crossword etc.) and the tool also supports the evaluation of the user answers and organising competitions. The games were applied to deepen knowledge on various topics related to our cultural heritage. The latest game development is represented by the serious educational game "The Thracians" running in a virtual 360º panorama environment, which presents the life, beliefs and traditions of the ancient tribes.

Keywords: Mobile Applications, Interactive Games, Serious Games, Game Development, Thracian Civilization

1 Introduction

Serious educational games provide a novel way to transfer knowledge on cultural heritage. They can provide new information to the users in an entertaining way by applying innovative interactive technologies. In addition to improving the understanding of the domain presented by the game, they engage the players in an active participation during the learning process and inspire them for creative thinking.

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Software developers of the Institute for Computer Science and Control, Hungarian Academy of Sciences (MTA SZTAKI) invented a game editor and a game portal for creating various games. The game types supported are being continuously extended and they currently include sliding puzzle, memory game, matching, ordering, crossword single and multiple choice, word search, blind map, etc. The games can be customized by different parameters (e.g. size, time limit) and adapted to different domains. The questions presented by the game can be randomly selected from a question pool. Tournament organisers are supported in defining rules for scoring. The users may register for playing online games. Competitions can be organised among the registered users with the help of the game portal.

The games can run online on the Web and both offline and online on mobile platforms (Android, iOS). HTML5 was successfully applied in the game development together with CSS3 technology. The game editor and the game portal support the use of multiple languages.

MTA SZTAKI has been involved in games development on various domains related to cultural heritage for years. Such games are in use for example on the Web page of the Bulgarian Iconographical Digital Library (BIDL) and the BOOK@HAND BIDL mobile application for game-based learning of the Bulgarian iconographical art (Luchev, et al, 2016). Another example is the Attila József in Ferencváros literary walk, which is available within the GUIDE@HAND Budapest mobile application (Gönczi, et al, 2017). Several games were created based on the content of the walk. They were used to organise a competition for secondary school students about the life of the poet.

Initially, games were individually implemented for existing Web and mobile applications. The idea of the game server was introduced to accelerate the game development process. Game templates were created from the available games, which can be further customised by using parameters and style sheets. Due to the application of templates, it is easy to integrate the games into existing Web pages and mobile applications.

The latest result of this development is a game engine for creating virtual 360º panorama environments. The environment consists of virtual rooms. The map of the rooms, wall textures, size and location of the images and hot spots on the walls can be defined in a Jason file. Java script can be used to define the logics of the operations assigned to the hotspots. The new game engine was applied to create a serious educational game – entitled "The Thracians" – about the life, beliefs and traditions of the Thracians (a group of tribes inhabiting ancient Eastern and South-eastern Europe). Section 2 of the paper introduces the Game Development, Management and Presentation Tool. Section 3 describes the game development steps by using the tool. Section 4 presents *"The Thracians"* as an example of our latest game development, also including the experiences of the pupils playing the game. The last section contains the conclusions of our development.

2 Learning Methods and Serious Games Applications in Cultural Heritage

Nowadays, the use of information technology rapidly changes the target areas and approaches in presenting cultural heritage. Technology allows new possibilities for the development of innovative methods, scenarios and tools for deeper understanding of cultural heritage. Multimedia applications, virtual environments and augmented reality have already been used for exploring cultural content. Serious games represent an innovative way to perceive cultural heritage in an entertaining and engaging way (Mortara, et al, 2014). Although computer games were originally developed for entertainment, the primary goal of a serious game is something else (Abt, 1970), (Chen, & Michael, 2005), (Damien, Alvarez, & Jessel, 2011). Games created for educational purposes can attract attention, support learning-by-doing and learning-by-authoring, inspire creative thinking and engage users in an active participation during the perception of knowledge. Serious games are widely applied in cultural heritage domain, as well (Draganov, et al, 2015), (Paneva-Marinova, Pavlov, & Kotuzov, 2017), (Bontchev, Paneva-Marinova, & Draganov, 2016).

