

Design of an Educational Escape Room by Future Teachers

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Abstract: As educators seek innovative ways to engage students in the learning process, educational escape rooms have emerged as a promising motivational learning strategy. This paper presents a study on the design and playing of such escape rooms by pre-service secondary mathematics and informatics teachers using online tools. The study involved students collaboratively creating their escape rooms and introducing them to their peers. We gathered data through observation, questionnaires, evaluation cards, and their webpages regarding their opinions on the potential of these rooms as a teaching tool. Results indicate that most students found the educational escape rooms to be highly engaging and useful in promoting collaboration, and problem-solving skills. Therefore, they are open to using educational escape rooms in their future teaching. The study sheds light on the potential of student-led design of educational escape rooms as a means of preparing future teachers to incorporate this motivational tool into their teaching practice, with implications for teacher education programs and classroom practice.

Keywords: Escape room, Pre-Service teacher, Design, Motivation

1. Introduction

The use of escape rooms as an educational tool is nowadays an innovative approach to learning that has gained popularity. Escape rooms are physical or digital games that require players to solve puzzles and clues to "escape" a locked room or virtual environment within a set time frame.

In this scientific paper, we explore the use of digital educational escape rooms as a means of preparing pre-service informatics and mathematics teachers at the Faculty of Mathematics, Physics and Informatics of the Comenius University in Bratislava. Specifically, we investigate how students evaluate designs of the escape rooms using the digital online tool Room Escape Maker <https://roomescapemaker.com/>. We were also interested in their opinions on the impact of the use of escape rooms on students during classes.

The significance of our research lies in its potential to promote this new learning method in education. By incorporating educational escape rooms into pre-service teacher preparation programs, universities can equip future educators with the skills and knowledge needed to create engaging and dynamic learning environments for their students.

In the following sections, we provide a literature review on the use of educational escape rooms in education, describe the methodology of our study, present our findings, and discuss their implications for teaching and preparation of future teachers.

2. Theoretical Background

The escape rooms are live-action, team-based games where players must discover clues, solve puzzles, and accomplish tasks in one or more rooms to achieve a specific goal, usually escaping from the room, within a limited amount of time (Nicholson, 2015).

Escape rooms are a relatively new concept that has gained immense popularity in recent years. According to an analysis by International Escape Room Markets (2019), it is estimated that there were more than 50,000 escape rooms in the world in 2019.

In addition to the common escape games designed primarily for entertainment, educational escape games are also becoming increasingly popular. Educational escape rooms are problem-style scenarios that are designed with specific learning outcomes in mind. They require learners to participate in collaborative playful activities, explicitly designed for knowledge acquisition or skill development. So, they need to accomplish specific goals by solving puzzles linked to learning objectives in a limited amount of time. They are usually physical or hybrid games that take place in classrooms or labs, with a time limit of 60 minutes or less and a team size of 5 or more (Fotaris & Mastoras, 2019).

Overall, the potential of educational escape rooms as an innovative and engaging method for promoting active learning is promising. Several studies suggest that appropriately designed educational escape rooms can increase student motivation and support their interest in learning (Taraldsen et al., 2022; Fotaris & Mastoras,

2019; Veldkamp et al., 2020; Videnovik et al., 2022; Manzano-León et al., 2021; Fotaris & Mastoras, 2022). According to Fotaris and Mastoras (2019), "...educational escape rooms can provide an enjoyable experience that immerses students as active participants in the learning environment." Solving escape rooms help learners in comprehending the importance of viewing problems from various angles, gives them opportunities to engage in collaborative teamwork, encourages them to stay committed to the task, promotes strong social relationships, encourages team spirit, and facilitates various learning benefits through group discussions (Fotaris & Mastoras, 2019).

From the point of view of pedagogy, escape rooms are based on a social-constructivist approach (Vygotsky, 1978), where learners construct their knowledge based on real-time experiences of advancing through several challenges in the escape room. They need to face new and often complex problems, which can be solved by interacting with their peers and getting support from their tutor.

