

Article

Educational Digital Escape Rooms Footprint on Students' Feelings: A Case Study within Aerospace Engineering

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Abstract: The introduction of game-based learning techniques has significantly swayed learning, motivation, and information processing in both traditional and digital learning environments. This paper studies the footprint that the implementation of ten short-duration digital escape rooms has had on the creation of an environment of positive emotions in the educational field. The digital escape rooms were created by employing the Genial.ly platform and RPG Maker MZ software. A feelings/satisfaction questionnaire has been conducted to study what emotions students have experienced, as well as the students' opinions about essential elements of digital escape rooms, to study whether positive feelings predominate in the performance of these activities. Results show a high incidence of positive emotions, and a very favorable opinion on the tools employed and the positive feelings on the acquisition of knowledge and skills.

Keywords: escape room; positive emotions; motivation; game-based learning



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1. Introduction

Creating an environment that favors the learning process is one of the main objectives of teachers and institutions that make up the academic world, and function as an enabler for the transmission of knowledge and competencies. Creating positive educational environments is not restricted only to the emotions experienced during the learning process or to the student's motivation. A more active control in the educational process, greater adaptability to the student's pace, or a learning structure promoting continuous improvement are strategies that can improve the educational environment. These latter strategies can be created using different educational methodologies, such as blended-learning (b-learning), which bestow the students with more control on the learning process [1–8] and provide them with more tools to manage their progress or correct cognitive deficiencies when combined with assessment techniques favoring feedforward [9–11]. However, the fact that these techniques improve the quality and smoothen the learning process does not necessarily imply that they are accompanied by an environment of positive feelings, even though some implications are presupposed on many occasions.

When focusing on the areas of science, technology, engineering, and mathematics (STEM), a high degree of demotivation has been previously reported [12,13]. The introduction of game-based learning (GBL) methodologies has provided an increase in the success rates, performance, and motivation [14–18] and has also led to an improvement in the acquisition of knowledge and in the development of transversal and specific competencies [15,16,19–22]. At the same time, GBL techniques have been proven to promote the generation of a favorable environment in which positive situational and dispositional emotions are predominant, encouraging active participation while solving problems and tests [14–16,19,23–26]. Indeed, positive affects such as engaged concentration, joy, and excitement for learning [27] have been reported in GBL, showing a significant positive

footprint on learning, motivation, and information processing in both traditional and digital learning environments [28]. GBL techniques can also generate negative emotions [29], such as frustration when the goals are difficult to achieve [30], but even in these situations, these negative feelings have been related with improved learning outcomes [31].

In general, feelings play an essential role in the psychological well-being of students, significantly affecting many aspects of their academic life [32–34]. Positive feelings have been proven to be associated with students' attention, concentration, commitment, and perseverance in learning activities and are positively correlated with academic achievement [33,35], improved educational and adaptive results [36,37], students' resilience [38] and the satisfaction of their psychological needs [39] and well-being [40]. On the contrary, situational and dispositional negative emotions generally reduce students' learning capacities and academic performance [33,41].

Thus, fostering an environment that encourages positive feelings in the educational setting is a tool that can improve academic performance, develop specific and transversal competencies and enhance resilience in students. The aim is, therefore, to promote a positive emotional environment in which the learning process is more attractive and inclusive, encouraging a cheerful attitude towards the educational process, not only by participating in this process, but also by extending it to the out-of-class environment [23,42,43].

On the other hand, Educational Escape Rooms (EERs) have aroused the interest of the educational community since they can be applied in a wide range of academic contexts and for their ability to foster teamwork, leadership, creative thinking, and communication in an engaging way for students [44,45]. EERs are student-centered, problem-based, and time-limited activities in which the purpose is to solve puzzles and quizzes to escape from a locked room [46]. Escape rooms (ERs) were created for recreational purposes [47], but when applied in educational contexts, they have shown to promote students' learning process and enhance the development of transversal competencies, such as teamwork, lateral and critical thinking, communication, work under pressure, etc. [48–51]. Escape rooms are based on implementing a theme and a narrative that serves as the guiding thread of the activity [52]. The tremendous thematic variety allows these ER to be applied in many contexts. Some interesting applications of ER in the educational context can be found in the literature [44,53–55].

The choice of the topic entails the adaptation and design of the puzzles to be held during the activity. There is a wide variety of puzzles to be incorporated into an escape room [44,50–52]. It is also paramount to consider the space where the activity takes place and how the puzzles are implemented [56]. In situ experiences enhance the positiveness of these activities and strengthen the competencies that are intended to be developed. Additionally, face-to-face environments promote students' fun and activation generating pleasant entertainment experiences [57]. An alternative to avoid the problems related to creating such an EER is to design a virtual or digital EER (dEERs) through computer applications [58–64], which can be easily adapted to the infrastructure that universities have nowadays. These virtual environments increase students' autonomy and creativity in an absence of negative effects [57,63,64].

The success of GBL activities, such as EERs, is based on the substantial number of positive emotions that students experience when they take part (joy, interest), favoring the teaching–learning process [44,48,59,61,63–67]. It has been proven that the higher the positive emotional performance, the better academic grades are obtained [18,52,61,64], and the greater the motivation of the STEM student [68]. Indeed, the acquisition of complicated scientific concepts significantly improves when introduced through recreational experiences, enhancing motivation and the emotional performance of students [59,61,63,69–72].

The creation of dEERs has been a tool used to improve student motivation and the development of specific and transversal competencies [52,58,59,61], together with a *dynamic continuous discrete assessment* (DCDA) strategy that favors feedforward [11]. The combination of a GBL methodology with such a method seems to promote student motivation

and participation in the dEERs since the knowledge and soft skills acquired are used to correct deficiencies.

This article focuses on the consequences, beliefs, and feelings that several dEERs, applied in the subjects of Mathematics I of the Degree in Aerospace Engineering, have had on the students who have participated in them.

