

# Using an Escape Room Activity to Enhance the Motivation of Undergraduate Life Science Students in Mathematics Classes: A Case Study

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**Abstract:** Mathematics is one of the school subjects where demotivation, dislike and failure are frequent concerns. To address this, it is important to actively engage students in the classroom and employ resources that make math classes more appealing and captivating, leading to meaningful learning experiences. Active, cooperative, and participative learning methods should be prioritized over traditional didactic teaching and the mere transmission of knowledge. Active learning methods offer alternative approaches to the conventional lecture format, actively involving students in the learning process. The concept of an escape room, a gaming experience where participants must solve challenges to escape from a locked room, has gained popularity in educational contexts. The educational escape room is an extension of this concept, aiming to promote real-time problem-solving, teamwork, and discovery of clues and mysteries to facilitate active learning. By engaging in various tasks within a room, students work together in teams, fostering an active learning environment. The educational escape room offers several benefits, including the enhancement of problem-solving skills, student performance, and motivation. By incorporating gamification strategies into teaching and learning processes, this approach proves to be an effective way of promoting active learning in mathematics. In this paper, we present a case study that explores the use of an educational escape room with first-year undergraduate students from a Portuguese higher education institution, with the goal of improving their mathematical problem-solving skills. The study aims to evaluate how escape rooms can contribute to increased student motivation. To assess the perception of students regarding this escape room methodology, a quantitative survey was conducted. The findings indicate that using the escape room as an educational approach effectively increased student interest and improved learning outcomes in mathematics.

**Keywords:** Higher education, Educational escape rooms, Mathematics education, Game-Based learning, Active learning, Problem solving, Soft skills

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## 1. Introduction

Mathematics, considered one of the basic areas of various education settings, is one of the school subjects where demotivation, dislike and failure are frequent concerns (Faulkner et al., 2014, Maharjan et al., 2022). Mathematics is often perceived as a challenging subject by many students, characterized by the need for memorization and repetitive tasks, lacking in interest or practical application. This outcome can be attributed to the traditional approach to teaching (Dhakal, 2018; Dahal et al., 2019), which emphasizes the transmission of knowledge and places value on memorizing procedures and content through repetitive exercises.

Engaging students in the classroom and utilizing resources that make math classes attractive and captivating is essential in fostering meaningful learning experiences. The undeniable importance of mathematics in everyday life and individual development further emphasizes the need for such engagement. One of the key challenges in mathematics education lies in addressing the lack of motivation among students towards the subject. According to several authors (Matos, 2011; Entwistle and Ramsden, 2015; Pais et al, 2018; Hall and Pais, 2018; Maharjan et al., 2022), motivation plays a crucial role in any learning process as it impacts not only the ability to acquire knowledge but also the quality of learning itself. The level of motivation we possess significantly influences our engagement and success in the learning process.

The world we live in is continuously evolving and undergoing constant change. The educational context is no exception and requires a renewal of paradigms (Morin, 1999; Voštinár and Mandrichenko, 2022). Often, teachers are faced with discouraged students: with glassy eyes, heads down on desks, students who do not remember content taught to them the day before! Mathematics classes are no exception. Quite the opposite! Profound changes to the role and function of both teachers and students are particularly vital. It is necessary to go beyond the traditional; the teacher must look for resources that make classes flow, so that the students acquire or increase their interest in mathematics. The Joint Mathematical Council of the United Kingdom (2011) states that it is of the utmost importance that the teaching and learning process of mathematics becomes more stimulating, taking into account modern society and the students' interests. Active, cooperative, and

participative learning methodologies should be prioritized over traditional didactic teaching methods that focus solely on the transmission of knowledge. One of the greatest challenges faced by teachers today is to effectively engage students, motivate them to learn, and encourage them to actively participate in their own learning process (Katsaris and Vidakis, 2021). If students develop motivation to learn a subject, they are much more likely to develop long-term understanding (Lester, 2013, Maharjan et al., 2022).

