

# Using Educational Escape Room to Increase Students' Engagement in Learning Computer Science

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**Abstract**— This paper presents the process of creating and implementing a large-scale experiment that involves students from more than 10 primary schools using the escape room style educational game in the classroom. The potential benefits and issues related to using technology in integrating this kind of games in education are explored and elaborated in the paper. An escape room is a game played by a team of people. They have to 'escape' from a room filled with challenges within a given time limit. In order to succeed, the players must solve the challenges using different hints and strategies. If these challenges incorporate education materials, students will have to master these materials, which will enhance their learning and increase their engagement.

**Keywords**— educational escape room, computer science education, game-based learning, gamification, collaborative learning

## I. INTRODUCTION

Contemporary teaching is learner-centered. Teacher's role in guiding students in the learning environment is to enable them to progress within the learning process at their own pace. There is no "one approach for all" for learning-centered teaching. Teachers should enable each student to learn according to their previous knowledge, abilities, and skills. Students' learning should upgrade while they carry on to advantage from fostering, mentorship, and direction of their teachers.

Learning experiences should be structured to challenge students' thinking in the way students could construct new knowledge. According to Zaibon & Shiratuddin [1], learning is active process of acquiring and constructing knowledge through meaningful ways and interactions based on prior experience.

Student engagement has a critical role in student achievement within the student-centered learning process [2]. With governments interested in measuring student outcomes [3], and findings that student engagement can act as a proxy for quality [4], a clear understanding of what student engagement is, becomes essential. Students' engagement is a complex process that brings together diverse threads of research contributing to explanations of student success [5].

Different educational games can increase students' engagement in the learning process [6]. By using digital games, we can create new ways of learning in the classrooms. These interactive learning experiences can increase the engagement of students, and thus, achieving learning outcomes can be more quickly.

Digital games offer students opportunities to develop skills that are not focused just on learning facts. According to

Sung and Hwang [7], digital games enable the development of problem-solving, decision making, and strategic planning skills. Different challenges are facing the implementation of learning scenarios that use technological resources in and out of distance learning environments [8],[9].

Many games are used in an educational context, but most of them are not enjoyable for the students. On the other hand, it is challenging to match popular games to the curriculum in order to use them in the educational process [10]. Augmented reality is one of the technological tools that can be used in educational processes ranging from simple elementary school games to simulation tools [11]. In recent years, augmented reality is mostly associated with mobile platforms. Since its introduction, augmented reality managed to create a more active, productive, and meaningful learning process [12]. The merging of augmented reality with education allows students to be immersed in realistic experiences [13]. The mobile-based treasure hunt game using augmented reality can improve learning experiences by supporting active discovery and by balancing physical and digital interactions [14].

In addition to being a well-liked form of recreation, escape rooms have drawn the attention of educators due to their ability to foster teamwork, leadership, problem-solving, creative thinking, and communication in a way that is engaging for students. As a consequence, educational escape rooms are emerging as a new type of learning activity under the promise of enhancing students' learning through highly engaging experiences [15].

An escape room is a game played by a team of people where they have to 'escape' from a room filled with challenges within a given time limit [16]. In order to win ('escape'), the players must solve the challenges (puzzles) using hints, clues, and developing a strategy. If these challenges incorporate course materials within their puzzles, students will have to master these materials in order to succeed, which will enhance their learning and will increase their interest and engagement in learning.

Educators have now introduced the so-called escape-games into their teaching or training practices. During a limited time, a team of learners collaboratively solves puzzles related to educational content. For learners, the aim consists of "escaping" from a room. For educators, an escape-game contextualizes educational content into a meaningful and inspiring experience based on game-based and collaborative learning [17].

The objective of this paper is to present the process of creating and implementing large-scale experiment that involves students from 12 primary schools using simple treasure hunt [18] and escape room [19] style educational

game in the classroom. The potential benefits and issues related to integrating this kind of games in education using technology are explored and elaborated within the paper. The main aim of conducting the educational escape room was to provide an engaging activity beneficial for the students' learning.