2. Materials and Methods

2.1. Digital Escape Rooms

For data collection, 10 short-duration dEERs (approximately between 20 and 30 min) were designed for different topics included in the syllabus of Mathematics I, subject of the Aerospace Engineering Degree. The subject is divided into 4 different blocks: (C1) calculus of one variable, complex numbers and introduction to differential equations, (A) linear Algebra, (C2) calculus of several variables and (S) Series. The dEERs were designed for the blocks of C2, where 5 dEERs were implemented, and S, where another 5 were implemented. Each dEERs aims to reinforce the knowledge obtained by the students, for which the tests and quizzes used are based on exercises corresponding to the block that is being evaluated. dEERs have also been used to introduce new concepts related to those studied and to develop new ideas.

The dEERs were implemented and designed using the Genial.ly platform [73] and RPG Maker MZ software [74]. Initially, they were meant to be played remotely during the confinement due to the COVID-19 pandemic. However, after returning to face-to-face classes, the digital format was kept, although the groups interacted face-to-face.

All dEERs were based on a specific narrative in which a final challenge is posed, which will be overcome if they are able to solve some puzzles and problems. dEERs must be solved in a limited time, and the quizzes and problems to be solved are based on the subject Mathematics I at the Degree in Aerospace Engineering at the Technical University of Valencia.

The designed the dEERs were intended to be played in groups of four or five players, depending on the number of students. Nevertheless, the dEERs are available for the students to replay in groups or individually. To solve the tests, the team members work collaboratively to find the right solution. In Figure 1, the basic scheme that has been followed when implementing an escape room can be seen.

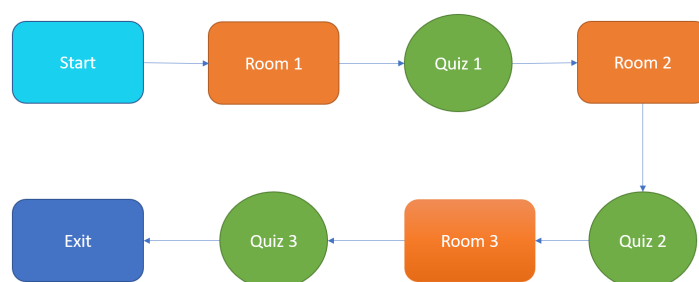


Figure 1. Basic scheme of an escape room to be played in groups.

Inside each room, there are usually tests that help to achieve the quizzes that allow them to leave the actual room. dEERs can be simplified to the main quizzes if time is reduced.

There is a second version of the game, in which some team members must play in parallel and each one solves a different test. The game scheme of this type of game would be the one shown in Figure 2. In this type of dEERs, the answer of each individual quiz is part of the key that allows the team to access the next room.

There are different possible combinations when designing this digital escape room. For example, the first quiz could be passed by dividing the group into two subgroups and not individually.

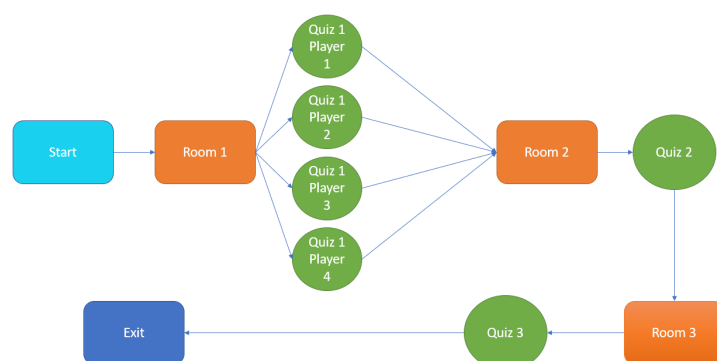


Figure 2. Basic scheme of an escape room to be played in parallel during the first quiz.

The puzzles of the dEERs were designed with a linear structure so that solving one puzzle allowed access to the next one. In addition, useless distracting clues were also used. dEERs joined together learning mechanics with game mechanics often used in ludic escape rooms and digital games. Solving the puzzles sometimes required a direct answer based on the specific knowledge and skills needed, and other times combined with typical escape room actions, such as finding hidden symbols or showing patterns. The tests embedded in the dEERs were designed trying not to be too challenging or too easy. Most puzzles have 3 or 4 main problems (challenges or quizzes), and 2 or 3 tests inside the rooms. Students could ask for help when they were stuck, but if one group was offered support, all other groups received the same benefit. However, in the same digital escape rooms, a count of the students' attempts is made, and the game itself offers clues and help.

In some games designed on the Genial.ly platform, failed attempts during the game are not penalized beyond the time used to carry out the test. However, in RPG Maker's designs, the students choose an avatar with certain characteristics (level of life, strength, intelligence), which are penalized if they fail the tests or rewarded with extra points if they succeed.

The tests or quizzes are integrated in diverse ways. Sometimes they are simple choice questions, other times they are multiple choice questions, sometimes they must enter the answer graphically, etc. In Figure 3, we can see some screenshots of the different tests that have been used.

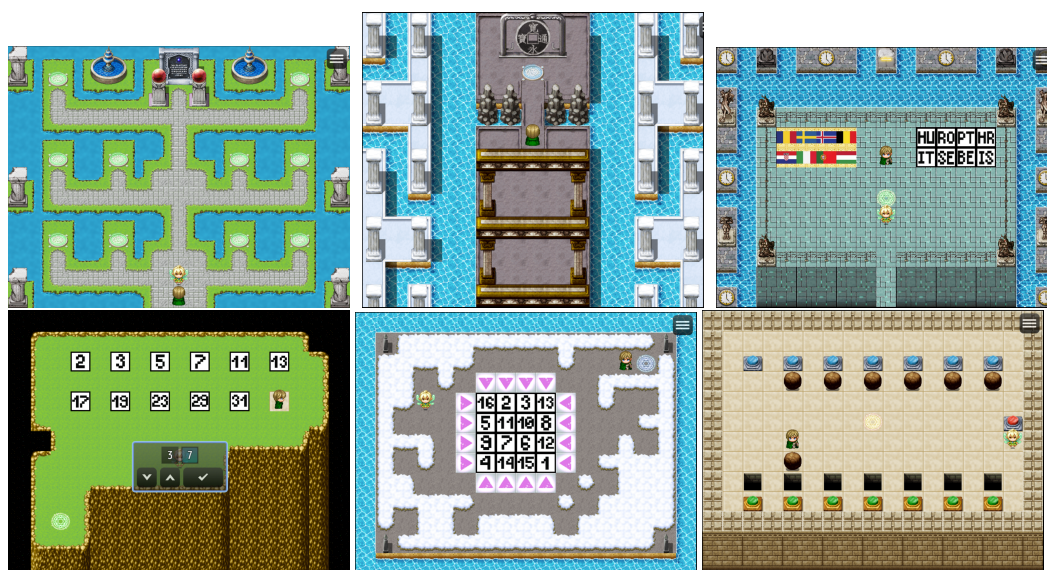


Figure 3. Screen captures of different quizzes designed with RPG Maker.