Escape rooms can be used as a method to learn a variety of subjects. According to a recent review study (Taraldsen et al., 2022), the most frequently mentioned are healthcare professions, science, technology, engineering, and mathematics (STEM). Fotaris and Mastoras (2019) reached similar results in their review study. They list the most common subjects as health and welfare, natural sciences, mathematics and statistics, social sciences, journalism, and information and communication technologies. There are examples of the use of escape rooms at different levels of education, but they are most used in higher education (Taraldsen et al., 2022; Fotaris, and Mastoras, 2019; Veldkamp et al., 2020).

Academically focused escape rooms were popularized by Breakout EDU, an immersive learning games platform founded in 2015 (Duggins, 2019). This platform provides escape room kits for instructors. Educational institutions and libraries have started to integrate this initiative into their programs or to develop their educational escape rooms. The research on this topic started to gain popularity and various interesting results were published.

Fotaris and Mastoras (2019), based on an analysis of 68 studies, concluded that "results seem to indicate that escape rooms are innovative, active, collaborative and constructivist instructional approaches that can shape learning more powerfully than conventional teaching." They also state: "Additionally, they allow learners to engage in an activity that rewards teamwork, creativity, decision-making, leadership, communication, and critical thinking."

Huang, Kuo, and Chen (2020) investigated the effect of digital escape rooms on students' learning performance, motivation, and problem-solving. They conducted research with an experimental and control group consisting of 20 fourth-grade students in each group. The experimental group used digital escape rooms for a 10-week duration, while the comparison group used direct teaching methods. The results showed an increase in learning motivation and problem-solving abilities in the experimental group compared with the control one. Both groups had the same performance levels. Students had positive perceptions of the digital escape rooms, and they believed that they were compelling and effective.

Veldkamp et al. (2020) conducted a systematic review of 39 studies that describe the design and evaluation of educational escape rooms, published between 2017 and 2019. They discuss some challenges and recommendations for developing and implementing educational escape rooms, such as aligning the game mechanics and pedagogical approaches, adapting to different settings and constraints, testing, and evaluating the escape rooms, and involving students in the design process. They conclude that escape rooms are promising and engaging learning environments that can foster various knowledge and skills in different disciplines, but they also require careful design and implementation to ensure their effectiveness and alignment with the intended goals. Fotaris and Mastoras (2022) pointed out that the major obstacle that educators face in designing their rooms is the lack of practical frameworks for such design. They propose Room2Educ8, a user-centered conceptual framework based on Design Thinking principles that provide heuristics for empathizing with learners, defining learning objectives and constraints, adding narrative, designing puzzles, briefing, and debriefing participants, prototyping and playtesting, documenting the whole process, and evaluating the escape room experience.

Taraldsen et al. (2022) concluded based on their recent review study, that more studies are needed on the use of escape rooms for educational purposes. They conclude: "It seems that research on this topic has reached a new phase, and there is a need for structured research and transparency in the research design and methods for data collection and analysis." They further state: "We see opportunities for the use of escape rooms as a didactic tool in primary and secondary education and teacher education." We also decided to contribute our

study to the knowledge in this direction, focusing mainly on the experience of pre-service teachers with designing their educational escape rooms and their beliefs about the usefulness of the escape rooms for the classrooms.

3. Methodology

In our research, we took a qualitative approach (Creswell, 2012) because we did not want to test pre-given hypotheses, but to explore the phenomenon of creating and using online escape rooms for teaching in as much depth as possible. Specifically, we decided to use a case study. It involved 24 pre-service teachers in the first year of their university study. The research took place in one of their university courses, Software for the Modern Teacher. Participating students created their escape rooms in groups (mostly 2-3 students in each group). As all of them had mathematics or informatics in their teaching combination their escape rooms also had to focus on any of these two subjects. After completing their rooms, the students played the escape rooms of the other groups.

