

Article

The History of Earth and Life: Escape Room for High School Students

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Abstract: Introduction: This study investigates how different teaching strategies influence students' learning outcomes and engagement. Objective: The primary aim is to evaluate the knowledge and motivation of students in the first year of high school (17 years old), before and after participating in an escape room activity on the History of the Earth and Life. Methodology: The research involved 50 students, divided into a control group that received traditional lectures and an experimental group that participated in a gamified experience. Pre- and post-intervention assessments were conducted to measure knowledge acquisition, and motivation was assessed through a survey. Statistical analyses, including ANOVA, were performed to compare the effectiveness of both teaching methods. Results: The study shows significant statistical differences between the two strategies, demonstrating a notable increase in learning through gamification ($F(1, 48) = 21; p < 0.001$). Additionally, students in the experimental group perceived the methodology as more engaging, highlighting its dynamic, interactive, and motivating nature. Conclusions: The findings suggest that incorporating interactive and dynamic learning experiences can foster deeper engagement with the content.

Keywords: escape room; teaching proposal; history of life; high school education



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1. Introduction

In recent years, interest in scientific literacy has increased substantially, thanks to didactic research and the development of new educational methodologies (Herrera, 2021). This interest is not fortuitous, as scientific literacy has been identified as a key tool for developing an informed and critical citizenry (Solbes et al., 2018). Education offers excellent opportunities to foster literacy of present and future citizens through work with students (e.g., Ballesteros-Ballesteros & Gallego-Torres, 2022). One of the main virtues of scientific literacy is that it increases the level of scientific knowledge of the population, as well as favouring critical thinking (Bernal et al., 2020; González et al., 2023). This aspect is crucial in the current context of planetary emergency, as Alcañiz et al. (2021) argue, which requires a citizenry capable of becoming actively involved in the transition towards sustainability.

In this sense, today's society faces numerous challenges in which Earth Sciences can play a fundamental role. However, the Spanish education system provides limited exposure to Earth science (Giner-Baixauli et al., 2024; Pedrinaci et al., 2013). These authors emphasise that for a person to be considered Earth science-literate, they must gain a comprehensive understanding of Earth's processes. Additionally, they should recognise that geological

phenomena operate on timescales far beyond human perception and improve their interpretation of contemporary environmental events. Furthermore, they should be aware of the interactions between life and the Earth's systems. Despite its importance, Earth Sciences remain underrepresented in the school curriculum. Authors such as [Clary et al. \(2009\)](#) or [Nam et al. \(2016\)](#) advocate for the inclusion of geological time scale comprehension as a fundamental component of scientific literacy.

It is important to note that, in the last decade, research in Earth science education has evolved from a static and fragmented view toward a holistic perception of Earth science as a complex system, according to [Orion and Libarkin \(2014\)](#) and [Guo et al. \(2020\)](#). Although research in this field is still limited, a solid foundation is being laid for its incorporation into secondary education. Within Earth Science, Earth History allows for the encompassing, integration, and correlation of various concepts about life and Earth, as well as the interactions between them, making it highly relevant for secondary education and didactic research ([Orion & Libarkin, 2014](#)). This topic, as pointed out by [Pedrinaci et al. \(2013\)](#) and [Orion et al. \(2020\)](#), encompasses areas such as evolution, environmental change, climatology, internal and external dynamics of the planet, extinctions, and life radiation.

Currently, student attitudes toward science are a major concern in the field of science education ([Muñoz et al., 2023](#); [Ayala & Hoyos, 2024](#)) due to their influence on scientific vocations. The application of innovative proposals is seen as a strategy that can improve such attitudes ([Solbes, 2011](#); [Lozano, 2012](#)). Although researchers such as [Betzner and Marek \(2014\)](#), [Young and Shepardson \(2018\)](#), and [Zamalloa and Sanz \(2020\)](#) stress the importance for teachers and researchers of student's attitudes in the learning process, there has been little research conducted specifically in relation to the subject of Geology. [Adetunji et al. \(2018\)](#) previously highlighted that geosciences face greater challenges than many other STEM disciplines due to the limited exposure to geoscience at the beginning of academic life.

