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Teaching calculus in the first year of an engineering degree using a Digital Escape Room in an online scenario

Ángel Alberto Magreñán[1] | **Cristina Jiménez**[2] | **Lara Orcos**[1] | **Simón Roca**[1]

[1]Department of Mathematics and Computation, Universidad de la Rioja, Logrono, La Rioja, Spain

[2]Department of Applied Mathematics, Universitat Politècnica de València, Valencia, Comunitat Valenciana, Spain

Correspondence
Ángel Alberto Magreñán, Department of Mathematics and Computation, Universidad de la Rioja, C/Madre de Dios 53, Logrono, La Rioja, 26004, Spain.
Email: anmagren@unirioja.es

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Abstract

In recent years, the way in which mathematics is taught has changed radically and there has been an increase in the percentage of online classes. One of the biggest challenges that teachers face in this type of online scenario is the need to motivate students so that they do not lose the thread and continue with their usual rhythm and seek methodologies that facilitate the teaching–learning process. The growth of educational technology has become a powerful ally in carrying out this study. This study presents the use of a digital Escape Room in an online scenario for teaching mathematics in the first course of engineering. To measure the results, a pretest–posttest experience has been considered with two different groups of the first course of engineering in an online university. Some comparison tests of the qualifications obtained by both groups shows that, despite they were homogeneous in terms of previous knowledge of calculus in the beginning, the differences obtained between those who have used the Escape Room instead of the traditional methodology are significative. In addition, the effect sizes obtained were intermediate and also considering the results of the survey allows us to conclude that the use of the digital Escape Room is a very good tool for teaching Calculus in Engineering. Finally, it is also important to highlight that the satisfaction of the student with respect to the experience has been very high and they asked for more experiences like this.

KEYWORDS

engineering, escape room, first course, mathematics, online environment

1 | INTRODUCTION

Digital development in the twenty-first century has followed an exponential curve, and Information and Communication Technologies (ICT), after integrating society, have been arriving in the classroom to stay. The pandemic era that has been experienced in recent years has shown that these ICTs, with good planning and proper selection, become a great ally in the classroom. But the current student body has not experienced that change since for them technology has always been there and their way of accessing knowledge, as well as the way

of communicating, is different from what it was years ago, that is why teaching staff must try to adapt to these changes. In addition, with the increase in mobile devices as well as the need for immediacy that arises precisely from the evolution of connections and of said devices, new models must be sought that allow taking full advantage of these and that, in addition, are more attractive to students with different options and needs than in the past.

New educational technologies and even dispositives, that can be used in the mathematics classroom, are constantly appearing to improve the teaching-learning process. The appearance of these tools, which range from software capable of helping with the visualization of different figures in three dimensions, such as the possibility of calculating the resistance of a certain material, has allowed the way in which classes are taught to evolve and the positive effects of the use of these tools have been pointed out by many researchers in the area [1, 3, 5, 7, 11, 19, 20, 22, 23, 24, 26].

The use of these technologies together with the appearance and development of new emerging methodologies such as the use of gamification and serious games in the classroom have shown that there are other ways of teaching mathematics at any level so that students can improve its assimilation and overcome the different learning obstacles present [2, 17, 28].

In this article, an experience in the classroom of the mathematics subject in the first year of engineering and more specifically in the Calculus part, which involves the computation of derivatives and optimization processes is presented. To carry out this experience, it has been decided to use a digital Escape Room that allows students to carry out the process properly and that is motivating and thus prevents them from disconnecting. Thus, in this study, we have worked with genial.ly to develop said Escape Room since it allows the development of very dynamic scenarios that are attractive to students. To verify the benefits of using this Escape Room, two homogeneous groups have been taken, one of them that has received the classes in a traditional way in an online scenario, considered the control group, and another group that has worked through the Escape Room and that has been considered as an experimental group. The organization of the article is as follows: Section 2 contains the state of the art in which some types of learning and its properties are presented, then in Section 3 the methodology used in this study is presented including the objectives, the sample, and the data collection instruments, Section 4 is dedicated to present the results, and Section 5 present the main conclusions drawn to this study.

2 | STATE OF THE ART: GAMIFICATION, ESCAPE ROOMS, AND GENIAL.LY IN MATHEMATICS LEARNING

The usage of games combined with information technologies in Mathematics classrooms is no longer a novelty across different educational levels and contexts. Once computers were present in a majority of homes and schools, and closely related to the advent of the Internet, teachers have been learning how to incorporate these tools into their daily-basis teaching practice.

Divjak and Tomić [6] conducted a literature review in which they could assess the effects of mathematical games on learning. They analyzed 32 previous works from 12 different countries and students of distinct levels, looking for evidence of the impact of these games on realizing educational goals and their effects on attitude and motivation. They concluded that there was major evidence of mathematical computer games leading to a more efficient and quicker realization of educational goals, as well as to a positive attitude towards Mathematics, by the time they contributed to boosting their motivation, acquisition, and long-term memory. As an example of a concrete case, Wang et al. [35] created a role-playing game to encourage elementary school students to learn mathematics, proving better learning achievements and motivation.

One of the distinctive elements of game-based education is the interaction of students with the game itself, as well as with their peers on several occasions when cooperative features are added. The fact that this interactivity can be provided by computers is well known. For instance, Drier [8] explored with preservice and in-service Math teachers at middle and secondary levels the usage of interactive spreadsheets with students. These tools promoted open-ended exploration of mathematical concepts, extending what students could do with pencil and paper, and establishing connections between numeric, algebraic, and graphic representations. His work, based on Microsoft Excel, resembles current resources designed with tools like GeoGebra.

In this sense, some game methodologies and formats are especially suitable to encourage interaction in students, with the subject, and between peers. Escape Rooms—playful scenarios in which a group of people has to pass tests, finding clues, with limited time, in a real environment—have been a popular approach to promote this interaction between students and a contextualized subject. Fuentes-Cabrera et al. [10] analyzed the potential of Escape Rooms as an active methodology in Secondary education. Students had to face a challenge in which there was a room with two computers and a tablet,

having to surf the web to try to solve codes and enigmas. All the tasks were related to curricular mathematic content. Using questionnaires they assessed the contributions of the Escape Room to improve learning achievement and decrease learning anxiety, motivation, and autonomy. López-Belmonte et al. [21] observed equivalent results with preservice Mathematics teachers, who manifested benefits in motivation, group cohesion, and engagement, as well as a decrease of negative effects on emotions, after participating in an Escape Room, among other measured elements of their experience through the GAMEX scale (Gameful Experience Scale) [9].

Several works show how these methodologies provide positive experiences among students. However, it is also relevant to measure how can these tools help to improve knowledge acquisition and academic performance. In Jiménez et al. [18] designed a two-session activity in which 14–15-year-old students had to face both a digital Escape Room and a breakout to review their own knowledge of algebra. These activities were contextualized in a way the solutions of the different mathematical exercises had a meaning in the environment of these games. In the case of academic performance, there was a significant improvement in the grades of the experimental group compared with the control one in their respective equation exam. In addition, students felt satisfied with the experience, considering that their learning results had increased, and that it was a fun experience that promoted greater autonomy in their learning.

