

Using digital educational escape rooms as a motivational review tool for Economics

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ABSTRACT

This paper addresses the issue of balancing engagement and learning outcomes within the realm of game-based learning theory. It demonstrates how digital educational escape rooms (DEER) serve as a means of stimulating motivation and facilitating content review. The experimental group outperforms their peers in this regard and has a significant perception that DEER enhances the quality of their learning process. The methodology involves the integration of both quantitative and qualitative instruments, specifically a digital questionnaire for the former and a debriefing or focus group for the latter. The experimental groups were selected randomly on an annual basis, with consideration given to controlling variables such as sex and prior academic performance. Data were gathered from students enrolled in the Economics degree who were taking Industrial Organization (Market Theory) courses over a three-year period from 2019 to 2022. The use of breakout activities in digitalising the learning experience has enabled their application to a broad range of subjects. While there may be comparable initiatives in other academic areas, this marks the initial implementation of such an endeavour within the domain of economic pedagogy.

1. Introduction

A key goal among educators in higher education, particularly those instructing courses that are abstract and theoretical in nature, is to enhance student motivation and engagement during instructional sessions. The concern regarding motivation has intensified in recent years due to the spread of online courses and hybrid and blended learning environments. COVID-19 exacerbated this. In a short time, organisations and educators were required to modify their approaches and instructional resources to suit virtual settings. The literature suggests that there is a decline in students' motivation during online classes (Hasan et al., 2010). In response, recent research has explored novel approaches to enhance students' motivation in online learning (Mendoza et al., 2022) and blended learning settings (Shi et al., 2021).

This essay expands on earlier research by Maroto (2021) and originally contributes to the literature highlighting the impact on learning outcomes. The learning outcome serves as a metric for assessing the effectiveness of students' learning and is a significant factor in evaluating the quality of teaching. As much as the existing literature on educational escape rooms is about motivation, there is a clear gap in learning outcomes.

Educators have implemented different methods to enhance student engagement and learning outcomes. Game-based learning (Alsawaier, 2018; Dichev & Dicheva, 2017) and digital tools (Yap, 2017) are 2 of the most extended approaches. Research suggests that

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e-learning can increase student motivation in higher education (Kim & Frick, 2011). This study combines these 2 approaches. We use digital educational escape rooms (DEER) to increase students' motivation. Moreover, these activities allow students to skilfully review the contents studied during the term.

Escape rooms (ER) were created for recreational purposes. However, educators have recently begun to use them for teaching objectives. Makri et al. (2021, p. 2) define educational escape rooms (EER) as “*problem-based and time-constrained pedagogical activities that require active and collaborative participants*”. These activities allow us to gamify and actively improve the learning process (López-Belmonte et al., 2020). In recent years, the development of virtual or digital teaching environments has introduced the concept of digital educational escape rooms (DEER).

This paper describes an applied experience of using DEER as a motivational review tool for business and economics. There have been some recent experiences in other higher education fields.¹ However, applications in social sciences in general and business or economics are still few.² This paper contributes to extend this field of literature and suggests one of the first attempts to evaluate the impacts of an educational escape room on both learning outcomes and motivation and how both spheres are complementary.

This objective was carried out by analysing 2 research questions. First, does the use of DEER as a reviewing tool improve the students' objective learning process? (RQ1). Second, does DEER increase the students' motivation in theoretical subjects like economics and business? (RQ2).

Next, we systematically review the literature. The third section explains the design of the experience, including the contextualisation material and methods. Results on learning outcomes and motivation are discussed in the fourth section. Finally, the paper summarises some conclusions of this teaching innovation and introduces limitations and suggestions for further research based on the findings of this study.

2. theoretical background

2.1. Game-based learning: motivation and learning outcomes

The use of the term ‘gamification’ was extended since Deterding et al. (2011, p. 10) defined it as ‘*the use of game design elements in non-game contexts*’. In recent decades, gamification, game-based learning, or serious game approaches have become increasingly prominent as active methodologies in education (Landers, 2015). This development has garnered significant attention in the specialised literature.³ Concerning the subject, the study deals with games, and economics are naturally linked (Lim, 1999).

Recent experiences show that game-based learning promotes students' interest and motivation and interactivity during classes (Deterding, 2012). Other studies have evaluated the advantages of using it to enhance students' learning (Dominguez et al., 2013; Faiella & Ricciardi, 2015). However, there are some debates regarding their impact on academic achievement (Tulloch, 2014). This paper engages this important point. There is huge research on implementation in primary and secondary education. However, the literature on experiences in higher education⁴ remains relatively limited.

