

Gamification in Education: Building an Escape Room using VR Technologies

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Abstract - The rapid expansion of media diversity and the growing popularity of "virtual worlds", created the need and opportunity to apply various innovative teaching methods. There is a change in the needs of learners who are no longer in the role of passive listeners. Interactive games can significantly increase learning effectiveness, motivation, and student achievement and turn students from passive to active participants in the learning process. This paper examines the place of gamification in formal education and its role in supporting traditional learning. The purpose of the report is to present a gamified lesson based on virtual reality technologies. The article is focused on two points: (1) introducing innovation in the education of students at the high school stage, and (2) motivating students to think critically, synthesize available information, and solve problems. The paper presents a model and implementation of a VR Escape room as a support tool for acquiring new knowledge in a digital environment. The innovative lesson model is applicable in both traditional and electronic learning environments. The model is independent of the study subject and educational level but is adapted to the attitudes, expectations, and needs of students in high school education.

Keywords - virtual reality; escape room; online learning; e-learning; distance education; serious games

I. INTRODUCTION

Transformations in the education system are most often provoked by rapidly changing circumstances on a global scale. In recent years, we have witnessed a permanent change in the e-learning model from asynchronous (via e-mail) to synchronous interactive learning (through the introduction of popular educational electronic platforms such as Moodle, Teams, etc.) [1]. According to Zunic et al, a catalyst for this process is the pandemic caused by COVID-19, which has significantly intensified the IT sphere of education, imposing e-learning as part of the measures to cope with the pandemic.

For a period of almost 2 years, for many of the training institutions, distance learning and working has turned out to be the only option. In a period of uncertainty, there was a need to search for appropriate solutions to ensure the adaptability of the educational process with a view to reducing inequalities, guaranteeing equal opportunities for quality education, ensuring the sustainability of acquired knowledge and skills and reducing the risk of students dropping out of school.

It is known that the ways of interaction between a teacher and a student directly affects the effectiveness and efficiency of the educational activity [2]. This case is especially relevant when it comes to training carried out through a digital channel. This interaction simultaneously involves technical indicators (such as Internet connection, access to a training platform, availability of technical means, including a computer, tablet, phone, etc.), non-technical indicators (educational resources and adapted to the form of training learning materials), as well as psychological indicators (motivation of learners and trainers).

Today, more and more teachers and teacher communities are beginning to use media technologies to facilitate the work process in a network and in the presence of asynchronous work [3]. On the other hand, the use of digital learning environments related to the creation of fascinating and engaging learning experiences lead to an increase in the use of opportunities for gamification of education and learning [4]. They in turn lead to a higher commitment of the students to the learning process, better acquisition of the material, while at the same time the training is implemented in a much more interesting and motivating way for them.

The aim of this paper is to show the possibilities of virtual reality (VR) technologies to support the learning process. The paper is organized into three relatively self-contained sections. The first section examines virtual education as a new form of interaction imposed by virtual reality (VR). The second section examines gamification as a possible and necessary approach for teaching high school students. The third section presents the construction of a VR escape room for the purpose of training students in the last year of high school education.

II. VIRTUAL EDUCATION – A NEW FORM OF INTERACTION IN THE EDUCATIONAL PROCESS

We most often associate e-learning with courses taught entirely online [5, 6], where the physical distance between teacher and student is irrelevant [7]. Usually, this form of learning takes place through an online platform [6, 8] for teacher-student interaction [6].

There is also the so-called hybrid learning approach that focuses on creating a cohesive learning experience combining face-to-face sessions with online learning materials and activities [8]. Along with the already

established practices imposed by electronic distance learning and the existing hybrid methods of interaction, we consider the presence of a third form combining the peculiarities of the previous two groups. We consider e-learning as a specific form of hybrid learning, where the simultaneous presence of a teacher and a student, or a teacher and a group of students in a common virtual space in real time is possible. For simplicity of expression, we will call this form of learning “VR education” or simply “virtual education”.