In a similar manner but applied to university students, Queiruga-Dios et al. [31] designed a breakout experience for freshmen engineering in a Calculus course. Students have to figure out by teams how to unlock a computer attacked by a virus. To do so, they add to apply different knowledge about Calculus and Cryptography. The students had to interact with themselves, and videos and theme cards related to the story. Some interesting conclusions after observing different players are that they typically would not review all the information they had until they did not know how to continue. Besides, apart from motivation, some students got very competitive.

On another hand, some of the exposed works rely on digital experiences, with different degrees of playful activities taking place in multimedia environments. In these cases, the way in which information and knowledge are presented is relevant. In relation to this fact, Sudakov et al. [33] discussed how to create infographics in educational settings, analyzing infographics in undergraduate mathematics and climate studies. They also polled US and Russian students about their experience with undergraduate courses. Several students manifested learning difficulties regarding too much information, lack of illustrative examples, and the acquisition of knowledge solely from lectures. The perceived usefulness of infographics by students varies across different disciplines, with higher values in Science and Math fields.

In a digital environment, teachers should rely on tools that simultaneously allow them to effectively include the information they want to share and be learned, the interactivity elements enhancing meaningful experiences for students, and the easiness to manipulate the tool both for teachers and students. Among the different alternatives available to create interactive presentations, this article put the focus on Genial.ly.

Genial.ly is a SaaS (Software as a Service) platform suitable for education, marketing, and communication, created in Spain in 2014 and HTML5 based [29]. It provides different and customizable templates in which texts, multimedia sources, animations, embedded objects, and so on, can be added and interacted with. In its relatively short existence, it has already been objecting to study as support in educational environments. Orellana-Cordero et al. [27] analyze the suitability of this tool to create virtual learning objects meeting the needs of both teachers and high school students. Teachers agree about the easiness to create interactive content, the quantity and quality of templates, and the ability to design them without knowing computer programming. Students find it relevant to be told which contents are to be learned in advance, how to use the object, be answered about doubts, or even be asked about design decisions. The authors provided different presentations showing different formats or templates, like quizzes and breakouts.

This kind of tool suddenly become popular in 2020 due to the COVID-19 pandemic, when teachers from all parts of the world and educational levels were forced to adapt in no time to distance education. Many people were familiar with different software tools capable of enriching and complementing this type of teaching, with tools like Genial.ly marked together with many others as useful for teachers and students [16].

Nevertheless, its value has been measured and taken profit of for years, independently of a face-to-face and/or distance learning scenario. Concretely, Genial.ly has been used in different contexts, such as in a personal image vocational training course to encourage students to create their own personal learning environments [25], combined with other tools like Scratch or Camtasia to update and make more attractive materials in Citizenship Education for Secondary Education [30] or to combine it with VoiceThread to improve the English pronunciation in university students [15].

3 | METHODOLOGY

This section will proceed to explain the method followed to conduct this experience, for which the objectives pursued in this study will first be presented, then the procedure followed and, finally, the variables considered and the instruments for collecting information.

3.1 | Objectives

In this study, the following objectives have been considered:

- To design and implement a digital Escape Room to work on Calculus in Engineering.
- To analyze the data obtained in both initial and final evaluation tests in a sample of Engineering Degree students and compare the results of the group who worked with the tool with those that worked in a traditional way.
- To analyze student satisfaction with working with the Escape Room as a tool for the mathematics classroom.
- To reflect on the potential of the use of a digital Escape Room as a learning tool in Higher Education.

3.2 | Sample

The sample of this study consisted of 51 students of Calculus in the first year of an Engineering Degree at a university located in Spain. From the sample, 30 students formed the experimental group, who worked with the Escape Room, and the other 21 formed the control group who worked on the contents in a traditional way in an online environment with slides and an online blackboard to show examples and applications of the theory.

3.3 | Experience of the Escape Room

This experience was related to Calculus contents, which are completely necessary for engineers since optimization, movements, and several applications are based on the use and computation of different derivatives and studying functions. The contents treated in this experience:

- Functions and their properties.
- Different types of functions and their study.
- Domain of a function in the real line.
- Derivatives.
- Optimization.
- Problems involving derivatives and optimization.
- Solving problems involving real situations in which they need to use all the previous contents.

The Escape Room has different clues based on the solving of some exercises and if the answer is right, the next clue appears, but when it is wrong there are some short videos explaining the theory involved until a right answer is given. In the designed Escape Room each of the missions have a clear purpose: the first one is to familiarize with the Escape Room and refresh the theoretical background, the second one is related to the continuity and derivability of functions, the third one is related to solving problems associated with optimization, the fourth one is based on an exercise that needs all the previous concepts to be used to obtain some values of parameters and the last mission is connected to the posttest to know the improvement after the use of the Escape Room.

First of all, students from both groups, control and experimental, have to answer the pretest. Then, the experience with the Escape Room begins with an introduction, see Figure 1, and then it appears a little explanation of how to use it in terms of usability of the map can be seen in the upper part of Figure 2. Each ubication, as it can be seen in the lower part of Figure 2, shows a miniature of the exercise that students have to solve and in the last ubication, it is the posttest linked. Once the first mission is clicked, see Figure 3, the exercise appears, which in this case is theoretical and multiple choice-type, in which only one is correct. If the option selected is incorrect students receive a different message explaining the mistake they have done with comments relative to the theory involved, see Figure 4, but if the option selected is correct a message is shown explaining why it is correct and the theoretical background involved, see Figure 5. Once this first mission is fulfilled, a clue to consider for the following parts of the game appears on the screen, see Figures 6 and 7. This first mission is the easiest one to make students familiarize themselves with the Escape Room and how it works.

The second mission needs first to consider the clue shown previously and to find the location on the screen, see the first three images in Figure 8. When students find it, a first clue is given on the screen, see the last image in Figure 8, this clue will be important for beating the mission. Then a problem that needs to be solved appears, see Figure 9. If they choose the incorrect answer they will receive a message explaining why it is wrong and a video with examples related to the question to illustrate the theoretical background. If they choose the correct answer, it is shown as a reinforcement of the theory, see Figure 9. After selecting the right answer, an important clue is given. Then, the second exercise

FIGURE 1 First and second screens of the virtual Escape Room

appears and, as can be seen in Figure 10, the itinerary is the same as in the first example, so they must select the right answer to get the clue. Once this second exercise is completed, the second mission is finished, and they have to go to the third one.

In the beginning of the third mission, a group of boxes appears in which and students have to consider the clues given in the previous mission to find the correct one. Once this box is selected, an optimization problem appears, see Figure 11. This mission has four different problems to be solved to obtain the solution and find the next clue, as shown in Figure 12. Again, if they fail in any of the answers, a screen with an explanation and information about the mistakes appears and if they select the right answer they also obtain an explanation to reinforce the desirable choice.