2.2. Educational escape rooms: theories underpinning their use for education

Escape games have gained popularity in recent years, as noted by Nicholson (2015, pp. 1–35). There have been attempts to exploit this concept for educational objectives, as highlighted by Clarke et al. (2017). The increasing performance of educational escape rooms can be attributed to their combination of fundamental game design principles and robust learning theories, such as active learning (López-Pernas et al., 2022). EERs provide an optimal atmosphere for facilitating active learning among students, as they are required to employ problem-solving skills to advance through various challenges presented in the activity (Huang et al., 2020).

Escape games can also be viewed as a pedagogical methodology that aligns with the social constructivist approach proposed by Vygotsky (1978) and the social cognitive theory proposed by Bandura (2001). Papert's constructionism, as a matter of fact, can be perceived as an implementation of Piaget's constructivism in the context of escape games (Papert, 1991; Piaget, 1955). The social cognitive theory posits that learning can transpire through observation, as opposed to the behavioural theories of learning (Martina & Göksen, 2020).

Finally, collaborative learning is another key aspect of EERs. They require students to confront new problems that can be resolved through collaborative interactions with peers and guidance from the teacher (Hermanns et al., 2017). According to King (1993), the teacher's responsibility is to organise the educational setting and offer instructional scaffolding to students. Moreover, very often escape activities are proposed to small groups of students, who are prompted to collaborate and communicate to solve a given problem situation (Giang et al., 2020).

¹ See Taraldsen et al. (2022) for a systematic review of studies using EERs.

² Makri et al. (2001) and Taraldsen et al. (2022) do not find any case for business or economics in their systematic reviews of EERs and DEERs, respectively. Fotaris and Mastoras (2019) only find one study for business, administration, and law (1,5% of the sample review). However, there are some recent works, such as Göksen et al. (2019), Martina and Göksen (2020), Macías-Guillén et al. (2021), Borrás-Gené et al. (2022), or Pickern and Costakis (2023), in the field of business, management, and entrepreneurship. There are no applications for economic theory yet. This would be the one.

³ See Lee and Hammer (2011) or Dicheva et al. (2015), among others, for a systematic review of research on gamification.

⁴ See Wiggins (2016) for a review of gamification in higher education.

2.3. Educational escape rooms: motivation and learning outcomes

According to [Manzano-León et al., 2021](#), educational escape rooms exhibit greater levels of motivation and engagement than conventional educational games. At higher education, where games are not commonly utilised EERs provide a level of complexity and innovation to instructional methods that are highly regarded and valued by students ([Macías-Guillén et al., 2021](#)). Since students today yearn for active engagement and are motivated by achievement and affiliation, designing EER challenges increases their interest in the subject ([Jambhekar et al., 2020](#); [Kinio et al., 2019](#)). A review of the recent literature⁵ shows that the main positive effect of EERs consists of the increase in the students' motivation.

On the other hand, EERs may be used to evaluate theoretical and practical knowledge and maximise learners' achievements ([Jiménez et al., 2020](#)). They improve the quality of the learning process by enhancing social skills and positively influence their participants' self-efficacy ([Diemer et al., 2019](#)). EERs may help to evaluate both an individual and team-focused reflection of learning ([Baker et al., 2020](#)). Additionally, participants acquire other high-order skills such as creativity, critical thinking, communication, or teamwork ([Duncan, 2020](#)). Finally, some authors assess that including the EER as a part of the subject's assessment is a key factor ([López-Pernas et al., 2019](#)).

This study contributes to the literature by combining these 2 impacts of the use of educational escape rooms: learning and motivation.

2.4. Educational escape rooms: design and elements

While EER may initially appear like a leisurely escape room, there exist certain distinctions between the two. [Veldkamp et al. \(2020\)](#) assert that the EER elements, namely puzzles, enigmas, and solutions, are tailored to a particular audience and are designed to address specific, clearly defined educational objectives. All problems, challenges, or activities within an EER are called puzzles ([Nicholson, 2015](#)). According to [Wiemker et al. \(2015\)](#), puzzles can be cognitive, physical, and meta-puzzles.

According to [Botturi and Babazadeh \(2020\)](#), the design of EERs must be conceived following the 5-star model.⁶ They must be correctly aligned to the objectives and evaluation criteria of the subjects ([Eukel & Morrell, 2020](#)). The Organization of EER can be open, sequential, pyramidal, or path based ([Nicholson, 2016](#)). We follow a sequential design in this paper. We present one puzzle after another and solving a puzzle unlocks the next until the meta-puzzle is solved.