A. *Place of virtual education in modern conditions*

Virtual education as a form of learning has the potential to partially or completely replace existing traditional learning. This is because in virtual reality the main advantages of traditional learning are preserved (we have real-time interaction and feedback). At the same time, features are added here that guarantee higher training efficiency. In the form of a real experience, virtual education will increase the interest and motivation of even the most disinterested and at-risk group for dropping out of the education system. On the other hand, virtual education guarantees real-time learning, stimulates team work, motivates the performance of individual tasks, based entirely on project-based learning.

It is important to note that in order to ensure an effective educational process, it is necessary to create a useful digital environment that meets the needs of learners and copes with the transforming challenges in education [9]. It has been proven that the use of innovative media increases students' interest in the learning process [10] and creates a beneficial learning atmosphere. Along with the existing technical limitations, we observe limitations imposed by purely psychological factors. The development of students' motivation in the conditions of distance learning is possible when creating an effective electronic educational environment, which in turn should provide quality content, interactivity and the possibility of individualizing the learning process.

Analyses show that distance learning is a challenge not only for students, but also for their teachers [8]. The reasons for this are complex, but are most often associated with: (1) the need to introduce new educational approaches to engage learners, (2) the need to develop new electronic educational resources adapted to the form of learning and (3) the need to provide a suitable environment for interaction between learner and trainer. The introduction of virtual reality in education will work simultaneously on all three indicators as: (1) it creates an innovative form of learning and interaction; (2) meets the conditions imposed by the learning environment and (3) provides an environment for interaction between a teacher and a student, between a teacher and a group of students, or only between a group of students in the process of their self-training.

The use of innovative media [11, 12] will increase students' interest in the learning process [12], create a fruitful learning atmosphere, and stimulate students' acquisition of more knowledge in a shorter period of time. This in turn leads to an increase in the effectiveness and quality of training.

Virtual reality, as an innovative media technology, allows the integration of gaming approaches. That is why VR finds its place in education, significantly increasing the efficiency of the educational process and giving the opportunity to upgrade, enrich and visualize the educational content. Moreover, virtual education has the potential to transform students from passive consumers of information into discoverers and creators of digital content.

III. GAMIFICATION AS PART OF VIRTUAL EDUCATION

In recent years, researchers as well as various industries have increasingly expanded their focus and interest from the pragmatic issues of human-computer interaction to include aspects such as user experience, emotion, satisfaction, and motivation [13]. One method that includes this concept is called “Gamification”: the use of game design elements in a non-game context [14]. The goal of the gamification methodology is to stimulate user engagement.

Gamification in education is a modern method of organizing the learning process, using game elements for learning, which can attract students to the active learning process [15]. The integration of game approaches in learning affects the behavior of students, their commitment and motivation, which in turn leads to the improvement of the knowledge and skills acquired by them.

In the last decade, gamification has started to become popular and gain more and more attention in educational contexts. The development potential of educational games arises from their ability to teach and reinforce not only knowledge, but also important skills (including problem solving, cooperation and communication). Their motivational power is conveyed in a number of mechanisms to encourage people to engage with them – without reward, just for the joy of playing and the possibility of winning [16].

According to Kapp, gamification is “using game-based mechanics, aesthetics and game thinking to engage people, motivate action, promote learning, and solve problems.” [17]. The specific factor here is that game metaphors, game elements and ideas are used in a context different from that of standard games.

The use of game mechanics improves students' abilities to acquire new skills [18], and gamification as a process allows students to become protagonists of their own learning process [19]. This advantage can be used in disciplines where there is little interest or lack of motivation on the part of learners.

A. *Applying escape rooms to training*

One emerging popular serious game format is the educational escape room [20, 21]. Escape rooms are increasingly used in all levels of formal, vocational and corporate adult education for multiple educational purposes [22, 23].