Serious games represent an intensively studied topic in the literature, although further empirical results are required to examine the effects of gamification (Hamari, Koivisto, & Sarsa, 2014). The literature review of the empirical experiences related to computer games shows that the game-based approach is being used for learning in many different areas, the players like to use it to acquire new knowledge and find it motivating and enjoyable (Connolly, et al, 2012). Games with educational purposes can provide the same psychological experiences as other games do. The intrinsic motivation for learning plays a key role in "making learning fun". The motivation can be encouraged by seven factors: challenge, curiosity, control, fantasy, competition, cooperation and recognition, which are all present in the games (Malone, & Lepper, 1887). The serious games can successfully assist, facilitate and support to achieve the effective goal of the learning process while the users acquire new knowledge, skills, and/or attitudes (Huotari, & Hamari, 2012). A literature overview of computer games and serious games illustrates the increased interest in the positive impacts and outcomes of these games, furthermore, the term "serious games" has become mainstream during the last ten years and it is used interchangeably with "games for learning" (Boyle, et al, 2016). The modern education can be characterised as personal, fun, collaborative, relevant, multimodal, technical and open-minded, where gamification can be treated like a tool to provide the above features (YDP, 2016). In this context, the educational games are effective in transferring knowledge and also in entertainment. Learning experiences based on games have unique particularities such as fun or engagement due to their game-based nature (Caballero-Hernandez, Palomo-Duarte, & Dodero, 2017).

3 Game Development, Management and Presentation Tool

The Tool has the following components:

- Game Template Developer
    - In the game template developer area, game developers can upload the necessary files and program code parts to the Game Server to let them be used by other users of the system. A game template thus consists of the game logic files and the list of necessary parameters with their types, but it does not contain questions, styles and settings.
- Game Editor
    - The game editor area is the component where the editors can put together the games from the available game templates. First, they select a game template and then they add the necessary question-answer combinations to them, select the desired styles, etc. Although the game could be playable at this state, however, it won't be available to any regular user yet.
- Game Publisher
    - The game publisher's task is to create game packages from the games created by the game editor. A game package contains at least one game, but in most cases multiple ones are combined. Game packages can be shared among members of a specified group of users who will be able to play the game.
- Game Portal
    - In the game portal area, the players can see all the game packages assigned to them. They can play any of the game packages and see their scores in rank lists.
- User Management
    - In the user management area, the administrator of the system can see and manage the user accounts of the Game Server.

4 Game Development Steps

The main steps of game development are as follows (see Fig. 1.):

1. Select game type
2. Create game style
3. Add question pool
4. Define game languages
5. Distribute to platforms

The set of game types implemented is being continuously extended. Currently, they include sliding puzzle, memory game, matching, ordering, crossword, multiple choice question, word search, and blind map. The game templates provide a wide variety of customisation possibilities including the size of the game, rules for scoring, time limit, etc. The same game template can be reused in various applications by simply setting the appropriate parameter values.

The layout of the games can also be easily set according to the preferences of the game organisers by using style sheets. The application of HTML5 together with CSS3 technology have made it possible to set up various style sheets containing layout parameters

which can be used to display the games in an appropriate form (colour, fonts, background, etc.).

The multiple-choice questions can be associated with a question pool, which can contain a large amount of questions along with the correct answers. The questions are randomly selected from the pool when the user plays the game. Thanks to this solution, different players can play the same game with different questions and the user can play the same game several times without repetition. The term of question pool can be generalised to other game types, as well. In this respect, the question pools can contain the content items of the game, which may further depend on the type of game. For example, in case of a sliding puzzle this content item can be a picture or – in case of a memory game – pairs of texts or pictures.

The implementation method of the games supports the use of multiple languages by applying translation keys. The source code of the game contains only the keys to text strings and the 'key to language–string' assignments are stored in a database. When the game is displayed, the keys are replaced with the text string corresponding to the key and the language of the game. To support the process of translation, the text strings can be displayed in a table form where the rows and columns belong to the translation keys and languages, respectively.

The games development is accomplished in HTML5 and JavaScript. The same game can be displayed on a Web page or in a mobile application (iOS and Android). After selecting the target platform, the game is generated for the required platform(s).