Section 2 of this paper elaborates methodology and describes created educational escape room and materials. Section 3 discusses the obtained results and identified challenges. Section 4 concludes the paper.

## II. METHODOLOGY

### A. Designing an educational escape room

The educational escape room is an experience in which students had to solve a combination of puzzles in a limited amount of time in order to win in the game. The puzzles of the escape room were arranged as a treasure hunt - each puzzle unlocked the next one. Thus, students were required to solve the puzzles in a specific order. Arrangement of the puzzles in a sequence requires the whole team to engage in the puzzle at a specific time.

The designed educational escape room combined computer-based and physical puzzles, in order to create a highly engaging activity without compromising its educational value. Puzzles consisted of information from the course material, but also encouraged improving students' knowledge and skills through teamwork, communication, collaboration, and learning from each other. The escape room was hosted in the computer laboratory and designed to last a maximum of one hour.

The process of creation of an educational escape room was composed of several steps. First, the educational objectives

that should be incorporated in the game were defined, and the puzzles were created taking into account to have physical and computer-based puzzles. The number of puzzles was defined according to the previous students' experience in playing an escape room and considering its duration. The escape room consists of 6 puzzles, which should be solved. Afterward, puzzles, clues, and additional resources needed to conduct the escape room experience were created.

Puzzles were created very carefully, paying attention to their complexity. If a puzzle is too hard, the students will enter a state of frustration and give up; whereas, if a puzzle is too easy, the students will get bored and stop playing. Since it is essential to prevent students from getting stuck at one puzzle for too long (students can get bored, frustrated, or even angry), hints on demand when students get stuck were involved. First four hints on demand are free, and after that penalties are applied.

The overall theme of the educational escape room was finding and deactivating a device that threatens to turn all humans in robots. The activity starts by telling students a story that aliens are observing our planet, and they wanted to conquer it by turning all humans in robots. The story continues that in order to succeed in this, aliens have hidden devices in the classroom. To stop them, students must find the device and destroy it. To find the device, students have to solve several puzzles in sequence order, which will lead to the place where the device is hidden.

Table 1 summarizes all the treasures that were integrated into the educational escape room activity. Each treasure point consists of the puzzle, hint where to find the next puzzle which should be open with the solution of the previous one.

TABLE I. SUMMARY OF THE ESCAPE ROOM PUZZLES

Treasure	Puzzle	Solution	Hint
Piece of paper that includes binary representation of the letters	Students should translate given binary code into a word	Discovered word is the password to enter the next puzzle	Somewhere in the classroom, they have to find a QR code
QR code which should be scanned and opened with the password	A web site containing six questions concerning course material. Students should answer them	The first letter of each answer create the next puzzle's password	One of the computers is discreetly marked with red.
Marked computer which turns on with the password. Excel file should be opened which is in folder Escape room on Desktop	Students should discover numbers that are hidden behind corresponding cells in the Excel file	Numbers are the 4-digit number code for the next puzzle.	Classroom tables contain the next treasure – a box.
The box which can be unlocked by a 4-digit number code	The box contains VR glasses, and the puzzle is students to discover the device that does not belong in the group	A device (monitor) is a place where the next puzzle is put	The teacher is not so innocent in the game, is a hint for the next puzzle
Teacher's monitor	Students should find a hidden key and discover what that key can open	Locker	/
The locker that can be opened with a key and contains two pictures	The last puzzle is to find the difference between two pictures	Place where the hidden device is put	End of the game!

After an educational escape room was created, the puzzles were tested, and a simulation of the game to test it in a real setting was performed.

Additionally, instructions for teachers that will implement this educational escape room was created, consisting of the explanation of each puzzle, solution, and how the next puzzle should be discovered. Instructions for students are created, too. They consist of the story and how to play the game.

