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A Generic Multilevel Structure for Educational Escape Rooms

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Abstract: The use of active learning activities for evaluation purposes has been reported to improve results in all areas within the education field. In this paper we describe a generic multilevel structure for educational escape rooms, along with a use case where such a design was applied for assessment in a course within the STEM area. Furthermore, a project-based learning activity was also added to complement that assessment. The results obtained expose an increase in both academic performance and success rate, where the percentage rises in both cases go in line to the literature. Additionally, a high level of engagement was measured during those active learning activities, which is reported to lead to better performance and improved learning. Hence, this high engagement seems to be the primary source of the increments experienced.

Keywords: active learning; escape room; gamification; innovative education; project-based learning

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1. Introduction

Active learning is an alternative paradigm to traditional lecturing, where a more student-centered approach is taken [1]. This way, students get a more proactive role in their education, while the teacher's role turns into a facilitator in their learning process [2]. Furthermore, extensive research states that scholars learn more if they get actively engaged in a classroom environment than if they are in a passive lecture condition [3].

Different approaches may be followed to deploy the active learning paradigm, such as flipped classrooms, serious educational games, project-based learning or team-based learning, in order for students to acquire the expected key competences [4]. However, in the active learning realm, educational escape rooms are one of the most appreciated activities by students, as they get embedded into a game experience, while they are actually undertaking a learning activity [5].

In this sense, educational escape rooms may be seen as competitive activities looking for increasing students' participation and motivation, which may be held as either multi-player or single-player competitions [6]. Also, they could be organized in many ways, such as moving through different locations in the learning premises, interacting with physical objects in the classroom, or setting it up on a learning management system [7].

In this paper, a generic multilevel structure for educational escape rooms is presented, which may be used as a backbone to implement escape rooms in any education field. Furthermore, a use case of creating and running this kind of specific type of educational escape room as an evaluation activity is presented in the context of a course of an engineering degree at College, as well as an additional project-based learning activity. In addition to the boost in results achieved, a measurement of the engagement level of the students has also been performed [8], which is a primary source of enhancing academic performance when the magnitude measured is high enough [9].

The rest of the paper is organized as follows: Section 2 presents the design of a generic multilevel structure for escape rooms, Section 3 shows the methodology, Section 4 exhibits the results, Section 5 exposes the discussion, and Section 6 draws conclusions.

2. A Generic Multilevel Structure for Escape Rooms

Educational escape rooms may be defined as a sequence of tasks to be accomplished within a time-constraint interval [10]. Regarding pedagogy, students build up their own knowledge while they move along the escape room, as they get involved in it [11]. As a matter of fact, there is a revised framework of Bloom's Taxonomy adapted to educational escape rooms, where the 6 categories of cognitive processes are described, such as 'remember', 'understand', 'apply', 'analyze', 'evaluate', and 'create' [12].

On the other hand, educational escape rooms are composed of a series of puzzles, which could be organized in different ways. For instance, open path structure offers a collection of concurrent puzzles to get to the final stage, whilst linear-path structure presents a string of puzzles to get there. Likewise, a path-based structure may be seen as a combination of the above, where a collection of redundant linear paths are available. Moreover, any hybrid combination is available, such as a pyramid structure [13].

In this sense, the structure proposed herein is a sequence of linear-paths, where each path must be cleared before taking up the next one [14]. This way, it is possible to dedicate each linear path to a different generic domain, which could be considered as a specific chapter or a particular didactic unit. Therefore, the generic multilevel structure proposed allows to evaluate the knowledge, skills and attitudes acquired.

Hence, the escape room proposed is composed of a series of sequential levels, which are the linear-paths, such that each level is formed by a string of sequential stages. This type of structure could be compared to a bidimensional array or matrix [15], where its rows are considered as levels and its columns are seen as the stages forming each level, where all stages within a given level must be traversed before getting into the next level.

This structure for escape rooms permits to take a series of exams whose questions are randomly taken out of a question bank related to a certain chapter, including multiple choice questions, as well as fill in the blank questions, and also calculated questions with random variables. The target is to get each exam done with the highest marks, as those determine the number of hops away taken in the escape room.

A full class session is dedicated to run a given escape room, and scholars may participate in groups, or otherwise, they could do it individually. In any case, the ultimate goal is to take the series of exams in the shortest possible time because the overall mark obtained when finishing the escape room will depend on the time spent to clear it. Hence, students are meant to apply the knowledge, skills and attitudes they learnt in a given chapter to get a good performance in the evaluation with escape room.