The fourth mission is shown in Figure 13 where it appears the previous test that needs the clues given in the third mission to be solved, is related to the values obtained in the last exercise of the last mission. Once the clue has been used, the problems related to the fourth mission are shown and, in Figure 14, appear the problems and the clue used to beat this mission, which consists in finding a pin of a mobile phone formed by the values of some parameters in the exercise.

Finally, the last mission path appears, which consists of answering the posttest to know if the use of the Escape Room is useful for students, and the experience survey to know their own perceptions about the use of the Escape Room in this way.

3.4 | Research model

The methodological design chosen is quasi-experimental since students belong to the groups without randomness since groups were fixed without the election of the

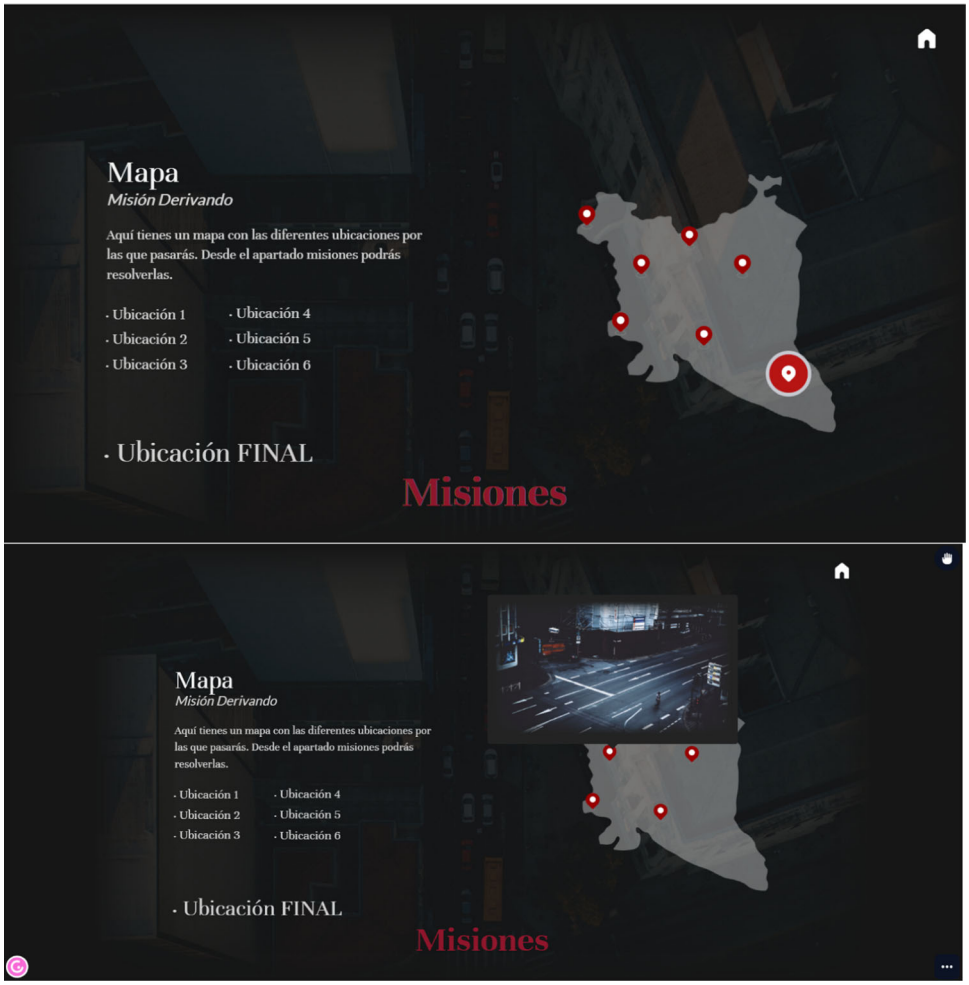

FIGURE 2 Explanation of the use of the map of the virtual Escape Room and one of the ubications

teacher and it such case a quasi-experimental model is chosen. Moreover, two different groups are considered, and two measurements have been collected. The pretest and the posttest were similar tests where five questions were involved:

- A theoretical question related to the derivative of given functions.
- One question related to the computation of the domain of a given real function.
- One question related to the computation of the domain of derivability of a given function.
- A problem related to the computation of different parameters knowing the properties of a given function.
- A real situation optimization problem in which they should find the maximum or a minimum value where they need to use previous concepts.

The pretest has been carried out by the students before the experiment and the posttest has been carried out afterward. The control group received the theory in an online traditional way slides, an online blackboard and other tools were used while the experimental group worked with the Escape Room. After they carried out the posttest a survey we used to know the perceptions of the students about the use of that Escape Room, with the following questions:

- Likert scale response (0–6) where: 0: Empty, 1: Completely disagree, 2: Disagree, 3: Partially disagree, 4: Partially agree, 5: Agree, and 6 Completely agree.
  - o Q1. Experience has made the math worked out seem easier.
  - o Q2. I liked doing the Escape Room.
  - o Q3. I would like to do more experiences like this.
  - o Q4. I consider that my motivation has increased with the experience.
  - o Q5. The experience has helped me better understand the procedures.

FIGURE 3 Appearance of the first mission and its information

- Q6. Being able to watch the videos more than once helps to resolve doubts.
- Q7. The experience has helped me to better internalize mathematics.
- Q8. I think it's a good experience to work math.
- Q9. The experience seemed like a good complement to online math classes.
- Q10. The experience has increased my interest in mathematics.

- Numerical response from 1 to 10:
  - What grade do you give to the experience?
- Open-ended question
  - Any other comment you want to add.

3.5 | Data analysis and research questions

In this study, a descriptive analysis of the results obtained both in the pretest and the posttest is firstly presented, then as the effectiveness of the use of the Escape Room is wanted to study, the Mann–Whitney *U* test (and Student's *t*) for the independent group were used to compare the qualifications obtained by the groups. Moreover, to compare if the experimental group improved their results along the Student's *t (paired samples)* and Wilcoxon tests have been carried out. On the other hand, as it is a well-known fact, it is not enough to compare groups, since results can be better in

FIGURE 4 Message shown when the wrong answers in the first mission are selected

FIGURE 5 Screen that appears when the only correct answer in the first mission is chosen