### B. Method (experiment)

The educational escape room event was implemented during the initiative Computer Science Week, from 10th to 14th of February. In total, 12 teachers in 12 primary schools from North Macedonia have registered on the open call to implement this activity with the students. The distribution of the schools is given on Figure 1.

Most of the registered participants were Computer Science teachers. In total, 881 students have participated in the experiment. Students were from 6th till 9th grade. There was

no significant difference between the number of students in different grades. Pictures from the implementation of an escape room are given in Figure 2.

The main aim of this study was to evaluate the students' perceptions of the implemented educational escape room and to provide information whether it could increase students' engagement in learning Computer Science. Quantitative measures of students' achievement were not filed of interest.

Information about students' opinion about performed educational escape room were gathered from their feedback at the end of the activity. Additionally, an online survey was conducted with some of the students. The survey was adopted from a similar survey concerning the use of an educational escape room for teaching programming in a higher education setting (López-Pernas, et al., 2019). Participation in the survey was voluntary, and it was offered just to the students of two participating schools, which were around 20% of all participants.

## Escape room

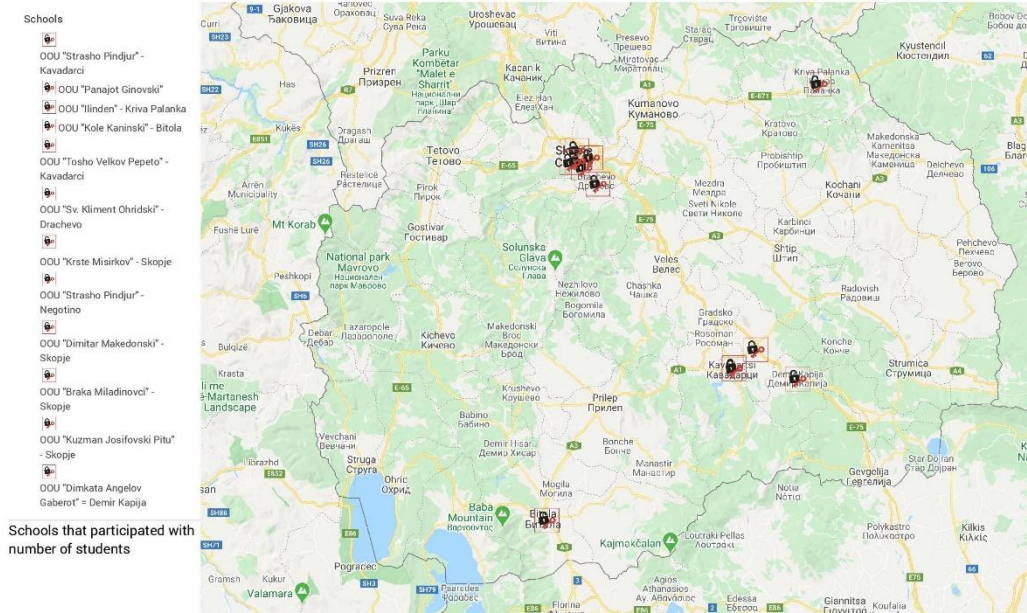


Fig. 1. Map of schools that have implemented educational escape room



Fig. 2. Educational escape room (permissions for taking students' photos are provided in advance)

The survey included some demographic questions, a list of statements with which students needed to agree or disagree using a 5-point Likert scale, and some opinion questions about further use of escape room. The questions aimed to assess the students' perceptions toward the use of the educational escape room as a learning activity, as a game, and the students' thoughts on the design of the escape room, as well as whether students preferred the escape room over a regular class.

### III. RESULTS AND DISCUSSION

At the very beginning of the organization of the escape room in the educational context, massive interest among students was achieved. Students were very enthusiastic about participation in an educational escape room, and they show a huge interest in it. They were impatient when will the activity be performed and started making some arrangements among the team members on how to achieve the goal fastest.

Implementation of the educational escape room has led to a lot of excitement, fun, and satisfaction among the students. They were very competitive, trying to solve puzzles, to find the next treasure and to succeed. Students were enjoying during the activity and showed great interest in it.