As we are based in Spain, we adjusted the structure of the escape room to the Spanish grading system [16], which ranges from 0 to 10 and the passing grade is 5. This way, we set up each exam with 10 questions, where each one is evaluated as either right or wrong, such that the former accounts for 1 point and the latter stands for 0 points.

Therefore, if the outcome of a particular exam is lower than the passing grade, then it implies no movement in the escape room. On the other hand, if the outcome equals or overcomes the passing grade, then it implies a movement in the escape room, whose magnitude is exposed in Table 1. However, as each level is independent from the other levels, it is no possible to go further than the beginning of the next level, so the extra hops obtained will get lost.

Table 1. Hops away assigned to the outcome of an exam.

Score	0	1	2	3	4	5	6	7	8	9	10
Hops away	0	0	0	0	0	1	2	3	4	5	6

As top marks account for 6 hops away, each level has been designed with 6 stages, as seen in Figure 1, where 4 levels are shown just as an instance. This way, if a group is at the initial stage of a given level and it gets the top score in an exam, then the group gets moved to the initial stage of the next level [17]. This allows to traverse a whole level with

just one move, which results in the possibility of traversing the whole escape room with just 4 moves if a group is able to obtain 4 exams in a row with top marks.

If top marks are not attained at the initial stage of a level, then the movement achieved will lead the group to a certain stage within the same level, thus the following movement might take the group as far as the initial stage of the next level, such that the remaining hops obtained will not be taken into consideration as they will be discarded.

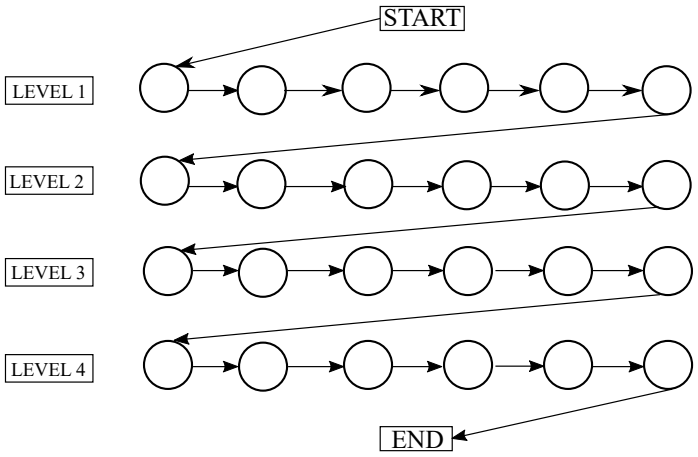

Figure 1. Flow chart in the escape room proposed.

On the other hand, the goal is to clear the escape room as soon as possible, such that top marks are awarded to all groups doing it within the 60% of the session time, whilst passing marks are awarded to the groups doing it by the end of the session, namely 100% of the session time. Furthermore, intermediate marks will be granted according to the time elapsed to finish the escape room, such as a grade of 9 for doing it before the 70% of the session time, a grade of 8 for the 80%, a grade of 7 for the 90%, and a grade of 6 for the 95%. Additionally, failing marks are granted to those not being able to finish it.

However, in case there are students in the course with learning disabilities who will probably require a longer time limit, it is to be taken into consideration that after the end of the session where students carry out the escape room, they have to attend another session related to another course, so it is not suitable to extend the time devoted to the escape room. Therefore, the most convenient solution in those circumstances is to assign those specific students an escape room with a lower amount of levels than their peers, such that they may have enough time to finish the shortened version of the escape room.

3. Methodology

Once the structure proposed has been duly exposed, then a use case is presented. This use case is set up in a course at college related to architecture and technology of computers. This way, each level within the structure is devoted to a specific didactic unit within the curriculum, whereas the puzzles composing each level are related to answering questions or solving tasks about the corresponding didactic unit assigned to that level. Besides, the marks achieved in each puzzle are related to how much players get moved ahead within a level in the escape room.

In this context, the evaluation of this course was done though an escape room of 3 levels, because the course was composed of 3 different didactic units, where the first one was devoted to binary arithmetic, the second one was dedicated to the building blocks of a computer, and the third one was committed to assembly language.

