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ENHANCING LEARNING AND MOTIVATION THROUGH DIGITAL ESCAPE ROOMS: A CASE STUDY OF FIRST-YEAR TOURISM STUDENTS

Sónia Pais[1,2], Ana Elisa Sousa[2] and Maria Sofia Lopes[2]
[1]*CIDMA - Center for Research and Development in Mathematics and Applications, University of Aveiro, Portugal*
[2]*CITUR - Centre for Tourism Research, Development and Innovation, Polytechnic of Leiria, Portugal*

ABSTRACT

Generation Z, born in the late 20th and early 21st centuries, is highly familiar with technology in their daily lives. Understanding how these technologies influence learning is crucial for developing pedagogical approaches that leverage technological applications for innovative teaching and self-learning strategies. Educational technologies offer several advantages, such as enhancing students' learning experiences, increasing their motivation, and improving their comprehension. Recognizing these benefits, the authors of this work developed an educational resource - a digital Escape Room - where students can explore their problem-solving skills. This paper presents a case study involving first-year undergraduate students in a Tourism degree programme at a higher education institution, using a digital escape room. The study aims to evaluate how the escape room contributes to increasing students' interest and motivation, as well as the consolidation of learning. Students' perceptions were assessed through a quantitative survey. The effect on students' comprehension was evaluated by comparative assessment with a reference group. The conclusions suggest that the digital escape room represents an effective educational approach that enhances student interest and helps consolidate learning.

KEYWORDS

Higher Education, Educational Escape Rooms, Mathematics Education, Game-Based Learning, Active Learning, Pedagogical Innovation

1. INTRODUCTION

Mathematics, considered a foundation subject in most higher education degrees, has been a cause for concern for many educators due to the enormous academic and educational failure to which it has been subjected. (Pais, Cabrita and Anjo, 2011; Faulkner et al., 2014; Pais and Hall, 2021; Santos et al., 2021; Maharjan, Dahal and Pant, 2022). The lack of interest and motivation

that students feel towards the subject is one of the problems identified in the failure of the teaching-learning process of Mathematics. 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! A fundamental aim of educators is to reverse the existing and widespread negative feeling towards Mathematics. To promote the success of students in mathematics subjects, educators aspire to motivate to encourage enjoyment and interest (JMC, 2011). If students enjoy Mathematics, they are much more likely to remember what they have learned. If students are motivated to learn about a subject, they are much more likely to develop a long-term understanding of that subject (Lester, 2013). A powerful ally in this demand is the use of technologies (Skuza, 2020; Billet et al., 2022).

In recent decades, technology has become a fundamental part of western society, significantly changing the way we communicate, socialize and work. These changes are also reflected in an educational context. Education is facing a paradigm shift and it is crucial to integrate school strategies with the new social realities (Roldão, 2000, p. 3). Technologies are part of the young people's lives, especially those who were born at the end of the 20th and beginning of the 21st century, often referred to as "Generation Z". There is, therefore, an imperative to reflect on their needs, the way they learn, the role of technology and the potential to incorporate technology-based pedagogical tools in their education.

Those who are nowadays students of Higher Education were born in the time of the internet explosion and the origins and development of new ways of "on-line" interacting. The widespread use of cell phones and smartphones, the proliferation of digital content and the emergence of the social networks are part of generation Z's childhood. Many authors (Fusco, 2012, 2018; Jennifer Skuza, 2020; Vanda, Pais and Hall, 2021; Billett et al., 2022) have posited that generation Z learn best with educational strategies based on challenges, with methodological applications that incorporate technology and with predominantly visual content.

One of the benefits of incorporating technology in educational contexts is that it can increase the motivation and engagement of students in the learning process (Ryan and Deci, 2017; Esteves et al, 2018; Pais and Hall, 2021; Vanda, Pais and Hall, 2021; Kukulska-Hulme et al., 2022; Pais, Sousa and Pires, 2023). According to several authors (Entwistle and Ramsden, 2015; Pais and Hall, 2021; Maharjan et al., 2022; Pais, Sousa and Pires, 2023), motivation plays a crucial role in any learning process, impacting not only the ability to acquire knowledge but also the quality of learning itself. Motivation significantly influences engagement and, subsequently, success in the learning achievements.