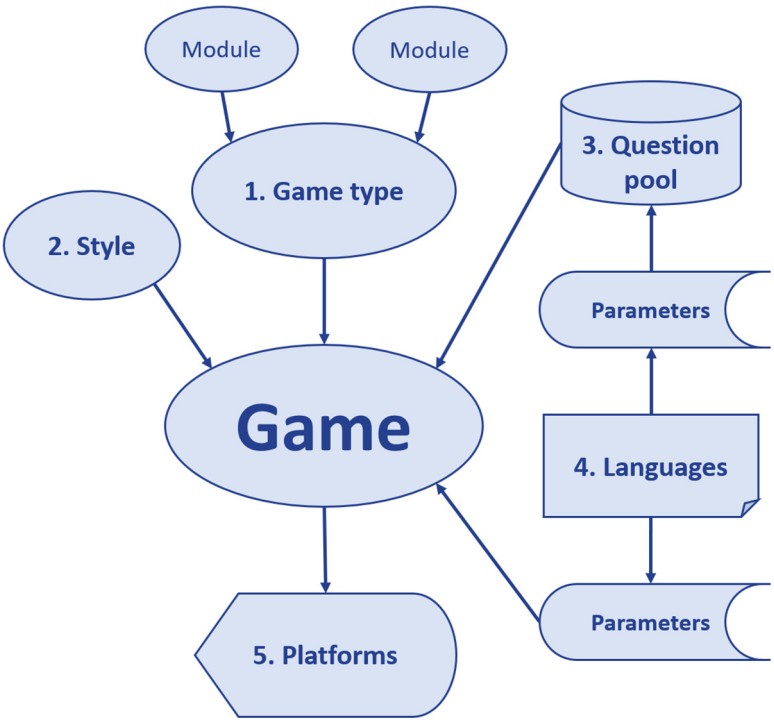

Fig. 1. The diagram of the game portal (Márkus, Paneva-Marinova, & Luchev, 2018).

Fig. 1. represents the diagram of the game portal. The following list contains remarks to the different items on the diagram:

- A **Game** is one playable unit.
- Each game is assigned a **Game type**, like single-choice, multiple-choice, ordering, puzzle, memory, etc. These game types are described by the game templates.
- The **game template** can consist of multiple programming modules. The **Modules** can be reused in game templates.
- Each game must also contain a **Style,** which describes the appearance of the game.
- The game must also include a **Question pool**. A question pool is where the game takes the questions and answers from.
- The game itself, the questions and the answers can also have multiple **parameters**. The parameters describe how the game should process them. A parameter can be, for example, the title of a question or a number telling how many questions should be taken from the question pool. Parameters can also be language dependent. This way one game can be translated to many different languages.

5 *The Thracians* – an Example of Games Developed

Many learning methods such as storytelling, demonstrations, guided-discovery, case studies, simulations, problem-solving, etc., which are typical in Humanities science education, are the core of activities in 4 – 7 grades for studying ancient history and civilization (in particular, the Thracian civilization). These methods try to depict an overall picture of the given civilization to the students, and cover stages, directions and dynamics of the development, factors and conditions that influenced the changes, the degree and strength of the influence and direction of the changes, new trends and so on. The teachers maintain the research and analysis of the domain, provoke discussions during the learning process, and gives specific tasks and projects engaging learners in active participation during the acquisition of knowledge, but sometimes the excessive quantity of facts with vague logic often lead to misunderstanding or weak students' interest. Modern technology in teaching and learning offers new possibilities for the development of innovative methods, scenarios and tools for deeper understanding, to attract attention, to apply learning-by-doing, and learning-by-authoring, as well as creative thinking often missing in the traditional educational practices (Draganov, et al, 2015), (Paneva-Marinova, Pavlov, & Kotuzov, 2017), (Bontchev, Paneva-Marinova, & Draganov, 2016). The development of the serious game *The Thracians* aims at enabling the student to focus on the lifestyle, beliefs and traditions of these ancient inhabitants of the Balkan Peninsula, taking the advantage of the interactive virtual world.