3.1. Design for the Escape Room Proposed

The design of the escape room proposed is a multilevel linear path, where students are facing a challenge within a story board to be sorted out on an individual basis. To start with, the teacher explains the background of the story, which is called “Save the Earth”. In order

to embed students into the plot, some epic music is played non-stop out of pixabay website, which offers music tracks without royalties. Furthermore, some royalty-free pictures from the same website are displayed on the interactive whiteboard in order for the students to feel more integrated into the story.

At the beginning of the escape room, an introduction is given for the students to understand the critical situation where they are immersed into. This background is exposed by the teacher to the students, as well as it is found when first accessing the escape room in the Moodle platform of the university. Basically, it is told that we are in the year 2050, where conditions are tougher than today. In that context, a huge meteorite is coming straight to Earth and the only chance for the planet to survive is to launch a space rocket with a brand-new laser system so as to destroy the meteorite before hitting the planet and destroy everything completely.

However, one key piece in the laser system is missing, which has been developed at our University. Hence, the mission is to get into our campus and find that piece as soon as possible. Nonetheless, the change in climate conditions during recent years has brought up new and dangerous species regarding flora and fauna, thus the whole path through the campus university is as tough as ever, because it is full of dangers.

The mission is divided into three stages, which are considered as three different levels, each of those composed of a number of states to be traversed in a sequential manner, namely 6 stages. In order for each student to advance through those steps, a test attempt needs to be made, where each attempt consists of a 10-question quiz to be done individually. The marks obtained at each attempt indicate the magnitude of that movement, as it has been previously described, such that the higher the grade obtained in a test, the larger the move to be made within the current level of the escape room.

Each level must be done on an independent basis, in a way that the stages included in each level must be cleared before starting with the next level in the next attempt. Eventually, the escape room finishes when the last level is cleared, although the aim for all students is actually to finish the game on their own. The first level is devoted to move through the University Campus to reach the University Rector's building. The second level is dedicated to move through the University Rector's building to get into the University Rector's office. The third level is committed to the University Rector's office, where the missing piece is located right in the last puzzle, also known as meta-puzzle.

In summary, the main goal of the escape room is to evaluate students about the knowledge, skills and attitudes they acquired during the course, although such an assessment is done through an active learning activity, as opposed to a traditional written exam. However, the use of an escape room for evaluation purposes also portrays a fun part due to the gaming environment induced, which acts as a complement of the evaluation part.

This could be broken down into two key aspects, such as the competitivity among players and the layout of the activity. Focusing on the former, the fun is in the motivation in order to compete with the rest of players so as to get ahead of them in the activity, which is boosted by the gaming environment. Centering on the latter, the fun is in the layout of the activity, such as playing a specific music during the competition, or wearing fancy dresses for the competition according to the curriculum being assessed.

Regarding the presentation of the escape room to the students, at the beginning of the session the teacher gets into the classroom dressed with a fancy jacket and a piece of apocalyptic music starts out. After a few seconds, the teacher exposes the background of the story, such that a big meteorite is about to hit the Earth, which is shown in the interactive board of the classroom, and our only option to avoid the collision is to find the missing piece of a laser system. This piece is located in our University and it will be found at the end of the escape room, so students must clear it as soon as possible in order to save the Earth.

3.2. Evaluation of the Course

The evaluation of this course related to Architecture and Technology of Computers was done through the aforementioned educational escape room, which accounted for two thirds of the final mark. As stated above, the marks assigned to each student depended on how long each student took to clear the three levels proposed, where each one was dedicated to one of the didactic units within the course.

On the other hand, the other third of the final mark was assigned through the development of a project in assembly language, which had to be exposed in a specific class session as a pitch presentation. Hence, this project-based learning activity was composed of 2 parts, such as the programming part and the presentation part, where the former was done by designing and developing the code to meet the specifications of the project, and the latter was done by preparing and delivering the presentation. Each project had to be carried out on an individual basis, whereas students had to assess all projects, including their own ones, on a peer review basis. This way, the pressure to get a great performance in the escape room was not so critical, because they could improve their marks with this project-based activity.

4. Results

First of all, it is to be mentioned that there are 25 students in the course in the current academic year, whereas there were 24 in the same course in the previous academic year. Hence, both amounts of scholars are comparable, which allows to confront the grades achieved in both years. In this sense, it is to be remarked that an active evaluation approach was taken in the current year, by means of using an escape room and a project-based learning activity. On the other hand, a traditional evaluation approach was followed in the past year, by means of using a traditional written exam.