2.2. Questionnaire

The questionnaire was designed *ad hoc* for data collection. Regarding emotions, the strategy used to design the corresponding part of the questionnaire is in agreement with the RULER strategy [75,76]. The validity of the questionnaire designed to study the students' feelings toward the dEERs was checked by subject area experts. The reliability and consistency of the questionnaire were checked by employing the Cronbach's α [77], and the Kaiser–Meyer–Olkin coefficient of sampling adequacy (KMO) [78]. The Cronbach's α was 0.97 and the Kaiser–Meyer–Olkin coefficient was 0.834, both positive results since they are greater than 0.8.

After the questionnaire, some students were interviewed, who volunteered to answer some questions related to the experience. An interview guide was developed based on the questionnaire items. Interviews consisted of ten questions and lasted about 15 min. Only 25 students volunteered and were interviewed at the Higher Technical School of Design Engineering (ETSID) at UPV. Detailed notes were taken during the interviews, reporting the answers and comments of the students.

This article aims to study:

- The creation of a positive emotional environment when students participate in dEERs;
- The students' perceptions toward these activities;
- The elements or mechanics most valued by the students.

The evaluation instruments were: a questionnaire to collect students' opinions and feelings after each activity and the RPG Maker MZ software and Genial.ly web platform to create the dEERs. These instruments enabled us to obtain information on the students' opinions, feelings and performance during the activities.

2.3. Sample

A total of 296 students completed the survey (see Table 1) during the 2019/2020, 2020/2021 and 2021/2022 academic years. The age of students ranged between 18 and 19 years. The data was collected just at the end of each experience.

The questionnaires were distributed through PoliformaT (Sakai) educational platform and Typeform [79]. The surveys were completely anonymous, they were not obligatory, and students could stop completing the questionnaires at any time. Only 25 students participated in the subsequent interviews.

Table 1. Students' participation.

Gender	Frequency	Percent
Female	135	45.6%
Male	161	54.4%
Total	296	100%

During the activities, students formed a total of 73 teams with sizes between 3 and 5 members to participate in the dEERs: 63 teams of 4 students, 7 teams of 5 students, and 3 teams of 3 students. The mean and median team size was 4.05 and 4, respectively, and the standard deviation was 0.3. Therefore, 86.3% of the students participated in teams formed by 4 members, 9.6% participated in teams of 5 members, and 4.1% in teams of 3 members.

2.4. Data Analysis

The analysis and treatment of the data were carried out with SPSS software. Excel software was used for the graphs derived from the data. The Shapiro–Wilk and Kolmogorov–Smirnov tests of normality were conducted to determine the normality of the data. Both tests showed that the questionnaire scores were not normally distributed and non-parametric statistical methods were employed when necessary.

3. Results

The students were asked to name the two predominant feelings during the performance of the dEERs; the first one mentioned was called primary feeling and the second secondary feeling. This strategy was used to broaden the spectrum of feelings described by the students. It is considered that the feelings of the students are a fickle and temporary element that is a combination of several factors and that several feelings can coexist at a given moment.

In addition, with the aim of evaluating more precisely the feeling described, the students were asked to rate the intensity of the feeling from one to ten. In this way, a more detailed description of the students' reactions to the dEERs can be made. Intensity, as well as emotions, are challenging to measure, so it must be considered that the assessments of the students' feelings is subjective.

Table 2 shows that the most common primary feeling has been Motivated with 18.9% incidence, followed by Happy, with 11.1%, and Stressed, Calm, and Confident with 7.4%, 6.8%, and 5.7%, respectively. It can be proven that the percentages between male and female answers are not significantly different (p -value > 0.05).

Among the aforementioned most common feelings, there are three that can be considered positive (Motivated, Happy and Confident), one that can be considered neutral (Calm), and one that, a priori, is considered negative (Stressed). When the students were interviewed, the choice of Stressed was not taken as a necessarily negative emotion. The uncertainty that is generated when taking a test in which the students' knowledge is going to be assessed generates a feeling of alertness and stress in most of the students. However, when asked if this feeling of stress was comparable to the feeling caused by any of the other tests that belong to the continuous evaluation process, the answer was mainly negative (90%). Teamwork and a game environment are the elements that seem to have the most strength when it comes to reducing the intensity of stress. Despite this, the intensity of the stress was, in the opinion of the authors, high enough to be taken into account for future implementations of the dEERs.

Table 2. Primary feeling and intensity information.

Feeling	Female	Male	Total	Average	Std. Dev.
Motivated	17.8%	19.9%	18.9%	8.46	1.36
Happy	10.4%	11.8%	11.1%	8.03	1.14
Stressed	7.4%	7.5%	7.4%	7.55	1.37
Calm	5.2%	8.1%	6.8%	7.75	1.37
Confident	4.4%	6.8%	5.7%	8.00	1.85
Nervous	7.4%	4.3%	5.7%	6.12	2.22
Overwhelmed	5.2%	5.6%	5.4%	7.13	1.73
Amused	4.4%	5.6%	5.1%	7.93	0.77
Optimistic	4.4%	5.0%	4.7%	7.21	1.61
Satisfied	5.2%	3.7%	4.4%	8.00	0.78
Thankful	5.2%	3.7%	4.4%	7.38	1.60
Worried	5.2%	3.1%	4.1%	8.00	1.68
Anxious	4.4%	3.7%	4.1%	8.00	1.08
Bored	4.4%	3.7%	4.1%	7.58	1.98
Disappointed	4.4%	3.7%	4.1%	5.83	1.21
Excited	4.4%	3.7%	4.1%	8.50	0.96

Once the main sentiment was chosen, the secondary emotion could not be selected again, so they had to add a different feeling or leave it empty. Motivation obtained 20.9% of the total number of students surveyed among the secondary feelings (see Table 3). Altogether, motivation has been a feeling chosen by 39.8% of the students, either as the primary or secondary feeling.

