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# Digital Educational Escape Room Analysis Using Learning Styles

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**Abstract:** Teachers often need to adapt their teaching methodologies in order to overcome possible limitations and ensure that education does not lose quality in the face of different scenarios that may arise in the educational environment, which are not always the most desirable. Techniques such as the Educational Escape Room (ERE) in higher education, are taking a great increase due to its popularity among young people as a leisure activity. This study shows an educational research based on the application of a Digital Educational Escape Room (DEER) to respond to the limitations of hybrid teaching with students divided between the classroom and their homes. Through the analysis of a control group, with a traditional lecture class, and an experimental group with the use of a pretest and a posttest, with the addition of studying the different learning styles of the students in each group, interesting results and conclusions have been obtained that offer a replicability of this technique for other fields and educational modalities.

**Keywords:** higher education; computer assisted learning; educational games; educational Innovation; educational escape room; learning styles

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## 1. Introduction

The health emergency derived from COVID-19 [1] has led universities and teachers to explore new ways to adapt to the measures imposed by different governments. Safe teaching models have been chosen from the health point of view, but not always the most appropriate from the educational point of view. The Rey Juan Carlos University has implemented a hybrid teaching model which implies that the lecturer needs to be aware of both online students and face-to-face students at the same time [2].

In order to overcome the barrier imposed by distance or hybrid education and maintain the highest quality of teaching, teachers have opted for the use of different methodologies, ensuring that students understand, retain, transform, and apply the educational content received [3].

On the other hand, knowing the different learning styles is one of the fundamental pillars of "learning to learn" and is one of the ways that the student will have to potentially expand their ways of learning [4]. Each student learns in a different way, and knowing their learning preferences will help us achieve better results [5]

The objective of this research is to analyze a game-based learning experience using the Escape Room technique to work on students' autonomous learning and explore students' learning styles.

For the subject "Introduction to Business", adapted to a hybrid model with two groups of students, one in the classroom and the other remotely from home, a Digital Educational Escape Room (DEER) was designed to try to break down the limits caused by this educational model forced by the health situation. Based on the division of groups proposed by the university, the students who attended in person were established as the control group, and those who attended remotely were established as the experimental group. The DEER was used in the experimental group to work on a new concept of the subject individually and autonomously for each student, while the control group followed a traditional method such as the master class.

This experience is based on the following research hypotheses:

**Hypothesis 1.** *Students attending in person exhibit better academic results than students attending remotely.*

**Hypothesis 2.** *Attending in person or remotely differently affects students with different learning style preferences.*

Section 2 reviews the scientific literature on Educational Escape Rooms, a hybrid teaching concept carried out for health reasons related to COVID-19. as Additionally, it reviews the learning styles proposed by Felder and Silverman, in order to obtain a brief understanding of its state of the art application. In Section 3, we describe the teaching experience in detail, from the design to the application of the DEER. The results are then presented in Section 4 through statistical analysis of the data obtained, considering other current work. Finally, in Section 5, the discussion and conclusions of the research are presented.

## 2. Literature Review

### *2.1. Learning Styles*

Not all students perceive and process information in the same way, hence the importance of making a diagnosis regarding the preferred learning style of university students in a particular subject. The didactic intervention supported by the optimization of learning profiles and the use of visual environments have a positive impact on the integral formation of the individual [6].

The concept of learning style emerged with Gibson [5], who proposed that everyone has a different way or preference when learning, and when the information is presented according to their preferences, the result is better. Alonso et al., in 1997 [7] concluded that when students were taught with their predominant learning styles, they learned better.

It is generally accepted that combining an individual's learning style with the appropriate form of an educational intervention significantly impacts student performance and their achievement of learning outcomes [8].

There are several studies in the literature that determine the different learning styles associated with different e-learning problems [9]. There is no consensus on the best method to determine the different learning styles, and some controversy exists in this regard, resulting in several tests to determine the different learning profiles. Ocepek et al. [10] in their study use four different learning style models to obtain four complementary views of students' learning preferences and characteristics. Othman and Amiruddin [11] discuss the different styles and recommend the VARK learning style for their research. However, Jarvis [12] states in their research that Felder and Soloman's style is the best instrument for determining learning styles, as it is the one that handles the greatest number of dimensions, which provides the maximum information for the teacher and the student about the way in which the student learns. The most current model is found in the studies of Richard M. Felder and Linda K. Silverman [13].

In 1987, Richard M. Felder and Linda K. Silverman formulated their model of learning styles, which was composed of five dimensions, and published in 1988 [13]. The original model was modified by Felder to have four dimensions: (1) Active/Reflective, according to the learner's preference for processing information; (2) Sensing/Intuitive, according to the type of information perceived by the learner; (3) Visual/Verbal, according to the preferred sensory channel for perceiving information; (4) Sequential/Global, based on the way of processing learning. Later, the questionnaire of the model was programmed and validated by Richard M. Felder and Barbara A. Soloman [14]. The questionnaire is based on 44 questions with answers A and B as shown in Table A1 (Appendix A).

### 2.2. Hybrid Teaching

As a consequence of COVID-19 and the need to reduce the number of students in the classroom, the hybrid teaching model was introduced. This model is characterized by the fact that half of the students attend class in person as usual and the other half stream the class online [2,15]. This model is similar to "blended learning", which has been applied for more than a decade in the classroom. "Blended-learning" is a format where part of the subject is taught in a traditional way and the remainder is carried out online through virtual classrooms, where the resources of the subject are found, exams are taken or activities are submitted [16,17]. This differs from the traditional scheduled lecture-exam modality used in most courses during the pandemic. This mixed modality (face-to-face/online) has been considered differently by several authors in recent years [18], in which students attended class in the classroom to have discussion sessions guided by the teacher, based on the content of the online course.