All serious games concerning the cultural heritage and history learning (except the ones located in exhibitions or used for augmented reality visits) can be used at school, but only a few of them are adapted for a specific students' level or curriculum (Mortara,

et al, 2014). As one of the reasons for the limited application of digital games in education might be the teachers' perceptions of the usefulness of digital games (Huizenga, et al, 2017), although the game-based learning approach might be highly effective in facilitating students' 21st century skill development (Qian, & Clark, 2016). Another reason for the lack of serious games dedicated to the educational process is because the serious game developers did not include educational experts in the game developing teams for the selection of educational content (in school history education, in particular). The involvement of scientists and specialists in the subject area of history and cultural heritage for the development of serious games to support history education is important for the scientific validation and reliability of the content, but it is not a widespread practice. It is also not easy to involve the content providers (museums, for example) for the specific use of their content for serious games in the school education. During the development of the game *The Thracians* these obstacles were analysed in advance and overcome for using the game for a more effective study of ancient history and civilization.

The specific task of the development is to produce an educational "design" to unfold current teaching and learning practices in the Humanities sciences, a discipline with excessive quantity of facts and vague logic often leading to misunderstanding. Moreover, the proposed solution has to be easily transferable to other domains, as well. The data and facts provided in the story derive from ancient documents, architecture, artefacts found during archaeological excavations, and from scholarly research by Bulgarian specialists. Some of the best examples of Thracian culture are framed in the interior of each chamber as pictures on the walls or placed into sentences in text boxes. The text boxes summarize important information about the Thracian culture, which is represented in the relevant room.

The Thracian civilization story gets unfolded through a serious game represented by a labyrinth of rooms. The game takes the learner through the rooms of the building uncovered beneath the Ostrusha Mound, located in the Valley of the Thracian Kings near the city of Kazanlak. The first part of the story (Thrace room) is related to the Thracian tribes and their traditions, manners, different areas of high achievements, place of habitation, costumes, etc. The second part of the story (Tomb room) presents Tomb traditions and rituals of the Thracians and their beliefs for the life after the death. The third part (Armory room) presents the military power applied during these glorious ancient wars. The fourth part (Heroon room) is dedicated to the Heroon building that honours the memory of a divine ruler, a prophet hero, who restores harmony in the tribe when an annual ritual is performed in his honour. The Heroon building has a key role for the Thracians because some of their tribes used to immortalize their rulers, priests and heroes and worshiped them as demigods. The fifth part of the story (Treasury room) presents treasures, feasts and abundance that accompany the everyday life of the Thracian kings and their deputies. This ancient civilization was glorified with its vast handmade and unique riches. The last part of the story (Sanctuary room) reveals the mysteries around the Thracian gods that were worshiped at that time (Fig. 2. depicts the main structure of *The Thracians* game).

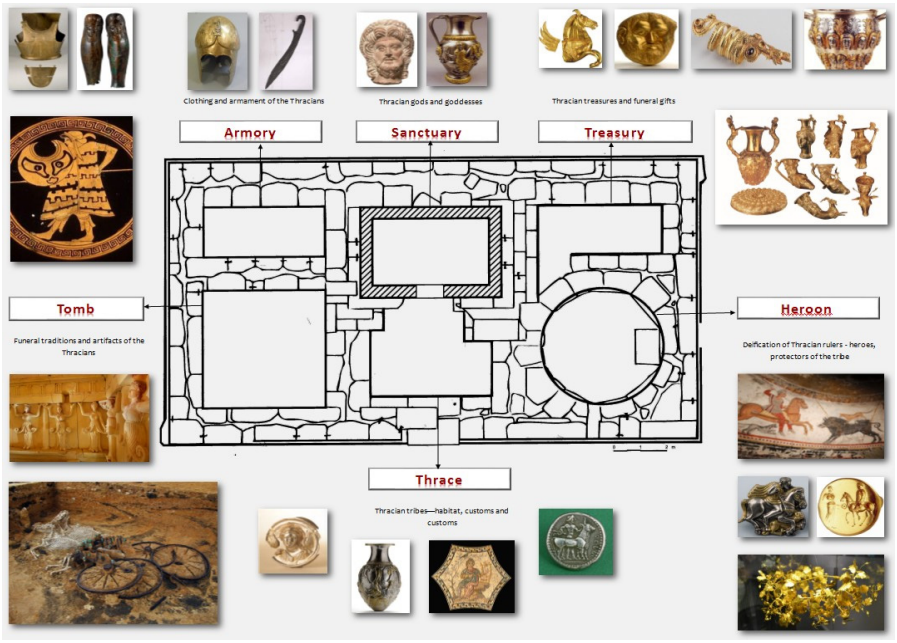

Fig. 2. Main structure of *The Thracians* game.