In practice, escape rooms are popular, interactive, group, live adventure experiences in physical spaces [24]. In the field of education, they can be presented as multisensory games that facilitate the perception of the

material, increase the ability to remember and accelerate the learning process, while allowing the achievement of educational goals. They create a sense of fun and relaxation in the learning process, and thanks to their mysterious format, escape rooms subtly develop memory, perception, ability to concentrate and contribute to the overall development of students.

Most often, the task of the participants is to perform a series of tasks of a different nature [25]. These can be puzzles, finding hidden objects, breaking codes, ciphers or opening padlocks. In them, every symbol, word or part of the environment can be significant and lead the participants to the end of the game. Exiting the room before the end of the specified time is perceived as equivalent to victory [24]. During a game, users are required to apply multiple skills, including analytical and critical thinking, problem solving, communication, teamwork and cooperation, ability to communicate in a group [26, 27]. The game also builds time management and stress skills – leading skills for certain fields of science.

It is noteworthy that digital educational escape rooms are mainly implemented in 2D and are considered a suitable tool to promote a deeper understanding of the material in online distance learning [22]. We believe that society is ready to embrace change through the introduction of both virtual education and virtual reality in education.

IV. GAMIFICATION OF TRAINING THROUGH A VR ESCAPE ROOM

There is currently a rapid development of a series of emerging exponential technologies including augmented reality [28]. and the metaverse. In recent years, there has been a particular interest in VR technologies, even in the field of education [29, 30]. Multi-user VR environments and virtual worlds enable the application of different forms of game-based learning [31].

The application of VR gamefication in the learning process will provide advantages among which: (1) a favorable environment for knowledge acquisition in the presence of low stress and the possibility of teamwork; (2) good opportunity for theoretical, practical knowledge and acquisition of new technological skills and last but not least (3) active self-learning that is critical and self-regulated with improved concentration and high motivation.

Our proposal in this direction is connected with the construction of an escape room realized through virtual reality technologies. We believe that its application in the educational process will lead to the following benefits:

- A higher level of commitment and motivation of players (students) to educational activities and processes.
- Gradual upgrading of knowledge in the process of passing the different levels in the game.
- Implementation of knowledge control by imperceptibly for the players (students) assessment of their incoming and outgoing skills.

- Encouraging student engagement and teamwork through collaborative and competitive work.

The lesson we use to build the escape room is interdisciplinary and combines knowledge from the applied fields of history, arts and informatics. The target group is students from the last high school stage, and the purpose of the resource is to exercise material related to Java Script programming. Based on the set goal, the game type is deep immersion, with a low-threshold approach to knowledge consolidation.

What is valuable for us in the design phase is to highlight the existing challenges for the learning resource design team. As a result of analysis, three main groups of challenges stood out:

- **Pedagogical aspects** - game design has the main mission of forming new knowledge and serving as an aid in the learning process. For this reason, the teaching methodology must be available, the purpose of the lesson must be clear. It is necessary for the designer to have sample scenarios of the traversal of the various scenes.
- **Design aspects** - as multimedia, an interactive product is created, it must meet certain design concepts and correspond to best practices in user experience. A well-designed graphic design would help build motivation, create engagement and lead to the achievement of the expected educational outcomes.
- **Aspects related to the content** – the educational resource must be provided with the necessary theoretical base and opportunities for its sharing and assimilation. A set of interactive elements is needed to provide learning information from the platform and at the same time provide mechanisms to request it in reverse order (from student to platform) in order to evaluate the acquired knowledge.
- **Storytelling** – allows interdisciplinarity and formation of new knowledge. Through storytelling, we introduce the players (students) into a real or fictional plot. The role of this element is fundamental – according to Lee Sheldon, it is here that the player's desire to discover what happens next in the game is unlocked. [32].