### 2.3. Escape Room in Higher Education

In recent years, a part of the research in teaching innovation has focused on the use of Escape Room (ER) games in educational settings due to the extensive opportunities this offers to support a learning process [19]. Although the first generation of ER focused on complicated logic puzzles [20], ERs have evolved into fully immersive environments, involving high-quality accessories and effects [21]. ERs represent a novel technique in teaching practice that can enhance conventional simulation approaches and provide a means for less traditional learning activities. They can also act as a low-cost, high-impact resource for a variety of learners when conducted effectively. Although they can be difficult to administer in practice, they have the potential to generate great benefits when used correctly [22]. Guckian et al. [23] highlight that this topic has been analyzed in literature to a considerable extent.

Educational Escape Rooms (EER) are immersive, engaging, dynamic, and activity-oriented online learning experiences that are developed due to their cost-effectiveness, accessibility, and practicality [24]. They possess numerous benefits; among others, they achieve engagement with a learning environment. Furthermore, interaction through collaboration helps learners develop social skills.

In their literature review, Veldkamp et al. [25] report that 51% of the EERs were conducted with the use of ICTs. According to this study, Digital Educational Escape Rooms (DEER) achieve different uses and objectives depending on the area of knowledge in which they are used, with medical disciplines and Science, Technology, Engineering and Mathematics (STEM) disciplines being the pioneers in this regard. Thus, in relation to the subject, Guckian, et al. [23] report in their study that the active acquisition of knowledge and a deeper understanding of new concepts were related to medicine, programming, biology, electronics, astronomy, mathematics, and engineering.

There are few publications referring to this type of teaching resource in the field of social sciences. Calle-Carracedo, et al. [26] analyze the use of a mixed methodological approach, combining EER with the use of ICTs. The participants' conceptions, evaluations, and perspectives on their experience, implementation, and educational potential lead them to a very positive evaluation in aspects related to the setting, design, tests, time, etc., as well as the motivational potential to generate learning. In the field of business economics, Authors [27] analyze motivation and emotion through the Educational Escape Hall, combining the physical and digital Educational Escape Room.

Regarding business training, no literature on DEER has been found.

## 3. Materials and Methods

This section will present the design of a research based on the use of Digital Educational Escape Room (DEER) within the university context. The implementation was performed in the subject "Introduction to Business" of the first course in the Marketing Degree at the Rey Juan Carlos University during the 2020-21 academic year with a total of 56 students, with a hybrid rotating model imposed by the pandemic.

### *3.1. Research Design*

The faculty team designed and implemented an experience with the aim of obtaining similar learning results in the two existing scenarios, with a remote turn and a face-to-face turn in the classroom. For this purpose, the Escape Room technique was chosen, in which the team already had experience [27], although in this case, it was applied as a strategy to review content already studied.

The Escape Room designed for this experience was completely digital and online, and was used for remote students to learn new content on the subject. The lesson was based on the market-to-book ratio (what it is, how useful it is, how it is calculated in different circumstances, and how to interpret its value). This lesson was designed to be worked on in a single class session.

The organization of the turns was imposed by the university and was randomized. The control group was formed by students in the classroom, applying a traditional face-to-face class to explain the lesson, contents were transmitted through a presentation and without any additional artifice. The experimental group was formed by the students online for which the DEER was applied.

In order to better understand the students' characteristics, on the first day of class, they filled out an anonymous online questionnaire on learning styles based on the Felder and Silverman model [13]. To analyze the experience, a pretest and posttest were designed as an element to measure the learning and knowledge acquisition of both groups [28–30].

The same test was presented to both groups at the beginning of the session and at the end of the session to identify what new knowledge they had acquired with respect to the knowledge they already had. All the tests were configured so that no feedback would appear at the end of the students' attempts, thus avoiding the transmission of information between them during the experience.

The test included eight randomly displayed questions with four possible answers (only one correct answer) and with the incorrect answers subtracting 25% of the total test grade. The questions were organized into three categories according to their difficulty:

- "Basic competencies" (questions 1 and 2). They could be answered without knowing the content of the lesson and just by applying common sense. They are used to check whether students were answering randomly or taking the test seriously.
- "Specific competencies" (questions 3, 4, and 5). They were related to the minimum competencies that the students were required to achieve in the subject for that lesson;
- "Advanced competencies" (questions 6, 7, and 8). They involved a greater cognitive process and a deeper assimilation of the content of the lesson.

The total experience lasted one hour and thirty minutes, dedicating one hour to work on the content (traditional face-to-face class or educational escape room, depending on the group of students). Then, the pretest and posttest took another 15 min each. The diagram in Figure 1 summarizes the proposed research design.