4.1. Escape Room

Regarding the escape room, Table 2 exhibits the amount of students within the different scores used to assess the performance in the escape room, as explained above. In this sense, it is to be said that students not completing the escape room failed the activity, although they were awarded 4 points if they got to clear two levels, or otherwise, they were awarded 2 points if they got one level cleared, whilst they were awarded 0 point if they did not achieve to clear any level whatsoever.

Table 2. Outcome of the educational escape room proposed.

Performance Obtained	Number of Students	Marks Achieved
Completed within the 60% of the session	3	10
Completed within the 70% of the session	3	9
Completed within the 80% of the session	4	8
Completed within the 90% of the session	5	7
Completed within the 95% of the session	3	6
Completed within the 100% of the session	4	5
Not completed, with 2 levels cleared	2	4
Not completed, with 1 level cleared	1	2
Not completed, with 0 levels cleared	0	0

The descriptive statistics referred to the results obtained are summarized in Table 3.

Table 3. Descriptive statistics of the educational escape room proposed.

Type	Statistic	Value
Centralization	Average	6.88
	25th percentile	5
	50th percentile	7
	75th percentile	8
Dispersion	Variance	4.36
	Standard deviation	2.09
	Coeff. variation	0.30

4.2. Project-Based Learning Activity

With regards to the project-based learning activity [18], the pitch presentation made by students to expose their projects had to be assessed by a construct composed of 6 items. Those items are exhibited in Table 4, which are classified in 2 categories, such as programming and presenting, where 3 items are included in each one. Basically, the first category is devoted to the coding structures used, the clarity of the code employed, and the comments made along the code, whilst the second category is dedicated to explain the functionality of the code presented, the execution of that code, and the communication skills shown when making the pitch presentation.

Table 4. Items within the construct to evaluate the project-based activity.

Category	ID	Item
Programming	Q1	Coding skills
	Q2	Code clarity
	Q3	Code comments
Presenting	Q4	Functionality
	Q5	Execution
	Q6	Communication skills

Prior to exposing the items, also known as questions, in the construct for students to evaluate the different projects on a peer-review basis, a panel of 5 experts rated each question according to 2 dimensions, namely the construction of each item and its clarity, in order to assess the validity of the construct [19]. Those ratings were made by means of a specific construct for those experts with 4-point Likert-type scales, where the value of 1 was assigned to 'strongly disagree', the value of 2 was tied to 'disagree', the value of 3 was associated to 'agree' and the value of 4 was linked to 'strongly agree'. Table 5 exhibits the averages of each item, as well as the average for each dimension considering all items, along with the overall average.

Table 5. Average marks assigned for the questions according to the dimensions defined.

	Q1	Q2	Q3	Q4	Q5	Q6	Dimension Average	Overall Average
Construction	4.0	3.8	4.0	3.6	3.6	4.0	3.833	3.783
Clarity	3.8	3.8	3.6	3.4	3.6	4.0	3.733	

Once the overall average has been obtained, then the Aiken's V test may be performed, which accounts for 0.928. This value is higher than the most common cutoff marks, such as the Aiken's benchmark, which is 0.87 [20], the Charter's benchmark, which is 0.70 [21], and the Cicchetti's benchmark, which is 0.50 [22]. This way, different degrees of agreement may be appointed accordingly, either tougher or looser. Therefore, as the value obtained in the Aiken's V test is greater than the benchmark established, which is the case for the three thresholds quoted, it may be concluded that the construct with the items selected has

been validated by the panel of experts. Hence, at that point, the construct was ready to be presented to the students for peer-review evaluation.

Regarding the results of the peer-review assessment, it is to be noted that the ratings of each item belonging to any of both dimensions were done through another construct for students with 5-point Likert-type scales, where the value of 1 was assigned to 'strongly disagree', the value of 2 was tied to 'disagree', the value of 3 was associated to 'neither agree nor disagree', the value of 4 was linked to 'agree', and the value of 5 was bound to 'strongly agree'. Additionally, it is to be said that the categories defined above, namely programming and presenting, are now considered as dimensions in this construct to measure the students' results. Table 6 displays the most common descriptive statistics extracted from those results.