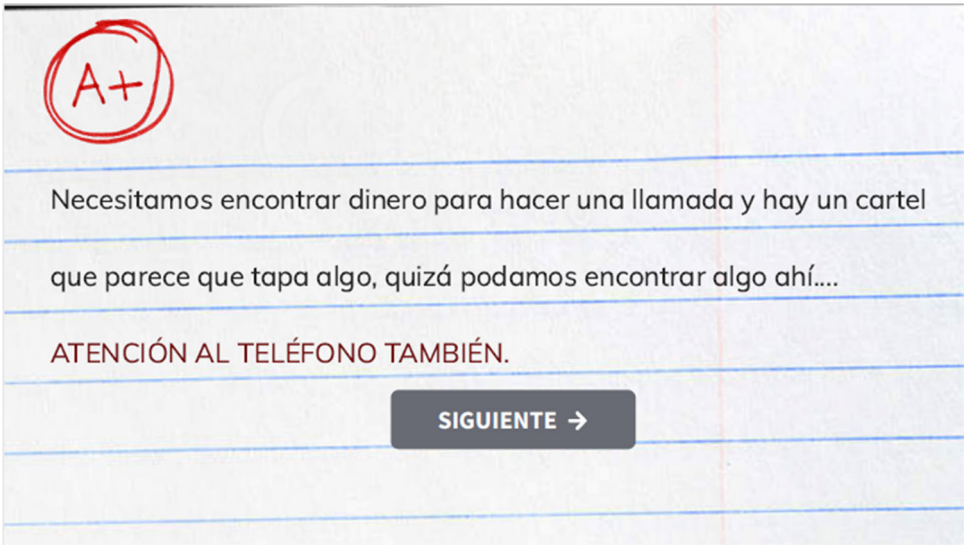

FIGURE 6 Screen, with the first clue, which appears when the right answer in the first mission is selected

FIGURE 7 Screen that shows that the first mission is fulfilled and that the second one is opened

one group, but it is necessary to know the differences in terms of magnitude [32]. So, different effect sizes will be computed. Finally, the results of the survey will be shown and studied by means of a descriptive analysis. All this analysis have been carried out using SPSS.

On the other hand, the hypothesis considered in this study are the following:

- HPretest_0: There are no significant differences between the pretest results of both groups.
- HPretest_1: There are significant differences between the pretest results of both groups.
- HPosttest_0: There are no significant differences between the posttest results of both groups.
- HPosttest_1: There are significant differences between the posttest results of both groups.
- H_EffectSize_0: The effect size of the differences is small.
- H_EffectSize_1: The effect size of the differences is at least medium.

4 | RESULTS AND DISCUSSIONS

In this section, the main analysis of the data will be presented. First, the data from both pretest and posttest will be presented and studied in a descriptive way, then group comparison tests will be done to

FIGURE 8 The way to find the second mission in which the clue received after beating the first mission needs to be considered. Students have to move the panel, pick the coins and go to the phone, then the first clue is given.

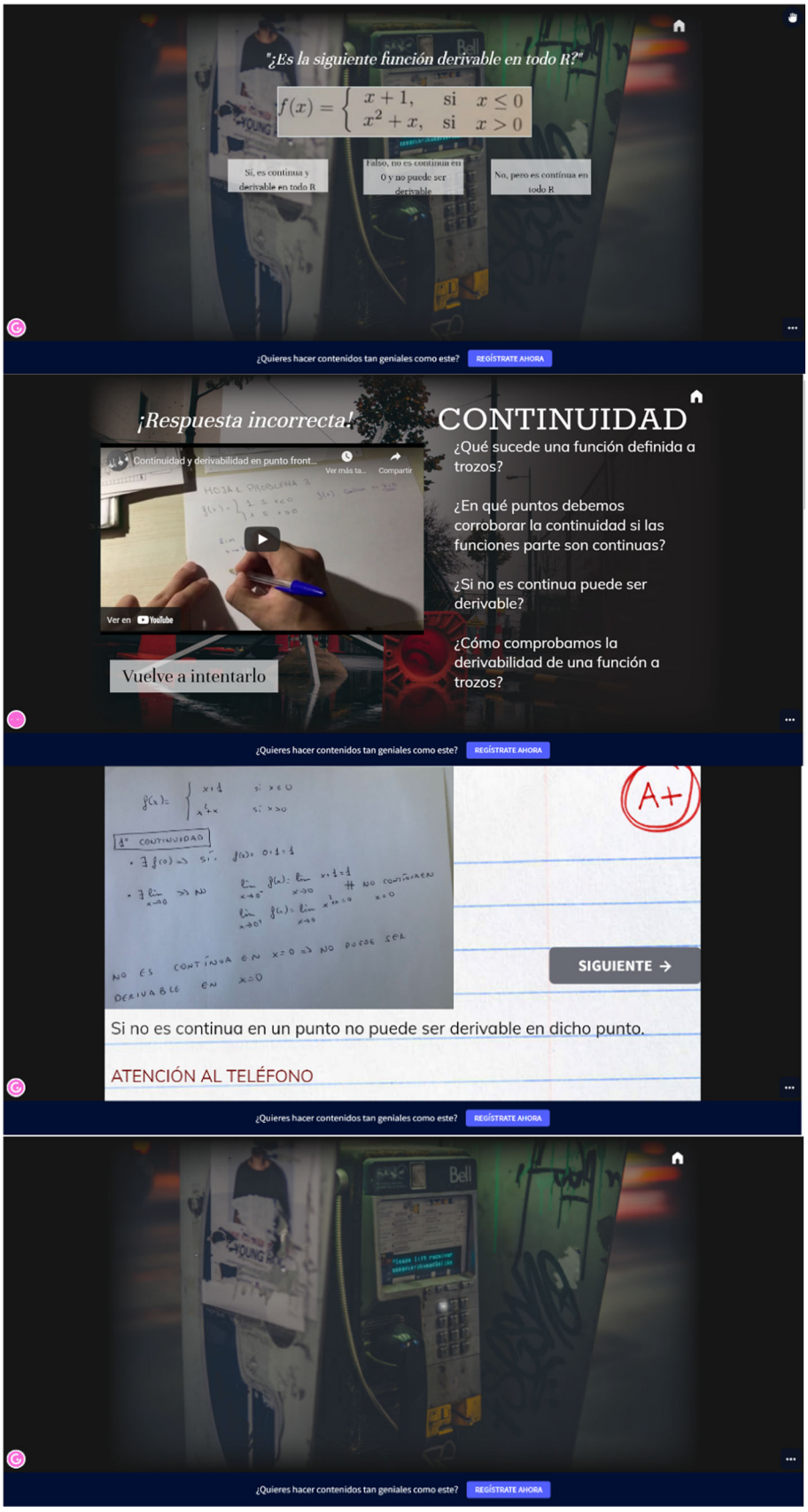

FIGURE 9 First exercise of the second mission. First image shows the exercise, the second one shows the screen that appears if the incorrect answers are chosen, the third one is the screen that appears if the correct answer is selected and the last one shows the clue given after selecting the right answer.