The educational game *The Thracians* is available in Bulgarian and the multilingual version is under development. The participants can play in a virtual 360º panorama environment consisting of seven scenes (called rooms), one of them is external the others are internal. The starting point of the game is outside of the tomb and the player can enter through a door. The player can move and turn with the arrow keys and the 'A, S, D, W' keys on the keyboard and "look around" with the mouse, too. Each room has several pictures, descriptions, games and doors. See Fig. 3. for a sample room.

Fig. 3. The “Thrace” room

The pictures and descriptions help to solve the interactive mini-games. Fig. 4. depicts a description belonging to a picture on the wall. The doors are initially closed, and they can be opened by solving the mini-games assigned to them. Fig. 5. presents a sample question table that appears after clicking the door opener to the right of the door. The colours of the symbols indicate the status (solved/unsolved) of the mini-game in the given room. The players can see the next room through the open door. The goal of the game is to solve all mini-games and get into the Sanctuary (Márkus, et al, 2018).

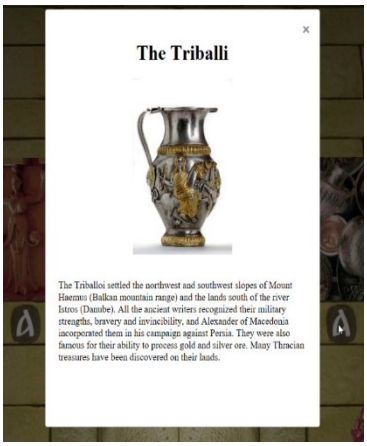

Fig. 4. The description of picture

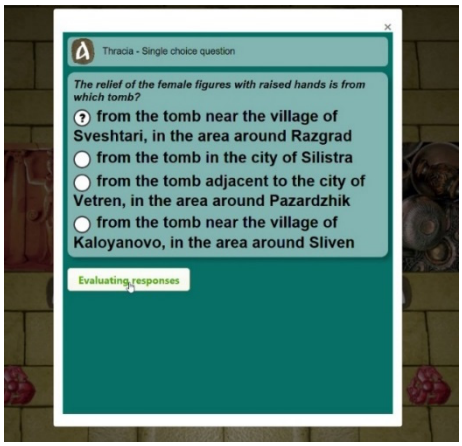

Fig. 5. Multiple choice minigame

The first version of the game *The Thracians* was tested in real conditions in a class with 9-11 years old students in third and fourth grades, respectively. After playing the game, the students answered 22 questions in an anonymous yes/no questionnaire, and also had the opportunity to clarify the reasons for the answers. The answers to the questions: "Did you enjoy playing the game?", "Was the content of the game clear to you?" and "Did you learn anything new about the Thracians from the game?" were all positive and it was visible how the students were learning with pleasure new things in this subject's area trying to solve the mini games. Having in mind that it is educational game, where the students have to build on their previous knowledge and to learn new things, it is understandable that the most negative answers were to the questions "Is the game tiring for you?" and "Is this game difficult for you?". Even more so, the observations after the end of the game in the classroom showed that students continued to play game.

6 Conclusions and Future Work

The games can bring cultural heritage closer to the users and reach a broad audience including young people. They make the knowledge transfer more attractive than the traditional forms of education. One of the key factors of spreading the games in the domain of cultural heritage is to make the game development process easier and faster. For this reason, we implemented a game portal, which facilitates creating, managing

and distributing games by reusing game templates and customisation with the help of parameters.

Beside the game technology, the high-quality content is also significant in the successful presentation of cultural heritage. For this reason, a continuous cooperation is required among the experts of the game technology, education and the presented domain. Our experience is that the content developers are also motivated in creating content for the games, if they can see how attractive is the form in which the provided content is presented.

The first version of the game has been very positively accepted by the students. The testing of the game in real conditions of the classrooms, continues and the results are analysed for improving new versions of the game.

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