Finally, developmental considerations include many other issues ([Cohen et al., 2020](#)), such as the availability of physical resources and budget and time constraints ([Vörös & Sárközi, 2017](#)). Other inconveniences might be related to scale economies when large groups are conducted ([Cain, 2019](#)); the need for guidance during the activity and a proper communication of instructions before gaming ([Monnot et al., 2020](#)); an accurate planning of the structure ([Eukel et al., 2020](#)); and the precise testing of the correct functioning of the puzzles and the game in general ([Beguín et al., 2019](#)). However, most of these challenges, mainly those related to time constraints, scale, and logistics, can be solved by implementing EERs in digital or virtual environments.

2.5. Digitalisation of educational escape rooms

ICTs have allowed for higher scales within games and introduced new tools ([Vlachopoulos & Makri, 2017](#)). These technical changes have extended the use of digital simulations and computer games in the last few decades ([Prensky, 2001](#)). These solutions improve instructional teaching ([Fletcher & Casey, 2014](#)). We can digitally simulate the puzzles and riddles that students must work out using one or more open web-based applications ([Kroski, 2020](#)). Digital educational escape rooms (DEER)⁷ are easier to use and have more flexible and versatile approaches. They function in any teaching domain or time during the term by adjusting only the levels of the game ([Ang et al., 2020](#)). Another advantage of digital implementations is the live interaction among all participants ([Vidergor, 2021](#)).

There are several digital platforms providing different templates to design different DEERs. Some examples are the applications of forms and questionnaires by Google or Microsoft ([Neumann et al., 2020](#)), but also the specialised website [Breakout.EDU](#) or other educational digital platforms such as [Genial.ly](#). In this study, we employ the latter.

Despite these advantages, the use of this digital technology in higher education is relatively new. Only one of 10 educational escape rooms is nowadays digital ([Fotaris & Mastoras, 2019](#)). For this reason, this paper originally contributed to the literature on the digitalisation of escape rooms in higher education. Furthermore, although there are various recent experiences in other university fields, this experience is one of the first attempts in the field of economics and business education.

3. Material and methods

The preceding section has emphasised the significance of DEERs in the new active pedagogical approaches implemented in higher education over the past few years. This section provides a detailed account of the contextual background, criteria for sample selection, and the methodological framework employed.

⁵ See among others, [Nicholson \(2018\)](#), [Gómez-Urquiza et al. \(2019\)](#), and [López-Belmonte et al. \(2020\)](#).

⁶ According to this model, EERs are five-element games. Four of them—narrative, game flow, puzzles, and equipment—are for amusement EERs, while the fifth involves learning. Context also influences EER design. Players, constraints, evaluation, and debriefing comprise the Star Model.

⁷ Also defined as educational *breakouts* in some studies and reviews ([O'Brien & Pitera, 2019](#)).

3.1. Context and sample selection

The experience was conducted during 3 academic years (2019–20, 2020–21, and 2021–22). The study sample was extracted among those students from the subject ‘*Industrial Organization*’. This subject is compulsory (4 h per week) and supposes the last approach of students to Microeconomic Theory (2nd term, 3rd year) during the degree in Economics. Participants were assigned to the experimental or control groups using a random sample. Instructors cannot choose which group teach in each subject and term. Average age is similar for all students in a group. For these reasons, inclusion/exclusion criteria were controlled to homogenise in terms of gender and previous knowledge of the subject. We use the average mark in previous subjects of Microeconomics for this control.⁸ Sample breakdown by group and year can be observed in Table 1.

3.2. Experiment design

We used a randomised controlled trial (RCT) with a pre- and post-test design. According to Makri et al. (2021), only one of each 5 previous works⁹ on EERs uses an RCT in their design. However, this methodology is regarded by policy makers as the ‘gold standard’ in educational (and other) research (Cochran-Smith & Fries, 2005) and has been widely used in educational research for a long time (Oackley, 2000). Some authors, such as Torgenson and Torgenson (2001), have claimed the need for this methodology in educational research. As Cochran-Smith and Zeichner (2005) argue, such an approach is appropriate where enough theoretical and empirical work has been completed to identify competing interventions that reflect the most promising alternatives known to have impact on the outcomes in question. Finally, this study meets the 3 scientific criteria introduced by de Meulemeester et al. (2018) following the CONSORT guidelines (Moher et al., 2010): it addresses a clearly stated question, the research is not redundant, and finally, the systematic review of available knowledge in the previous section evidences its value added.