As a mathematics teacher, the first author of this article is confronted year after year with the unmotivated students, a general lack of interest in mathematical analytical approaches and a subsequent increased failure rate of students in mathematics related subjects.

With the aim of seeking strategies to foster interest in Mathematics, motive student enthusiasm and make the learning process itself more engaging, the author developed a math-related digital escape room activity for first-year students in a tourism and hotel management undergraduate degree. The aim of the study was to assess how (digital) escape rooms can contribute towards student motivation, interest and the consolidation of their learning.

This study represents a classroom application experience. After working on the escape room activity, students were invited to participate in a survey questionnaire to share their perceptions about the use of the digital escape room activity. In order to check whether the ER activity had contributed to improving learning outcomes, a few days later the students also had to take an assessment test on the syllabus contents covered in ER.

2. ESCAPE ROOMS AND LEARNING

2.1 Escape Rooms

Escape rooms (ERs) are a relatively new type of entertainment that aim to provide an unforgettable experience. According to Nicholson they can be defined as "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" (2015, p. 1). ERs first appeared in Japan in 2007, but have grown in popularity worldwide, with rooms available across most continents including Asia, Europe and America (Makri, Vlachopoulos and 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 is helping Alice escape from Wonderland, hunting ghosts in a haunted mansion, retrieving important notes from a locked school locker before an upcoming exam, or discovering the formula to cure the world from a pandemic, these narrative-driven scenarios evoke emotional investment and curiosity among players. "Although escape rooms are adventure activities, while playing, players must use multiple analytical skills, thinking skills, problem-solving, cooperation, and communication skills, which takes the whole activity to a higher cognitive level" (Huraj, Hrmo and Sejutová Hudáková, 2022, p. 2). As they navigate through the rooms and solve the presented challenges, the game atmosphere is set, fostering engagement and a sense of adventure.

2.2 Educational Escape Rooms

In recent years Escape Rooms have become a popular recreational activity which has also drawn the attention of teachers and educators. The educational community quickly realised the potential of using escape rooms as a didactic strategy, and escape room experiences in educational contexts proliferated.

"An educational escape room (EER) is an innovative pedagogical concept wherein participants, typically students, engage in a purposefully designed immersive environment filled with puzzles, challenges, and riddles that are linked to unambiguous learning objectives" (Fotaris, Mastoras and Lameras, 2023, p. 180).

Educational Escape Rooms have been shown to be a fun and entertaining activity if brought to the classroom. A time limit to solve ER problems incorporates an aspect of competition that students often enjoy. 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, Eukel and Santurri, 2020; Sowell 2021). The contextual scenarios of Educational Escape Rooms help students to analyse problems from different perspectives, exposing them to teamwork and collaborative work, reinforce social interactions and lead to effective outcomes in learner attitudes and behaviour (Makri et al., 2021).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 emphasizes the enjoyable experience that immerses students as active participants in the learning environment. These benefits have contributed to educators feeling increasingly motivated to incorporate Escape Room games into various educational contexts.

2.3 Digital Educational Escape Rooms

Digital educational escape rooms are essentially the online version of traditional escape rooms, which were originally designed for entertainment or adapted for classroom learning activities. However, this transition is not just a simple conversion; it requires incorporating game elements including the structure, background narrative, and puzzle design. As highlighted by Veldkamp et al. (2020), these aspects must be thoughtfully aligned with the educational goals.

This alignment requires connecting game mechanics with educational strategies, meaning the design must be guided by both pedagogical principles and game design techniques.

The rise of digital platforms led to the emergence of digital escape rooms. These digital versions allow students to experience the thrill of searching for clues and the satisfaction of solving puzzles on their digital devices, whether at home, on mobile devices, or school computers. According to Huang et al. (2020), digital escape rooms can be seen as "an innovative teaching method that combines digital content with real-world elements".

Digital escape rooms, also known as digital breakouts, are an excellent method to incorporate play and problem-solving into a lesson. They can serve as an engaging activity for the entire class or as an alternative for students who progress more quickly than their peers (Ang et al., 2020).

A digital escape room typically includes: a) a virtual "room" where students search for clues, b) a digital lock, usually created using an online form like Google Forms, which students must unlock, c) a themed setting designed to captivate the participants, and d) a difficulty level tailored to the intended audience, ranging from easy to very challenging (Kuo et al., 2022).

