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Input:  $i, x, y$ 
 $min \leftarrow 5$ 
LastState  $\leftarrow 7$ 
LastLevel  $\leftarrow 3$ 
While  $i \geq min$  do
   $y \leftarrow y + 1$ 
   $i \leftarrow i - 1$ 
  If  $y == LastState$  do
    If  $x == LastLevel$  do
      break // End of Game!
    Else
       $x \leftarrow x + 1$ 
       $y \leftarrow 0$ 
      break // Keep Playing!
    EndIf
  EndIf
EndWhile

```

Algorithm 1. Pseudocode representing the behavior of a given exam score in this escape room

It is to be noted that if a player is at the starting state of a given level and top marks are obtained, which is 10, then the player reaches the end point of its current level, which automatically leads to the starting state of the next level. Therefore, the design of this escape room permits to clear one level in just one move, as long as top marks are obtained, which leads to move end to end in the escape room with just four exams if top marks are obtained in all cases.

On the other hand, if the first exam is passed, but top marks are not obtained, then the player gets moved to an intermediate state of that level. Hence, the target for the next exam is to get to the ending point of that level, no matter the score attained because the excess of marks after reaching the end point of a level is not taken into consideration. That is why this layout is considered to be formed by a string of multiple independent levels, as movement in two consecutive levels cannot be made with a single exam, such that one exam only allows to move until the last state of a single level.

This feature opens up a bunch of strategies when facing the escape room. This way, some players may decide to go for the minimum marks needed to reach the end point of a level in order to get there as soon as possible, although that plan may backfire if only a question is answered in a wrong way. Otherwise, other players may decide to go for the maximum marks no matter how much they need to get promoted to the next level so as to assure the clearance of the current level.

Obviously, any other possible master plan could also be followed in between the two options described, where the former could be considered as a risky option and the latter could be labeled as a conservative option. Nonetheless, it must be taken into account that the more questions are asked in an exam, the more time is needed to ask those questions, even though the more certainty is

achieved in securing the necessary marks to get promoted into the next level.

Eventually, the goal in this escape room is to get it done in the shortest possible time, as it accounts for top marks for the quickest player, whilst high marks are granted for those clearing it within a tight time constraint. Likewise, those players clearing it within a loose time constraint obtain passing marks, whereas those not being able to clear it in a timely manner will fail. Furthermore, it is to be noted that we considered one hour as the tight time constraint and one hour and a half as the loose time constraint, although those benchmarks could be adjusted to fit other time restrictions.

3. Results

To start with, it is to be noted that the number of students in the previous academic year in this course was 24, while the amount of scholars in the current academic year within the course was 25, hence the values obtained from both courses are comparable. It is to be reminded that traditional evaluation was undertaken last year by assessing scholars with a written exam, whereas active evaluation was considered this year by deploying the escape room. Having said that, on the one hand, Table 1 exhibits the average final grades obtained by the students in both academic years, along with the percentage of increase between them.

Table 1. Average academic performance

2022-2023 average marks	2023-2024 average marks	Average mark variation
6,79	7,60	12%

On the other hand, Table 2 exposes the success rate achieved by students in both academic years, along with the percentage of increase between them.

Table 2. Success rate

2022-2023 success rate	2023-2024 success rate	Success rate variation
$18/24 = 0,75$	$22/25 = 0,88$	13%

4. Discussion

According to the literature, the use of educational escape rooms in STEM-related subjects provides an increase of around 15% in the academic performance of learners [28]. If this rate is compared to the average mark variation exposed in Table 1 above, which is 12% between the marks obtained in the previous and the current academic years, it may be said that the rise obtained herein is pretty coherent with the increase rate seen in the literature.

Analogously, the literature provides an increase of around 20% in the success rate when introducing educational escape rooms in STEM-related subjects [29]. If that rate is confronted to the success rate variation exhibited in Table 2 above, which is 13% between the success rates achieved in the previous and the current academic years, it may be stated that the rise achieved herein is fairly coherent with the success rate viewed in the literature.

Additionally, we measured the level of engagement of learners by means of the ISA engagement scale [30]. This type of measurement was not undertaken in the previous academic year, even though we considered to carry out such a measurement in the current academic year in order to check the impact of the introduction of educational escape rooms as an evaluation tool.

