

The use of Educational Escape Rooms in the Lifelong Training of Mathematics Teachers

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Abstract: Educational escape rooms represent an innovative and engaging educational approach, with a high potential for the development of problem-solving and collaboration skills. That is why it is important to familiarize teachers with them and support them for their use in the teaching practice. Our paper presents a case study investigating the utilization of two versions of digital educational escape rooms (DEERs) within the lifelong training of mathematics teachers. Thirty-two mathematics educators of pupils aged 10 to 19 participated in the research. DEERs were developed in two digital platforms: Room Escape Maker and Google Forms, offering an interactive adventure game and a story-based text game, respectively. The study aimed to explore teachers' perceptions of these DEER versions and their potential applications in teaching. Data collection employed observation and a questionnaire survey, followed by qualitative evaluation through thematic analysis. The research's limitations include the sample size and the specifications of the utilized DEERs.

Keywords: Mathematics, Teachers, Educational Escape Rooms, Design, Lifelong Learning

1. Introduction

Escape rooms are defined as live-action, team-based games in which players discover clues, solve puzzles, and accomplish tasks in one or more rooms to achieve a specific goal, typically escaping from the room, within a limited amount of time (Nicholson, 2015). Specific examples of the use of escape rooms in education are digital educational escape rooms (DEERs). These represent modern digital applications of game-based learning that offer engaging, hands-on learning experiences across various educational settings.

Educational escape rooms show promise as an innovative and captivating approach to supporting active learning. Numerous studies indicate that well-designed escape rooms can enhance pupils' motivation and improve their enthusiasm for learning (Fotaris & Mastoras, 2019; Fotaris & Mastoras, 2022; Manzano-León et al., 2021; Taraldsen et al., 2022; Veldkamp et al., 2020; Videnovik et al., 2022). Fotaris and Mastoras (2019) emphasize that educational escape rooms offer an enjoyable experience, engaging pupils as active participants in the learning process. By solving challenges within these rooms, learners gain insights into problem-solving from diverse perspectives, engage in collaborative teamwork, and develop social connections, all contributing to their educational experience.

Regarding pedagogy, escape rooms adhere to a social-constructivist framework (Vygotsky, 1978), where learners build their understanding by actively engaging with challenges presented in real-time within the escape room. These challenges consist of tackling novel and sometimes intricate problems, fostering collaboration among peers to solve them effectively.

Taraldsen et al. (2022) highlight healthcare, STEM fields, including science, technology, engineering, and mathematics, as prominent areas benefiting from DEERs. Similarly, Fotaris and Mastoras (2019) identify health, natural sciences, mathematics, social sciences, journalism, and ICT as common subjects integrated with DEERs. Although escape rooms find application across educational levels, higher education predominantly utilizes them.

As educators face evolving demands, continuous professional development becomes increasingly crucial. Educational escape rooms offer a novel approach to engaging participants in meaningful learning experiences, fostering collaboration, problem-solving, and critical thinking skills (Veldkamp, 2020). Consequently, they hold significant potential for integration into the lifelong learning of practicing teachers.

This paper investigates DEERs application in the lifelong training of mathematics teachers, aiming to explore their opinions on their use and their preferences for two different DEERs' designs. The goal of our paper is to share our observation from the use of two different DEERs during the lifelong learning session with the 32 mathematics teachers organized at the Faculty of Mathematics, Physics and Informatics, Comenius University in Bratislava and their opinions on the use of such pedagogical tools and on the preferences for design for each educational escape room.

2. Methodology

In our research, we adopted a qualitative approach (Creswell, 2012), specifically a case study, due to the aims of the paper, the nature of the research, and the research sample. Thirty-two in-service mathematics teachers participated in the research. Participants worked in groups of 2-3 while playing DEERs. Overall, we chose the research methodology to obtain information that will help us answer the research questions:

Q1: What was the activity and engagement of the players during the DEERs playing?

Q2: How did the participants like the given DEERs?

Q3: How did participating mathematics teachers rate the DEERs in terms of their appropriateness for their pupils and usability in the classroom?

Q4: How did teachers compare the two different versions of the DEERs and which design elements did they prefer?