When creating a learning-focused Digital Educational Escape Room (DEER), there are four key factors to consider:

1. Learning Objectives: Define the goals to ensure the content is effectively covered, evaluate the student's learning outcomes, and identify which indicators need improvement.
2. Single or Multidisciplinary Theme: Decide whether the game will focus on a single subject area or integrate multiple disciplines to enhance the learning experience.
3. Soft Skills Development: Incorporate interactive elements that promote the development of soft skills like communication and teamwork.
4. Troubleshooting: Introduce problem-solving challenges to keep the game engaging and enjoyable for players (Lior, 2020, p. 25)

Makri et al. (2021) note that the use of digital technologies for designing educational escape rooms is still a relatively new area. However, research in this field is expanding, with a growing focus on design frameworks and principles for physical, hybrid, and digital educational escape games (Botturi and Babazadeh, 2020; Grāvelsiņa and Daniela, 2021; Moffett and Cassidy, 2023; Repetto et al., 2023; Reuter et al., 2020; Veldkamp et al., 2020). Repetto et al. (2023) have also introduced an evaluation tool that includes five key requirements—usability, pedagogical soundness, internal coherence, creativity, and engagement level—to help teachers in the development of digital educational escape rooms. Despite this, Reuter et al. (2020) highlighted that many educators are often unaware of effective strategies for creating these escape rooms. The primary challenge in practice is that many teachers lack familiarity with game design principles and seldom use the suggested models, frameworks, and evaluation tools when designing digital or hybrid escape games for their classrooms. Hakshurian (2023) suggests that training programs for teachers are necessary, as not all teachers have the skills and knowledge needed to create effective escape games. In this regard, numerous online platforms have

emerged to support this task, such as Google Slides, Genially, Thinglink, Google Sites, Canva, Google Forms, LearningApps, Flippity and Padlet for developing game environments, locks and puzzles (Ambrožová and Kaliba, 2021; Repetto et al., 2023; Şahin, 2023). Recent studies (Cooper, 2023; Hadi Mogavi et al., 2024; Pérez Colado et al., 2023) have highlighted how artificial intelligence can play an important role in supporting the creation of digital escape rooms.

There is growing empirical evidence to suggest that the use of digital escape rooms in education can have a positive impact on student engagement and learning outcomes, particularly in STEM education (Lathwesen and Belova, 2021). Numerous studies have shown that digital escape rooms can enhance student engagement and motivation (Yllana-Prieto et al., 2023; Huraj et al., 2022; von Kotzebue et al., 2022). In terms of learning outcomes, digital escape rooms can improve students' problem-solving skills. Miranda and Habon (2024) state that the main benefits of digital educational escape rooms are: 1) Improved Academic Performance; studies show that students participating in DEERs can achieve significantly higher scores compared to those in traditional learning environments. 2) Enhanced Motivation; research indicates that DEERs increase student motivation and engagement with the use of game mechanics making learning enjoyable, which can lead to a more enthusiastic approach to education; 3) Collaboration and Teamwork; DEERs promote collaboration among students, fostering teamwork skills as they work together to solve challenges. This collaborative environment contrasts with the often-individualistic nature of traditional learning; 4) Attention and Focus; the interactive nature of DEERs captures students' attention more effectively than traditional methods. Engaging narratives and challenges help maintain focus on learning objectives; 5) Technology Acceptance; by integrating technology in a fun and engaging way, DEERs can help students become more comfortable and adept with digital tools, enhancing their overall tech literacy; 6) Improved Retention and Self-Efficacy; explicit instruction paired with DEERs has been shown to enhance knowledge retention and boost students' confidence in their abilities; 7) Development of Soft Skills; DEERs help students develop essential soft skills such as negotiation, decision-making, and socialization, which are less emphasized in traditional educational settings; 8) Flexible Learning Environment; the digital format allows for greater flexibility in how and where students engage with the material, accommodating different learning styles and paces; 9) Access to Diverse Learning Topics: DEERs can be customized to cover a wide range of subjects, making them versatile educational tools that can be adapted to various curricula; 10) Entertainment Value; incorporating elements of fun and entertainment into learning can significantly enhance the educational experience, making it more appealing to students.