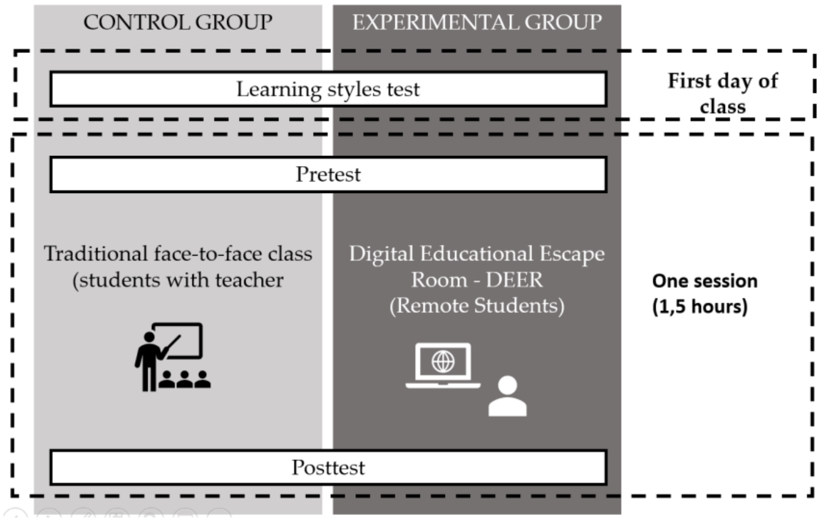


**Figure 1.** Research design. Source: Own elaboration.

The following subsection will develop the design of the DEER applied to the experimental group.

### 3.2. *Digital Educational Escape Room*

For the experimental group, a Digital Educational Escape Room (DEER) was designed with a 100% digital environment, and a clear effort for the acquisition of learning in an autonomous way by the student, without any physical elements

Figure 2 shows the design of the DEER and the different technologies used. One of the objectives of this design was to make the process as simple as possible for the students, so that they would not lose time in understanding its operation and would focus on the subject knowledge to be acquired, concentrating the whole activity in the same digital space. The university's Learning Management System (LMS), based on Moodle, was used, and the rest of the web resources that formed part of the DEER were embedded through HTML code.

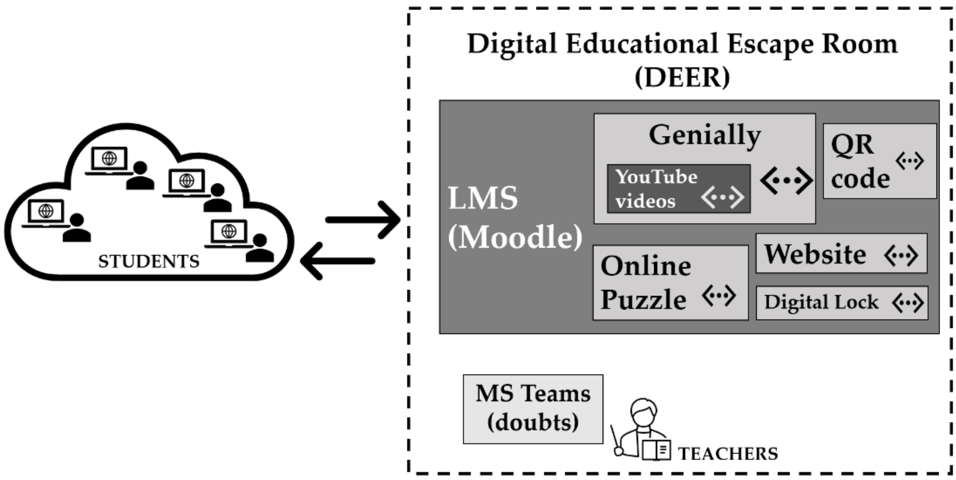


**Figure 2.** Digital Educational Escape Room (DEER). Source: Own elaboration.

The Moodle resource "Lesson" was used to create the main DEER site and include all the necessary resources within it. The objective of the experience was that the students discover by themselves the contents to be transmitted, through the DEER activities (theoretical materials and puzzles).

First, a narrative was defined to place the student at the center of the action, involving him/her in the activity and following the different learning objectives of the session. Coinciding with those in the control group, a script was developed containing the contents and a series of activities were designed to help understand them. In the story, the objective of the student, who had become an intern at a company, consisted of solving a series of tasks entrusted by his boss to escape from the office and return home.

The digital contents were associated with the subject matter of the theoretical session and in the form of various activities. They were generated using different technologies and were embedded in the lesson within Moodle:

- Using the interactive platform Genially, two activities were created based on conversational games with various options that the student should choose correctly to be guided to the end of each activity and so to achieve each learning objective (Figure 3). Within these games was the theoretical content.
- Using the YouTube streaming platform, videos were created with information of interest for the students: a video of the escape room presentation and instructions and another video embedded in one of the Genially activities (Figure 3 right). Both videos were dramatized with actors.
- Other technologies, such as QR codes, digital puzzles, simulated websites, and digital locks, were also used.


**Figure 3.** Examples of content with Genially. Source: Own elaboration.

- Inside the Moodle lesson, numerical questions were created with a single correct value that students had to answer correctly to advance.
- To implement both tests, the “Exam” tool of the University’s Moodle platform was used.

Finally, the MS Teams channel of the course was used for communication with the student during the DEER (Figure 2) in case of possible technical problems. A teacher, external to the course, was connected during the entire session for incident resolution.