Active learning occurs through playful activities creating powerful learning environments (NCTM, 2020). Integrating games as a playful tool offers learners the opportunity to engage in imaginative scenarios and challenges, which can also be collaborative in nature and governed by specific rules. This approach allows for a quantifiable outcome, adding a measurable element to the learning experience. (Vidakis et al, 2019; NCTM; 2020, Vidakis et al. 2020; Papadakis, 2020; Kalogiannakis et al., 2021).

In the last decade, the interest in fostering motivation with gameful approaches has been rising (Koivisto and Hamari, 2019).

As lecturers in higher education within the polytechnic sector, the authors are faced with all these changes and cannot help but reflect on them and consider what their contribution (however small it may be) could be to improve the quality of higher education in Portugal.

One of the authors being a mathematics teacher, she is also confronted year after year with the demotivation, lack of interest, and subsequent failure of students in relation to mathematics subjects.

These reasons formed the starting point for the project "You can escape from the room, but not from Knowledge." Given the imperative need for changes in the educational model, a different perspective on learning and the role of teaching and learning methodologies is essential. It is crucial to prioritize active, cooperative, and participative learning methodologies, breaking away from traditional lecturing and mere "knowledge transmission." In order to reverse the existing and widespread sentiment towards mathematics, it is necessary to motivate and foster interest, thus promoting student success in mathematics subjects.

Guided by the research question, "How can we motivate and foster interest in mathematics, making the learning process more engaging?" the authors developed an escape room activity in the field of mathematics for first-year students in a life science course.

## **2. Escape Rooms and Learning**

### **Escape Rooms**

Escape Rooms (ERs) are "live-action team-based games where players accomplish tasks while participating in multiple procedures, in one or more spaces, with a specific goal, in a limited period of time" (Nicholson, 2015). ERs appeared initially in Japan in 2007, but have grown in popularity worldwide, with rooms available across most continents including Asia, Europe and America (Makri, Vlachopoulos, & Martina, 2021). ERs provide players with an immersive narrative experience, creating a meaningful and memorable escape scenario. Players are transported into a narrative circle where they are faced with intriguing challenges and missions. Whether it's capturing a group of thieves who have stolen valuable artwork from a museum, retrieving important notes from a locked school locker before an upcoming exam, or saving the planet from a nuclear threat, these narrative-driven scenarios evoke emotional investment and curiosity among players. As they navigate through the rooms and solve the presented challenges, the game atmosphere is set, fostering engagement and a sense of adventure.

### **Educational Escape Rooms**

Escape Rooms have become a popular recreational activity which has also drawn the attention of teachers and educators in recent years. Educators are increasingly motivated to incorporate Escape Room games into diverse educational contexts. Educators are increasingly inspired to adapt Escape Room games into various areas of education (Cable, 2017; Clarke et al., 2017; Nicholson, 2018) as a method to develop playful and productive failure techniques for encouraging continuous development (Whitton, 2018). Educational Escape Rooms have been shown to be a fun and entertaining activity if brought to the classroom. At the same time they have been proven to be a solid activity where, while trying to break out of the room, students can develop soft skills as well as subject-matter related competencies (Morrell et al. 2020, Sowell 2020). A systematic review carried out by Fotaris and Mastoras (2019) highlights their positive impact on student motivation and soft skills development such as teamwork, creativity, decision-making, leadership, communication, and critical thinking, and emphasises the enjoyable experience that immerses students as active participants in the learning environment.

“The Escape Rooms methodology provides a playful foundation for learning experiences to be designed into a more contextualised manner. Using narratives [...] could invoke the much-needed curiosity and motivation to be persistent on problem solving” (Arnab et al. 2021, p.2).

### **3. Methodology**

#### **Research Aim, Procedure and Instruments**

The aim of the study is to evaluate how Escape Rooms can contribute to increase students' motivation, making the learning process more interesting and promoting a more positive attitude towards mathematics. The authors chose to conduct a case study, with primarily exploratory intentions. To facilitate this experience, inquiry techniques and direct non-participant observation were employed, and the data collection instruments included a final questionnaire and field notes. In this article, we present an analysis of the questionnaire responses and the researchers' observations obtained through direct non-participant observation.