It is to be noted that the ISA engagement scale associates engagement to three dimensions, which are intellectual, social and affective. Such dimensions are estimated by means of three standard questions for each one, which are all rated on a 7 point Likert-type score according to the perspective of each student. Afterwards, the average of the questions related to each dimension for all students is calculated, thus providing the values of those three facets of engagement, and finally, the average of those facets gives the overall level of engagement. Therefore, if the engagement values for each facet and overall is at least 6, then it is considered a high level of engagement, which is the expected outcome.

The Table 3 provides the three standard questions for each of the three dimensions, which could be fitted into an educational environment, or any other area, although the ISA engagement scale was originally created for working environments, and that is the reason why the nine standard questions of the ISA engagement scale specifically refer to work [31]. Nonetheless, many studies in the literature consider this scale as appropriate for measuring the level of engagement in educational environments [32].

Table 3. The ISA engagement scale

Dimensions	Questions
Intellectual engagement	I focus hard on my work.
	I concentrate on my work.
	I pay a lot of attention to my work.
Social engagement	I share the same work values as my colleagues.
	I share the same work goals as my colleagues.
	I share the same work attitudes as my colleagues.
Affective engagement	I feel positive about my work.
	I feel energetic about my work.
	I am enthusiastic in my work.

With respect to the three dimensions, it is to be

said that intellectual engagement refers to the degree of intellectual absorption that students experiment when carrying out a particular task, whereas social engagement refers to the degree of feeling socially connected that scholars experiment towards their peers when doing a particular task, whilst affective engagement refers to the degree of positive feelings experienced that learners experiment when undertaking a particular task. Additionally, the level of engagement overall is obviously the average of all three dimensions or facets of engagement [33].

The average results for each dimension and overall are shown in Table 4.

Table 4. Level of engagement achieved with ISA scale

Intellectual engagement	Social engagement	Affective engagement	Overall measure
6.22	6.43	6.51	6.39

Looking at the results obtained in the ISA engagement scale, it appears that the level of engagement is high for all facets, as the related scores are above 6. However, the intellectual one obtained the lowest score, whilst social and affective facets achieved quite similar values. Those results could be explained by assuming that scholars feel a bit more motivated by the overall gaming experience and the competence among teams than the cognitive motivation. Additionally, the affective facet achieved slightly higher outcome than the social one, which may be explained by assuming that the gaming environment gets scholars a bit more motivated than the competence among their peers.

Anyway, those levels of high engagement seems most likely the key factor so as to explain the outcome achieved in academic performance and success rate, as it has been pointed out in the literature cited above. This way, learners work harder in order to perform better in the escape room, which leads them to attain better grades whilst having fun.

5. Conclusions

In this paper, a design for a model of educational escape room as an assessment tool has been presented. The structure proposed is a variation of a sequential path model, even though it is made of a collection of multiple independent levels. This way, each level is composed of a string of puzzles interconnected as a sequential path, although each level must be cleared before being promoted to the next one within the structure of the escape room. Eventually, the goal is to clear all levels as soon as possible in order to the higher marks, where puzzles forming the different levels of the escape room are set up according to meet the educational objectives.

This type of escape room was used as an assessment tool in a college course devoted to

introduction to computer science, which was held in the first semester of the current academic year, namely 2023-2024, with a number of 25 respondents. The outcome attained have been confronted to those attained by the 24 scholars attending the same course in the previous academic year, namely 2022-2023, whose evaluation was done with a written exam.

The results obtained with the active evaluation paradigm in the current year, namely the escape room, achieved a better academic performance of 12% above the outcome attained with the traditional evaluation in the last year, namely the written exam. Likewise, the results obtained with the escape room in the current year achieved a higher success rate of 13% above the figures attained with a written exam. Those figures were pretty similar to those quoted in the literature for STEM courses.

Additionally, the ISA engagement scale was used in order to measure the level of engagement of scholars when taking part in the escape room. The values obtained for the three dimensions accounted, namely intellectual, social and affective, were all above 6, meaning a high level of engagement.

Finally, a high level of engagement is considered in the literature as the driving force to improve both academic performance and success rate when applying escape rooms as an evaluation tool, and the results obtained herein prove it right.

6. References

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