Investigating the Role of Digital Escape Rooms in Enhancing Educational Outcomes through Game-Based Learning

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Abstract—This research investigates the integration of a Digital Educational Escape Room in teaching fifth-grade history. The study explores how the Digital Educational Escape Room can enhance student engagement, collaboration, and learning outcomes. The game is designed to improve students' understanding specifically of Justinian's reign. It aligns with Bloom's taxonomy and involves six interactive puzzles that cater to various learning styles, including visual, auditory, and kinesthetic. The adapted evaluation framework assesses four critical dimensions: learning and training, system, user experience, and affective dimension. Forty-four fifth-grade students participated, engaging in the activities designed to improve their understanding of Justinian's reign. Results indicated significant improvements in students' historical knowledge, critical thinking, and teamwork. Students reported high satisfaction levels and positive emotional engagement, despite encountering some technical issues. By integrating game-based learning with digital technology, digital escape rooms offer a promising alternative to traditional teaching methods, potentially transforming the educational experience for primary school students.

Keywords—Digital Educational Escape Room (DEER); Game-Based Learning; History Education; Student Engagement; Collaboration; Bloom's Taxonomy; Interactive Learning; Primary Education; Educational Technology; Critical Thinking

I. INTRODUCTION

Today's students live in a technological world, and the age-old methods of teaching do not attract them sufficiently to get engaged and participate. A lecture, a presentation of content on boards or slides, or using textbooks does not impress modern students, who are used to getting involved in more interactive methods of learning [1], [2], [3]. This is especially true for subjects like history. These students find it very difficult to connect to a subject that seems so abstract and away from daily life.

According to [4], history is one of the most challenging and least attractive subjects to both pupils and teachers. The traditional way of teaching history, which is majorly teacher-centered and narrative, has the potential to leave huge voids in

one's understanding and does not serve one's interests well [5]. Apart from the use of obsolete textbooks and oversimplified lesson plans, some teachers may choose this kind of approach to maintain control of the classroom, based on their insecurities or lack of training, and keep the students from running off the learning rails [5].

In response to these challenges, innovative educational strategies such as Digital Educational Escape Rooms (DEER) have emerged [6], [7], [8], [9], [10], [11], [12], [13], [14], [15], [16], [17], [18], [19], [20], [21], [22]. These methods try to incorporate relevance in daily lives and student interest in learning [23]. An escape room is a live-action team-based game in which players discover clues, solve puzzles, and complete tasks in one or more rooms in order to achieve a specific goal or task within a set time limit to "escape" from the room [10]. The concept originated from the Real Escape Game in Kyoto, Japan, in 2007, and has since gained popularity worldwide [24].

Escape rooms in education foster teamwork, leadership, creative thinking, and communication [13]. DEERs align with learner-centered, problem-solving-oriented, cooperative, and interdisciplinary learning principles, promoting critical skills necessary for future challenges [25]. These games offer intellectual, social, emotional, and psychological benefits, enhancing logic, memory, concentration, conflict resolution, teamwork, and self-knowledge [23].

Since 2017, the academic study of escape rooms has expanded, incorporating technological tools and focusing primarily on higher education, particularly in STEM and health sciences [12]. However, fewer studies have explored DEERs in primary and secondary education, and their application in subjects like history remains under-researched [26], [27]. This gap is especially evident in Greek education, where innovative teaching tools are scarce.

This paper aims to design and evaluate a DEER for primary school history lessons, specifically focusing on the reign of Justinian, using the Genial.ly [1] web platform. The study investigates students' perceptions of learning through play and the development of 21st-century skills such as collaboration and teamwork. The DEER is based on Bloom's taxonomy [28], [29],

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[1] https://genial.ly/

ensuring that each puzzle corresponds to different cognitive levels from remembering to creating.

The research questions guiding this study are:

1. Can a DEER enhance cooperation among team members?

2. How do students perceive learning history using a DEER?

The remainder of this paper is organized as follows: Section 2 describes the DEER, section 3 provides examples of DEER operation, section 4 presents evaluation results and conclusions, and finally, section 5 outlines limitations and future research directions.

II. DESCRIPTION AND DESIGN OF DEER

DEERs are innovative instructional methods that integrate game-based learning with educational objectives [30], [31], [32], [33], [34]. They create immersive, interactive experiences where students collaborate to solve puzzles and complete tasks within a limited time. DEERs are designed to enhance engagement, critical thinking, and teamwork by incorporating elements of fun and challenge into the learning process.