*3.3. Learning Styles*

In order to assess learning styles to each student, we employed Felder and Soloman questionnaire [14], a methodology that is currently used in other research [31,32]. The questionnaire consists of 44 questions with dichotomous answers (“a” or “b”), and considers four scales, one for each dimension of the Felder-Silverman model [13]: (1) Active-Reflective (how information is processed); (2) Sensing-Intuitive (type of information best perceived); (3) Visual-Verbal (how sensory information is perceived); and (4) Sequential-Global (progress towards comprehension of information). Each scale consists of 11 randomly distributed questions. The score for each one of them is obtained by counting the number of responses “a” and the number of responses “b”, then subtracting the smaller number from the larger one, and the predominant letter is added to the resulting number. The answers with letter “a” correspond to the first pole of each of the four scales, while the answers with letter "b" correspond to the second extreme. A score of 1 to 3 indicates a balance between the two dimensions of the scale and therefore, the student can learn with teaching methods that favor both basic dimensions. A score of 5 to 7 indicates a moderate preference for one dimension of the scale, suggesting that a student learns more easily with teaching methods that favor that dimension. A score of 9 to 11 indicates a strong preference for one dimension of the scale and, according to Felder and Soloman [14], such a student will find it more difficult to learn under teaching methods that do not support that dimension. Thus, after applying this method, students are classified in a 1–5 scale for each one of the four mentioned dimensions. For instance, for the Active-Reflective dimension, scale may take values:

1. Strong preference for active learning
2. Moderate preference for active learning
3. Balance between active and reflective
4. Moderate preference for reflective learning
5. Strong preference for reflective learning and in a similarly for other three dimensions

## 4. Statistical Analysis

In this section we present the statistical analysis developed using the statistical software R. We define the learning results, our variable of interest, as the difference between the numerical results obtained in the posttest and the pretest. Our data contains 55 observations, corresponding to the students that complete the learning styles questionnaire and the pretest and posttest successfully, for which we observed (Tables 1–5).

**Table 1.** Numerical summaries of learning results: sample size (n), mean (m) and standard deviation (sd) for Control and Experimental groups.

| | | **Numerical Summary** | |
|---|---|---|---|
| Group | n | m | sd |
| Control | 29 | 4.22 | 2.14 |
| Experimental | 26 | 3.94 | 1.48 |

**Table 2.** Numerical summaries for the Active/Reflexive factor and the Control and Experimental groups.

| | | **Active/Reflexive** | |
|---|---|---|---|
| Group | 3 | 4 | 5 |
| Control | 21 | 8 | 0 |
| Experimental | 17 | 8 | 1 |

**Table 3.** Numerical summaries for the Sensing/Intuitive factor and the Control and Experimental groups.

| | | **Sensing/Intuitive** | | |
|---|---|---|---|---|
| Group | 2 | 3 | 4 | 5 |
| Control | 1 | 18 | 6 | 4 |
| Experimental | 0 | 15 | 10 | 1 |

**Table 4.** Numerical summaries for the Visual/Verbal factor and the Control and Experimental groups.

| | | **Visual/Verbal** | | |
|---|---|---|---|---|
| Group | 2 | 3 | 4 | 5 |
| Control | 10 | 15 | 3 | 1 |
| Experimental | 8 | 15 | 0 | 1 |

**Table 5.** Numerical summaries for the Sequential/Global:factor and the Control and Experimental groups.

| | Sequential/Global: | | |
|---|---|---|---|
| Group | 3 | 4 | 5 |
| Control | 22 | 7 | 0 |
| Experimental | 18 | 7 | 1 |

### 4.1. Control/Experimental Groups Effect

Following Section 1, we are interested in testing the hypothesis:

**Hypothesis 1.** *Students attending in person exhibit better academic results than students attending remotely.*

According to the standard theory of hypothesis testing, we enunciate our test using a null and an alternative hypothesis, where the null hypothesis is the claim that there is no effect on the population, and the alternative hypothesis (Ha) describes our research question, therefore it claims that there is an effect. Therefore, we enunciate the null and alternative hypotheses as:

- H1: On average, the learning results are the same for students attending in person and students attending remotely.

The null hypothesis states that the Control Group (students attending in person) and the Experimental Group (students attending remotely) are identical populations regarding the learning results acquired during the academic term. The Welch Two Sample t-test evaluate the difference of learning results by Grupo (mean in Control group = 4.22, mean in Experimental group = 3.94), suggesting that the effect is positive, statistically not significant, and very small (difference = 0.27, 95% CI [−0.72, 1.26], t(49.91) = 0.55, $p = 0.582$). As the $p$-value turns out to be 0.582, and is less than the 0.05 significance level, we reject the null hypothesis. Therefore at 0.05 significance level, we cannot conclude that there are significant differences between Control Group and the Experimental Group.

It would be of interest to consider not just the group in which the students have developed their learning during the term, but also the learning style that students prefer. In other words, we are interested in evaluating our second hypothesis.

**Hypothesis 2.** *Attending in person or remotely has different effects on students with different learning style preferences.*

Therefore, we are interested in employing the information provided by the survivor presented in Section 2.1. Hence, we consider four other factor variables regarding the learning styles, namely: Active/Reflexive, Sensing/Intuitive, Visual/Verbal, and Sequential/Global.

Note that here, we are not just interested in analyzing the impact that each of these factors may have had on the development of learning, but we are especially interested in the interaction that these factors may have with the type of teaching, that is, whether preferring a particular type of learning affects the fact that belonging to the Experimental or Control group has affected the learning results.

In the following subsections, we present descriptive statistics and perform two-way analysis of variance for each one of the categorical variables describing the learning preferences of students.