At the same time, however, we acknowledge the limitations of experimental research in the social sciences, such as the difficulty in accounting for the complexities of the social world, the capacity to control for several variables, and the ethical challenges associated with differentially providing desirable interventions (Gore et al., 2015). We have taken these into account, so we designed the RCT to gather comprehensive quantitative and qualitative data.

This design is the same for both research questions. We evaluate both motivation and learning outcomes with a similar design but different instruments. Fig. 1 shows a timeline that clarifies the design of the experiment.

To evaluate the RQ1 (learning outcome), we used as a pre-test instrument the mark obtained by the students in the midterm exam (around weeks 6–7). We used an online questionnaire on motivation¹⁰ as a pre-test to assess the RQ2. This survey was carried out at the beginning of the terms (weeks 1–2).

Then, the treatment (DEER) was played by students belonging to the experimental group at the end of the term (week 14). The aim was to evaluate the impact of the game as a review tool for the theoretical and practical contents of the subject. Teams of 4–5 students were assigned. The assignment of students to each team was arbitrary. The time limit was 90 min. During this time, each team had to complete 5 levels or stages and a final lock. We measured the time each team wasted in each stage and overall. After the game, a focus group session was conducted. This debriefing had the objective of co-evaluating the results with the students. We collected data about the experience during this session (week 15).

The data combine both qualitative and quantitative instruments for the research. We created another online survey¹¹ using MS Forms. This post-test questionnaire evaluates the participants’ self-perceptions of their motivation and the utility of the DEER as a review tool. We use 8 Likert-type questions and an open question where students can rate any other issues related to these topics. Additionally, some other questions on teamwork and some sociodemographic control variables were included. Also, previous experience in playing escape room activities was asked for. Responses were anonymous. Then, we analysed the qualitative aspects of the information collected, both in the open questions of the survey and in the focus group conducted with the participants.

Responses on motivation are compared to those collected with the pre-test survey to test the RQ2. Answers on usefulness complement the quantitative analysis of the post-test on learning outcomes. To evaluate RQ1 on learning outcomes, we use as a post-test the marks obtained by the students in the final exam of the subject. This exam is aligned to the partial one at the midterm and to the contents of the DEER.

3.3. The specification of DEER

Our DEER was set up into many levels or stages with a linear flow according to the escape box theory (Duggins, 2019). Teams had to complete each stage’s puzzles and collect all the codes before moving on to the next and so forth until the final lock. In this study, each level was associated with a particular block of contents. There are alternative possibilities for the contents. For instance, it might be created in accordance with the many knowledge types that will be assessed (graphical, numerical, theoretical, etc.). Our decision favours the game’s plot and enables a better assessment of the students’ learning processes. The issues and inquiries in the game mirror

⁸ T-tests for samples with homogenous variance were implemented between both groups for the average previous mark in Microeconomics ($p > .0.77$; $p > .0.83$; and $p > .0.69$, respectively, for each year).

⁹ For example, Glavas and Stascik (2017) for mathematics and Eukel et al. (2017) for pharmacy.

¹⁰ This questionnaire (pre-test) on motivation is available <https://forms.office.com/e/Hrgzu6XJtr>.

¹¹ This questionnaire (post-test) is available <https://forms.office.com/r/7x4jFCGmBX>.

Table 1
Sample breakdown by group and year.

	Year 2019/20		Year 2020/21		Year 2021/22	
	Experimental group (EG)	Control group (CG)	Experimental group (EG)	Control group (CG)	Experimental group (EG)	Control group (CG)
Total participants	35	33	36	33	33	32
Male participants	18 (51,4%)	16 (48,5%)	19 (52,7%)	17 (51,5%)	18 (54,5%)	17 (53,1%)
Female participants	17 (48,6%)	17 (51,5%)	17 (47,3%)	16 (48,5%)	15 (45,5%)	15 (46,9%)
Avg. previous mark	6,33	6,38	6,18	6,09	5,98	5,87

Source: Own elaboration.

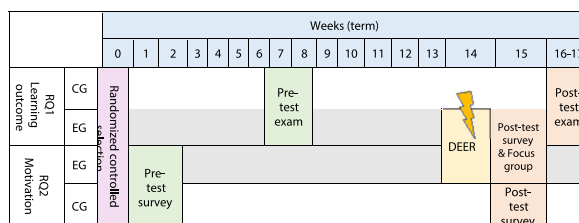


Fig. 1. Timeline of the design of the experiment (2 randomised controlled trial with a pre-test and post-test).

Source: Own elaboration.

those that they would face on the relevant exams. Finally, this design gives the teacher the flexibility to add or remove levels in accordance with the time constraints, course objectives, or any other factor affecting the activity design.