In our research, we focused on exploring how students worked to create their escape rooms in an online tool offered (Room Escape Maker). We were interested in what they liked or disliked about this process and how they collaborated within their group. We also sought their opinions on the use of digital escape rooms in the classroom. Specifically, we were interested in how they perceived the possibilities of using these rooms in the classroom and how engaging they could be for students. We also specifically looked at their views on the usefulness of designing educational escape rooms for the development of problem-solving as well as collaborative skills. To investigate the mentioned phenomena, we formulated 2 research questions:

Q1: How do the pre-service mathematics and informatics teachers evaluate designing their own educational online escape rooms in group work using the Room Escape Maker tool?

Q2: How do they perceive the possibilities and impacts of using educational online escape rooms in the classroom?

We used several methods to collect the data. We observed the students while they were designing the rooms and were interested in how they were doing. We also observed them while they tested the rooms created by the other groups. We also found out how they perceived the rooms created by others using evaluation cards, in which they had to evaluate what they liked or disliked about each room and what they would suggest to the authors to change. These evaluation cards also provided valuable feedback for each group to improve their room. Students' opinions on how they worked to create their escape rooms and their overall perceptions of the possibilities of using online digital escape rooms in their future teaching were also gathered using a questionnaire. Another source of data was their evaluation of this topic on their website, which they created and updated after each activity in the course.

We analyzed all the collected data qualitatively to answer our research questions. For the study of written data that we obtained through the evaluation cards and questionnaire, we used thematic analysis (Braun, Clarke, 2006). We processed the data using open coding and based on it, we identified several topics connected with our research questions. These topics students mentioned in their evaluation of designing their escape rooms in the Room Escape Maker environment and in their beliefs about the possibilities of using online escape rooms in classroom education.

4. Results

Based on the analysis of the obtained data, we identified several themes related to our research questions. In section 4.1 we will address the topics that are related to the Q1, in section 4.2 to the Q2. In section 4.3 we will focus on how students evaluated the escape rooms created by their classmates.

4.1 Evaluation of Designing Educational Escape Rooms in the Room Escape Maker Environment

In this section, we will address the themes that students pointed out in their evaluation of creating online learning rooms in the Room Escape Maker environment.

Overall evaluation of creating the escape room

Most students evaluated the creation of their escape rooms using Room Escape Maker positively, as confirmed by the responses in the questionnaire. 93.3% of students said that they liked the activity. One student even evaluated: "I froze when I had to make the room myself. But in the end, it really caught me so much that I dare to say that the process of design is even better than playing the game itself." The students perceived that the

process was fun, even though it also required some effort on their part. For example, one student stated: "Making this room was fun, but also quite challenging. It was difficult for me to come up with all the things, but when I got into it, I was already adding extra things and just confusing the kids a little bit."

Creativity in the room design process

Students especially appreciated the opportunity to use their creativity when developing their rooms. One student, e.g., stated: "I liked that I could invent what was going to be done there [in the escape room] and that I could do it my own way."

Furthermore, the students specified more in detail that they enjoyed "the process of inventing puzzles", "engaging creativity while hiding the key", and "creating various connections and mysteries". They also liked the fact that they needed to think about the player during this process. They also positively assessed that they were creating something meaningful for someone else. For example, one student commented: "I liked that I had to create a puzzle that someone would have to solve." Another student appreciated that this way she can create something meaningful for her students: "I like the overall idea of the game, that I can make it myself and use it in teaching at the same time."