Q5: What interest would the teachers have in other similar escape rooms?

We used several methods to collect the necessary data. We observed participants' reactions and their engagement and activity during the gameplay. After playing each of the games, participants completed an online form that included survey items to determine how they liked each DEER and their opinions about the applicability of the DEER in the classroom and its appropriateness for their pupils. After playing the two DEERs, the teachers used the online questionnaire to compare the rooms, which differed in their design and content. This questionnaire also asked whether teachers would like to have more of such games available.

We analyzed all the collected data qualitatively to answer our research questions. For the study of written data that we obtained through the online questionnaires, we used content analysis (Schreier, et al., 2019). We processed the data using open coding in MaxQDA and based on it, we identified several topics connected with our research questions.

Regarding the individual DEERs, in the following text, we provide the context of their application during the research and their characteristics. The escape rooms were used in the context of a lifelong learning session for mathematics teachers of pupils aged 10-19. This training is entitled "Activating Motivational Methods for Developing Positive Attitudes of Pupils towards Mathematics in Primary and Secondary Schools" and is offered by the Faculty of Mathematics, Physics and Computer Science at Comenius University in Bratislava. The training has online and face-to-face sessions and the meeting was the second face-to-face meeting with the participants. In the morning, the teachers attended a popularization lecture on the history of mathematics, and the use of DEERs constituted the afternoon program lasting about 3 hours.

First used DEER (Vankúš, n.d.) was implemented within Google Forms. It was a series of mathematical problems that were linked by a story in which their solution led to the players escaping the castle. By its nature, therefore, the first DEER can be characterized as a story-based text game. The theme and problems used were inspired by an existing escape room by Elizabeth Joyce, from Pinellas County Schools in Florida (Joyce, n.d.). As part of our used DEER's version, we adapted the task assignments, the graphic design of the escape room, and localized it into Slovak language. In this escape room, learners solve 6 contextually focused problems from different areas of mathematics, such as combinatorics, numerical operations, geometry, divisibility of numbers.

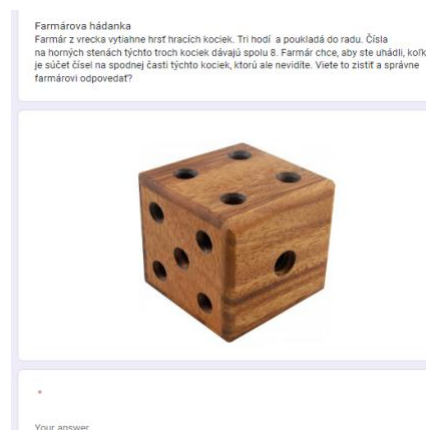


Figure 1: Sample from DEER Escape from the Castle

Second DEER (Terezkajesuper, n.d.) was created by mathematics education students in the Faculty of Mathematics, Physics and Computer Science as part of the online tool Room Escape Maker <https://roomescapemaker.com/>. This escape room can be characterized as an interactive adventure game. We have described the process of creating this escape room in our previous publication (Čujdiková & Vankúš, 2023). The game requires the use of several interactive elements such as a bolt cutter, a remote control, a battery, scissors, a crowbar, a hammer, and two lock keys. The escape room contains 4 coded locks, where in two cases the key is a word password and in two cases a numerical password, which is obtained by numerical operations with the data found during the game. In one of the problems leading to the numerical code, there is an error in the assignment where a parenthesis is missing. This fact could have potentially affected the participants' work to some extent.



Figure 2: Sample from Students' DEER

During the solving of both escape rooms, both authors of the article were available to answer any questions the teachers might have.

In the text that follows, we describe the results we obtained with the research instruments and our evaluation of the data in terms of each of the research questions.

3. Results

In this chapter, we present our findings. Sections 3.1 and 3.2 also present our answers to research questions Q1, Q2, and Q3. In Section 3.3, we present our findings for research questions Q4 and Q5.

3.1 Escape From the Castle

As the game Escape from the Castle took the form of a simple online form, we did not find it necessary to explain to the participants how to play it. Therefore, we only instructed them to form groups of two or three and start playing.