In non-participant observation, the researcher assumes the role of an external observer, not taking any initiative in the evolution of the situations he/she observes (Marietto, 2014). The non-participant observation method was utilized by the authors to capture and document non-verbal cues and insights during the game situation. This approach involved observing the participants in the Escape Room without any interference from the researcher, thus enabling the documentation of challenges, dynamics, and spontaneous behaviors and attitudes. By employing non-participant observation, the authors aimed to evaluate the effectiveness and impact of the Escape Room experience.

To understand how the methodology of this Escape Room was perceived by the students, quantitative and qualitative data were collected through a questionnaire developed by the researchers. A preliminary version of this instrument was analyzed by three higher education teachers, tested with four individuals from the same group, and modified based on the suggestions collected and difficulties detected during its completion. Statistical analyses were performed with Excel and Statistical Package for the Social Sciences (SPSS), version 28. Descriptive statistics (frequencies, mean and standard deviation) were computed to examine the results.

#### **Participants**

The case study was conducted at a higher education institution in the central region of Portugal. The participants were undergraduate students majoring in Life Science, specifically enrolled in the Mathematical Analysis II course during the second semester of the academic year 2021-2022. The case study included a total of 20 students, with 19 of them completing the questionnaire. Among the respondents, 16 (84.21%) were female, and 3 (15.79%) were male. The age of the participants ranged from 18 to 24 years. It is important to note that this was a convenience sample, meaning that the participants were easily accessible to the researchers.

#### **Study description**

The Escape Room was designed by two researchers of this study, a mathematics teacher and an ICT teacher, who created the challenges that the students had to develop in order to escape the room. Prior to carrying out the activity, the Escape Room was tested at the school by a group of 3 students and 2 teachers aged 18-41 years.

The two teachers in charge of the Escape Room acted as observers, refraining from interfering with the game. The participants were divided into four groups, each consisting of five students. They were placed in a university classroom for a duration of 30 minutes. An introductory video provided information about the game's objective and the time limit. The students were then prompted to begin solving the challenges, with a stopwatch keeping track of the time remaining for them to escape the room.

The first clue presented the students with a mathematical problem that needed to be solved in order to obtain the code for a safe. Inside the safe, the key awaited, which would allow them to successfully escape. The students received assistance in tackling the mathematical problem through various challenges that provided helpful hints and guidance.

In these challenges an invisible ink pen was used to write the hints on paper, which could only be read by using a fluorescent light, a stack of books that hid the hint on a particular page, only revealed by solving a mathematical operation, and a magnifying glass to read a formula, which could only be read by using it. In order to overcome the challenges, the students had to carefully follow the provided clues, which guided them towards understanding the ultimate goal and the steps required to obtain the necessary hint. Armed with these clues, the students would return to the initial mathematical problem and attempt to solve it. The solution to this problem yielded the code for the safe, which contained the key to escape from the room. Upon successfully

using the key to exit the room, the students' completion time was recorded. This facilitated the identification of the winning team based on two criteria: successfully solving the challenge and doing so in the shortest amount of time.

#### 4. Findings

This paper intends to evaluate how an escape room activity can contribute to increase students' motivation and if it contributes to improved learning outcomes.

To reach this goal, direct observation, field notes and analysis of a quantitative survey were the main instruments used.

Regarding the objective stated previously – investigate if an Escape Room activity contributes to increase students' motivation – several results may be reported.