As in the case of the primary feeling, in the secondary there are no signs of significant differences between the choices of the male and female students (p -value > 0.05). In this

case, the number of feelings mentioned was reduced from 16 to 13, with, as in the case of the main feeling, a significant difference in the percentages obtained can be observed. It should be noted that among the secondary feelings mentioned by the students, eight of the thirteen are positive feelings, while five are considered negative.

Table 3. Secondary feeling.

Feeling	Female	Male	Total	Average	Std. Dev.
Motivated	20.0%	21.7%	20.9%	7.89	1.18
Happy	17.8%	16.1%	16.9%	8.08	1.34
Amused	8.1%	12.4%	10.5%	8.39	1.21
Excited	8.1%	3.7%	5.7%	7.82	1.54
Overwhelmed	6.7%	3.7%	5.1%	6.93	2.11
Anxious	5.9%	4.3%	5.1%	6.67	1.49
Calm	5.9%	9.3%	7.8%	7.65	1.31
Optimistic	5.2%	8.7%	7.1%	7.95	1.68
Satisfied	5.2%	4.3%	4.7%	7.79	1.42
Confident	4.4%	4.3%	4.4%	8.85	1.10
Disappointed	4.4%	3.7%	4.1%	7.58	1.80
Sad	4.4%	3.7%	4.1%	7.58	1.89
Worried	3.7%	3.7%	3.7%	7.55	1.56

The students were surveyed if these activities were beneficial to reinforce the knowledge learned in the theory sessions or the out-of-class environment (as part of the flip teaching methodology). The answers, shown in Figure 4 have been very positive since 26% of the answers strongly agreed, 50% agreed, and only 12% strongly disagreed or disagreed. Another 12% were neutral to this statement.

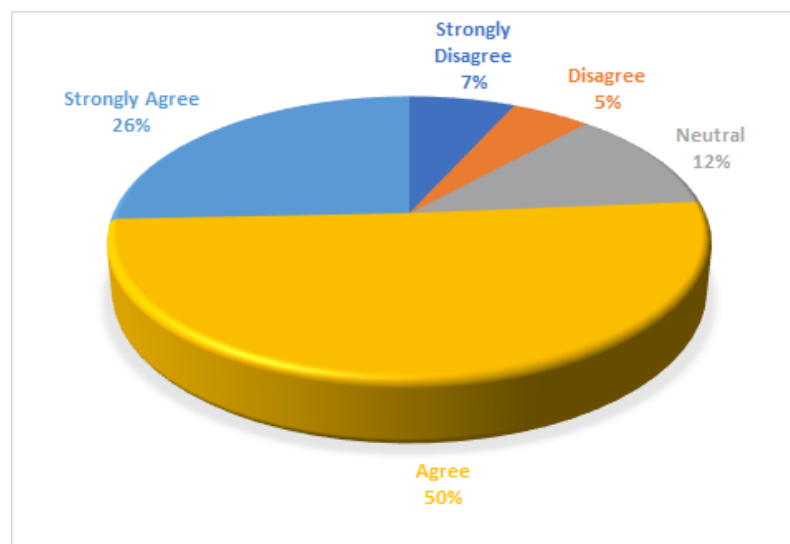


Figure 4. Answers to a Likert five-point scale to the question: Do you think this activity (dEER) has helped you reinforce the knowledge related to the topic?

Some of the elements used in the dEER were analyzed to evaluate their footprint both on knowledge and competencies acquisition and on the promotion of positive feelings. The first element evaluated was teamwork. It can be seen that teamwork is an important element in the students' opinion, since it seems to enhance their motivation, as can be seen in Figure 5.

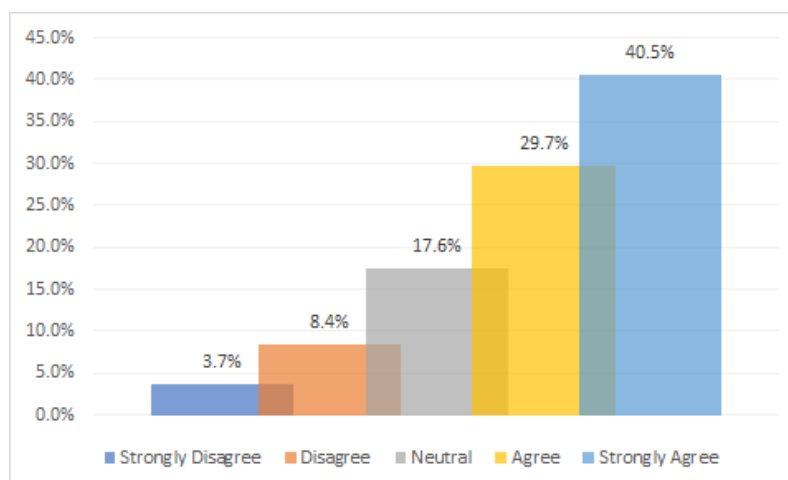


Figure 5. Answers to a Likert five-point scale to the question: Do you think team-working has helped you to enhance your motivation?

The students were also asked if they believed that teamwork improved the generation of positive feelings during the activity. In this case, the answers were positive (see Figure 6), since most of them think that working in a group allowed them to actively interact with their classmates and share doubts and solutions. This, on the other hand, can also be seen as a problem when the group dynamics are not adequate.