We could observe the excitement and commitment while playing this room. Participants read the story within their group with enthusiasm and discussed their ideas for solving each puzzle. The solving process was smooth and fluid, and it was not the case that any group could not figure something out for an extended period of time. Different groups took different lengths of time to escape, but in the end everyone managed to escape successfully.

Based on the observation of the participants during the course and their answers in the questionnaire, we can assess that they perceived this escape room very positively. As we can see in Figure 3, when asked to comment on how much they liked the room, up to 89.5% of the groups chose the values 9 or 10.

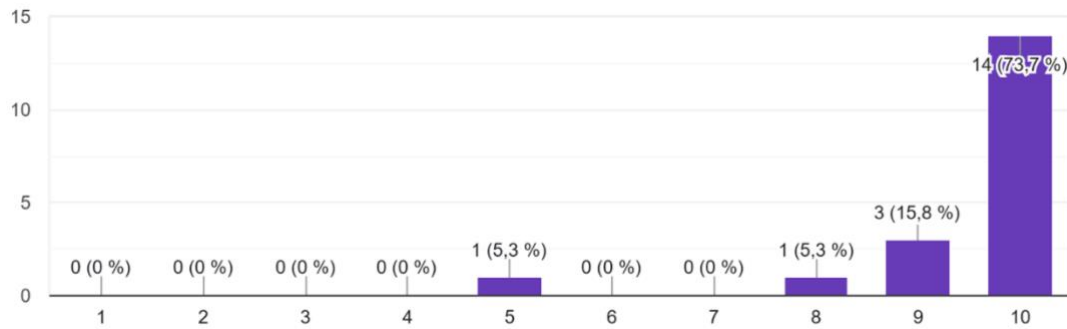


Figure 3: Participants' rating of how much they liked the Escape from the Castle escape room (1- I didn't like the room at all, 10- I liked the room a lot)

This room was also perceived by the participants as being very suitable for pupils. As can be seen in Figure 4, up to 89.5% among all groups rated its suitability for pupils as 9 or 10. No group rated it as unsuitable.

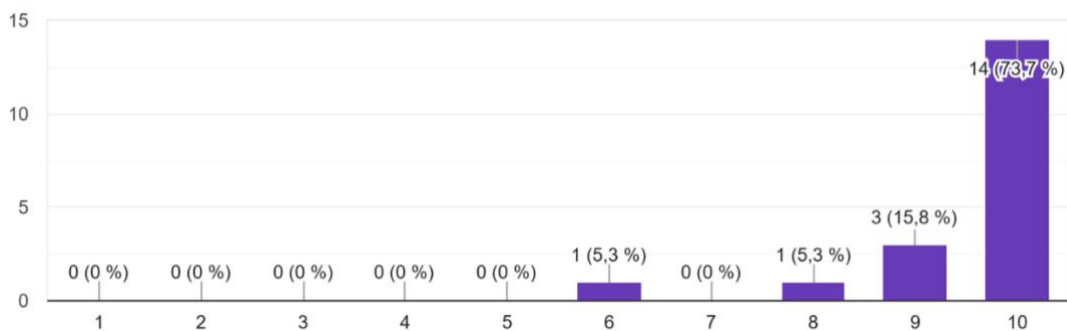


Figure 4: Participants' assessment of their perception of the suitability of the Escape from the Castle escape room for pupils (1 - I consider the room completely unsuitable, 10 - I consider the room very suitable)

Several groups indicated that this escape room is particularly suitable for pupils in the second year of primary school. The mathematical areas they identified in it included working with numbers, number theory, number operations, divisibility of numbers, geometry, combinatorics and logic.

Opinions varied as to how specifically they would use this escape room with their pupils. Some teachers could envisage its use within a regular mathematics lesson, particularly in revision. Apparently because they perceived that the room covered a wide range of mathematical topics, they indicated that they would use it for "practicing the material in all topics" or "for ninth graders as a general review." There was also a suggestion to use it as part of a motivational lesson. Other groups evaluated that they could imagine using it more in a substitute lesson or for a special occasion, e.g., "as part of a St. Nicholas celebration" or "to brighten up the classroom at the end of the school year." Other groups considered it appropriate only in activities outside the regular classroom, e.g. in an after-school club or mathematics competition.