Educational goals / Incorporation of educational goals

The escape rooms created by the students were supposed to be usable in classes, specifically in the subjects of mathematics or computer science. For this purpose, we recommended students read the new state educational programs for Slovakia. Several students rated the inclusion of educational goals as the most difficult part of creating their room. One student stated: "The thing that bothered me the most was such a small specification in the assignment - my escape room is supposed to develop some of the educational goals listed in the new educational programs for mathematics or computer science. Maybe the specification is not that small, ha-ha. I studied the standards for mathematics because we did this project in groups where we were mixed [subjects' combinations]. And our common subject is mathematics. I relied on two goals [stated in the educational program] - the third and fourth - to propose problem-solving strategies and to think critically and argue". And then she added: "Although I think that these two goals are naturally reached by escape rooms".

Several other rooms aimed to develop logical thinking. Some groups also incorporated specific concepts into their room, including the use of cycles in the programming, converting between number systems, solving quadratic equations, and multiplication. However, even the students who focused on a certain concept also perceived that their escape room also developed logical thinking and problem-solving, which are important parts of mathematics or computer science. For example, one student commented: "In my ESCAPEROOM, I used arithmetic with addition and multiplication with decimal numbers. It's an activity that I also enjoyed a lot, so I can imagine that I will use it in practice as well. It develops brilliantly not only in the area of selected [mathematical] tasks but especially in logical thinking, which is the most important thing in mathematics."

Several students pointed out that it was difficult for them to add [to the escape room] their ideas for the connection [of puzzles] with mathematics or computer science, due to the limitations of the used environment. So, they had to use what they had available and adjust their original idea accordingly. In the end, however, all groups managed to come up with it successfully.

Cooperation

Almost all students evaluated that they cooperated well with their classmates when creating the escape room. What they liked most was that they could brainstorm, share ideas, and think about the whole concept together. Someone said that they could have created a more elaborate room by working together, and it was also felt that they had better ideas as a group. Another positively perceived aspect was the possibility of mutual help: "As always, when you work with someone, if you don't know something, you have someone to help you". On the contrary, they negatively assessed that the Room Escape Maker environment does not allow sharing the project between several creators, so they had to work together on one computer. However, although they would have appreciated such an opportunity to share the project in the environment, in the end, most of them concluded that they managed to work together successfully even without it.

Despite the positive perception of cooperation among most students, two students stated that they worked rather poorly in the group. One of them stated: "As an introvert, working in a group does not suit me more or less, but I am willing to make an exception." The other said: "I think it's something that is better done independently; everyone has a different idea." So, compared to other students, he did not see the difference

of ideas as something beneficial, but rather as a limitation. One student worked during the escape room design alone.

The intuitiveness of the used tool

Opinions on the intuitiveness of the Room Escape Maker environment differed significantly among students. Some evaluated that it is "quite clear and easy to navigate" and that it has "good UX [user experience]" and is "user-friendly." Others, on the contrary, perceived that it is difficult to control, and it is difficult for a new user to figure out what works and how. During the creation of the rooms at the seminar, we could observe in some groups how they try to discover individual functionalities themselves, but they do not manage to figure out how to work with them and gradually begin to succumb to frustration. In such situations, we directed them to watch the video tutorials that are accessible on the tool page. It turned out that it was not easy for students to notice that these instructions were there. Some students then stated that after looking at the instructions and "getting into it", they already worked well with this tool. One student described her progress in getting to know this tool by saying: "When I started doing it, I had quite a problem. I didn't know what to work with. I was confused by the tool. But then I managed it and fought it to a successful end."

Paid features of the tool

Several students did not like that many functions or options that would be useful to them were only in the paid version of the application. One student even commented: "The app has potential, but I don't think many people will actively use it if they have to pay to express their creativity."

Students found the locking of most graphic objects in the free version of the tool particularly restrictive. When creating their room, they had to use a relatively limited offer. They were also bothered by the fact that they could not add their links but only had to work with pre-prepared texts. However, in the end, despite these limitations, they managed to creatively use what they had available and create rooms that they were happy with. One student summed it up by saying, "I was a little surprised that most of the content was premium for the money, so our options were limited, but we still managed to create a cool room."