The teacher explains the rules of the game before the action begins. Also addressed are the subject's goals, rules, and how they connect with those goals. Richter et al. (2015) assert that the game is ineffective without a proper incentive structure. We discussed those rewards and incentives.¹²

The storyline is a significant component of an escape room's motivational elements. It was described as a treasure quest in the game. Each team received a QR code from the teachers that links to an interactive digital map with all stages and levels available. Finally, this code was added to the subject's *MOODLE* platform's general channel. Once on the map, each team must work together to find solutions to the various puzzles, riddles, and challenges presented in each level of the game using their various technological tools. Hits and hints are 2 more crucial game elements. We deliberately employed a codebook for each stage. The same interactive map has this assistance. This codebook is available for students to use as needed and contains the correct spelling of each password.

The ability of the teacher to alter the game's phases by including or deleting interactive map connexions is one benefits of the digital experience. Codes to begin some stage levels may also be included. This enables the instructor to manage the game's proper flow. Additionally, it aids game designers in creating various game pathways and grading the game's difficulty. Another benefit is that participants can restart at any point. Students can repeat them if necessary to learn from their mistakes and accurately study the activity contents. After the game was finished, the teacher reviewed with the participants in the focus group the steps they took to complete each stage. Additionally, the teacher can comment on some more challenging questions or tasks.

4. Results and discussion

In this section, we present the results (on average) based on information gathered from the post-test instruments. We analysed the answers to the post-test survey and the marks in the final exam. Also, some other qualitative issues collected in the focus group are displayed. Findings cover the 2 main goals of the paper. First, we present the findings on the activity's motivational impact. These results were compared to those from the motivational pre-test survey, which concerned the game's value as a learning tool for review. The differences between experimental and control groups will then be the subject of another quantitative analysis. The discussion will conclude with some general conclusions about the exercise.

Seven teams participated in the game each year (experimental group). Four to 5 students made up each squad ($n = 35, 36$, and 33 , respectively). Approximately half of these participants were either male or female, as was previously noted (see Table 1). 73.25 percent of the total number of students enrolled in the class completed the pre-test survey, and 88.8 percent completed the post-test surveys.

¹² In this experience, the rewards consisted of additional points to the final mark for each member of the 3 teams that finished the game. In particular, 0.5, 0.25 and 0.1, respectively.

4.1. Digital escape room as a useful reviewing tool for learning (RQ1)

Most instructors who use traditional methods frequently criticise active methodologies and game-based learning for just enhancing student fun at the expense of their academic performance and learning. Understanding this discussion is essential to comprehending the analysis of RQ1 and the value added to this paper. To improve student participation and endogenous motivation (as demonstrated in the following section), the experience must be engaged and interesting. However, it should also help participants improve their understanding of the subject content.

The analysis of *DEER*'s contribution to improve students' learning outcomes was the paper's first aim (RQ1). As a result, data are examined using multivariate variance analysis (MANOVA) 2×2 .¹³ In the Table 2, we compare outcomes¹⁴ across time (pre- vs. post-test) and between conditions (experimental group vs. control group). Then, we present the students' self-perceptions of the game's usefulness.

Over the course of 3 years of the experiment, we can detect positive effects of both condition (group) and time. Additionally, there is an influence from the interaction between the 2 effects. Before *DEER*, there were no appreciable changes between the experimental and control groups' average marks. Nevertheless, after the treatment, students who used it scored higher than those who did not (see Fig. 2).

The findings shown in Fig. 3 support the previous quantitative results. The responses to questions 4.2.1–4.2.3 reveal that students believe that the *DEER* activities have improved their knowledge. They have done both theoretical knowledge (76.2% rate this as true); graphical comprehension (57.5%); and mathematical and numerical analysis to solve practical problems (54.5%). Additionally, according to 76.2% of respondents (control questions 4.2.4), this activity's relationship to the rest of the subject is accurate. This suggests that the *DEER* aims agree with the year's overall evaluation. *DEER* is seen beneficially by students as a tool for studying before final exams. 87.1% believe that these games complement their learning from other tools and approaches, and 83.2% believe that these games increase learning.

Qualitative research reveals a beneficial relationship between *DEER* and students improved learning. They connect the activity to ideas like utility and effectiveness. They perceive the exercise as a helpful means of reviewing the material and properly preparing for the related final exams.

4.2. Motivational effect of digital escape rooms on students (RQ2)

The second aim of the study was to investigate the motivational factors of students in the field of business and economics regarding *DEERs* (RQ2). The study employs a multivariate variance analysis (MANOVA) 2×2 to scrutinise motivation scores, which compares time (pre- vs. post-test) and condition (experimental vs. control group). Subsequently, the motivating features of the game are presented from the perspective of the students.