3.2 Students' DEER

For the second type of escape room, which took the form of an interactive adventure game, we assumed that its rules might not be clear to all participants. We expected that teachers who had no experience with such games would be present at the training. For this reason, we selected two Students' DEERs. We wanted to run the first Students' DEER together with everyone to familiarize them with the rules of the game, and the second Students' DEER was to be played independently in groups afterward. However, to our surprise, all participants, after we showed them the first steps, had already started solving this first escape room on their own. Thus, we stopped presenting the solution and devoted ourselves to observing the participants and helping them when needed. Based on this situation, we spontaneously decided to change the plan and omitted the second Students' DEER completely, focusing only on this first Students' DEER. This is the room we introduced in the previous chapter.

We could also observe a great deal of enthusiasm when dealing with this escape room. Participants discussed in their groups and explored the game environment together with interest. They enjoyed every object they

discovered as well as finding a way to use it. They were also delighted if they managed to enter the correct code. However, after some time, the first problems started to appear in some groups and we could observe their growing frustration. In this case we tried to find out the reason and help them to overcome the problems. One of the problems was trying to solve a problem with a wrong assignment. We then revealed to them that there was a bracket missing in the example and this was mostly enough for them to go on to solve it successfully. In other cases, the group got to the point where they couldn't find a particular item they needed or figure out a way to use the items. In those cases, we tried to give them hints that would guide them to a solution but not completely give it away and rob them of the joy of their own discovery. In a small number of groups, we observed that they felt definitely lost and clicked helplessly on random objects in the hope of randomly carving out a room.

In spite of the problems mentioned above, based on the overall prevailing atmosphere during the meeting but also based on the answers from the questionnaire, we can assess that a large part of the groups perceived this room quite positively as well. As we can see in Figure 5, when asked to comment on how much they liked the room, up to 53% of the groups chose the values 9 or 10 and another 17.9% chose 8. At the same time, however, the number of groups that did not like the escape room at all or hardly at all increased compared to the first escape room. A total of 3 groups or 17.3% chose values 1 to 3.

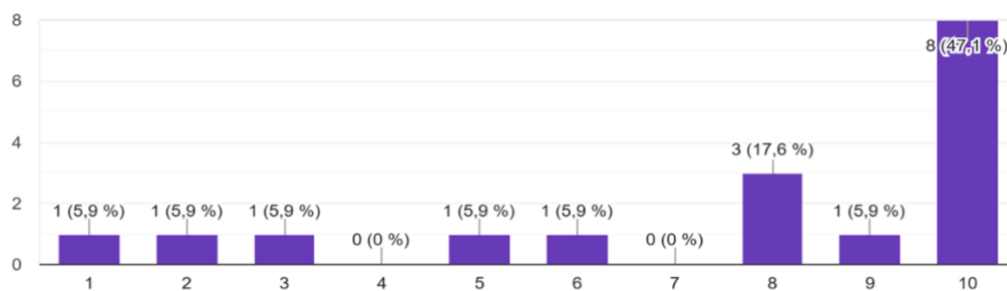


Figure 5: Participants' assessment of how they liked the Students' DEER (1- I didn't like the room at all, 10- I liked the room a lot)

This escape room also received an overwhelmingly positive evaluation from the different groups regarding its suitability for pupils. As can be seen in Figure 6, 64.5% of them rated its suitability for pupils as 9 or 10. This indicates that a larger proportion of the participants also perceived the escape room as a valuable tool for teaching. On the other hand, some groups (23.6%) rated it with grades 1 to 3, expressing doubts about its suitability for working with pupils.