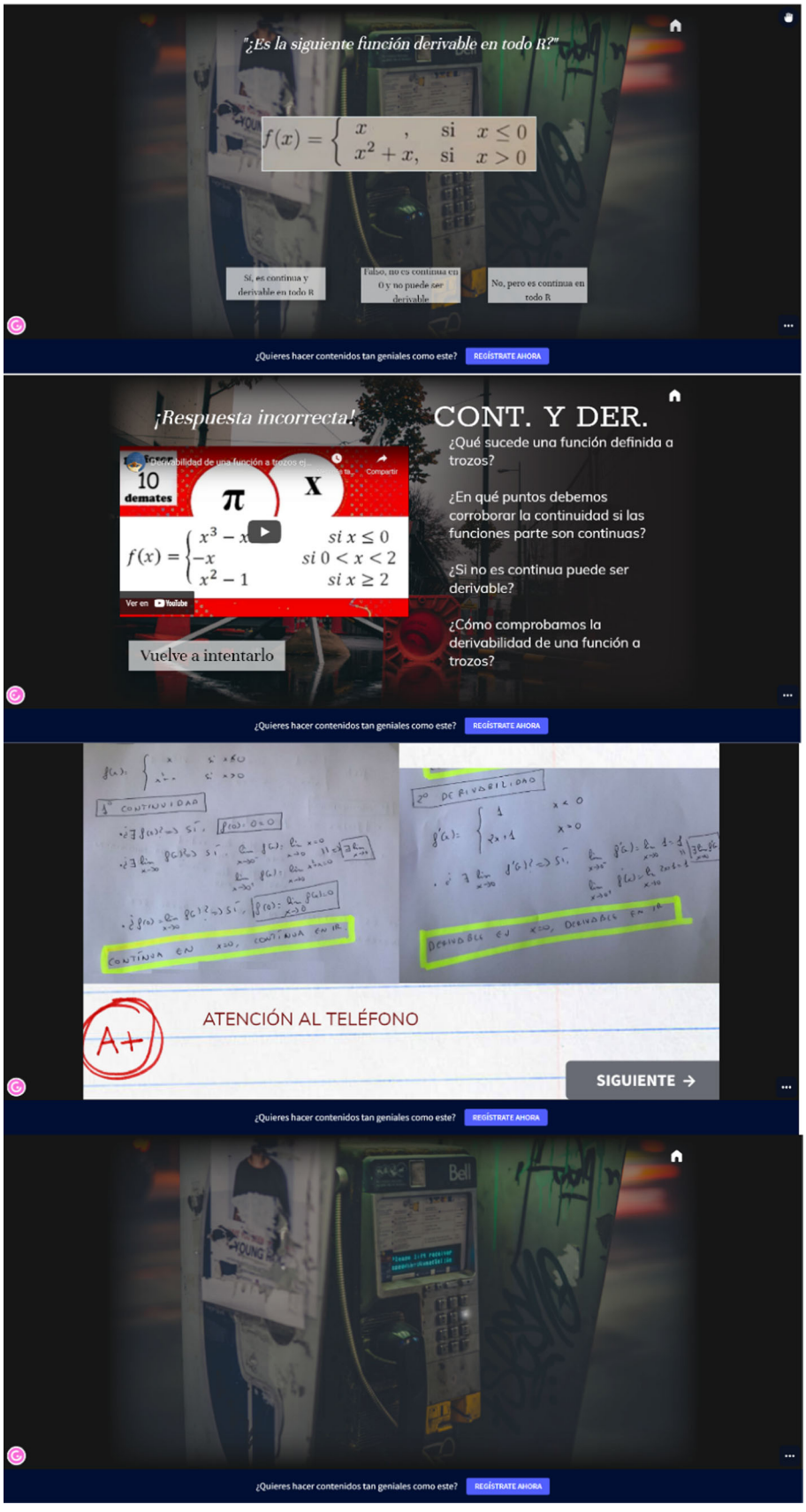

FIGURE 10 Second exercise of the second mission. The first image shows the exercise, the second one shows the screen that appears if the incorrect answers are chosen, the third one is the screen that appears if the correct answer is selected and the last one shows the clue given after selecting the right answer.

FIGURE 11 Screen of the beginning of mission 3 when students have to choose the correct box to find the next clue considering the clues given in the second mission

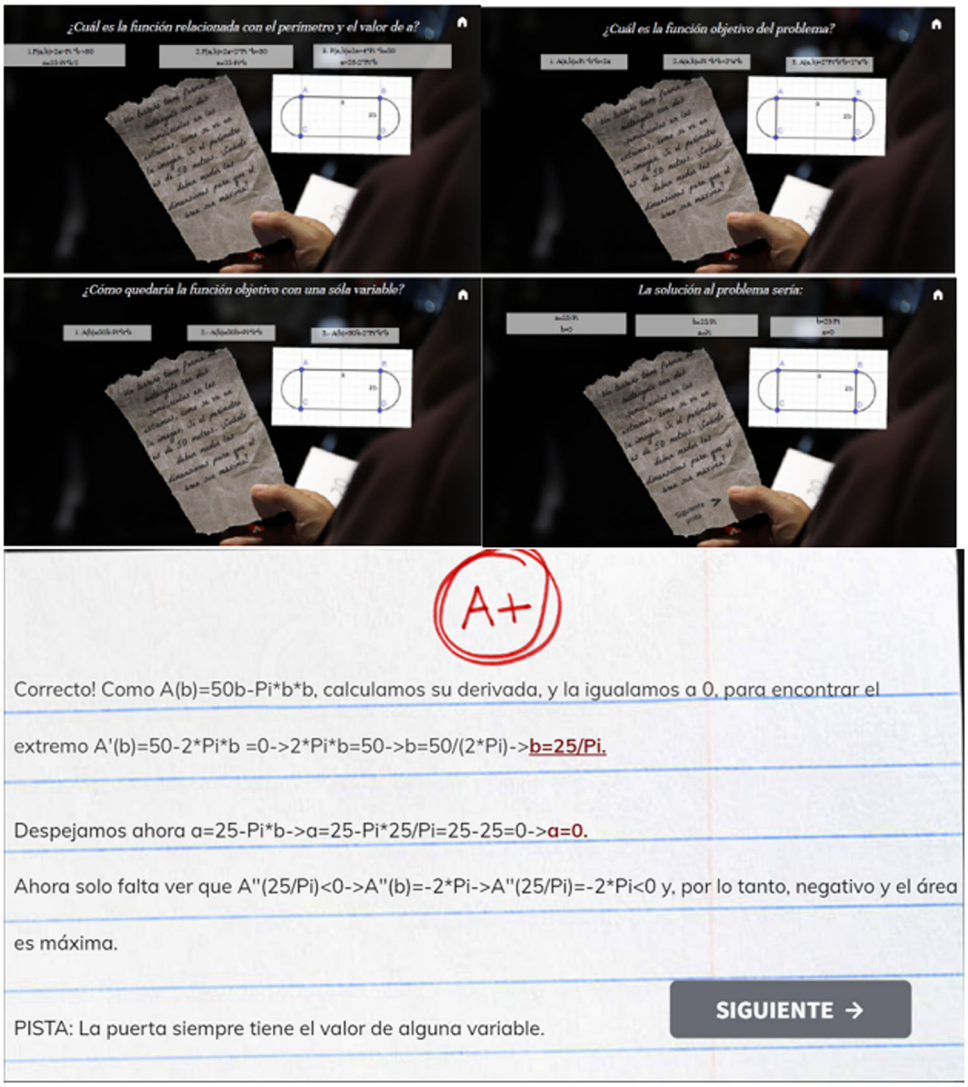

FIGURE 12 The fourth exercise that must be solved to beat the third mission and the clue for the fourth mission

finish this section by means of studying the responses to the experience survey given by students.