As another negative aspect of the free version of the tool, they perceived that it was not possible to edit the room after sending it for publication. At the time when they tested their rooms between the groups, they had already published them or sent them for publication, and thus they could not include proposals in the final version of their escape room. Some students coped with this by using the 2-day trial version of the tool, in which it was possible to make the necessary changes. Overall, however, students were quite disappointed by this fact.

Time requirements

At the same time, some students expressed the opinion that although they like the idea of online escape rooms for teaching, it is very time-consuming to create such a game. One student summed it up with the words: "I like these kinds of games and I am fond of them, so I can imagine that if someone invented them for me, then I could "play" them in class. That's why I take it as a wonderful addition to the class, but inventing and creating such a game is quite time-consuming."

4.2 Beliefs on Possibilities and Impacts of Using Educational Online Escape Rooms

In this section, we discuss the topics that students pointed out about their beliefs on the possibilities and impacts of using educational online escape rooms for teaching.

Motivation

Students find educational escape rooms motivating because they are based on learning through play. They all agreed that such playing is engaging for the pupils. They evaluated that this activity represents "fun in class" and allows "the use of the practical example or a theoretical knowledge in a playful way." They think that solving escape rooms can add variety to the lessons. One student even voiced the opinion that "Even the idea of a test in this form is something very interesting." Furthermore, students also consider solving escape rooms as a motivating way to repeat or practice certain concepts with which the pupils have already become familiar.

Development of logical and critical thinking

Many students see escape rooms as a means to develop logical thinking. For example, there was an opinion that: "Their solution fulfills not only an entertaining function, but also teaches children to cooperate and, above all, to use logical thinking and deduction."; or: "In my opinion, it is useful to use the concept of escape

rooms in teaching as well because solving puzzles or ciphers can help the students to improve their logical thinking." Someone else commented: "Children need to utilize logical thinking in a good escape game." but he went on to state: "Of course, it all depends on the focus of the given escape game." In addition, some students perceive that solving escape rooms also develops pupils' critical thinking.

Development of problem-solving skills

Students conclude that thanks to playing escape rooms, pupils can also develop their ability to solve problems. One student who in his created room focused on the goal of "analyzing problems and developing abstraction and logic," expressed his opinion: "Nowadays it is important to be able to solve problems of different levels of difficulty under pressure. At a given moment, it doesn't matter so much how much information the person has, but how he can use it." He sees the advantage of the escape rooms published on the Room Escape Maker website because the individual tasks are interesting, and the player can choose the preferred difficulty.

Cooperation

The students also evaluated that the escape rooms allow the pupils to "improve in cooperation with the classmates with whom they play the given room.". Several students considered the fact that pupils learn to work together in solving escape rooms as a key part of this activity.

Development of creativity

The students also expressed the opinion that playing escape games is a creative activity or directly stated that it develops the pupils' creativity. They often mentioned this aspect together with other characteristics associated with this activity.

4.3 Evaluation of Escape Rooms of Other Groups

Based on the analysis of the evaluation cards filled out by the students regarding the rooms created by their classmates, we identified what they appreciated the most about the created rooms, and what they perceived as ideas for improvement. We discuss our findings in detail in this section. You may find spoilers about the solutions of the individual escape rooms here, so if you are interested in playing the games, we recommend you continue reading after you try them. Together, students in all groups created a total of 9 educational escape rooms. Links to all rooms can be found here <https://www.comae.sk/escape.pdf>.

In Figures 1–4, we can see screenshots from the four escape rooms that the students most often rated as the best. They liked the overall handling of them and acknowledged that you could see that the writers had put a lot of effort into them.

In these, as well as in the other rooms, the students appreciated a variety of solved puzzles and the use of diverse objects. They evaluated positively if they found more objects than needed to be used and had to think which of them are necessary for solving. They also highlighted the integration of some unexpected specific items that they considered creative. For example, they liked the use of a screwdriver to remove the wooden slats under which they found the safe (Figure 1) or the need to use a magnifying glass to read the clues on the found pieces of paper (Figure 2).