The same authors emphasise that the integration of digital educational escape rooms into teaching, as a pedagogical strategy, requires a series of challenges. The key challenges included: 1) Engagement Decline: many students experienced reduced motivation and engagement in traditional learning settings, leading educators to seek innovative methods to re-engage them; 2) Transition to Online Learning: the rapid shift from in-person to online education required teachers to adapt quickly to new technologies, often without adequate training or resources; 3) Need for Collaborative Learning: educators recognized the importance of maintaining collaboration and teamwork among students, which was difficult in a remote learning environment; 4) Accessibility Issues: some students struggled with accessing learning materials and resources online, necessitating creative solutions to ensure all students could participate fully; 5) Critical Thinking Development: there was a pressing need to foster critical thinking and problem-solving skills among students, which traditional methods struggled to promote

effectively in an online format; 6) Technological Limitations: many educators faced challenges related to technology, including varying levels of student access to devices and internet connectivity; 7) Time Constraints: teachers often found themselves under pressure to deliver curriculum content within limited time frames while ensuring that students comprehended the material; 8) Need for Fun and Engagement: there was a desire to make learning more enjoyable and gamified to rekindle interest in academic subjects among students; 9) Stress and Mental Health: the pandemic increased stress levels for both educators and students, highlighting the need for engaging activities that could help alleviate anxiety; 10) Innovation in Pedagogy: the crisis acted as a catalyst for educators to explore and implement non-traditional teaching strategies that incorporated technology and creativity to enhance learning outcomes (Miranda and Habon, 2024).

3. MATERIALS AND METHODS

To understand how the particular methodology of this Escape Room space was perceived by students, data were collected using a survey questionnaire developed by the researchers. The questionnaire included a list of statements and respondents were asked to rate their level of agreement using a 5-point agreement (Likert) scale. The statements were about the ER activity, such as contribution for learning, difficulty level, and the entertainment component of the activity. A preliminary version of this instrument was analysed by three higher education teachers, tested with three individuals from the same group, and modified based on the suggestions and the difficulties detected during its completion. The questionnaire was distributed online at the end of the activity.

In order to find out whether the escape room activity helped to improve learning outcomes, an evaluation test on the contents covered in the activity was conducted. Results were analysed and compared with the results obtained by a similar group of students from the previous school year that did not participate in the ER experience.

Statistical analyses were performed using MS Excel. Descriptive statistics (frequencies, mean, standard deviation, quartiles, maximum and minimum) were computed to summarize and compare results. A Mann-Whitney test was performed using IBM SPSS Statistics to compare the evaluation results of the two groups.

3.1 Participants

This case study was conducted at a higher education institution in the central region of Portugal. The participants were undergraduate students, majoring in tourism and hotel management, enrolled in the Mathematics Applied to Management course during the first semester of the academic year 2023-2024. The case study included a total of 30 students; 28 students completed the questionnaire.

It is important to highlight that the class was heterogeneous in terms of previous mathematical knowledge. Some students had studied maths for 9 years, while others had studied maths for 12 years. Among those who answered the questionnaire, 17 (63%) were female, and 10 (37%) were male. The age of the participants ranged from 18 to 38 years (average 20.8).

4. THE DESIGN OF THE DIGITAL EDUCATIONAL ESCAPE ROOM (DEER)

To design the DEER, the author took in consideration some aspects thought to be relevant in the creation of educational escape rooms (Nicholson, 2018; Huraj, Hrmo and Sejutová Hudáková, 2022). Although physical ERs are more immersive, they are expensive and difficult to implement. Therefore, we decided to implement a digital ER. Like a physical Escape Room, where the aim is to follow all the clues to solve the puzzles proposed, leaving the space in which the student was trapped, the virtual Escape Room proposes various questions/problems along the way through the different levels, which must be answered correctly to successfully complete the game.