4.1 | Descriptive statistics in general

First of all, the general results of the 51 students that have participated in this experience, in both groups, are presented in Table 1.

From Table 1, it seems clear that there are differences in the results obtained in both pretest and posttest, but there is a need to know if the differences are the same in both groups or not, so the results will be studied in a separated way considering the control and experimental group in a separated way.

4.2 | Descriptive statistics of both groups

In Table 2, the results of the pretest and the posttest of both groups are presented, in which it seems that there are almost no differences in the pretest but the differences in the results of the posttest of both groups are considerable.

So, from the data obtained in Table 2, the differences in the prestest are only 0.08 greater in the control groups, although the median is greater in the experimental group, while the differences in the posttest are of 2.355 points greater in the experimental group which is clearly greater and a really big difference in the median is also show. The next step will consist of studying the significance of the differences by means of comparing them.

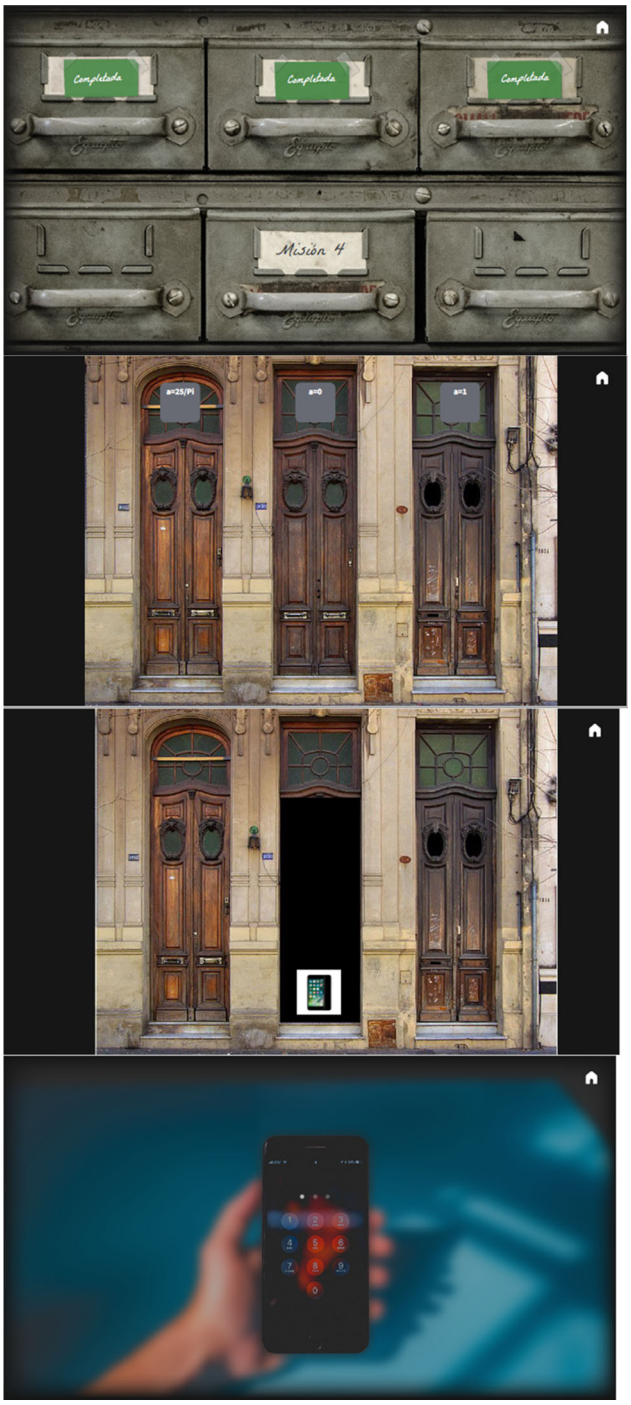

FIGURE 13 The screen of the fourth mission and its appearance when it is unlocked

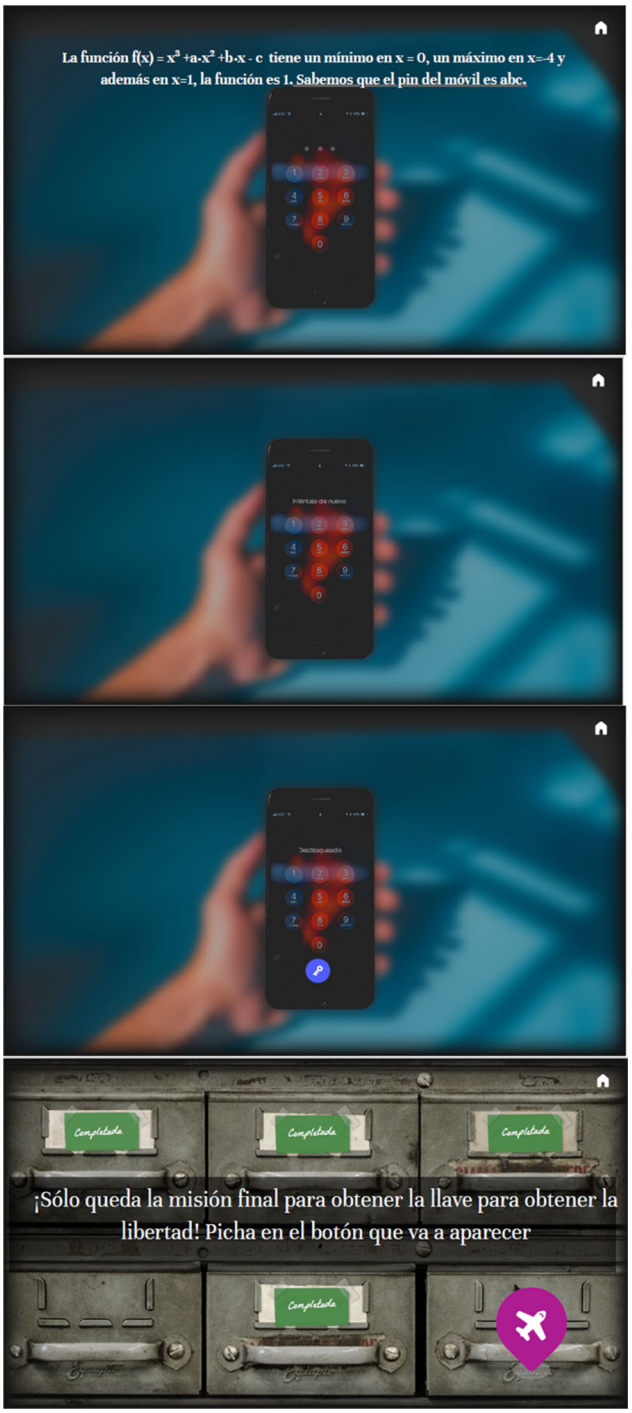

FIGURE 14 The exercise that must be solved to beat the fourth mission which needs a code, related to three parameters, to obtain the pin to unlock the phone and the answers obtained if students fail or find the right pin. In the last image, it appears the last mission redirects to the posttest to answer it.