After each finished escape room, a discussion with students was carried out. They were motivated to express their opinion about the activity, what they liked about it and what can be improved. Discussion about the puzzles and their level of difficulty was carried out. Students emphasized their strengths and weaknesses during the activity.

The most important fact that could be noticed during the activities in all participating schools was that students who had good teamwork and coordination among team members achieved the best results. Proper distribution of tasks among the students in the group had led to faster fulfillment of the task. Groups that on their initiative appointed a team leader who delegated tasks and managed the process were more successful. In that manner, the development of communication, collaboration, management, and leadership skills is one of the most important benefits of this kind of teaching strategy.

The time limit was beneficial in the implementation of the activity. Adding a timer created an urgency that drives student teams to engage with the content in a way that a traditional activity structure may not. They were running around the classroom, trying to organize themselves in order to finish the activity as soon as possible. Students had to work together to win or lose as a team. They took control of their learning and tried to manage the best that they can.

Developing critical thinking and problem-solving skills during solving puzzles and finding the next one, according to a hint, was another benefit from this kind of activity.

The combination of the computer-based and physical puzzles was a huge success because it made an activity more dynamic and excited for the students.

The initial guidance about the process was essential. Groups that did not understand the guidance well or did not listen carefully lose a significant amount of time in the beginning. For that reason, when organizing an educational escape room teacher should be sure that students understand the final goal of the escape room, the first puzzle that should be solved, what the solution of the puzzle means, and where

to find hints. They must understand that there is an option to ask for help if they get stuck during the activity.

Discussions with students lead to the conclusion that they like the activity very much, they were impatient to enter the escape room, to play it, and to reach the end of a game. Some of the students mentioned that they should be better organized next time and finish the game quicker. The interest and motivation for participation in the educational escape room were enormous. Students liked the puzzles; they were not too difficult to be solved, and they have stated that they learned new things during the activity. Overall, most students gave very positive comments that they thoroughly enjoyed the educational escape room experience and that they would like more hands-on activities like this one. They wished that other classes undertook similar initiatives and thanked the teacher for the experience.

It should be mentioned that students evaluated their work very well, successfully identifying their strengths and weaknesses during the game. Students were happy with the feedback received from their teacher about their activity during the game. They were even asking questions on how their activity could be improved, taking into account what they learn from some of their activities.

In addition, the evaluation survey was completed by a total of 95 students who volunteered to do so. Table 2 shows the results of the evaluation survey, including, for each question, the mean (M) and standard deviation (SD).

Of the 95 students of the sample, 35 were male (36.84%), and 60 were female (63.16%). It is interesting mentioning that there are no gender differences in answers to the survey's questions. These findings indicate that, although females seem to have reservations concerning games in general, the escape room attracted students of both genders equally. Educational escape rooms seem to be attractive and useful for both genders equally, which is a highly valuable insight into the research and educational communities.

Most students expressed a prior interest in games ( $M = 4.82$ ,  $SD = 0.51$ ), which was a good starting point in expecting students' interest in playing an escape room. The results of the survey show that students had a very positive overall opinion on the educational escape room ( $M = 4.96$ ,  $SD = 0.20$ ) and thought it was a fun experience ( $M = 4.89$ ,  $SD = 0.54$ ).

Most of the students were very competitive during participation in the escape room ( $M = 4.74$ ,  $SD = 0.61$ ), and they were impatient to open the next puzzle ( $M = 4.81$ ,  $SD = 0.53$ ). They have also noticed that teamwork and good task management are very important. They like working in teams ( $M = 4.84$ ,  $SD = 0.64$ ), too. The competition that was raised developed students' collaboration, interest, motivation, critical thinking, and problem-solving skills, increasing their engagement in the classroom activities at the same time.

A percentage of 98.95% of students stated they would recommend other students to participate in the escape room, and 100% claimed that they would like other classes to embrace similar activities. This excellent outcome obtained for student engagement confirms that educational escape rooms can be an excellent way to foster motivation and increase students' engagement in computer science.