Table 6. Descriptive statistics of the results of the project-based activity proposed.

Type	Statistic	Programming Dimension	Presenting Dimension	Overall
Centralization	Average	4.61	4.51	4.56
	25th percentile	4	4	4
	50th percentile	5	5	5
	75th percentile	5	5	5
Dispersion	Variance	0.32	0.33	0.33
	Standard deviation	0.57	0.58	0.57
	Coeff. variation	0.12	0.13	0.13

The reliability of the results obtained was measured according to the Cronbach's alpha [23], as shown in Table 7. The benchmark for an acceptable level of reliability according to the value of Cronbach's alpha is 0.70 [24], which also accounts for the internal consistency of the data considered in both dimensions, as well as a high level of correlation among them. This is the case herein, as not only the overall value obtained is above that benchmark, but also the values referred to the dimensions are also higher than the benchmark.

Table 7. Reliability of the results by means of Cronbach's alpha.

	Programming Dimension	Presenting Dimension	Overall
Cronbach's Alpha	0.738	0.762	0.801

Nonetheless, the degree of correlation between dimensions has also been measured by calculating the Pearson's correlation coefficient and the Spearman's rank correlation coefficient between the data belonging to both dimensions. Both coefficients are greater than 0.50, which usually implies a high level of correlation [25], as seen in Table 8.

Table 8. Correlation of the results belonging to programming and presenting dimensions.

Type of Correlation	Value
Pearson's correlation coefficient	0.504
Spearman's rank correlation coefficient	0.536

4.3. Measurement of the Level of Engagement

The level of engagement during both active learning activities, namely the educational escape room and the project-based learning activity, was measured through the ISA engagement scale. This is a 7-point Likert-type construct with three dimensions, namely intellectual, social and affective, where each one contains three standard items [26]. The ratings assign a value of 1 to 'strongly disagree', whilst a value of 2 is assigned to 'disagree', and a value of 3 is associated to 'partially disagree'. Also, the ratings assign a value of 4 to 'neutral', whilst a value of 5 is assigned to 'partially agree', whereas a value of 6 is associated to 'agree', and a value of 7 is tied to 'strongly agree'.

Therefore, the goal in this construct is to achieve an average of at least 6 in all dimensions, as this is the value corresponding to 'agree', which will lead to an overall value of above 6 as well. Furthermore, this scale was originally thought for employees working in organizations, although it may be extrapolated to other fields, such as education [27]. Table 9 displays the items assessed in the ISA engagement scale, along with their corresponding dimensions.

Table 9. Items organized by dimensions to evaluate the level of engagement achieved.

Dimensions		Items
1	Intellectual	Q1: I focus hard on my work. Q2: I concentrate on my work. Q3: I pay a lot of attention to my work.
2	Social	Q4: I share the same work values as my colleagues. Q5: I share the same work goals as my colleagues. Q6: I share the same work attitudes as my colleagues.
3	Affective	Q7: I feel positive about my work. Q8: I feel energetic in my work. Q9: I am enthusiastic in my work.

Table 10 exhibits the descriptive statistics corresponding to each dimension and overall, according to the results collected in the ISA engagement scale. On the other hand, the reliability of those results related to the level of engagement was measured by calculating the Cronbach's alpha, whose outcome is exhibited in Table 11.

Table 10. Descriptive statistics of the engagement results of the project-based learning activity proposed.

Type	Statistic	Intellectual Dimension	Social Dimension	Affective Dimension	Overall
Centralization	Average	6.51	6.64	6.69	6.61
	25th percentile	6	6	6	6
	50th percentile	7	7	7	7
	75th percentile	7	7	7	7
Dispersion	Variance	0.58	0.26	0.22	0.35
	Standard deviation	0.76	0.51	0.46	0.60
	Coeff. variation	0.12	0.08	0.07	0.09

Table 11. Reliability of the engagement level results by means of Cronbach's alpha.

	Intellectual Dimension	Social Dimension	Affective Dimension	Overall
Cronbach's Alpha	0.925	0.736	0.788	0.703

The values of reliability attained are higher than 0.70, which implies an internal consistency of data, along with a high level of correlation among dimensions. This point was reinforced by calculating the correlation coefficients according to Pearson and Spearman, as displayed in Table 12.

Table 12. Correlation of the engagement results among dimensions.