4.3 | Result comparison of both groups

Once the differences between both groups have been presented, some comparison tests to know if those differences are significant are needed. First non-parametric test, as one group is composed of less than 30 students, but the parametric test will be also used to give more strength to the results, as the

TABLE 1 Descriptive statistics of the pretest and the posttest

	Mean	Standard deviation
Pretest	2.33	3.038
Posttest	6.980	3.1416

Kolmogorov–Smirnov and Shapiro–Wilk test of the posttest of the control group show that normality cannot be discarded, and the experimental group has 30 students. Moreover, from the Levene test, the equality of variances cannot be discarded.

From the data shown in Table 3, it is clear that the differences in the median of the pretest are not significant, and considering that fact together with that the means of both groups are similar and the observation of the teacher involved both groups can be considered homogeneous in terms of knowledge of the contents of the Calculus involved. On the other hand, the differences between the results of the posttest of both groups are significant as the two tests used, Mann–Whitney *U* (median) and Student *T* (mean), were significant. But it is a well-known fact that it is needed to compute the effect size to measure the differences in terms of comparison of both groups. Moreover, from the data the differences in the experimental group are significative and of 5.65 points greater in the posttest from the Wilcoxon's test the median of the differences (posttest-pretest) is positive and also significative, so working with the experience helped this group.

From the data in Table 4, the effect size obtained in the pretest is almost depreciable or even has no effect according to Cohen [4], which means that the differences between groups are depreciable and while the effect size of the posttest, higher in the experimental group, is medium in both effect sizes.

4.4 | Analysis of the questionnaire responses

The final part of the experience consisted of answering the experience survey related to the perception of the experience of the participants in the experiment. The responses obtained are shown in Figures 15 and 16.

The results of the first five questions are shown in Figure 15. Related to "Q1. Experience has made the math worked out seem easier," responses showed that only one student think that the experience has not made the work easier meanwhile the rest of the responses were positive including that more than the 75% responded very positively to that question, so the experience was perceived in general as an experience is perceived as a tool that facilitates the understanding of the mathematics involved. Related to the responses to questions "Q2. I liked doing the Escape Room" and "Q3. I would like to do more experiences like this," the results showed how the students really liked the experience and even requested more similar experiences for the rest of the course work since they consider that it has been very helpful, results endorsed with open-ended responses. Moreover, responses to "Q4. I consider that my motivation has increased with the experience" showed all the students who answered the questionnaire except one felt that the experience improved their motivation, which is an important result, since before the experience the

TABLE 2 Descriptive statistics of the pretest and the posttest of both groups

Test and group	Mean	Median
Pretest of the control group	2.38	0
Pretest of the experimental group	2.30	1
Posttest of the control group	5.595	5
Posttest of the experimental group	7.950	9

TABLE 4 Effect size of the data shown in the posttest (Control-Experimental)

Effect size	Test	Value	Interpretation
Mann–Whitney *U* [34]	Pretest	0.000	Almost depreciable or no effect
Mann–Whitney *U* [34]	Posttest	0.34	Intermediate effect
Glass rank biserial (rg)	Posttest	0.39	Intermediate effect
Cohen's *D*	Posttest	0.75	Intermediate effect

TABLE 3 Comparison tests used

Comparison test	Par	*Z* value	Sig. (bilateral)
Mann–Whitney's *U*	Pretest (Control-Experimental)	0.082	0.935
Mann–Whitney's *U*	Posttest (Control-Experimental)	−2.431	0.015
Wilcoxon's *W*	Pretest-Posttest (Experimental)	−4.580	0.000
Comparison test	**Par**	**Mean difference**	**Sig. (bilateral)**
Student's *T* (paired)	Pretest-Posttest (Experimental)	−5.650	0.000
Student's *T* (indep.)	Posttest (Control-Experimental)	−2.3548	0.007

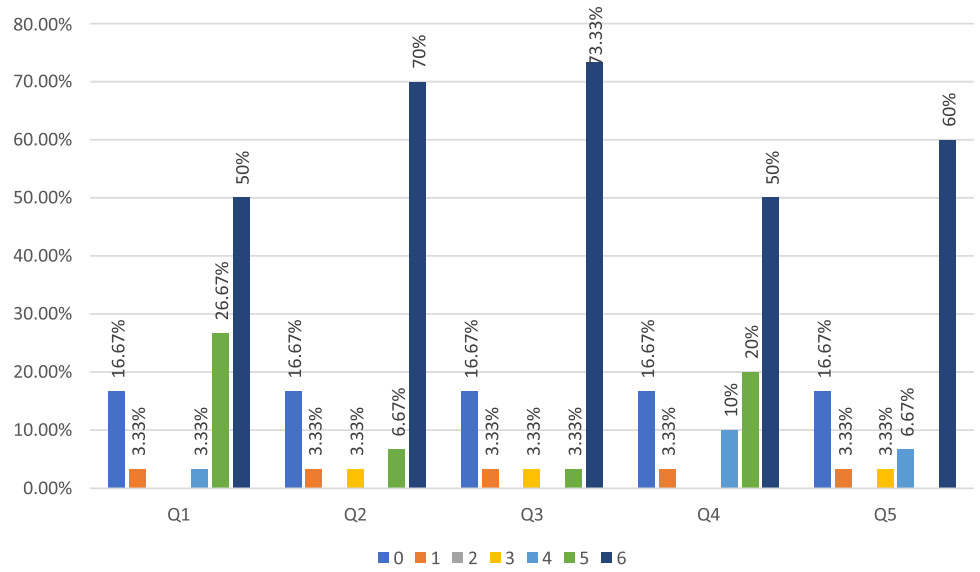

FIGURE 15 Responses to the first part of the questionnaire (Q1–Q5)