##### Field notes analysis

The teachers observed that the participants in the activity thoroughly enjoyed and found the Escape Room (ER) experience to be highly enjoyable and entertaining. According to the students' feedback, this type of active and dynamic class proved to be more appealing compared to a traditional approach focused on solving exercises. Mathematics, in particular, was perceived as a more engaging and positive subject through the implementation of the ER activity. Some participants expressed their enthusiasm, stating that the classes became much more enjoyable and interesting with this interactive approach. Additionally, another group expressed a desire to see such activities extended to other topics within the curriculum and across different subjects. One student commented the following to one of the teachers: "I think the escape room was a very dynamic and fun activity to unite us as a group and challenge our math skills". These facts support a positive answer to the established objectives: evaluate if an ER activity contributes to making the learning process more interesting and promoting a more positive attitude towards mathematics.

##### Questionnaire analysis

To collect information about students' insights on the use of the Escape Room a questionnaire was delivered at the end of the activity. From the 20 students who took part in the activity, 19 answered the questionnaire.

The first section of the questionnaire concerned the characterization of the respondents with respect to gender and age. Ages ranged from 18 to 24 years and most students were female (84.21%), whereas 15.79% were male.

In the second section of the questionnaire, students were asked to provide their opinions on the ER activity. Using a five-point Likert scale ranging from 1 (very poor) to 5 (very good), students were asked to rate their overall evaluation of the ER activity. The results indicated that the majority of students responded positively. Only two students (10.53%) gave a neutral rating of 3, while none of the participants gave a negative response.

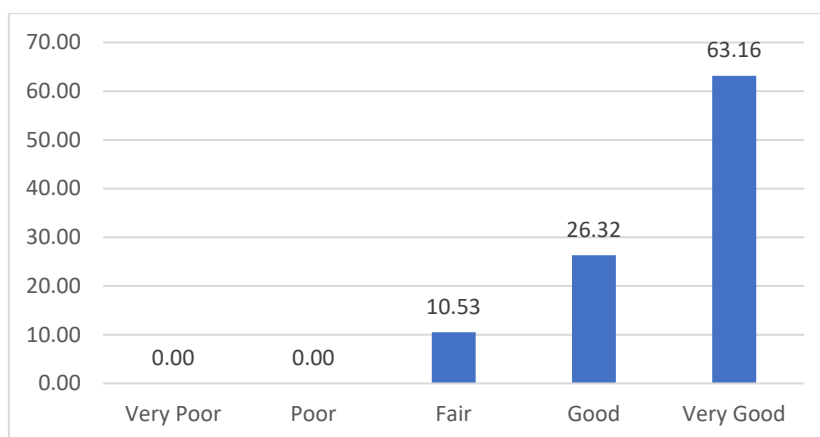


Figure 1: Rate your general evaluation of the ER activity

Analyzing the results of the questionnaire presented in Table 1, we observe that the mean values are clearly positive for most questions. The students' proficiency in digital skills was evident in their high level of ease in handling technology. The questionnaire results revealed that the ER activity served as a motivating factor for students and facilitated content consolidation, while also being enjoyable. The majority of students agreed that the activity was well-organized, the allocated time was appropriate, and the level of difficulty was manageable.

The least consensual statement, but still positive, is about the fact that they contributed to having a better grade in the CU (mean=3.21 out of 5; sd=1.07) and the fact that they learned more with the ER activity than with a class to consolidate the syllabus (mean=3.16 out of 5; sd=1.22).

Based on the information provided, it is evident that the majority of students had a positive reception to the ER activity, perceiving it as a valuable contribution to the learning process and enhancing motivation for learning. Consequently, students recommend the utilization of escape rooms as an effective teaching methodology.

**Table 1: Summary of the satisfaction survey responses (answers on a Likert scale: 1-strongly disagreement, 5-strongly agreement)**