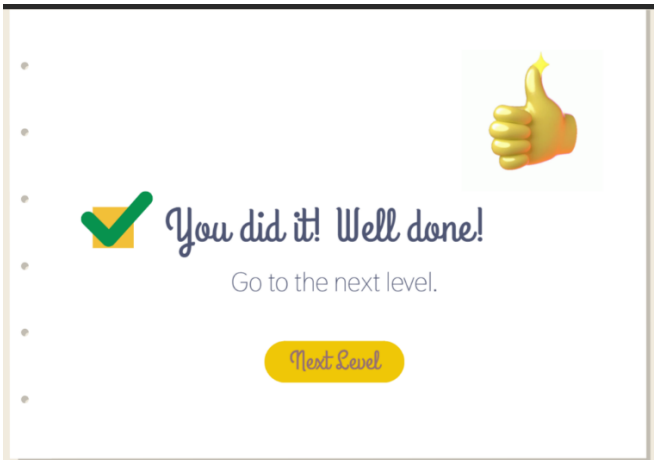


Figure 1. Message that appears at the end of each successfully completed level

Figure 2. Message that appears when you successfully complete the Escape Room

The ER had 4 levels and the difficulty increases with each level. Each respective level included 3 problems. A linear concept of the escape room was implemented, i.e., students could only move to the next problem after successfully completing the previous one.

The activity lasted 1h15mins and was implemented in teams of 2 students, since working in pairs would require students to communicate their ideas, listen to other opinions, discuss strategies, justify critiques and thereby contribute towards a positive and comprehensive learning process. Furthermore, working in pairs is frequently employed in the classes of this course and students have previously communicated that they enjoy it. The learning aims were to practice some mathematical contents, specifically on primitives and integrals, which are usually considered a difficult topic in this course.

The DEER was developed using Genially – a platform for the creation of interactive and animated contents. This platform has a free version; it is easy to use and requires no previous knowledge in web-design or programming.

The downside of this application, in its free version, is that it does not provide a report on your students' performance. Therefore, to monitor the students' performance, they were asked to write down on a sheet of paper all the reasoning they had used to solve each problem.

In order to increase students' engagement with the activity, the DEER development also aspired to the following principles:

- To create an attractive and challenging narrative:

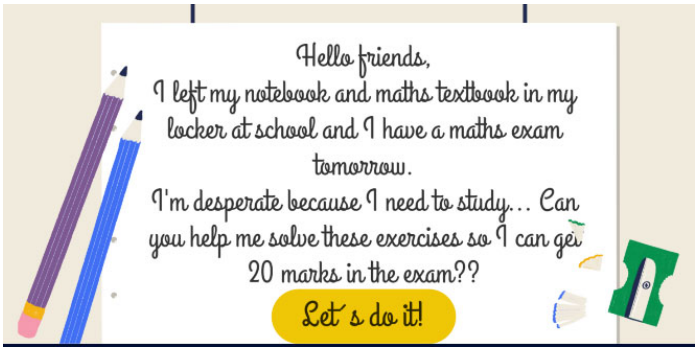
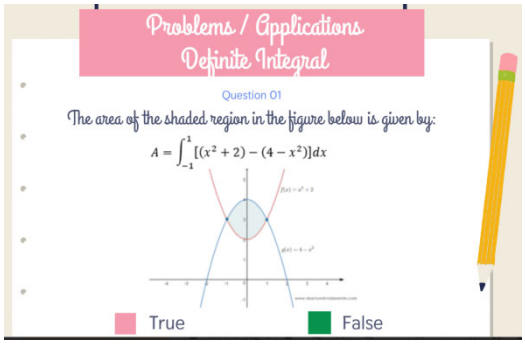
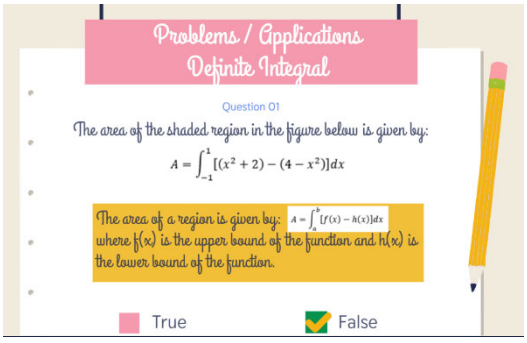


Figure 3. The ER narrative

- To provide clues: clues were related to the contents explored in the ER;





Figures 4 and 5. Example of a clue

Figure 6. Example of another clue

To create digital locks: to move to the next level, students had to successfully complete all the tasks on the previous one. So, to unlock the digital locks, the participants had to correctly solve the challenges.