Type of Correlation	Intellectual vs. Social	Intellectual vs. Affective	Social vs. Affective
Pearson's correlation coefficient	0.562	0.547	0.636
Spearman's rank correlation coefficient	0.571	0.531	0.662

5. Discussion

With respect to the data analysis procedure, it is to be distinguished among the data collected out of the escape room, which have been presented in Section 4.1, the data compiled from the project-based learning, which have been exposed in Section 4.2, and the data referred to the measurement of the level of engagement, which have been displayed in Section 4.3. Moreover, all data have been anonymized and aggregated, such that it is not feasible to associate any single student with any kind of data.

On the one hand, data extracted from the escape room are aggregated according to the time elapsed for each student to finish it, where data are aggregated by time intervals. Then, descriptive statistics are applied to such data in order to find out the measurements of centralization most commonly used, such as the average and the quartiles, and the measurements of dispersion most commonly used, such as the variance, the standard deviation and the coefficient of variation.

On the other hand, data extracted from the project-based learning come from two different sources, such as those coming from the panel of experts in order to validate the peer-review construct and those coming from the students to perform the peer-review evaluation of the projects. With respect to the former, just the overall average is necessary, as it is mandatory in order to find out the Aiken's V test, which validates the construct.

With regards to the latter, data are aggregated by the discrete values obtained, and in turn, descriptive statistics are applied to the dimensions proposed with such data in order to calculate the most common centralization and dispersion measurements, as exposed for the escape room. Furthermore, the Cronbach's alpha is calculated for each dimension in order to assess the reliability of each dimension and overall, as well as the Pearson's correlation coefficient and the Spearman's correlation coefficient are used to calculate the correlation among dimensions, which reinforces the information given by the Cronbach's alpha.

Eventually, data extracted from the measurement of the level of engagement with the ISA engagement scale is compiled and the same data analysis procedure is applied as the one described for the data collected for the peer-review evaluation of the project-based learning.

Regarding the results obtained in the escape room, in Table 3 was quoted an average value of 6.88 out of 10, which is the the top mark in the Spanish grading system. Furthermore, the first quartile value is 5, the second one is 7 and the third one is 8. This represents that most of the students got to finish the escape room proposed, as the first quartile is 5, and also over half of them did it ahead of time, as the second quartile is 7. Actually, only 3 out of 25 students were not able to do it, which represents just a 12% of the overall scholars. Also, the coefficient of variation is 0.30, which is just the boundary of a moderate variation of data with respect to the average, that being seen as acceptable.

Considering just the escape room, and comparing the academic performance and the success rate attained this current academic year with respect to the previous academic year in the same course, Table 13 exposes a rise in academic performance and in success rate as well. On the one hand, the average grade attained in the last year was 6.25 out of 10, whilst in the current year it was 6.88 out of 10, thus resulting in a rise of 10% in academic performance. On the other hand, the success rate in the last year was 19 out of 24 students, namely 0.77, whereas in the current year it was 22 out of 25 students, namely 0.88, thus accounting for a rise of 14% in success rate.

Table 13. Rise in academic performance and success rate, considering only the escape room.

	Previous Academic Year	Current Academic Year	Variation Ratio	Percentage Rise
Academic performance	6.25 out of 10	6.88 out of 10	6.88/6.25 = 1.10	10%
Success rate	19 out of 24 = 0.77	22 out of 25 = 0.88	0.88/0.77 = 1.14	14%

With respect to the outcome attained in the project-based learning activity, the first thing to be noted is that a construct for evaluation purposes was built up with 6 items. In turn, this construct was assessed by a panel of 5 experts on the grounds of 2 dimensions for each of its 6 items, namely its construction and its clarity. This assessment was done through ratings in a 4-point Likert-type scale, such as the overall average resulted in 3.783, which yielded a value for the Aiken's V test of 0.928. Hence, as this value is greater than any of the benchmarks considered, namely 0.87 for the Aiken's one, 0.70 for the Charter's one, and 0.50 for Cicchetti's one, then the construct got validated.