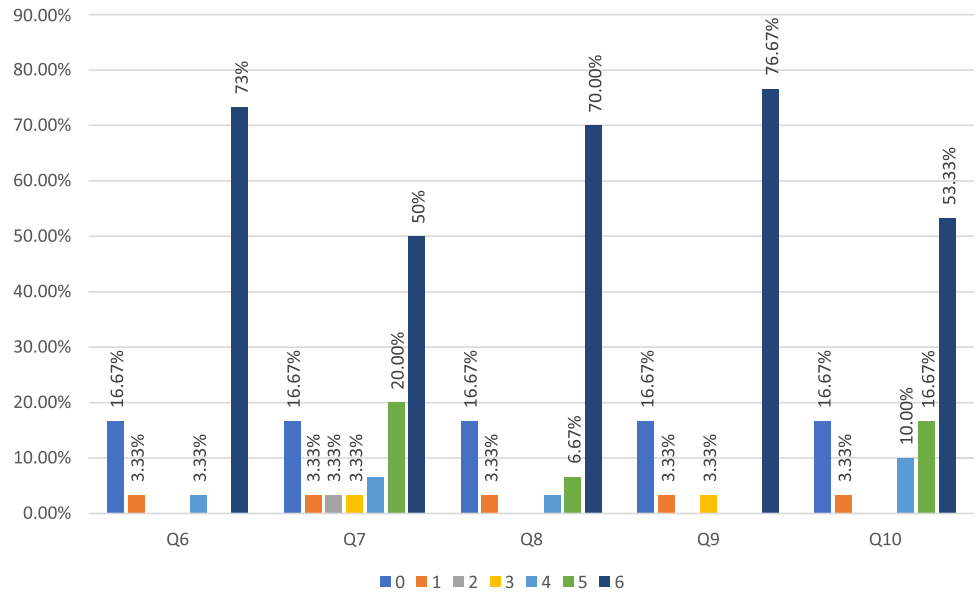

FIGURE 16 Responses to the first part of the questionnaire (Q6–Q10)

motivation levels were exceptionally low. Furthermore, the answers to "Q5. The experience has helped me better understand the procedures" showed that the main feeling between the participants in this experience was that the understanding of the procedures involved was improved by means of using the Escape Room.

The results of the last five Likert-scale questions are shown in Figure 16 and reveal that the experience was perceived as a really valuable tool to work mathematics. In concrete, the responses given by students to "Q6. Being able to watch the videos more than once helps to resolve doubts," show that the possibility of watching the videos at its own pace is highly valued by students as not all students work at the same speed, which was shown before the experience and evidenced during the practice. Moreover, the responses to "Q7. The experience has helped me to better internalize mathematics" showed except only two of the students think that the experience is a useful tool to internalize the mathematics involved, which was helpful for them as they told in the open-ended questions. On the other hand, related to responses to "Q8. I think it's a good experience to work math" and "Q9. The experience seemed like a good complement to online math classes" reveals that most students consider that the experience is a valuable tool for the maths subject and even more for the online classes as a

complement to the theory as they fell they can work mathematics in a better way than in the traditional online class. Finally, the responses to "Q10. The experience has increased my interest in mathematics." showed that, except one student, all the responses were positive, and they felt that the interest in the subject, which is really important, and also in Mathematics increased with the experience and the use of a virtual Escape Room in an online format.

Lastly, the response of the qualification they give to the experience Q10, was 9.52 in the mean of possible 10 points, so the experience was highly valued by the students and also by some of the comments made by students in Q11 which are listed below:

> I greatly appreciate the initiative, it is easier to fix knowledge this way, sometimes the amount of information in a class overwhelms me a bit, seeing the problems this way certainly helps a lot.
>
> I think it is a very good activity and it helps a lot to understand the subject.
>
> I was delighted that we solved the exercises since we had the results, and you can see where you have failed others if something is not clear to you or you have doubts we have the videos.
>
> It is the first time that I like it and I find mathematics interesting, even if it is hard and it costs me a lot of effort.
>
> I think this type of games to learn mathematics is a great idea.

5 | CONCLUSIONS

In general terms, all the objectives set in this study have been met. The first of them consisted of the design and implementation of an experience based on a virtual Escape Room for calculation work in the first year of an engineering degree. On the other hand, in the implementation of the experience it was wanted to observe if, with its use, the low level observed in said part could be improved and compare the results obtained by the group that has used said Escape Room with those obtained by the group that has worked usually in an online environment. Regarding this objective, it has been possible to contrast that the results obtained by the group that has worked through the Escape Room have been quite superior to those that have worked in the usual way, despite the fact that the starting point was similar between both groups. In addition, the third of the objectives, linked to the satisfaction of the participants in said experience, it has been possible to verify that the satisfaction has been very high as well as the usefulness that the student body observes of said experience. Finally, the fourth objective, which was linked to showing that the use of this experience can be very beneficial for the work of mathematics, has been fulfilled as a result of the results obtained that have been commented on the second and third objectives, since those students who have worked through the Escape Room have obtained in general better results and the level of satisfaction of the participants has been very high.

Assessing now each of the objectives separately, starting with the first of them, which consisted of the design and implementation of an experience based on a virtual Escape Room, following some of the ideas shown in [1, 12-14] where it was shown that the potential of these types of experiences are very positive in the Mathematics classroom.

On the one hand, regarding the objective related to the statistical study of the results obtained both in the pretest and in the posttest, it has been possible to prove that the group that used this experience obtained much higher results in the subsequent test than the group that worked with usual way, despite the fact that in the test before the experience the results were similar. The differences obtained in the scores in the pretest have not been significant, while in the posttest they are with a significance level of 0.05, so the use of the escape room has been shown to be more effective than the traditional class to work the calculus part in the mathematics subject in the first courses of an engineering course at an online university. In addition, taking into account the calculated effect sizes, it has been obtained that while in the pretest said differences are practically insignificant, in the posttest the differences are of intermediate sizes. The control group, in general, obtained a lower grade than the experimental group, which shows that the experimental group has had an acquisition of content and concepts much higher than the control group.

On the other hand, the answers to the survey showed that students find the experiment really interesting and useful for the acquisition of the contents and the understanding of the concepts and the procedures involved. Moreover, students think their motivation and interest in the subject have increased with the use of this experience, which agrees with the conclusions in [1, 12] and even more students also asked for more classes in this way, which allows concluding on the use

of this kind of experiences in engineering mathematics in an online environment.

DATA AVAILABILITY STATEMENT

Data available on request from the authors.

ORCID

Ángel Alberto Magreñán http://orcid.org/0000-0002-6991-5706

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AUTHOR BIOGRAPHIES

Ángel Alberto Magreñán has a tenure track position at Universidad de La Rioja and his research is centered in the use of technology in mathematics education. He has a PhD in Mathematics obtained in 2013 and has published more that 100 papers and several chapters and books.

Cristina Jiménez has been working in the last 19 years at La Inmaculada Concepción Secondary School. Cristina holds a Bachelor's degree in Mathematics, she is in progress to obtain a PhD in Didactic of Mathematics and has published a few papers.

Lara Orcos is an assistant lecturer at Universidad de La Rioja and before that she was teacher at a School in Logroño. She has a PhD in Mathematics Education obtained in 2019 and has published several papers and chapters related to mathematics education.

Simón Roca is a Telecom engineer and current Math teacher at the IES Bajo Cinca highschool in Fraga (Spain). He worked before as a predoctoral researcher at Universidad Carlos III and he collaborated with Universidad de la Rioja doing research while completing his preteaching studies there.

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