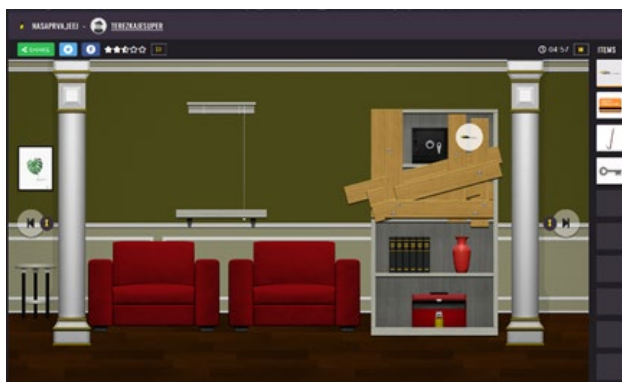


Figure 1: Room 1 <https://roomescapemaker.com/u/terezkajesuper/mojaprvawau>

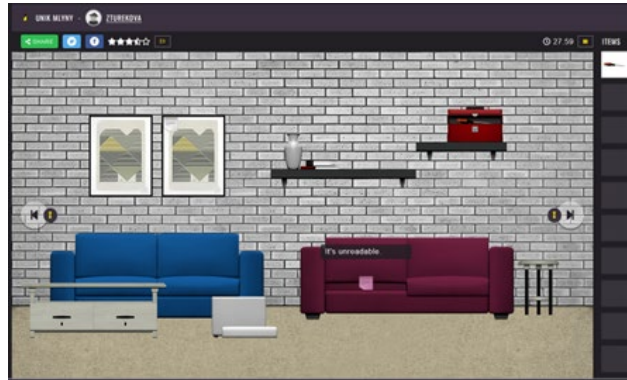


Figure 2: Room 2 <https://roomescapemaker.com/u/zturekova/unikmlynny>

Students also positively evaluated when mathematics or computer science was somehow interestingly involved in the classrooms. For example, in Room 3 (Figure 3) they liked the creative use of converting numbers between different number systems. In this room, to obtain one code, it was necessary to find several numbers, each of which was in a different number system, convert them to the decimal system, and add them up. On the contrary, they gave a rather negative evaluation if they felt that there were only a lot of mathematical tasks in the room and nothing else was needed except for their calculation.

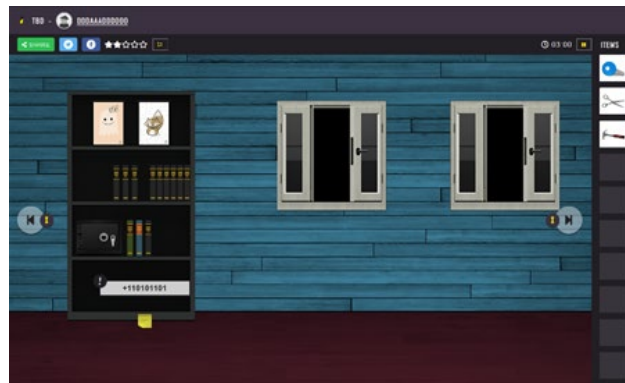


Figure 3: Room 3 <https://roomescapemaker.com/u/dddaaadddooo/keksik>

Furthermore, students rated positively when the rooms were more complex (Rooms 2 and 4, Figure 2 and 4). They liked it when they presented enough of a challenge for them, but at the same time, they could solve them with enough effort. On the contrary, they evaluated negatively when they were too simple or too difficult. In case they considered the room too easy, they recommended the authors add more puzzles or use more challenging puzzles. If they found the room too difficult, they recommended adding more clues.