Initially, a comparison was made between the experimental and control groups, where the latter did not engage in *DEER*. We examine the disparity in average motivation¹⁵ levels observed before the intervention (pre-test) and after the treatment. Multivariate variance analysis (MANOVA) was employed to compare the impact of the condition (group) and time of assessment (time) on the motivational score exhibited by students annually. The results are presented in Table 3.

The study reveals significant impacts of both the condition (group) and time throughout the three-year duration of the experiment. Moreover, the interaction between both factors yields positive impact as well. There were no substantial variations in the average motivation scores of the experimental and control groups before the implementation of *DEER*. However, after treatment, participants who engaged in the game exhibited greater motivation scores than those who did not (refer to Fig. 4).

The perceptions of students regarding certain aspects of the endogenous motivation of the *DEER* are depicted in Fig. 5. The results indicate that most of the participants, specifically 86%, expressed a positive response towards the activity. In contrast, a minority of the sample, specifically 3%, reported a negative sentiment towards the activity. The responses of endogenous motivation and entertainment of the *DEER*, specifically questions 4.1.2–4.1.5, exhibit values that surpass the average motivation scores of the students, as indicated by question 4.1.1. This suggests that the use of escape rooms as an educational tool may provide a greater level of motivation compared to other activities and resources employed within the same academic subject and degree level. Specifically, most 87.1% of respondents believe that they have exhibited a higher degree of participation than usual during the experience, while 82.2% have demonstrated active engagement with the game. Furthermore, a significant majority of 81.2% of participants acknowledge that the activity has generated a heightened level of interest in the subject matter, surpassing other tools and methodologies employed throughout the same academic year. Furthermore, the responses to query 4.1.6, which serves as the control question, indicate that the students' perception of conventional methodologies is considerably inferior to that of the *DEER*. Empirically, a significant majority of 74.3% exhibit a lack of preference towards conventional modes of education.

Subsequently, an analysis was conducted to categorise the qualitative data obtained from the open-ended question regarding motivation in the questionnaire. The students establish a connexion between the activity and concepts such as entertainment and

¹³ Another conventional test for mean differences between groups, such as the Mann–Whitney rank test and Student T-test, was estimated. Results are robust with those observed with MANOVA analysis.

¹⁴ Measured as the average mark in pre- and post-test exams (over a maximum of 10).

¹⁵ We measure motivation as the average of answers to question 4.1.1 in the post-test questionnaire. A similar question was asked of the rest of the students who did not play the escape room.

Table 2
Comparison of average learning marks (MANOVA 2x2 results).

		Year 2019/20		Year 2020/21		Year 2021/22	
		Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Experimental group (EG)	Pre-test	6,0	0,49	6,2	0,60	5,3	0,87
	Post-test	7,5	0,88	7,9	0,82	6,7	0,89
Control group (CG)	Pre-test	5,5	0,80	6,3	0,98	5,2	0,92
	Post-test	6,2	0,96	6,6	0,50	6,0	0,97
Condition (group) effect		F = 8,59 p < .005		F = 5,38 p < .008		F = 13,53 p < .006	
Time effect		F = 20,82 p < .005		F = 7,61 p < .003		F = 6,94 p < .001	
Interaction effect		F = 14,77 p < .001		F = 14,56 p < .003		F = 10,24 p < .003	

Note: Marks have a maximum of 10.

Source: Own elaboration.