Afterwards, this construct was used for the students to rate the projects delivered, where each item had to be rated in a 5-point Likert-type scale. As exposed in Table 6, the overall average value is 4.56 out of 5, which is the top mark. However, this mark is easily converted into the Spanish grading system by just doubling it up, thus yielding 9.12 out of 10. Furthermore, the first quartile is 4, whereas the second and third quartiles are 5. This represents that most students got high marks, as the value 4 corresponding to the first quartile is associated to 'agree', whereas the value 5 is assigned to 'strongly agree'. Additionally, the overall coefficient of variation is 0.13, which represents low variability of the results obtained, which is seen as pretty trustworthy for being lower than 0.15.

Moreover, the reliability of the data obtained was measured through the Cronbach's alpha, which yielded an overall value of 0.801, whilst it accounted for 0.738 for the programming dimension and 0.762 for the presenting dimension. As values above 0.8 are considered as good, and those greater than 0.70 are viewed as acceptable, it may be said that the results obtained have internal consistency, considering the overall data as well as the data related to each particular dimension. Besides, those values account for high correlation between the dimensions considered, which was reinforced by calculating both the Pearson's correlation coefficient and the Spearman's rank correlation coefficient. In fact, both values were higher than 0.5, which are taken as high correlation.

As per the evaluation system stated above, it is to be reminded that the contribution of the escape room to the final mark of the course was two thirds, whereas the project-based learning activity accounted for the other one third. Hence, considering both activities and the different weights assigned to each one, the final academic performance attained is given in (1).

$$\frac{2}{3} \times 6.88 + \frac{1}{3} \times 4.56 \times 2 = 7.63 \quad (1)$$

Likewise, with respect of the final overall success achieved, it is to be seen that the marks achieved in the project-based learning activity were pretty high. This fact basically assured that the great majority of students passing the escape room activity got an increment in their final grades, while none of them got a final mark under the passing score. Otherwise, one of the students who failed the escape room got a final mark which overcame the passing score of 5, whilst the other two students could not make it. In short, there were 23 students out of 25 who eventually passed the course, whereas other 2 students failed.

Therefore, considering both the escape room and the project-based learning activity, and taking into account the evaluation system exposed above, it has to be compared the final academic performance and the final success rate attained this current academic year with respect to the previous academic year in the same course. In fact, Table 14 exhibits the rise in the final academic performance and in the final success rate as well.

On the one hand, the final average grade achieved in the previous year was 6.25 out of 10, whilst in the present year it was 7.63 out of 10, which stands for a rise of 22% in the final academic performance. On the other hand, the success rate in the previous year was

19 out of 24 students, namely 0.77, whereas in the present year it was 23 out of 25 students, namely 0.92, thus accounting for a rise of 19% in final success rate.

Table 14. Rise in final academic performance and final success rate, considering both the escape room and the project-based learning activity.

	Previous Academic Year	Current Academic Year	Variation Ratio	Percentage Rise
Final Academic performance	6.25 out of 10	7.63 out of 10	7.63/6.25 = 1.22	22%
Final Success rate	19 out of 24 = 0.77	23 out of 25 = 0.92	0.92/0.77 = 1.19	19%

In short, the rise in academic performance is 10% when considering just the escape room, while it is 22% when considering both the escape room and the project-based learning activity, whereas the rise in success rate is 14% in the former and 19% in the latter. At first sight, it seems clear that adding the project-based learning activity led to an increase the values attained. However, it may be argued that the distribution of the weights assigned in the evaluation system implemented could be the reason why the final figures grew. Likewise, other possible reasons might be the deployment of a peer-review system for evaluation, where students were quite generous in their assessments, or even that the further activity was not as demanding as the original one.

Anyway, according to the literature, the increment described in academic performance when implementing active learning in STEM courses is reported to be around 15% [28], whereas the increment reported in success rate is reported to be around 20% [29]. Hence, the increments achieved herein when considering only the escape room are relatively close to the figures reported, whereas the increments attained when considering both the escape room and the project-based learning activity get even closer to the values reported, although the reasons exposed before may have influenced the definitive figures achieved [30].

Consequently, sticking only to the escape room results, it may well be said that the percentage rise achieved herein, namely 10% in academic performance and 14% in success rate, could be considered to be both in line with the increments reported in the literature when applying the active learning paradigm in the field of STEM education.

With respect to the measurement of the level of engagement, which was done through the ISA engagement scale [31], the outcome exhibited in Table 10 presents average values above 6 in all dimensions, namely 6.51 for the intellectual one, 6.64 for the social one and 6.69 for the affective one. Hence, the overall average considering the 3 dimensions involved is 6.61, which is clearly above 6. This benchmark is assigned to 'agree' in the 7-point Likert-type scale used, and as a consequence, it could be stated that a high level of engagement has been achieved during the activities developed [32].