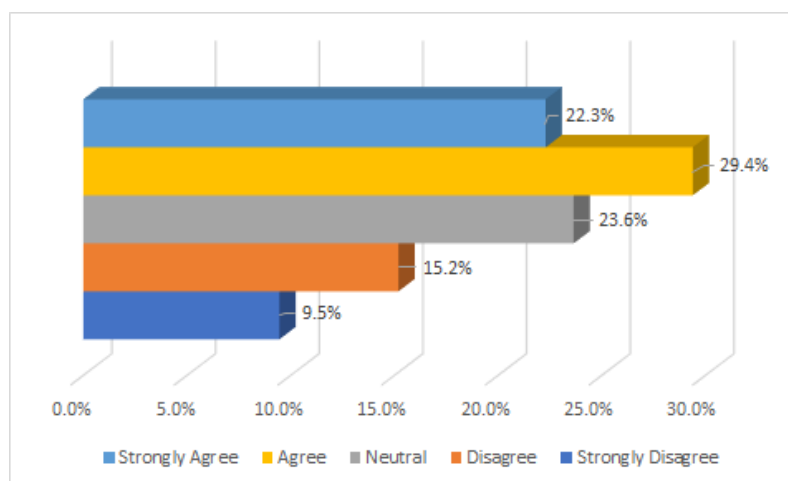


Figure 6. Answers to a Likert five-point scale to the question: Do you think team-working has helped to generate a positive-emotion environment?

The setting and storytelling is essential in the development of escape rooms. Finding an engaging theme that promotes participation is critical to creating a gaming environment. Although the themes and topics used have been different in the dEERs, the objective is to analyze the footprint of the storytelling in creating an environment of motivating positive emotions. In Figure 7, the results obtained by surveying the students regarding whether the storytelling has fostered motivation are presented. It can be seen that more than 60% strongly agree with the statement that storytelling has improved motivation, and that more than 26% agree. When the students were questioned about this fact, in 75% of the cases, “they appreciate an approach to problems with a plot background”, and they differentiate it positively from the traditional approach to problems and exercises. Only 1% of the students disagreed. The students were also surveyed on whether they believed that the dEERs storytelling benefited in creating an environment of positive feelings. The answers obtained are very similar to those obtained for motivation, 61% strongly agree, and 29% agree. Only

2% felt that an environment of positive feelings was not generated. This results are shown in Figure 8.

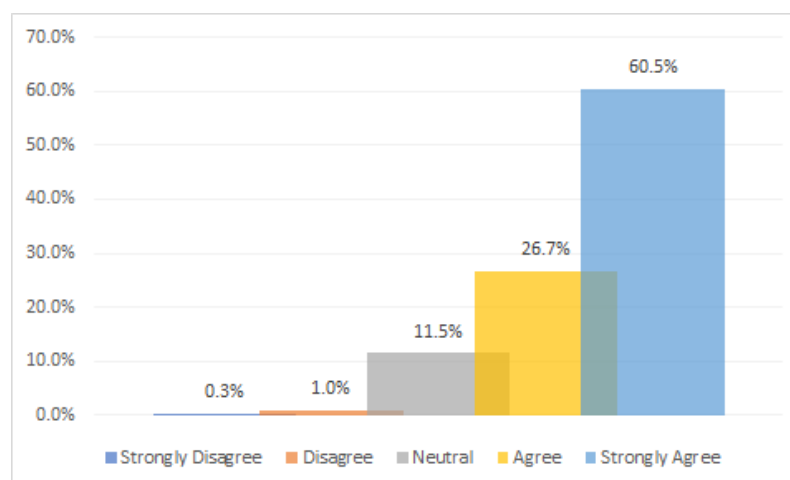


Figure 7. Answers to a Likert five-point scale to the question: Do you think storytelling has helped to enhance motivation?

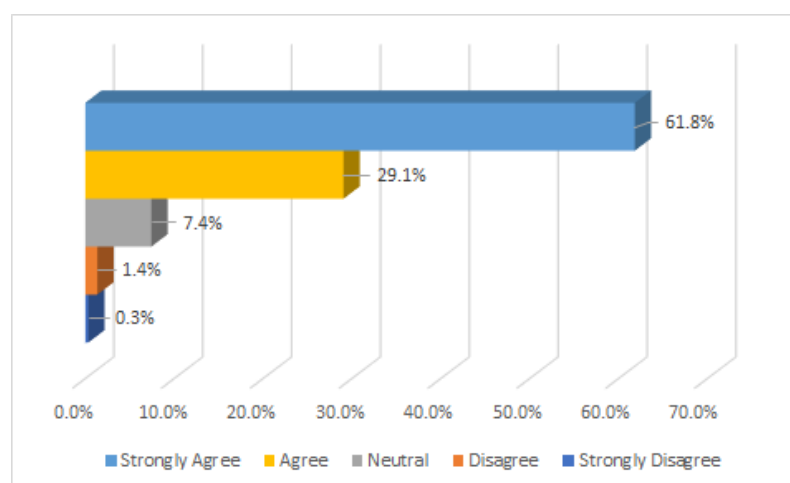


Figure 8. Answers to a Likert five-point scale to the question: Do you think storytelling has promote a positive-emotion environment?

The type of questions used in the dEERs are not significantly different from those used in the in-class or out-of-the-classroom environment; however, it does combine different types of tests and quizzes, adding the time component to the experience. When the students were asked for their opinion on whether the tests and quizzes used in the dEERs increased their motivation, the responses were once again very positive, as can be seen in the Figure 9. In Figure 10 it can also be seen that the students think that the tests and quizzes used help generate an environment of positive emotions.

One of the main aims of the use of GBL strategies is the reinforcement of the concepts and knowledge that students need. The question of whether the tests and quizzes used helped them in the development and reinforcement of the knowledge that was being evaluated returned positive answers, as can be seen in Figure 11. The quantification of the answers to this regard was positive (Mean = 3.74, Median = 4, Standard Deviation = 1.22). Approximately two out of three rated this item with a 5 or 4 (63.6%), 17.5% rated it with a 3, and only 19% of the students rated it with 2 or 1.

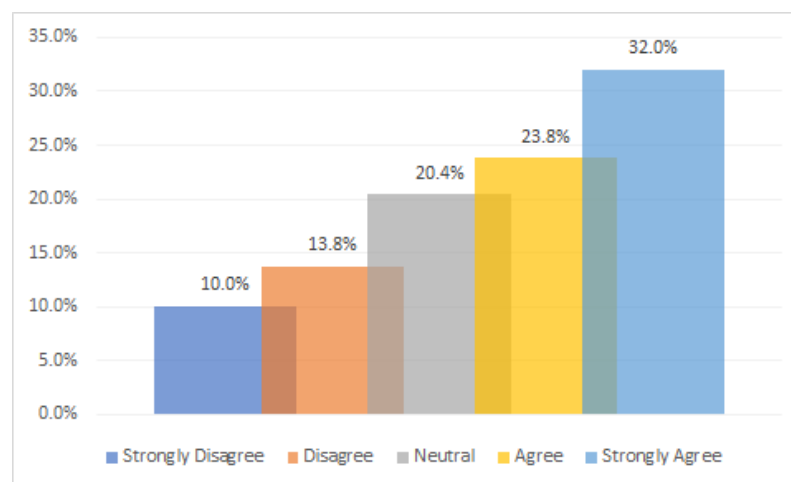


Figure 9. Answers to a Likert five-point scale to the question: Do you think tests employed in the dEERs have helped enhancing motivation?