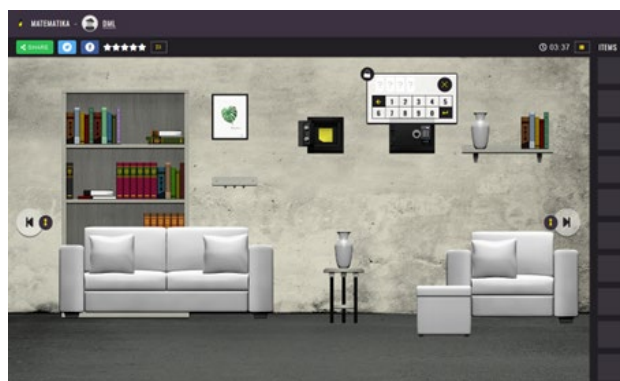


Figure 4: Room 4 <https://roomescapemaker.com/u/dml/dml>

If the students liked the appearance of the given room, they also appreciated its visual aspect. They evaluated negatively when something was illogically incorporated into the room's design.

The students also pointed out several small issues. Among them were wrong settings causing the items to remain in the inventory even after they were used, the ability to click on objects that could not be used, and a few minor errors in the escape room's quests. They also negatively evaluated the settings of too little time for the solving of the escape room. They pointed out that this aspect caused them to feel stressed when dealing with it.

5. Conclusion

Our article presents the findings of a study that explored pre-service teachers' evaluations of their experience designing educational escape rooms in group work using the Room Escape Maker tool. We also focused on how they perceive the possibilities and impacts of using educational online escape rooms in the classroom.

24 pre-service teachers were involved in the research, who created a total of 9 original educational escape rooms within the groups. We think the rooms the students created would be usable in the classroom after incorporating comments from their peers. However, for use by other teachers, we recommend that the students create a methodical manual for them, which would contain the educational goals of the room and the solution procedure.

In an attempt to answer our Q1, we found that students rated creating their educational escape rooms in the Escape Room Maker environment overwhelmingly positive. They especially liked the opportunity to engage their creativity and collaborate in creation with their group members. Students' opinions on the intuitiveness of Escape Room Maker varied. Some considered the tool simple, others fumbled with it in the beginning. For the further use of this tool for the creation of educational escape rooms in the preparation of pre-service teachers, we would therefore recommend first watching the video instructions available on the tool's page. However, it turns out that these instructions are not easy to discover on the site, so it may be appropriate to direct students to them directly. It also turned out to be problematic that the rooms created in the Escape Room Maker free version could no longer be edited after being sent for publication. Therefore, it would be more appropriate if the students first test each other's rooms, incorporate the received comments, and only then publish the finished room. Several students also did not like the fact that many objects and functions in this tool are only available in the paid version, which they considered as a factor limiting their design. In the future, we would therefore like to explore other environments that would be completely free or try to create such an environment ourselves. According to students' comments, this environment should also include the ability to share a project of the escape room for multiple creators.

In an attempt to answer our Q2, we found that pre-service teachers in our research sample found playing educational escape games in mathematics or computer science classes to be motivating. They perceive that this activity can develop students' logical and critical thinking, creativity, and ability to solve problems. At the same time, they pointed out that students can practice a previously learned concept in this playful way. In addition, they stated that playing in a group also develops the ability to cooperate. When they played escape rooms created by their peers, they appreciated if mathematics and computer science were meaningfully incorporated as part of the puzzles. On the contrary, they rated it negatively if it was only about e.g., solving arithmetic tasks and the room did not contain other challenges. They liked the rooms containing a variety of puzzles and requiring the use of several objects. They rated rooms that were more challenging more positively than rooms that they could solve without effort. They were also able to appreciate the nice visual appearance of the rooms. These findings can also serve as support for the further design of online educational escape rooms by students.

The limitation of this research is its small sample size, which only includes students who attended the given course at the selected faculty. In the future, it would be beneficial to involve students from different years of study and other universities, eventually not only from Slovakia.

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