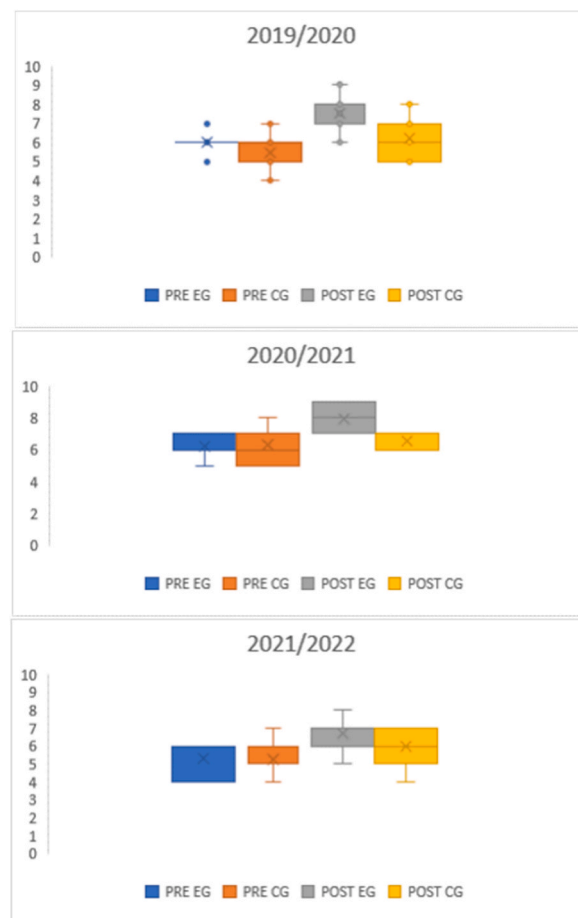


Fig. 2. Boxplots relating learning outcomes by years and group.

Source: Own elaboration.

engagement, and they assign greater importance to the experience as compared to learning through conventional methodologies. It can be inferred that there exists a positive correlation between motivation and the use of *DEER*.

4.3. Students' overall assessment of the digital escape room

Table 4 presents a comparative analysis of *DEER* and the average assessment of the other active methodologies carried out in these years. *DEER* has received positive assessments from all groups, with marks consistently exceeding 8 or 10 across all periods. Furthermore, these scores exhibited a comparatively higher score in comparison to the remaining methodologies. According to the data collected during the academic years of 2021–2022, students have reported the highest evaluation. Additionally, a noteworthy rise

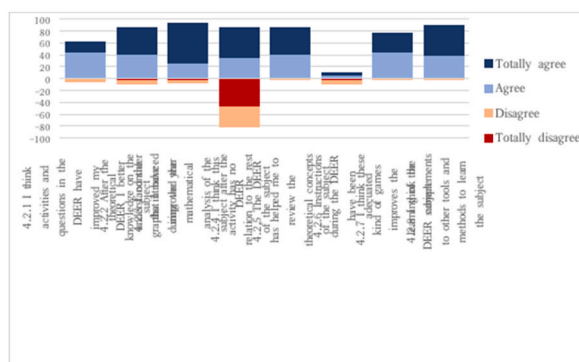


Fig. 3. Students' self-perception of usefulness for learning the DEER.

Source: Own elaboration.

Table 3

Comparison of motivation scores (MANOVA 2x2 results).

		Year 2019/20		Year 2020/21		Year 2021/22	
		Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Experimental group (EG)	Pre-test	2,3	0,47	2,5	0,51	2,4	0,50
	Post-test	4,2	0,45	4,8	0,41	4,4	0,50
Control group (CG)	Pre-test	2,4	0,50	2,4	0,50	2,7	0,64
	Post-test	2,7	0,64	2,9	0,80	3,1	0,93
Condition (group) effect		F = 7,55 p < .007		F = 4,13 p < .013		F = 15,63 p < .001	
Time effect		F = 23,18 p < .001		F = 6,64 p < .009		F = 7,44 p < .009	
Interaction effect		F = 16,61 p < .001		F = 13,23 p < .001		F = 9,92 p < .003	

Note: Motivation score (questions 4.1.1) has a maximum of 5.

Source: Own elaboration

in assessment is manifest across the years (8.33, 8.66, and 9.6). This suggests that the self-perception of the students has not only been favourable but has also shown upgrading compared to previous years.

It is essential to emphasise that the efficacy of DEER in the domains of Economics and Business is not contingent upon the incorporation of gamification or similar activities into students' learning experiences. The results provided in this section demonstrate a significant outcome, as they were derived from a large sample size. Specifically, 57% of the participants had no prior experience with similar activities, while 90% had never engaged in a DEER game. The data indicate that engagement in these activities is helpful to both enhanced motivation and learning outcomes. Furthermore, the data suggest that prior training is not a prerequisite for attaining these objectives.

5. Conclusions and research limitations

Several academic papers have been published in recent years that examine the impact of gamification on motivation or learning outcomes in higher education. The proliferation of novel technologies and the dawn of e-learning have significantly transformed the landscape of pedagogical approaches. The educational use of escape rooms is considered one of the most groundbreaking methodologies in the realm of game-based learning. As a result, digital educational escape rooms (DEER) have been integrated into our academic curricula. The objective of this study is to examine the impact of employing digital educational escape rooms (DEERs) in theoretical subjects in business and economics. This outcome complements previous applications of this methodology. The study makes a valuable contribution to the existing literature by examining the impact of interventions on both motivation and learning outcomes.