Furthermore, the first quartile value is 6, the second and third quartiles are both 7, which proves that most of the students taking part in the activities were highly motivated. Additionally, the overall coefficient of variation is 0.09, which represents low variability of the results obtained, which is seen as pretty trustworthy for being lower than 0.15. In addition to it, the coefficient of variation corresponding to all dimensions were also lower than that benchmark.

Besides, the data reliability was calculated by means of the Cronbach's alpha, which accounted for an overall value of 0.703, while it resulted in 0.925 for the intellectual dimension, 0.736 for the social one, and 0.788 for the affective one. As those values are all above 0.7, they are considered as acceptable, even though the value attained in the intellectual dimension is greater than 0.90, which is viewed as excellent. Hence, it may be said that the results related to engagement have internal consistency, either the overall data, or the data related to a given dimension.

Moreover, such values account for high correlation among the dimensions considered, which was reinforced by finding out both the Pearson's and the Spearman's rank correlation coefficients for data corresponding to every pair of dimensions. All values

attained were higher than 0.5, so it may be said that there is a high correlation among the dimensions considered.

Additionally, it has been reported that student performance in active learning contexts is geared by student engagement, which may be modeled as a product of two factors, such as student motivation and active learning experiences [33]. In other words, high motivation in active learning contexts leads to high engagement, which in turn leads to better performance and improved learning, which is the ultimate goal [34].

As a final note, it is to be reminded that the course where the escape room and the project-based learning activities where implemented as an active evaluation scheme had 25 students, so the sample size of this study is limited to these scholars. It might be considered that this sample size is too small to undertake this kind of refined statistical analysis, even though it was done in order to be as rigorous as possible with the conclusions achieved out of the results presented in spite of the small sample size, as those conclusions could be useful and extrapolated to similar courses.

In addition to it, there are other research studies in the literature in the education field with the same sample size dedicated to different areas, such as quantum physics [35], mathematics [36], technology [37], or physical education [38].

6. Conclusions

In this paper, a generic multilevel structure for educational escape rooms is proposed. Basically, the layout suggested is a sequence of linear paths, such as a given path must be cleared before starting the following one. This setup allows to dedicate each path to a different didactic unit, chapter, or issue. Therefore, this design could be used in any educational areas within humanities, social sciences and STEM education.

This instance of escape room was used as an evaluation tool in a course devoted to architecture and technology of computers. Such a course was composed of three didactic units, hence the escape room was designed with three levels, where each one was dedicated to a specific didactic unit. In addition to it, a project-based learning activity was also proposed, whose assessment was done on a peer review basis, such that the escape room contributed with two thirds of the final grade of the course, whereas the project-based learning activity accounted for the other third.

Comparing the evaluation of the same course in the previous academic year, where traditional evaluation was carried out, and in the current academic year, where an evaluation based on an active learning approach was undertaken, it happens that a rise in both academic performance and success rate has been detected. Specifically, if only the escape room is considered, then the rise in the former was 10%, whereas the rise in the latter was 14%, which are not far away from the figures reported in the literature.

On the other hand, if both the escape room and the project-based learning activity are considered, according to the evaluation system exposed above, then it occurs that an increase in both academic performance and success rate is spotted as well. Specifically, the rise in the former was 22%, whilst the rise in the latter was 19%. Those values get closer to the figures reported in the literature, even though the calculation of those figures are conditioned by different factors, such as the distribution of weights assigned to the different activities, or the use of a student-centered assessment as opposed to a teacher-centered assessment.

Additionally, the level of engagement was also measured regarding both evaluation activities, which resulted in a high level of engagement according to three dimensions, such as intellectual, social and affective. According to the literature, high engagement leads to better performance and improved learning, hence it seems that the high level of engagement experienced in the active learning activities proposed is the primary source of the rise in both academic performance and success rate.

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Abbreviations

The following abbreviations are used in this manuscript:

ICT	Information and Communication Technologies
IP	Internet Protocol
IT	Information Technology
PBL	Project-Based Learning
SDL	self-directed learning
SEG	Serious Educational Games
STEM	Science, Technology, Engineering, Mathematics
TBL	Team-Based Learning

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