The design of the escape room follows a linear structure. Solving one clue will provide the object needed to solve the next clue, and so on until students can solve the quiz as a team and escape the room. Problems in a linear room must be solved in a certain order. The average game duration is 60 minutes. For the correct implementation of the tasks in the specified time, the emphasis is on the organization, communication and cooperation between the teammates. The route can be traveled in a different way, but its purpose is to test the knowledge of the participants. For this purpose, test riddles have been prepared for each step, based on the study material.

A. Storytelling and technical realization

The thematic Escape room with Java Script quizzes has been named FunClassTomb. Students immerse themselves in the virtual cultural-historical world from the beginning of the 3rd century BC in the Thracian tomb located in the city of Kazanlak, Bulgaria. There the participants are “buried” together with the beloved wife of the ruler Roigos – the heir of Sevtus III or also Sevtes III (Thracian ruler from 330 BC to 300 BC and the last great ruler of the Odris Kingdom). The players’ mission is to find the codes hidden in the mural and jewelry, decipher them and open the two doors of the underground tomb.

The game welcomes players with a screen featuring a map of the tomb and the puzzles to be solved. The musical background is Thracian music, and the start of the game is counted down by a timer that is activated by the start button. This initial screen of the game is shown in Fig. 1.



Figure 1. Home screen of the escape room

The game can be for both teams and for achieving individual results. At the entrance, the entry-level participants are tested using a closed questionnaire of 4 questions. Only those who pass the test are given information on how to enter the tomb. Successfully solving the main quiz unlocks the next level. The answer to each of the quizzes is based on several keys in the corresponding level, built using hotspots. The general scheme that follows the educational escape room is presented in Fig. 2.

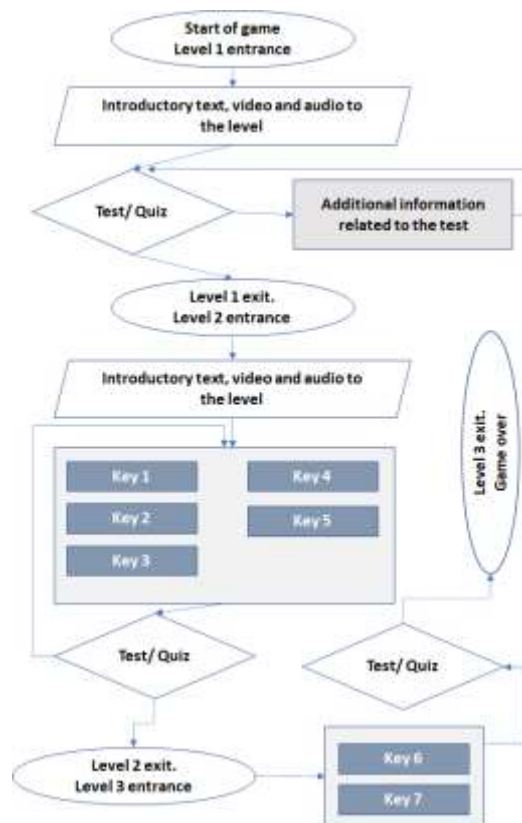


Figure 2. General scheme of the escape room game

It is worth mentioning that the current game is realized on several levels. These levels are related to the level of knowledge required. Appropriate study materials including text, video, audio, and relevant questions have been implemented for each level. Each successfully completed level allows entry to a higher level of the game.

The time limit to solve all the quizzes and get out of the tomb is 45 minutes (equivalent to one lesson). In case the time runs out before solving the puzzle, the game ends with the message “Timeout”. Since the room was created for educational purposes, the possibility of replaying the game has been provided. The screen with such a message is shown in Fig. 3.