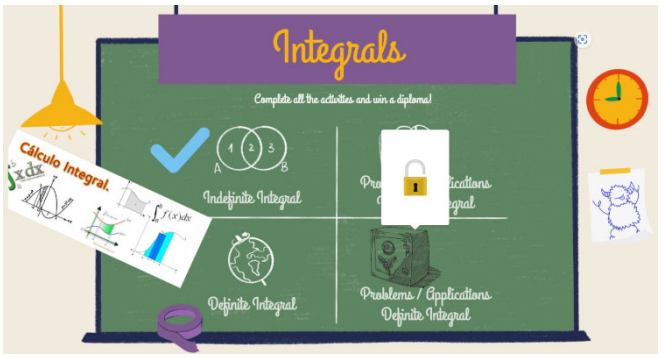


Figure 7. One of the digital locks used in the ER

Prior to carrying out the activity, the Escape Room was tested by a group of 4 students and 2 teachers aged 18-48 years.

5. ANALYSIS OF THE QUESTIONNAIRE

Respondents rated globally the ER activity as very good (54%) and good (43%).

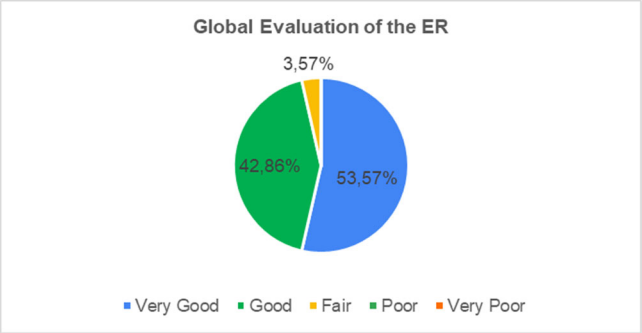


Figure 8. Rate your general evaluation of the ER activity

The majority of students reported that the activity had contributed towards their learning process, "allowing the consolidation of the syllabus contents" (36% totally agreed, 46% agreed) and considered that they "learnt more from the ER activity than in a conventional class dedicated to consolidation of syllabus contents" (32% totally agreed, 21% agreed). Most participants also "recommended the use of ER as pedagogical methodology" (36% totally agreed, 39% agreed).

Participants thought the activity "was well organized" (57% totally agreed, 39% agreed), but some students found "the ER was difficult" (18% totally agreed, 25% agreed) and 39% considered that the time available was not adequate. The authors believe that the high percentage of students who found the activity difficult and had insufficient time to complete the challenges is due to the fact that the contents covered in the activity are often considered difficult by tourism students. Despite this, it should be noted that the overwhelming majority of students did not find the activity difficult and considered the timeframe adequate. Only one team failed to finish the activity.

Students were also asked about the entertainment dimension of this activity. They revealed they "had fun" (57% totally agreed, 32% agreed) and "enjoyed it more than a conventional class for exercises resolution" (64% totally agreed, 14% agreed).

In spite being an enjoyable activity, students did not consider that it was just a distraction (72%). They considered that it "contributed towards a more positive vision of Mathematics" (29% totally agreed, 64% agreed), making the "learning process more interactive" (29% totally agreed, 61% agreed) and more challenging, interesting and stimulating (36% totally agreed, 39% agreed). Table 1 shows the detailed responses to these questions in a heatmap with the observed frequencies as well as the respective mean and standard deviation values.

Table 1. Heatmap with frequencies of responses to questions about the use of an ER activity in the classroom; mean and standard deviation
(1 – total disagreement; 2- partial disagreement; 3 – neutral; 4 – partial agreement; 5 – total agreement)

Statement: The use of an ER activity in math classes…	**1**	**2**	**3**	**4**	**5**	**mean**	**s.d.**
contributes to a more positive attitude towards mathematics	1	0	1	18	8	4.14	0.62
makes mathematics more boring and demotivating	14	10	1	3	0	1.75	0.90
makes the learning process more interactive	1	1	1	17	8	4.07	0.78
serves only to entertain for a while	10	11	3	4	0	2.04	1.03
provides a less rigid method of learning, making it more challenging, interesting, and stimulating	1	2	4	11	10	3.96	1.11

Students recommend that their colleagues participate in the ER activity (82%) and wished that this kind of activities would also be developed in other courses (90%).