### 4.2. Active/Reflexive Factor

In this section we consider the factor describing whether the students prefer a more active of more reflexive type of learning. Students have been classified in 5 levels from 1 to 5 (1 indicating more active and 5 more reflexive preference) using their responses to the

Felder and Soloman questionnaire [14]. Note that our students belong to only three of the five levels, namely 3 (n = 38, 69.09%), 4 (n = 16, 29.09%) and 5 (n = 1, 1.82%).

### 4.2.1. Descriptive Statistics for Control/Experimental Group and Active/Reflexive

Table 6 and Figure 4 show descriptive statistics for learning results for the different levels (3 and 4) of the Active/Reflexive factor and the Control and Experimental groups.

**Table 6.** Numerical summaries for learning results: sample size (n), mean, standard deviation (sd), minimum (min), 1st quantile (Q1), median, 3rd quantile (Q3), and maximum (max) for the different levels (3 and 4) of the Active/Reflexive factor and the Control and Experimental groups.

| Group | Active/Reflexive | n | Mean | sd | Min | Q1 | Median | Q3 | Max |
|---|---|---|---|---|---|---|---|---|---|
| Control | 3 | 21 | 4.34 | 2.19 | 0.00 | 2.50 | 3.75 | 6.25 | 8.75 |
| Experimental | 3 | 17 | 3.53 | 1.54 | 0.00 | 2.50 | 3.75 | 4.75 | 6.25 |
| Control | 4 | 8 | 3.88 | 2.12 | −0.25 | 3.44 | 3.75 | 5.31 | 6.25 |
| Experimental | 4 | 8 | 4.84 | 1.04 | 3.75 | 3.75 | 5.00 | 5.31 | 6.25 |

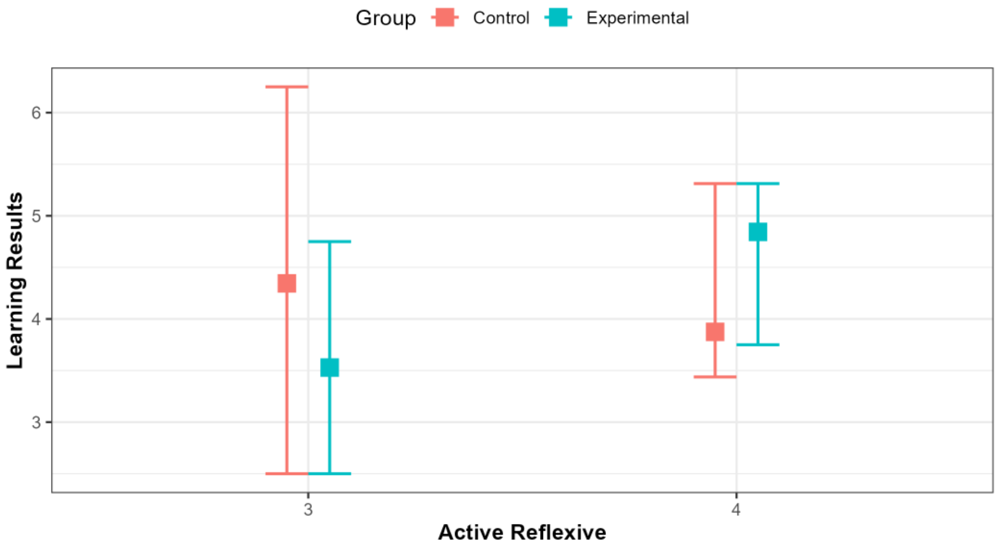


**Figure 4.** Boxplots relating Learning Results for the Control/Experimental and Active/Reflexive groups of students.

Note that both graphical and numerical summaries of learning results do not show big difference for students at level 3 or 4 of Active/Reflexive factor. Nowadays, in the following section, we test whether these differences are or not statistically significant. also It is also notable that level 5 is not considered here. Since there is only one student at that level, this does not allow us to test the differences with the other two levels.

### 4.2.2. Two-Way Analysis of Variance for Control/Experimental Group and Active/Reflexive

The two-way analysis of variance (two-way ANOVA) is a statistical procedure to examine the influence of two different categorical independent variables on one continuous dependent variable. The two-way ANOVA can evaluate not only the main effect of each independent variable but also the potential interaction between them. Here, we can test whether the different levels of the Active/Reflexive Factor and the Control/Experimental group are related to the variable of interest, in this case, the result of learning. By making the correct hypothesis, we can test two main effects and one interaction effect. Here we state the corresponding null hypothesis:

- H2.1: On average, the learning results are the same for different Active/Reflexive levels.

- H2.2: On average, the learning results are the same for Control/Experimental Groups.
- H2.3: On average, the learning results for Control/Experimental groups does not depend on the different Active/Reflexive levels (this is there is not interaction effect between them).

The ANOVA suggests that:

- The main effect of Control/Experimental Groups is statistically not significant and is very small ($F(1, 50) = 0.30$, $p = 0.588$).
- The main effect of Active/Reflexive is statistically not significant and is small ($F(2, 50) = 0.26$, $p = 0.773$).
- The interaction between Control/Experimental Groups and Active/Reflexive is statistically not significant and is small ($F(1, 50) = 2.59$, $p = 0.114$).