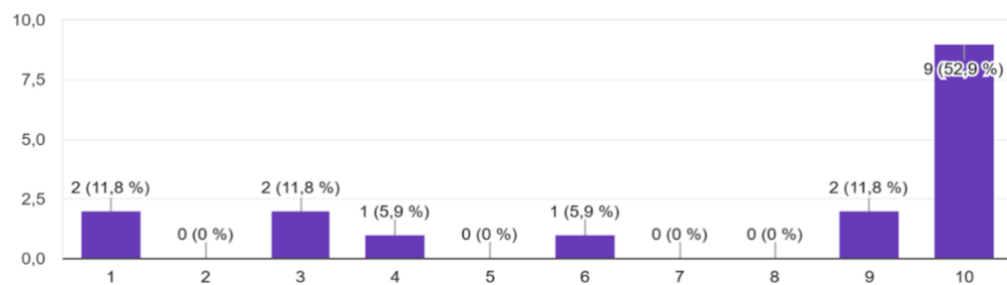


Figure 6: Participants rating of their perception of the suitability of the Students' DEER for their pupils (1 - I consider the room to be completely unsuitable, 10 - I consider the room to be very suitable)

Participants perceived this escape room as more suitable for secondary school pupils. The specific mathematical areas they identified included numerical operations, functions, equations, combinatorics, and logic.

Again, some of the groups could imagine using the game as part of their regular teaching, specifically in teaching the areas they directly identified in the game, especially equations or logic. Another part saw its suitability more in the context of substituted lessons or on a special occasion. Some groups expressed the belief that the game would be more appropriate for computer science lessons. However, there was also a statement pointing to the link between the two subjects: "I like the game as a reinforcement of cross-curricular links with computer science - pupils may be motivated to create such an escape game one day." Even with this escape room, several groups

perceived its use to be more outside the regular classroom, in clubs or competitions. In addition, there was a view from several groups that they would not use it at all with pupils.

3.3 Comparison of the Perception of Individual DEERs

Participants perceived the Students' DEER as more visually interesting and attractive to pupils. Compared to that of the Escape the Castle room, they appreciated that it contained more mathematical tasks. They described the mathematical tasks in this game as "more concrete" than in the Students' DEER. For the Students' DEER in comparison, some perceived that "more logical thinking and searching is needed." Other participants expressed the view that the Students' DEER did not contain enough mathematical tasks and emphasized more on "frantic clicking."

The two escape rooms also differed in that in the first case it was a linear game and in the second case the challenges could be solved in different order. Participants rated the linearity more positively. One group stated, "With the first one we liked the 'immersion' and that the line was clear, the problems came one after the other and you just had to solve them." The non-linearity in the second DEER may have contributed to some groups getting 'lost' and not knowing how to continue the solution. As the same group assessed, "With the second game, we felt more of that 'randomness' - at some point we didn't know what to use where and just clicked everything to everyone."

Participants also pointed out that the game Escape from the Castle contains more text. This was perceived positively by one group: 'The castle was more meaningful, it makes you read', but others assessed that this could be perceived by pupils as more of a disadvantage. In this regard, there were comments along the lines of, "The other one would appeal more to children because they do not have to read." Or that "there was more text in Escape from the Castle and sometimes pupils do not want to read." One group even speculated, "maybe the whole text would not be read by the children."

We also surveyed participants to see if they would be interested in more escape rooms like Escape from the Castle and Students' DEER being made available. As we can see in Figure 7, all participants agreed that they would be interested in DEER similar to Escape from the Castle. Up to 84.2% of all groups chose the value of 10, i.e. they agreed that they would be very interested in similar games. Participants were slightly less interested in DEER similar to the Students' DEER. As we can see in Figure 8, 64.7% of the groups chose a value of 10, i.e. they would also be very interested in this type of DEER. Another 11.8% chose values of 7 and 8. However, 17.7% of the groups would not be interested at all or hardly at all in a similar DEER.

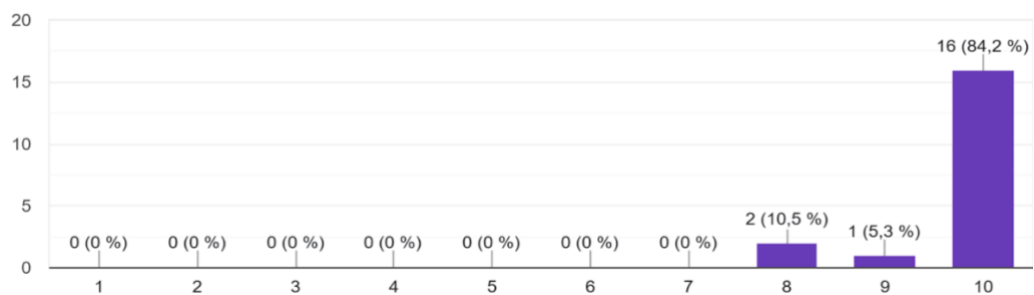


Figure 7: Interest in escape rooms similar to Escape from the Castle (1 - I would not be interested at all, 10 - I would be very interested)