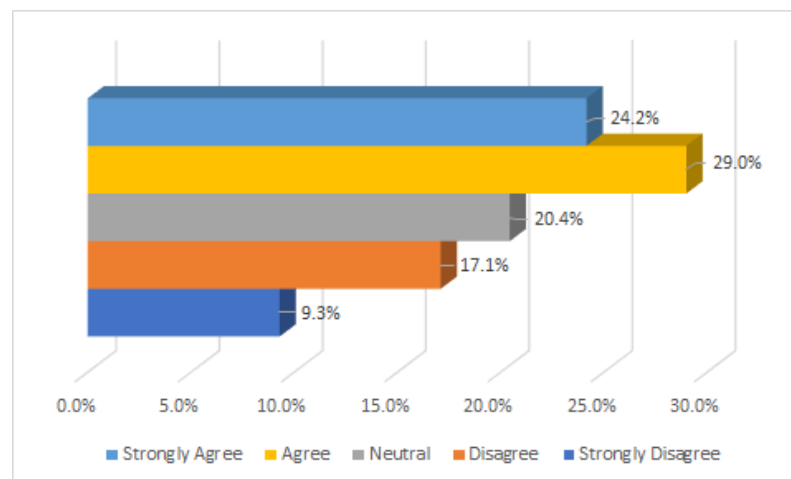


Figure 10. Answers to a Likert five-point scale to the question: Do you think the tests employed have helped generating a positive-emotion environment?

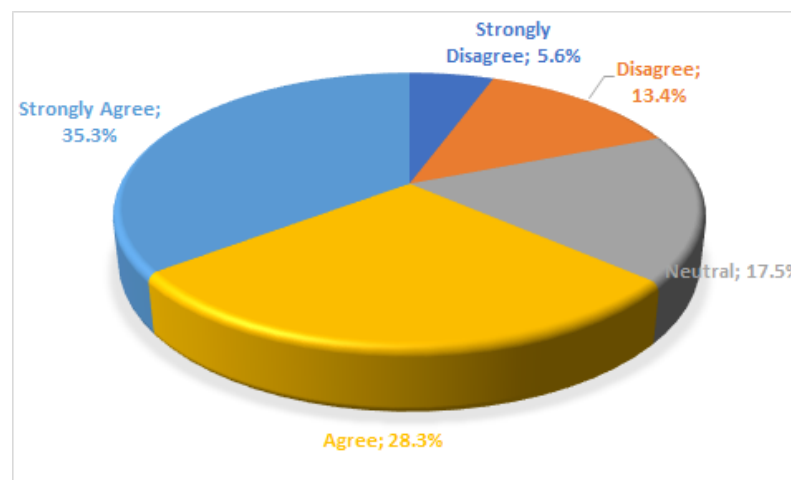


Figure 11. Answers to a Likert five-point scale to the question: Do you think the tests employed have helped in the development and reinforcement of the knowledge that was being evaluated?

Finally, the students were surveyed if they thought that this type of activity was beneficial for the development of soft skills such as group work or critical thinking. The responses are shown in Figure 12.

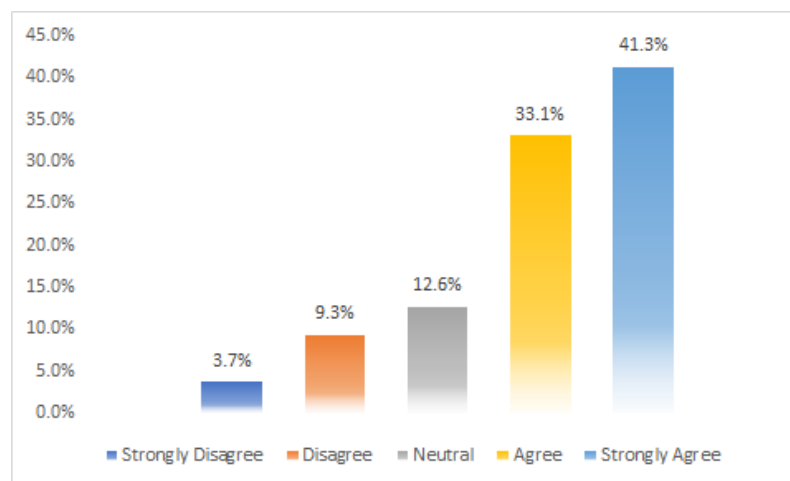


Figure 12. Answers to a Likert five-point scale to the question: Do you think that these types of activities are beneficial for the development of competencies such as teamwork or critical thinking?

The results of the questionnaire referring to the overall assessment suggested positive feelings towards the use of dEERs. The students showed an excellent overall opinion of the activity (Mean = 4.44, Median = 5, Standard Deviation = 0.66). Indeed, 53% of the students rated these activities with a 5, 38.3% rated them with a 4, 8.2% rated them with a 3, and 0.4% (i.e., only one student) rated them with a 2. No student selected option 1.

Concerning the difficulty of the activities, results show an appropriate medium-level (Mean = 2.89, Median = 3, Standard Deviation = 1.07). In general, the students did not think the dEERs were too difficult (4.5% rated them very difficult and 27.5% rated them difficult), or that they were too easy (23.8% rated them easy and 11.5% rated them too easy). Additionally, 32.7% rated the activities with the right difficulty.

Finally, a study of the final grades of the students has been developed, considering their participation in the dEERs. A sample of $n = 387$ has been employed in this study, encompassing students that participated and students that did not participate. The students were selected through a survey in which they allowed sharing their participation in the dEERs, genre and final score data for research purposes. This is the reason for not including all students in this analyses.