### 4.3. *Sensing/Intuitive and Visual/Verbal Factors*

Next, we replicate the statistical procedure described in Section 4.1 for the Active/Reflexive factor for the rest of the qualitative variables describing learning style preferences of students. In particular, for Sensorial/Intuitive and Visual/Verbal factors, results are similar to those obtained in the previous section for the Active/Reflexive factor, concluding therefore that there are not significant differences between the learning results of students with different style learning preferences, and that these preferences have no interaction with the Control or Experimental group they experimented.

### 4.4. *Sequential/Global Factor*

In this section, we analyze whether the different levels of the *Sequential/Global* Factor and the Learning environment group are related to the variable of interest, the result of learning. By making the correct hypothesis, we can test two main effects and one interaction effect.

#### 4.4.1. Descriptive Statistics for Control/Experimental Group and Sequential/Global

Table 7 and Figure 5 show descriptive statistics of the variable of interest (learning results) corresponding to the Sequential/Global factor and the Control and Experimental groups.

**Table 7.** Numerical summaries for learning results: sample size (n), mean, standard deviation (sd), minimum (min), 1st quantile (Q1), median, 3rd quantile (Q3) and maximum (max) for the different levels (3 and 4) of the Sequential/Global factor and the Control and Experimental groups.

| Group | Sequential/Global | n | Mean | sd | Min | Q1 | Median | Q3 | Max |
|---|---|---|---|---|---|---|---|---|---|
| Control | 3 | 22 | 4.83 | 1.86 | 1.25 | 3.75 | 5.00 | 6.25 | 8.75 |
| Experimental | 3 | 18 | 3.89 | 1.59 | 0.00 | 3.75 | 3.75 | 5.00 | 6.25 |
| Control | 4 | 7 | 2.29 | 1.88 | −0.25 | 1.25 | 2.50 | 3.12 | 5.00 |
| Experimental | 4 | 7 | 3.75 | 1.02 | 2.50 | 3.12 | 3.75 | 4.38 | 5.00 |

Note that here, Table 2 and Figure 4 show how learning results seem to be higher in the experimental group than in the control group for students with a level 4 (means 2.29 and 3.75 for Control and Experimental respectively) but lower for students with a level 3 (means 4.83 and 3.89 for Control and Experimental respectively) in the Sequential/Global variable. In order to test whether these differences are significant, we need to employ the ANOVA test as in the previous sections.

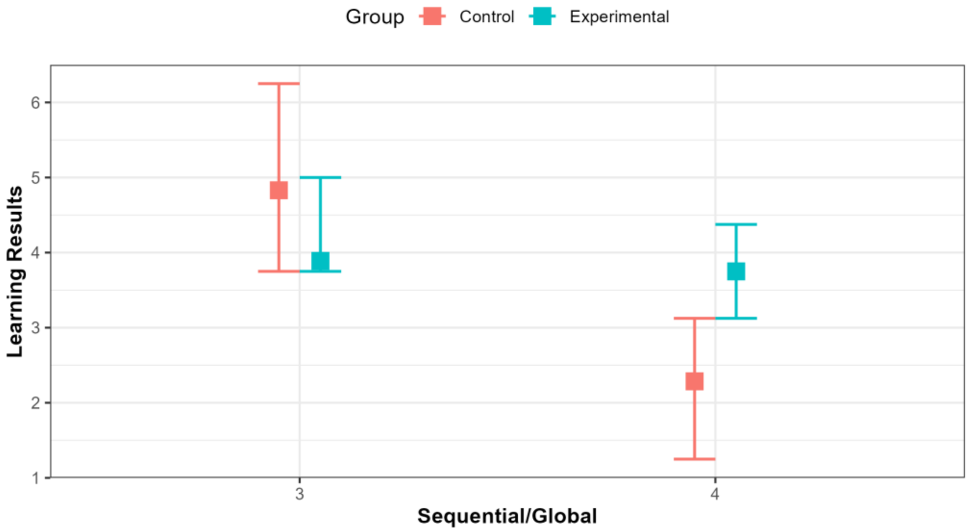


**Figure 5.** Boxplots relating Learning Results for the Control/Experimental and Sequential/Global groups of students.

#### 4.4.2. Two-Way Analysis of Variance for Control/Experimental Group and Sequential/Global

Once more, we test the following hypothesis:

- H2.1: On average, the learning results are the same for different Sequential/Global levels.
- H2.2: On average, the learning results are the same for Control/Experimental Groups.
- H2.3: On average, the learning results for Control/Experimental groups do not depend on the different Sequential/Global levels (meaning there is not interaction effect between them).

Proceeding as in the previous sections, the ANOVA suggests that:

1. The main effect of Control/Experimental Groups is statistically not significant and very small ($F(1,50) = 0.36$, $p = 0.553$).
2. The main effect of Sequential/Global Factor is statistically significant and large ($F(2,50) = 4.37$, $p = 0.018$).
3. The interaction between Control/Experimental Groups and Sequential/Global is statistically significant and medium ($F(1,50) = 5.22$, $p = 0.027$).

Note that a significant interaction between the factors in this analysis show that a preference for a Sequential/Global learning style affects the impact that belonging to the Control/Experimental group may affect the students performing on the subject.

Although these results should be taken with caution given the size of the sample, they undoubtedly leave an open door to consider the type of learning that students prefer when expecting learning based on a virtual escape room.