TABLE II. RESULTS OF THE EDUCATIONAL ESCAPE ROOM SURVEY CONDUCTED AMONG STUDENTS

Question	Mean	SD
What is your general opinion on the Escape room? (1 Poor - 5 Very good)	4.96	0.20
Please state your level of agreement with the following statements (1 Strongly disagree, 5 Strongly agree)		
In general, I like to play games (video games, board games, etc.)	4.82	0.51
It was easy to reach the end of the Escape room	4.48	0.63
The Escape room was fun for me	4.89	0.54
The Escape room allowed me to improve my knowledge of the Computer Science	4.71	0.81
The Escape room was well organized	4.89	0.45
I was impatient to open the next puzzle in the Escape room	4.81	0.53
The Escape room encourage me for a competition	4.74	0.61
I like working in teams during Escape room	4.84	0.64
I like the Escape room more than a regular class	4.83	0.43
I can learn more with the Escape room than I would do during regular classes	4.56	0.81
	Yes	No
Would you recommend other students to participate in the Escape room	94 98.95%	1 1.05%
Would you like other classes to include activities like this?	95 100%	0 0.00%

Regarding learning effectiveness, students stated that the escape room helped them improve their knowledge of computer science ( $M = 4.71$ ,  $SD = 0.81$ ). These results were consistent with previous studies, which also found that educational escape rooms can improve students' knowledge on a specific topic. However, there is not much research concerning computer science in primary education.

Regarding the design of the escape room, students thought it was well organized ( $M = 4.89$ ,  $SD = 0.45$ ). Most of the students think that it was easy to solve the puzzles and to reach the end of the escape room ( $M = 4.48$ ,  $SD = 0.63$ ). When compared with the other classes of computer science, students declared that they prefer the escape room over them ( $M = 4.83$ ,  $SD = 0.43$ ).

Based on the previous discussion, it can be suggested that the appropriate use of educational escape rooms can have significant positive impacts on student engagement and learning in computer science. These findings provide evidence that educational escape rooms constitute a compelling way to increase student engagement.

Educational escape room has been very little used in the field of computer science, and there are just a few experiences reported in the literature, mainly in higher education. That is the reason why this first step in implementing an educational escape room is made just to see how students will accept it and whether it can improve their engagement in the classroom activities. Further work in this field could consider creating an educational escape room in order to guide their learning process or to evaluate students' achievements.

This experience can be applied to other subjects in different fields, such as mathematics, arts, or biology, too. For example, a biology teacher has already adapted created educational escape room to her classroom, adding puzzles connected to the biology curriculum. Students' feedback after the implementation of this escape room was very positive, enthusiastic, and motivated for new lessons conducted similarly.

Although the initial investment of time and effort on the teacher to design and create an educational escape room is, in principle, notably higher than that of other traditional classes, their significantly positive effect on student engagement as well as their ability to be reused in the following years makes it worthwhile.

#### IV. CONCLUSION

The designed educational escape room combined computer-based and physical puzzles, in order to create a highly engaging activity without compromising its educational value. Puzzles consisted of information from the course material, but also encouraged improving students' knowledge and skills through teamwork, communication, collaboration, and learning from each other. The escape room was hosted in the computer laboratory and designed to last a maximum of one hour. In total, 881 students from 12 different primary schools have participated in the experiment.

This paper is to present the process of creating and implementing a large-scale escape room in primary education. The main goal of conducting the escape room was to provide an engaging activity for the students.



The most important finding during the activities in all participating schools was that students who had good teamwork and coordination among team members achieved the best results. Proper distribution of tasks among the students in the group had led to faster fulfillment of the task.

This research throws up many questions in need of further investigation. For instance, a quantitative assessment of how educational escape rooms impact student academic performance on a specific topic is certainly needed in order further to understand the pedagogical utility of this novel teaching method.

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