DEER (Fig. 1) is a game that is intended to secure the active participation of pupils in the learning process of fifth-grade history on the subject of the Emperor Justinian. The game starts with a note that challenges players to uncover the mystery about the theft of Justinian's valuables. The in-game scenario represents a virtual Byzantine Museum where pupils find and return the stolen jewel just before the curtain falls. The plot will draw pupils into the historical context and stimulate them to work actively with the material.

Fig. 1.   Start screen of DEER.

The DEER consists of six puzzles, each intended to align with various levels of Bloom's taxonomy and give learners a generally educational experience that involves higher-order thinking skills. The puzzles include ciphers, coded messages, combination locks, and rebuses and lend to various learning styles: visual, auditory, and kinesthetic. As an instance, the first puzzle includes the decoding of hidden symbols to reveal letters of the Greek alphabet and develops one's comprehension and analysis skills.

The puzzles are designed to be linear in structure so that the student works through one at a time, making the learning experience guided. This design ensures focus and progression, but students may hit a bottleneck for some of the puzzles. Hints and an interventionist support in the form of an avatar, Theodora, are integrated into the game to give direction and follow-up to the students.
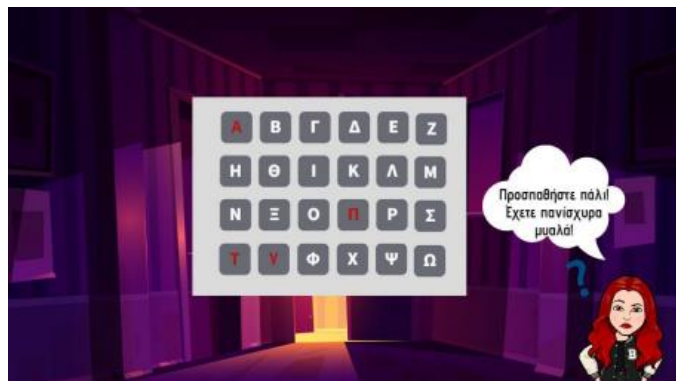

Fig. 2.   Feedback message to players: "Try again! You have powerful minds!".

DEER was developed in the Genial.ly tool, which allows the development of interactive digital content. Intuitive design of the tool allows educators to design a really complex activity which is interactive and engaging without the requirement of high technical skills in development. The whole experience is also very appealing visually and aurally as it includes the combined use of other tools: images are from Freepik, avatars are from Bitmoji, designs of objects are from Canva, and sound effects are from Pixabay.

Notwithstanding these benefits, some technical challenges have been encountered with the Genial.ly platform when more than one user accessed the game at the same time. Sometimes it was necessary for students to repeat activities because the platform had no option of resuming from the previous work. These challenges clearly outline the needs of technical robustness and support in an environment implementing DEERs.

Overall, the conception and designing of DEER and all the planning to make it testable and implementable in class took three months. Initial designs were made in the Wordwall tool and then later transferred into Genial.ly for better usability. Further piloting with students was done to get some valuable feedback that can be used in future versions and improvements. Changes included the redesign of clarity in text presentations, puzzle difficulties, the inclusion of interactive elements such as Theodora's Bitmoji, and background sounds.

Throughout, the focus was on making an engaging, informative, and user-friendly experience. The result: a DEER that engaged students with historical content and helped to build 21st-century skills like collaboration and problem solving.

III. EXAMPLES OF DEER OPERATION

The DEER occurred in a 5th grade history class. It provided a shift from the traditional approach to one where students were active and responsible for guiding the learning. Here are some

examples of how the DEER was functioning and highlight the task at hand, student problem-solving approaches, and their collective efforts.

At the beginning of the class, students were paired and instructed to discuss the possible ways in which the puzzles could be solved, allowing them to escape from the room. In the course of the process, each pair of students used a computer to work on their puzzle, promoting collaboration in the course of work, hence ensuring that every student participated. The students were allowed to note important information in their detective notebook, therefore helping them keep track of any numbers obtained after successfully solving a puzzle.

One interesting group included two boys who were particularly interested in history. They were visibly excited as they carefully read each question and guarded their solutions from the adjacent groups, revealing a little competitive spirit. It did not take them long to finish the games, and they were operating at different cognitive stages such as in Bloom's taxonomy.