## 5. Discussion

Previous literature explores and reviews the existing relationship between learning styles and game-based learning experiences [33,34]. According to Khenissi et al. [35], the use of computer games for learning also has the potential to negatively affect the learning experience if the characteristics of individual learners are not considered. The research presented in this paper aims to test whether students who learn completely new concepts through the DEER technique, autonomously online, learn less than if they had received the explanations of their teacher, in the traditional face-to-face classroom. Furthermore, we are interested in testing whether that possible effect may also be related with the learning style preference of the students.

Jarvis' research [12] validates the Felder and Soloman style, concluding that it is the best instrument for determining learning styles, as it is the one that handles the greatest number of dimensions, which provide the maximum information to the teacher and the student about the way in which the student learns. For this reason, in our teaching research we have used the most current model, as described in the studies of Richard M. Felder and Linda K. Silverman [13].

Hwang et al. [36], in their study of developing a personalized educational computer game based on students' learning styles, concluded that game-based learning through ICT resources can be significantly promoted if learning styles are considered. Moreover, from the point of view of learning outcomes, the methodology used enabled individual students in the experimental group to learn in a way that matched their styles of information perception and processing, so that their learning achievements were significantly better than students in the control group.

The new requirements due to the COVID-19 health crisis have meant that the entire educational community has had to make an effort to adapt to the circumstances existing at that time. This has required new hybrid formats to comply with the standards imposed by the health authorities and the teaching staff has been under the pressure to find solutions that respond to this challenge. With the aim of overcoming the limitations of having half of the students at home following the class from a screen, we designed a DEER that has led them to learn a new concept: the *market-to-book ratio*. In addition, considering the different learning styles proposed by Felder and Silverman [13], we have been able to analyze the degree of learning according to these styles.

Previous studies, which conducted DEER showed a significant relationship between improved motivational outcomes, positive behaviors, which significantly influenced students' engagement [37–40].

In this area, a recent study analyzed the scientific research on Educational Escape Room and concluded that adopting this type of technique can generate learning benefits for students. However, regarding research on the use of DEERs, being a novel topic, they concluded that there is "fertile ground for future research" and "since no scientific evidence was found on DEER learning outcomes in educational settings, it is crucial to analyze the effects of escape rooms in digital educational environments and harmonize them with learning objectives" [22]. In 2017 Eukel et al. [41] conducted a cross-sectional pre- and post-test investigation to assess performance in a sample of 74 players. These obtained an 81% average score in a posttest, which was considerably higher than the 56% obtained in the mean test. It is noteworthy that between the two, seven days elapsed between the pre-test and the DEER. This was the determining factor for designing the DEER presented in this work and thus observing whether this technique could be used to learn completely new knowledge immediately, with no time between pretest and posttest.

In social sciences, Manzano-León et al. [42] conducted an experience using DEER resources during the COVID-19 confinement. In their research, they conclude that online escape rooms can be motivating active learning strategies for students and propose as future lines of research to study their impact on students' academic performance. Additionally, in this field, Calle-Carracedo et al. [26] examine a blended escape room methodological approach, combining traditional EER and DEER, with master's degree students in teacher education, and analyze the participants' conceptions, assessments, and perspectives on their experience of implementation and on the educational potential of blended ER.

In line with this research prior to ours, there is a growing interest in the literature in DEER as a didactic resource for increasing motivation and learning, which analyses the results of educational research related to this type of didactic experience, both at the level of motivation, which is so necessary today, and at the level of learning, in order to measure to what extent this technique can be a useful tool associated with learning styles.

## 6. Conclusions

One of the objectives of this research was to test whether students who learn completely new concepts through the DEER technique, remotely, even if it is synchronously, learn less than if they had received explanations from their teacher in the traditional face-to-face classroom setting (H1). We have observed that there are no significant differences in the learning results in the two groups analyzed, which allow us to affirm that, as long as an adequate design is elaborated and guided by an expert, the use of the DEER technique has not been an obstacle for learning new contents. These results justify the effectiveness of DEER as a teaching resource, and allow extrapolation to different remote teaching scenarios, such as e-learning. Additionally, this may prove to be an opportunity to create DEER materials adapted for use when digitization becomes necessary.

Moreover, by testing our second hypothesis (H2), we were interested in considering different learning styles, in order to test whether these could have and interaction with the teaching methodology applied. In other words, we are interested in testing whether conclusions to the to the first hypothesis may change when considering students with different learning style preferences. Regarding the first three learning styles analyzed, no significant differences between the experimental group (DEER) and the control group (traditional face-to-face classroom) have been observed. However, significant differences have been identified for the Sequential/Global style, between the two groups. Although the sample size used for this project is not very large and we must be cautious with this result, this leads us to the conclusion that there is a field of research in this direction. We believe that an analysis with a larger sample, based on the results obtained, could lead to very interesting consequences in the field of game-based learning under the DEER technique, or other fully online teaching techniques, considering information regarding students learning styles. Knowing in detail which learning styles are more suitable could help to set up groups of students with a higher learning efficiency and to design sessions adapted to them.

Future work includes studies with a larger sample of students repeating the experience to adapt the DEER to the different learning styles, as well as the use of other methodologies, such as expository class, debate, exposition of results, conceptual maps, etc. The objective is to achieve an adapted teaching that considers the heterogeneity of the students and to favor the plurality of learning styles in the achievement of key competences of each subject.