The Shapiro–Wilk and Kolmogorov–Smirnov tests showed that the data was not normally distributed, and Mann–Whitney U test was employed to compare the distribution of the grades considering the participation in the dEERs. The final grade for the students participating in the dEERs (Mean = 7.27, Standard Deviation = 1.23) is significantly greater than the final grade for the students not participating (Mean = 6.69, Standard Deviation = 1.85), with a p -value = 0.009 (see Table 4). This does not mean that participating in the dEERs is the only factor that determines an increase in student achievement. In fact, participation in the dEERs is already an indication of the previous motivation of the student, and therefore these data must be taken with caution. However, they can be considered positive and open up new possibilities for study.

Table 4. Final grades vs. participation in dEERs.

Final Grade	Mean	Std. Deviation	n
dEERs	7.27	1.23	217
No dEERs	6.69	1.85	170
Total	7.01	1.61	387

In [44], similar results are shown, in which a comparison between the results of a pre-test and a post-test is provided. In their study, the mean and standard deviation of the pre-test scores (before a remote educational escape room was implemented) were 6.8 and 1.8, respectively. In contrast, the mean and standard deviation of the post-test (after a remote educational escape room was implemented) were 8.5 and 1.5, respectively. The difference between these scores was found to be statistically significant. In our study, the scores correspond to different students (that participated or did not participate) and cannot be considered paired.

Table 5 summarizes the responses to the Likert-type questions, their mean and standard deviation.

The distributions were studied using the Mann-Whitney U test and the Independent Sample Kruskal–Wallis test to determine if there was a significant difference between the answers according to gender. A significant difference has been obtained between the questions shown in Table 6. The girl's answers are on average significantly higher in terms of the usefulness of the dEERs in reinforcing knowledge (Mean = 4.01, Standard Deviation = 1.05) compared to those of the males (Mean = 3.69, Standard Deviation = 1.08). Similar results have been obtained for the influence of team-working and the tests on motivation, of team-working on the creation of an environment of positive emotions, the tests on the reinforcement of knowledge, and on the opinion of whether these activities are beneficial for the development of skills (see Table 6).

There is also a significant difference between the difficulty of the dEERs, ($M = 3.04$, $SD = 1.01$) for girls vs. ($M = 2.78$, $SD = 1.16$) for boys, and in the results where the greatest difficulty of the dEERs falls, ($M = 4.01$, $SD = 1.05$) for girls vs. ($M = 3.69$, $SD = 1.08$) for boys. These results are in agreement with those obtained by in [43].

Furthermore, as mentioned in this study, the significant gender difference in scores may be attributed to boys' traditionally greater contact and familiarity with computer games and technology. However, despite this hypothetical boys' greater experience, from which one would expect a significant gender difference in favor of boys in the final scores, no such difference was noted (p -value = 0.39). In order to explore the impact of gender and participation on students' final scores, the means of the scores were compared through 2×2 ANOVA, finding a significant interaction between gender and participation on the final scores (p -value = 0.023).

For the other questions, no significant differences were found based on gender.

Table 5. Responses to Likert-type questions.

Likert-Type Responses	Mean	Std. Dev.
Which is your overall opinion on the dEERs? (1 Poor–5 Very Good)	4.49	0.65
Has the dEERs helped you reinforcing the knowledge related to the topic?	3.83	1.08
Do you think team-working has helped you enhancing your motivation?	3.95	1.12
Do you think team-working has helped generating a positive-emotion environment?	3.40	1.25
Do you think storytelling has helped enhancing motivation?	4.46	0.76
Do you think storytelling has promoted a positive-emotion environment?	4.51	0.72
Do you think tests employed in the dEERs have helped enhancing motivation?	3.53	1.30
Do you think the tests employed have helped generating a positive-emotion environment?	3.41	1.25
Do you think the tests have helped developing and reinforcing the knowledge that was being evaluated?	3.73	1.21

Table 5. Cont.

Likert-Type Responses	Mean	Std. Dev.
Do you think dEERs are beneficial for the development of competencies (teamwork or critical thinking)?	3.90	1.16
Do you think you have learnt more with dEERs than you would have with a normal activity?	4.39	0.71
The duration of the dEERs was: (1 Too Short–5 Too Long)	2.34	1.81
The greatest difficulty in solving the puzzles laid in having the necessary knowledge of the subject	4.02	1.01
The biggest difficulty in solving dEERs puzzles and tests lay in the mechanics used to solve them	2.04	1.41
The difficulty level of the escape rooms was generally (1 Very Low–5 Very High)	2.89	1.01
The difficulty of the subject Mathematics I is (1 Very Low–5 Very High)	3.07	1.15

Table 6. Responses to Likert-type questions vs. Gender.

Likert-Type Responses	Genre	Mean	Std. Dev.	Sig. Mann-Whitney U Test
Has the dEER helped you to reinforce the knowledge related to the topic?	Male	3.69	1.08	0.002
	Female	4.01	1.05	
Do you think team-working has helped you enhancing your motivation?	Male	3.78	1.18	0.006
	Female	4.15	1.02	
Do you think team-working helped generating a positive-emotion environment?	Male	3.78	1.18	0.013
	Female	4.15	1.04	
Do you think tests employed in the dEERs have helped enhancing motivation?	Male	3.36	1.28	0.006
	Female	3.74	1.32	
Do you think the tests employed have helped generating a positive-emotion environment?	Male	3.24	1.23	0.011
	Female	3.60	1.25	
Do you think the tests employed have helped developing and reinforcing the knowledge that was being evaluated?	Male	3.54	1.20	0.002
	Female	3.95	1.19	
Do you think dEERs are beneficial for the development of competencies?	Male	3.73	1.19	0.002
	Female	4.11	1.09	
The greatest difficulty in solving the puzzles of the dEERs laid in having the necessary knowledge of the subject	Male	3.69	1.08	0.01
	Female	4.01	1.05	
The difficulty level of the escape rooms was generally (1 Very Low–5 Very High)	Male	2.78	1.16	0.012
	Female	3.04	1.01	

4. Discussion

Teaching innovation aims to promote, foster and hone students' talents and soft skills in an educational setting. Several teaching innovations have encouraged student creativity, problem-solving, and active learning [1,2,4,6,7,10]. Game-based learning has provided a new active learning didactic and motivating approach, aiming to actively or experientially involve students in the learning process, encouraging their participation in meaningful

ludic learning activities. Among the GBL strategies, escape rooms have achieved good learning results and have drawn the attention of educators [14,16,19,20]. These activities are consistent with the concept of interdisciplinary, cooperative, problem-solving, and student-centered learning. Indeed, several strategies are fostered in escape rooms, such as search, observation, correlation, memorization, or pattern recognition. Educational escape rooms combine key concepts of game design with educational approaches, such as active learning and collaborative learning, to enhance students' soft skills in a motivating way [15,19–21].