	1	2	3	4	5	NOp	Mean	S. D.
<b>1 - In general, I like to play games (video games, board games, etc)</b>	0	0	1	7	11	0	4.53	0.61
<b>2 – The ER allowed me to consolidate the syllabus</b>	0	0	4	10	4	1	3.79	0.70
<b>3 – Resorting to the ER will contribute to a better grade.</b>	0	2	8	2	5	2	3.21	1.07
<b>4 - I found the Escape Room to be an enjoyable experience.</b>	0	0	0	3	15	1	4.58	0.45
<b>5 - The ER was too difficult</b>	6	11	2	0	0	0	1.79	0.63
<b>6 - The ER was well organised</b>	0	0	1	5	12	1	4.37	0.64
<b>7 – The time allocated to the activity was adequate.</b>	0	0	0	7	11	1	4.37	0.54
<b>8 - I liked the ER better than the exercise-solving class.</b>	0	0	3	4	11	1	4.21	0.80
<b>9 - I learned more with the ER than I would have with a class to consolidate the syllabus.</b>	1	3	3	6	4	2	3.16	1.22
<b>10 - I recommend the ER as a pedagogical methodology</b>	0	0	0	7	11	1	4.37	0.54

The third and last section of the questionnaire concerned the use of an ER activity in math classes. Students were asked to give their opinion, in a five-point Likert scale, about five statements.

When asked if the use of an ER activity in math classes:

- contributes to a more positive attitude towards mathematics: 18 (94.74%) had a positive opinion, 1 (≈5.26%) had a neutral opinion and no one had a negative opinion.
- makes mathematics more boring and demotivating: everyone (100%) had a negative opinion.
- makes the learning process more interactive: everyone (100%) had a positive opinion.
- it is only a way to keep us entertained for a while: 13 (68.42%) disagreed with this statement, 5 (26.32%) had a neutral opinion and 1 (5.26%) had a negative opinion.
- provides a less rigid method of learning, making it more challenging, interesting, and stimulating: everyone (100%) agreed with this statement.

Figure 2 shows the detailed responses to these questions in a heatmap with the observed frequencies. It is clear from the heatmap, and the information described above that the majority of the students find that the use of an ER activity in math classes contributes positively to the learning process (making it more interesting, interactive, challenging and stimulating) and to improve the motivation for learning mathematics.

<b>Statement: The use of an ER activity in math classes...</b>	1	2	3	4	5
contributes to a more positive attitude towards mathematics	0	0	1	7	11
makes mathematics more boring and demotivating	11	8	0	0	0

Statement: The use of an ER activity in math classes...	1	2	3	4	5
makes the learning process more interactive	0	0	0	6	13
it is only a way to keep us entertained for a while	3	10	5	1	0
provides a less rigid method of learning, making it more challenging, interesting and stimulating	0	0	0	8	11

Figure 2: Heatmap with frequencies of responses to questions about the use of an ER activity in the classroom

## 5. Final Remarks

The main limitation of this study is its small sample size. However, despite this limitation, the study's results demonstrate that incorporating an Escape Room (ER) activity enhances student engagement and motivation for learning by making the learning process enjoyable. These findings align with similar studies conducted by Babazadeh and Frigerio (2021), Huang et al. (2020), Nicholson (2018), and Papadakis and Stavarakis (2020). Furthermore, students perceive the ER activity as an effective tool for promoting learning and recommend it as a pedagogical methodology.

Based on the results of this study, we conclude that the use of an ER activity in math classes promotes a positive attitude towards mathematics and thus fosters motivation to learn it. Therefore, we recommend the use of ER activities in classes. It is a means to help students improve their abilities, their motivation for learning and, consequently, their performance. Overall, it contributes to a successful learning process.

This study can be valuable not only for all teachers but specifically for mathematics teachers, as it provides insights into educational Escape Rooms (ERs). The findings can serve as a foundation for educators who aim to create a fun and engaging learning environment in their classrooms while ensuring that meaningful learning is taking place.

For future research, it is recommended to include a larger sample size to further validate the results and enhance the generalizability of the findings. Additionally, investigating other aspects related to ERs, such as their impact on specific learning outcomes, different subjects or different student populations, would be beneficial for expanding our understanding of their effectiveness in education.

## Acknowledgments

This work is supported by Portuguese Foundation for Science and Technology (FCT - Fundação para a Ciência e a Tecnologia), within the Center for Tourism Research, Development and Innovation (CITUR), through project references UIDB/04470/2020.

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