In the first puzzle, they carefully read the clues and used Theodora's guidance (Fig. 3) to find the hidden scroll with symbols, converting them into Greek letters. They then rearranged the letters to discover the name of the owner, showcasing their comprehension and evaluation skills. As they moved to the second puzzle, their collaboration remained strong, allowing them to solve an anagram and identify key historical elements related to the Hagia Sophia. Their ability to analyze and apply historical knowledge was impressive, and they successfully completed the final puzzle by entering the collected numbers, escaping the DEER swiftly.

Fig. 3. Guidance message from Theodora: "Guys I have to go away for a while. Don't worry! I left you a recorded message. Maybe there are two or more: Hmm... Look for the right objects so you can listen to the messages! Attention! The messages refer to specific persons! Good luck!".

In contrast, two groups of girls appeared hesitant to share their knowledge initially, fearing mistakes. This apprehension affected their early progress. The first group had difficulties grasping the guidance in the first puzzle message and the teacher had to help them. However, despite the struggling at first, they went ahead to contribute well to the collaboration.

They were able to solve subsequent riddles—where they discovered hidden notes and managed to complete a self-assessment linked to the Hagia Sophia—with the aid of Theodora. Although the fourth puzzle was quite difficult, as it required putting a series of events from the Byzantine Empire in chronological order, they asked for assistance from groups in the vicinity and were finally able to solve the puzzle. In order to work through this kind of challenge, the fact that these two worked together as a team testified to resilience and the role of collaborative learning.

Another group was consistently indecisive and found nearly every puzzle to be challenging. They frequently wanted to know what the other groups were doing and received considerable help from Theodora and the teacher. They became somewhat frustrated with the technical malfunctions in the fourth puzzle but regrouped and continued with stronger effort. However, they did eventually finish the DEER, which emphasizes that perseverance and assistance pay off in the.

The dynamism with which the students engaged in the historical content was available throughout the DEER activity. DEER had facilitated very rich interaction, critical thinking, and teamwork. The students had learned how to divide responsibility with their colleagues, to respect their partners, and that there is value in a group effort. The operation provided examples of diversity in experiences and learning outcomes, showing the potential that DEER has to contribute to transformation in normal education with methods of interactivity and collaboration.

IV. EVALUATION

The adapted framework, inspired by [35], evaluated the DEER environment across four critical dimensions: learning and training, system, user experience, and affective. A multi-faceted evaluation reflects the overall view of how DEER would function within a classroom.

They included 44 fifth graders from a public primary school in Greece. The children were purposively selected as their enrolment in the history class regarding the years Justinian ruled. In order to facilitate collaboration and to ensure that all students were directly engaged, they were put into pairs. The pairing was purposely done to put in a type of motivation toward peer support and interaction. Students were free to select their partners in a way that would make them comfortable and cooperative for better interaction and cooperation.

The current quantitative-based investigation was planned to examine the effectiveness of DEER in the 5th-grade classroom. This approach helped examine the student experience, perception, and collaborative behavior during the DEER activity. It was possible to sum up the general effect of DEER on learning and teamwork.

After the DEER activity, students answered a questionnaire which aimed to measure their perceptions about learning history through the DEER and how they perceived the teamwork experience.

The testing was conducted over the period of 4 weeks after which, the students were required to answer two questionnaires based on the Lynch-Ghergulescu model. The questionnaires contained twelve questions, rated on a scale from 1 to 7, where 1 was the lowest and 7 the highest score, as shown in Table I.

Dimension (D)	No	Question
Learning and Training (D1)	1	How much do you feel your understanding of Justinian's reign has improved after completing the DEER?
	2	How efficient was the DEER in using your time effectively to cover the historical content?
	3	How well did the DEER activities help you progress from simple recall of facts to more complex analysis and creation?
System (D2)	4	How often did you experience technical issues (e.g., crashes, delays) while using the DEER?
	5	How helpful were the hints and guidance provided by Theodora in solving the puzzles?
	6	How effective was the linear structure of the DEER in guiding you through the learning process?
User experience (D3)	7	How satisfied are you with your overall experience using the DEER?
	8	How easy was it to navigate and use the DEER interface?
	9	How engaging did you find the use of digital tools (e.g., Genial.ly, Freepik, Bitmoji, Canva, Pixabay) within the DEER?
Affective dimension (D4)	10	How engaged were you while participating in the DEER activities? (1 - Not Engaged
	11	How motivating did you find the DEER as a tool for learning history?
	12	How much of a sense of accomplishment did you feel upon completing the DEER puzzles?