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## Appendix A

**Table A1.** Felder & Soloman [14] Questionnaire programmed from Felder & Siverman's Learning Styles Model [13].

| | |
|---|---|
| 1. I understand something better after I<br>a. try it out.<br>b. think it through. | 23. When I get directions to a new place, I prefer<br>a. a map.<br>b. written instructions. |
| 2. I would rather be considered<br>a. realistic.<br>b. innovative. | 24. I learn<br>a. at a fairly regular pace. If I study hard, I'll "get it".<br>b. in fits and starts. I'll be totally confused and then suddenly it all "clicks". |
| 3. When I think about what I did yesterday, I am most likely to geta.<br>a picture.<br>b. words. | 25. I would rather first<br>a. try things out.<br>b. think about how I'm going to do it |

**Table A1.** *Cont.*

| | |
|---|---|
| 4. I tend to<br>a. understand details of a subject but may be fuzzy about its overall structure.<br>b. understand the overall structure but may be fuzzy about the details. | 26. When I am reading for enjoyment, I like writers to<br>a. clearly say what they mean.<br>b. say things in creative, interesting ways. |
| 5. When I am learning something new, it helps me to<br>a. talk about it.<br>b. think about it. | 27. When I see a diagram or sketch in class, I am most likely to remember<br>a. the picture.<br>b. what the instructor said about it |
| 6. If I were a teacher, I would rather teach a course<br>a. that deals with facts and real life situations.<br>b. that deals with ideas and theorie | 28. When considering a body of information, I am more likely to<br>a. focus on details and miss the big picture.<br>b. try to understand the big picture before getting into the details. |
| 7. I prefer to get new information in<br>a. pictures, diagrams, graphs, or maps.<br>b. written directions of verbal information. | 29. I more easily remember<br>a. something I have done.<br>b. something I have thought a lot about. |
| 8. Once I understand<br>a. all the parts, I understand the whole thing.<br>b. the whole thing, I see how the parts fit. | 30. When I have to perform a task, I prefer to<br>a. master one way of doing it.<br>b. come up with new ways of doing it. |
| 9. In a study group working on difficult material, I am more likely to<br>a. Jump in and contribute ideas.<br>b. The whole thing, I see how the parts fit. | 31. When someone is showing me data, I prefer<br>a. charts or graphs.<br>b. text summarizing the results |
| 10. I find it easier<br>a. to learn facts.<br>b. to learn concepts. | 32. When writing a paper, I am more likely to<br>a. work on (think about or write) the beginning of the paper and progress forward.<br>b. work on (think about or write) different parts of the paper and then order them. |
| 11. In a book with lots of pictures and charts, I am likely to<br>a. look over the pictures and charts carefully.<br>b. focus on the written text. | 33. When I have to work on a group project, I first want to<br>a. have "group brainstorming" where everyone contributes ideas.<br>b. brainstorm individually and then come together as a group to compare ideas |
| 12. When I solve math problems<br>a. I usually work my way to the solutions one step at a time.<br>b. I often just see the solutions but then have to struggle to figure out the steps to getto them. | 34. I consider it high praise to call someone<br>a. Sensible<br>.b. imaginative. |
| 13. In classes I have taken<br>a. I have usually gotten to know many of the students.<br>b. I have rarely gotten to know many of the students. | 35. When I meet people at a party, I am more likely to remember<br>a. what they looked like.<br>b. what they said about themselves. |
| 14. In reading nonfiction, I prefer<br>a. something that teaches me new facts or tells me how to do something.<br>b. something that gives me new ideas to think about. | 36. When I am learning a new subject, I prefer to<br>a. stay focused on that subject, learning as much about it as I can.<br>b. try to make connections between that subject and related subjects. |
| 15. I like teachers<br>a. who put a lot of diagrams on the board.<br>b. who spend a lot of time explaining. | 37. I am more likely to be considered<br>a. outgoing.<br>b. reserved. |
| 16. When I'm analyzing a story or a novel<br>a. I think of the incidents and try to put them together to figure out the themes.<br>b. I know just what the themes are when I finish reading and then I have to go backand find the incidents that demonstrate them. | 38. I prefer courses that emphasize<br>a. concrete material (facts, data).<br>b. abstract material (concepts, theories). |
| 17. When I start a homework problem, I am more likely to<br>a. start working on the solution immediately.<br>b. try to fully understand the problem first | 39. For entertainment, I would rather<br>a. watch television.<br>b. read a book. |
| 18. I prefer the idea of<br>a. certainty.<br>b. theory. | 40. Some teachers start their lectures with an outline of what they will cover. Such outlines are<br>a. somewhat helpful to me.<br>b. very helpful to me. |
| 19. I remember best<br>a. what I see.<br>b. what I hear. | 41. The idea of doing homework in groups, with one grade for the entire group<br>a. appeals to me.<br>b. does not appeal to me. |
| 20. It is more important to me that an instructor<br>a. lay out the material in clear sequential steps.<br>b. give me an overall picture and relate the material to other subjects. | 42. When I am doing long calculations,<br>a. I tend to repeat all my steps and check my work carefully.<br>b. I find checking my work tiresome and have to force myself to do it. |
| 21. I prefer to study in<br>a. study group<br>b. alone. | 43. I tend to picture places I have been<br>a. easily and fairly accurately.<br>b. with difficulty and without much detail. |

**Table A1.** *Cont.*

| | |
|---|---|
| 22. I am more likely to be considered<br>a. careful about the details of my work.<br>b. creative about how to do my work. | 44. When solving problems in a group, I would be more likely to<br>a. think of the steps in the solution process.<br>b. think of possible consequences or application of the solution in a wide range of areas. |

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