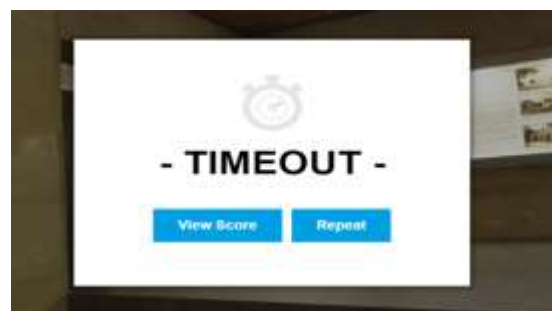


Figure 3. Timeout screen

In the course of the game, the student alone or in a team must correctly complete all the tests and collect all the keys to the levels.

The main keys (archaeological objects) serve to assist the player during solving the quiz. Discovery of the keys

does not necessarily occur in a fixed sequence. They include information that forms new knowledge needed to complete the game, but also indicate a letter that is involved in forming the answer to the final quiz. Each level ends with a specific puzzle, the solution to which leads to the entrance to the next level. The total number of levels is 3 (Fig. 2).

To achieve a realistic feeling and full immersion, VR is used, built on the basis of 360-degree images. The screen of the final product is adaptive: the game automatically adapts according to the size of the device used by the student. Also, it doesn't matter if the player is viewing the picture horizontally or vertically.

Quizzes are hidden by hotspots, and upon discovering their location, a Quiz appears with questions or a key to the final quiz. In order to acquire new knowledge, but also for better immersion in the storytelling of the game, hidden clues have been created (through HotSpot points), each of which opens multimedia (text fields, audio and/or video information). Such hotspot points are visualized in Fig. 4.



Figure 4. Distribution of hotspots at Level 2

It should be mentioned, that the use of virtual reality allows the created elements of the puzzle to be changed regularly, without the need for a complete change. In this way, the reuse of already defined elements is obtained.

Successful completion of all tasks leads to the end of the game and displays a message about the achieved result (see Fig. 5).

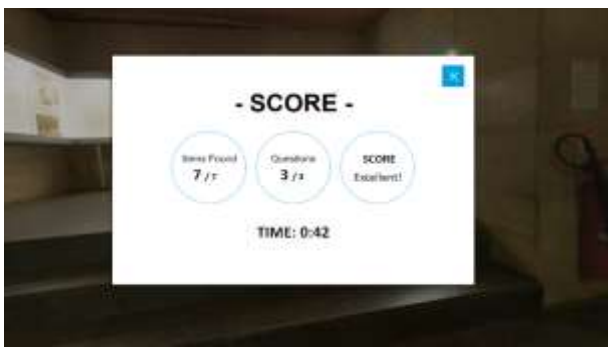


Figure 5. Successful completion of the game screen

The game presented in this section has a demonstration character and combines knowledge from several academic disciplines. In the course of the pilot test, satisfactory results were reported, meeting our preliminary expectations. We observed higher motivation on the part of the learners and more recent results of the

learning process, reported already during the game. The created example demonstrates that gamification through escape rooms is applicable and certainly could be applied to other subject areas of the educational system regardless of the age groups.

V. CONCLUSION

Virtualization in education is a process that has already begun. By introducing VR, the learning process will become more dynamic, more efficient, more interesting, and much more economical. The implementation of VR technologies benefits students, teachers, educational institutions, and the learning process itself. Teachers need to quickly transfer traditional classrooms to virtual ones, replace traditional teaching methods with interactive ones and reorganize the learning process in the form of research games.

The described approach in the current article can be seen as working in the right direction toward the coming age of active learning. On the other hand, virtual reality adds additional advantages related to the learned objects. The proposed model and implementation of VR Escape room as a tool for acquiring new knowledge in a digital environment is implemented on the example of a Thracian tomb located in the city of Kazanlak, Bulgaria. The used tools for the realization of such educational game based on thematic escape room using VR Technologies rely on JavaScript and HTML. Therefore, this approach can easily be used in any school as it only requires the presence of a browser.

Future directions for the development of such themed escape rooms involving VR technologies are related to the development of both appropriate questions and determining their difficulty to engage with an appropriate level of educational play.

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