This study demonstrates that the use of DEER results in an enhancement of the participants' endogenous motivation. Additionally, it effectively helps students review the contents studied during the year. Furthermore, other transversal skills such as collaborative teamwork and communication, critical and deductive reasoning, and practical problem-solving are also enhanced. Everyone actively contributes to the attainment of the game's objectives. Collaborative problem-solving is a key feature of puzzles, riddles, and other similar games. As such, these activities can serve as valuable tools for preparing students to undertake complex tasks in their future jobs.

The methodology presented in this study is applicable to various teaching domains and academic levels. The applied digital environment exhibits a reduced barrier to entry and acquisition of knowledge. In addition, various templates and formats are at one's disposal. They can be customised to suit any academic subject matter and the level of complexity. After the design of the DEER, the presence of scale economies becomes outward. The results presented here are derived from the implementation of the game at the end of the term. Nevertheless, it has been assessed that the potential and efficiency of the game remain consistent whether it is integrated

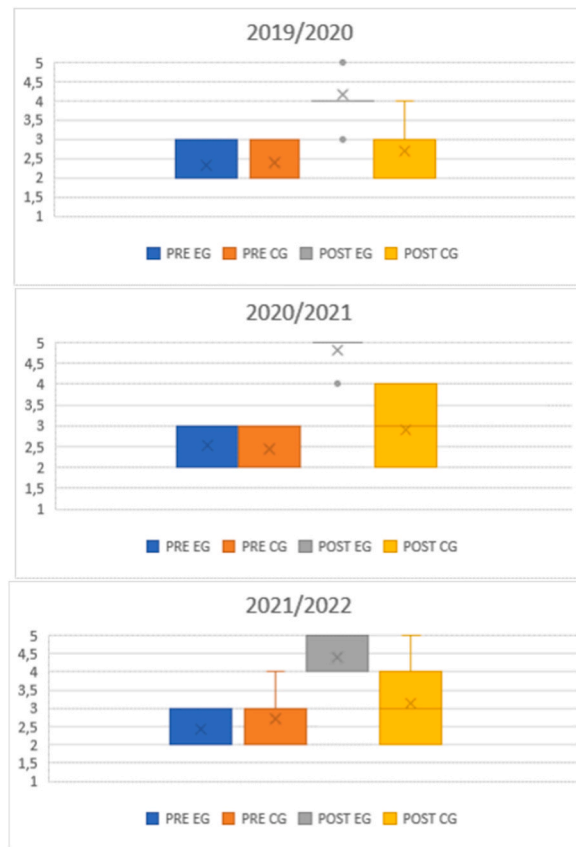


Fig. 4. Boxplots relating motivation scores to year and group.
Source: Own elaboration.

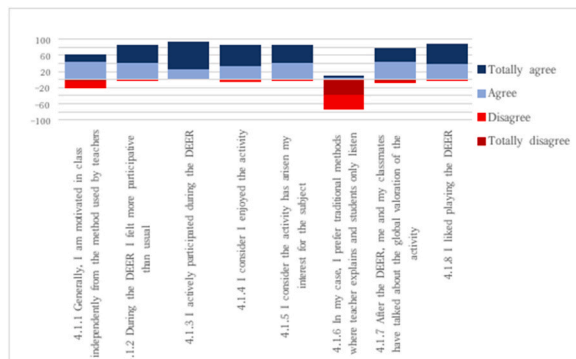


Fig. 5. Students' self-perception of endogenous motivation of the *DEER* (in % of total participation).
Source: Own elaboration.

Table 4

Overall assessment of *DEER* (Score scale: 1–10).

	Year 2021/22	Year 2020/21	Year 2019/20
Rest of activities	8,87	8,33	7,96
DEER	9,60	8,66	8,33

Source: Own elaboration.

throughout the term. It can be divided into separate levels based on various developmental phases. The versatile nature of digital tools exploited in *DEER* enables its application to various pedagogical goals owing to its adaptability and interactive features.

Notwithstanding its contribution to the existing literature, this study is subject to certain limitations. Initially, this study represents one of the first attempts to assess the influence of escape rooms on learning achievements. The approximation was made by using the average marks achieved by students on their exams. However, alternative variables could be employed to assess the academic progress of the students. Furthermore, it may be beneficial to categorise the educational objectives into separate elements. In the field of theoretical economics, there exist 3 fundamental categories of items, namely conceptual, visual, and numerical. Subsequent studies may conduct a comparative analysis of the effects of *DEER* on these individual items. Ultimately, it has been proposed that *DEER* may offer additional transversal skills to its participants. Subsequent studies may direct their attention towards exploring additional effects of the game, such as its influence on collaborative efforts and teamwork.

Data availability

Data will be made available on request.

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