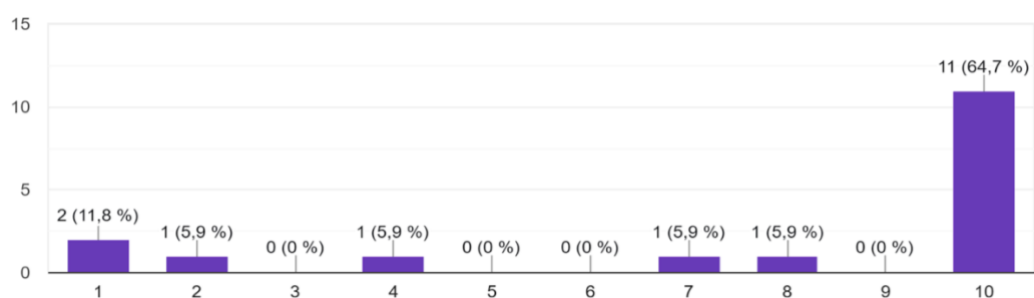


Figure 8: Interest in escape rooms similar to Students' DEER (1 - I would not be interested at all, 10 - I would be very interested)

4. Conclusion

In our paper, we present the findings of a case study in which we investigated mathematics teachers' perceptions of two DEERs and their appropriateness for pupils. We were also interested in what specific elements of game design they most valued in these DEERs. The first DEER, *Escape from the Castle*, was implemented using Google Forms; the second DEER was an interactive adventure game created by our students in the online tool *Room Escape Maker*. The research was conducted with 32 teachers in a lifelong learning session. During the meeting, the participating teachers played both DEERs in groups consisting of two to three members.

While playing both DEERs, we could observe mostly engagement and enthusiasm in the participants. The solution of the first DEER went smoothly in all groups without our help until the end. During the second DEER, some problems were encountered in some groups. One of them was related to an error in the assignment of the mathematical problem, which we were not able to correct due to environmental constraints (more details in (Čujdiková, & Vankúš, 2023)). Other issues were related to the fact that some groups could not find a certain needed game item or a way to use the items they had available. After a little help from our side, they were mostly able to continue successfully. However, some participants became frustrated with the problems encountered and the enthusiasm in their group waned. In a follow-up survey to assess how much they liked the given DEER, for the first one, a large proportion of the teachers rated that they liked it a lot. No group outright disliked this DEER. The second DEER was also liked by the majority of the groups, but a smaller proportion did not like it at all or hardly at all. At the same time, participants rated both rooms as largely suitable for pupils. They perceived the first DEER as more suitable. The main criticism of the Students' DEER was that it contained few directly assigned mathematical problems.

For both DEERs, participants appreciated several elements of the game design. For DEER *Escape from the Castle*, they positively perceived its linear design. They suggested that the non-linearity in the Students' DEER may have caused some confusion in solving it. For the Students' DEER, they particularly appreciated the eye-catching visuals. Several also considered the fact that this DEER contained less text to be positive for pupils. There was great interest among participants in other similar educational escape rooms, especially those such as "*Escape from the Castle*," indicating a demand for similar educational tools.

A limitation of our research is the small number of participants. We also suspect that the rating of the Students' DEER, and therefore the overall lower rating of this type of DEER, may have been influenced to some extent by the specific choice of the selected room and its particular shortcomings. The second room, which we had prepared and did not use in the end, was free of errors and also contained more directly assigned mathematical examples. Therefore, in the future, we plan to conduct another similar research with a different group of mathematics teachers using this particular room.

Acknowledgement

This paper was created with the support of the grant KEGA 037UK-4/2024 Innovative learning technologies in the preparation of future mathematics teachers provided by the Ministry of Education, Science, Research and Sport of the Slovak Republic.

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