Although the activity was on the last topic of the syllabus and was carried out towards the end of the semester, it was clear from direct observation that the students were more enthusiastic than usual about this subject and that, for many, their attitude changed after carrying out the ER activity. This personal observation is supported by the results obtained in the evaluation.

With regard to the results obtained in the evaluation test on the contents worked on in the ER activity and compared with those obtained in the previous academic year, there was a clear increase in the number of students who obtained a positive grade (Table 2). It was also noted that, in general, students obtained higher marks this academic year. A Mann-Whitney U test was performed to compare the results in the evaluation test in the two groups. There was a significant difference in the results ($z = -1{,}984$; $p = 0{,}047$).

Table 2. Results obtained in the evaluation test (on the contents worked on in the ER activity)

academic year 22-23	academic year 23-24
n=28	n=22
percentage of positive scores: 57,14% (assessment test)	percentage of positive scores: 68,18% (assessment test)
highest grade: 19,86	highest grade: 20,00
lowest grade: 3,00	lowest grade: 6,00
$\bar{x}$=10,40 Q_1=6,18 Q_2=9,86 Q_3=14,50	$\bar{x}$=13,30 Q_1=8,50 Q_2=11,86 Q_3=19,50

6. DISCUSSION

In this work, a digital ER was used as an educational tool in a Mathematics course for Tourism undergraduate students. The results show that students recognized the value of this activity, rating it positively. They considered the activity fun and also that it contributed to a more challenging learning process. These findings align with evidence from other researches, such as Babazadeh and Frigerio (2021), Huang et al. (2020), and Papadakis and Stavrakis (2020). These results also confirm that technology can be used as an ally in the development of activities and learning tools that increase motivation and engagement (Ryan and Deci, 2017; Esteves et al, 2018; Pais and Hall, 2021; Vanda, Pais and Hall, 2021; Kukulska-Hulme et al, 2022; Pais, Sousa and Pires, 2023). Besides the entertainment component and the feeling of being challenged, students also considered that the activity actually contributed to their learning process and that they learnt more that in a conventional class. These findings align with previous research asserting that generation Z learns more effectively with strategies based in challenges and incorporating technology and visual content (Fusco, 2012, 2018; Jennifer Skuza, 2020; Vanda, Pais and Hall, 2021; Billett et al, 2022). Moreover, the use of the digital ER seems to actually have contributed to better learning, with the group having a better performance in the final assessment test, which corroborates with results from similar studies (Nicholson, 2018; Huang et al, 2020; Sowell, 2021, Pais et al, 2023). This reinforces the observation that motivated students are more likely to develop a better long-term understanding of the subject material (Lester, 2013) and shows that the use of digital ER can provide an effective tool to to motivate and encourage interest in the topics explored in the classroom (JMC, 2011).

7. CONCLUSION

In this study we presented students' perceptions about the use of a digital ER based in Mathematics and we compare their subsequent performance in an assessment with a reference group of otherwise similar students. The number of students participating in the activity was small, which is the main limitation of this study. However, the results are emphatically positive with students perceiving the Digital Escape Room (DER) activity as a valuable tool that had a positive effect on their motivation and interest and as an otherwise entertaining activity. Moreover, students considered that the ER activity contributed towards their learning process and helped shift their vision of Mathematics topics in general. As a result of these opinions, students expressed that it should be adopted as a pedagogical tool in other courses. It also appeared to promote student success, with an observed improvement in learning outcomes.

The results of this research suggest that a DER activity is an efficient strategy of motivating and fostering interest in Mathematics and making the learning process more engaging and, therefore, more efficient and ultimately successful.

Although this study was developed in a Mathematics course, the focus is on the use of an educational resource, combining formal contents with technology and entertainment. These findings are, in essence, generally applicable and could be applied by teachers and educators wishing to explore alternative pedagogical approaches.

For future research, it would be insightful to apply this activity to a larger recipient group and in different educational courses. It would also be interesting to analyse the relationship between students' perceptions about this kind of activity and their attitude towards other characteristics, such as the application of interactive technologies, compared with their views about more conventional educational approaches.

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