TABLE I.   QUESTIONNAIRE

The students' responses to the questions outlined in Table I have been organized based on the framework's dimensions and are presented in Fig. 4.
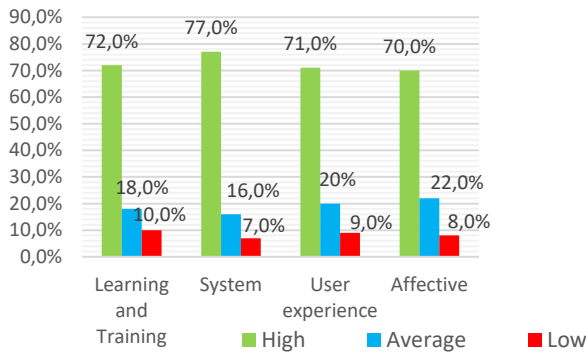

Fig. 4.   Responses to the questionnaire.

In DEER, the Genial.ly platform was used to create an engaging and interactive environment. However, some technical issues arose due to multiple users accessing the platform simultaneously, causing delays and requiring some students to restart the game. Despite these challenges, the system was rated positively by the students, with 77% indicating a high level of satisfaction, 16% an average level, and only 7% a low level. They found the hints and guidance provided by Theodora, the avatar, helpful in navigating the puzzles. The linear structure ensured that students followed a guided path, although it sometimes caused bottlenecks if a puzzle proved too difficult.

The intelligent design of the game, with puzzles progressively increasing in complexity, was effective in maintaining engagement and promoting learning.

Feedback collected through post-activity discussions and questionnaires indicated high levels of satisfaction among students. For the user experience dimension, 71% of students reported a high level of satisfaction, 20% an average level, and 9% a low level. They enjoyed the storyline, the challenge of the puzzles, and the interactive elements such as Theodora's guidance and the multimedia components.

Students rated the DEER as user-friendly, with clear instructions and engaging content. The familiarization with the digital tools used (e.g., Genial.ly, Freepik, Bitmoji, Canva, Pixabay) contributed to a positive experience. The background sounds and visual elements added depth to the learning environment, making the history lesson more enjoyable and memorable. Observations and personal diaries revealed that students were highly engaged and motivated. The competitive element, coupled with the collaborative aspect of the game, fostered a lively and dynamic classroom environment. For the affective dimension, 70% of students reported high engagement, 22% average engagement, and 8% low engagement.

Students expressed excitement and a sense of accomplishment upon solving puzzles and progressing through the game. The interactive and game-based nature of the DEER helped mitigate boredom and disengagement often associated with traditional history lessons. Emotional engagement was even more supported by the avatar Theodora, who was very likable and comforting throughout the entire game.

The evaluation results confirmed that DEER was able to improve learning outcomes, fully support the system, provide a good user experience, and very highly maintain the emotional engagement. In that regard, 72% of students reported high improvement in learning and training, 18% indicated average improvement, and 10% indicated low improvement. DEER has, in essence, converted the classroom into a diversified, interactive, and collaborative learning environment, thus holding the promise for digital game-based learning in education.

V. CONCLUSIONS

The current paper presented a study on the implementation and evaluation of a DEER in a Grade 5 history classroom. The DEER was organized for the promotion of student engagement and collaborative learning in the game-based learning environment in an interactive and immersive manner for enhancing learning performance. This paper presents the evaluation of the DEER, conducted under four heads: learning and training, system, user experience, and affective dimensions. It concludes reporting that significant improvements were attained in the understanding of historical content, satisfaction from the learning process, and emotional engagement among students.

The study also brought out several weaknesses. The need for adjustment of lessons in the schools negatively affected other lessons. High noise levels in the environment and technical issues concerning the Genial.ly platform also had an impact on

the smooth implementation of the DEER. The other limitation related to the linear structure of the puzzle, which disabled the capability of the students to pick up from where they left in case of technical interruptions.

Future research shall focus on applying DEERs in a wide array of subjects and levels of education, emphasizing how these technological tools may be developed to become flexible and robust. More research should be done on different puzzle structures and advanced hint delivery systems, as that would be more beneficial for the learning experience. Furthermore, by engaging the students in the process of designing the DEERs, their creativity and understanding of the material may be enhanced.

Thus, the platform demonstrated the astounding future of DEERs to transform traditional teaching into something interactive and appealing, with major improvement in all learning outcomes and development of competencies necessary in the 21st century.

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