In STEM, the introduction of GBL methodologies has provided an increase in the success rates, performance, motivation, and acquisition of knowledge and soft skills [16,19,20,22]. Educational escape rooms have been developed also remotely or digitally, when time and budget limitations appear or when the right conditions are met for their implementation [44]. In this line, several dEERs have been implemented in a first year mathematics subject of the Aerospace Engineering degree to improve motivation and increase students' mathematical competencies. This strategy of learning through games can complement the flipped teaching methodology used in this course, especially the practical laboratory sessions, since both of them reinforce, or put into practice, the knowledge they have acquired outside the classroom in a motivating way.

Creating an environment of positive emotions in the educational field has proven to increase student motivation resilience, and knowledge acquisition. The introduction of GBL techniques promotes the blooming of these environments and catalyze the participation of students in their learning process.

Strategies aimed at maintaining and increasing experiences of positive emotions are important for the well-being of students, and may be particularly useful for building resilience to stressful events [38]. Positive emotions have been proven to play a crucial role in academic achievements [33,36,37,41,44,66,76].

This study provides a generalized vision that studies the feelings that students experience during the realization of digital escape rooms on a mathematics topic, and presents which elements of said activities have had a fundamental role in the creation of positive emotions. This study is in agreement with prior research about emotions and the role of GBL on students' performance [33,37,64,67,68,71,75].

Among the most relevant results, it should be noted that one of the feelings that have stood out the most is *motivation*, which, as a primary or secondary feeling, has been selected by 40% of the students. This result corroborates previous studies such as [12,35,43,54,61,71]. Other emotions such as happiness (joy) or stress have been named with significant incidence.

Stress is a feeling that can be understood and associated with any test that students face, under a limited time for its completion. The same students have indicated that, although they have felt stress at some point in the test, the fact that it was carried out in a group and the possibility to share doubts have lowered the intensity of said feeling.

These types of activities use game elements that make the experience more immersive. For example, storytelling is essential in creating an activity such as dEERs improving motivation (85%), and generating an environment of positive emotions (90%). These results are in agreement with prior studies, such as [52–55,57].

Teamwork has also been highlighted as an element that improves student motivation. In this case, having a limited time for the answers and being an activity of a short duration, in the authors' opinion, has improved the interaction between the components of the group. However, the answers to whether they improve motivation and help in the generation of a positive environment are not as good as those obtained with storytelling. Specifically, 70% think it enhances motivation, and only 50% that it generates a positive environment.

Another advantage of this type of activity is that students feel an improvement in the acquisition of concepts (76%). The variety of tests and quizzes used make the students feel an improvement in the acquisition of knowledge (63%) and in the development of soft skills (74%), such as teamwork and critical thinking.

The overall opinion of the students was very positive, and the results obtained are in agreement with the opinion found in [44], although in this study the escape rooms were conducted remotely. Additionally, about the acquisition of knowledge, results show that they believed that taking part in the dEERs was beneficial for improving their mathematical knowledge (Mean = 3.74, Median = 4, Standard Deviation = 1.22). These results are similar to the ones in [44] (Mean = 3.9, Median = 4, Standard Deviation = 0.9) and corroborate that educational escape rooms (remote of face-to-face) can be cataloged as effective learning activities. Prior studies reported on the use of these educational escape rooms [16,19–21], but only recently [44] educational escape rooms have been assessed in terms of instructional effectiveness.

Regarding the difficulty of the activities, results indicate an appropriate medium-level (Mean = 2.89, Median = 3, Standard Deviation = 1.07) very similar to the ones found in the literature (Mean = 2.7, Median = 3.0, Standard Deviation = 1.0) [44]. Thus, it can be said that the design of the dEERs succeeded at balancing the difficulty, which is a major aspect of the experience according to the Csikszentmihalyi's flow theory [80]. Additionally, some information can be found in [30,31]

A significant improvement in the final grades of the students participating in the dEERs has been found. This does not mean that participating is the only factor that determines an increase in student achievement. However, these results can be considered positive and open up new possibilities for study.

Additionally, some significant differences in the scores in terms of the gender have been found. Girl's scores are significantly higher when evaluating the influence of the test and team-working on motivation.

It can be concluded that the dEERs used as GBL elements improve student motivation and help generate an environment of positive emotions. In addition, students feel that knowledge is improved and soft skills are developed.

5. Conclusions

In this paper, we share an agile approach to an educational context where changes need to be done in order to seek meaningful active methodologies that get the students involved in their learning process. Herein, we have analyzed the feelings that flourish when applying digital escape rooms during classes in the subject of Mathematics I of the Bachelor in Aerospace Engineering degree at UPV. The results show that the implementation of this GBL methodology significantly enhances the generation of an environment of positive emotions.

Motivation has stood out among the feelings since was experienced by 40% of the students. Other positive feelings such as happiness have also been mentioned. It should be noted that the application of dEERs also entails negative feelings such as stress that must be taken into account when designing escape rooms.

Among the elements that make up the escape rooms, the narrative seems to be a key element in promoting motivation and in generating the environment of positive emotions. Group work is also an element valued by students as positive, although the group dynamics can generate some problems during the game.

The general feeling of the students is that these activities improve knowledge and skills. However, the learning effectiveness of the dEERs has been assessed only based on the students' self-reported measures and therefore the relationship between students' feelings and actual learning effectiveness should be further examined.

These results provide a better understanding of the benefits of applying digital educational escape rooms and suggest that these kinds of activities provide a very favorable atmosphere for fostering students' positive feelings.

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