Regarding attitude and motivation, game-based learning and gamification can play a crucial key role in science teaching ([Galarza & Batista, 2024](#)), promoting the development of competencies, skills, and knowledge acquisition ([Cornellà et al., 2020](#)). [Edo \(2004\)](#) argues that the use of play as a learning tool and as a developmental element is more widely accepted in early childhood education and the initial years of primary school than in later education stages, particularly secondary school. The high academic demands and extensive curricular content in high school could explain the limited presence of didactic proposals incorporating gamification at this level. Despite this, many students are motivated by the game and spend their free time playing ([Rodríguez & Santiago, 2015](#)), making its integration into the learning environment a highly recommended strategy.

When using games for educational purposes, it is important to clarify the meaning of the term gamification. According to [Nousiainen et al. \(2015\)](#), 'it is a way of teaching that promotes and enhances learning in a meaningful way'. Escape rooms and breakouts are two of the most successful and widely used examples of content gamification in schools in recent years ([Veldkamp et al., 2020](#); [Taraldsen et al., 2022](#)). Gamification is a highly effective and increasingly common teaching strategy for science education ([Kalogiannakis et al., 2021](#)). [Mills et al. \(2020\)](#) emphasise that through creative activities, students have the chance to learn actively and through hands-on experiences. Educational escape rooms have been introduced in classrooms due to their potential to stimulate students' cognitive abilities ([Lázaro, 2019](#)). Some authors, such as [Rodríguez-Rivera and Manzano-León \(2024\)](#) and [Rodríguez-Rivera et al. \(2025\)](#), indicate that the design of digital escape rooms enhances creativity, promotes cooperative learning, boosts problem-solving skills, and positively impacts the development of transversal competencies in higher education. These game-based methodologies are shown to significantly improve student engagement, motivation,

and performance, providing more dynamic and comprehensive assessments of student competencies (Rodríguez-Ferrer et al., 2025).

Several studies on Geology teaching in secondary education have shown that students exhibit higher motivation and improve their understanding when content is gamified, whether through role-playing games (Chen et al., 2016), the use of electronic tablets (Sánchez et al., 2015), or video games (Westrin et al., 2020). Within the subject of the History of the Earth and life, a study carried out at the university level (Historical Geology and Palaeontology) demonstrates that incorporating game elements boosts students' engagement and motivation, facilitating learning (Reuss & Gardulski, 2001), provided that prior knowledge is adequately ensured.

As mentioned above, there is a significant gap in the application and research of gamification at the high school level, as most studies focus on earlier educational stages, such as primary and lower secondary education (Luo, 2022). This study aims to contribute to a better understanding of the impact of gamified educational proposals in high school by developing and evaluating a structured proposal, thus expanding the theoretical and practical corpus of game-based learning in diverse educational contexts and providing a solid empirical basis for future research in this field.

The aim of this work is to assess the impact of a gamified teaching methodology—specifically, an escape room—on learning and motivation in first-year high school students.

The main hypothesis is that students participating in a gamified escape room activity will experience significant improvements in their perception, motivation, and knowledge of the History of Earth and Life compared to those who receive instruction through traditional lectures.

2. Materials and Methods

In order to test the working hypothesis discussed above, a gamified experience was developed, and the effectiveness and students' perception were evaluated through questionnaires, namely, a pre-test and a post-test, each with assigned scores.

This section is divided into three parts: the first summarises the teaching sequence, the second focuses on the questionnaires, and the last describes the methodology used to analyse the results obtained from the questionnaires, which combines quantitative and qualitative approaches.

2.1. Description of the Work Sequence

A five-session intervention was conducted with 50 first-year high school students (17 years old) from two groups at the same educational centre, all enrolled in the subjects of Biology and Geology. Each group consisted of 25 students. The school was a publicly funded school located in an urban area of the city of Valencia (Spain), with a medium socio-economic and cultural background.

As shown in Table 1, both groups (control and experimental) were given 45 min to complete a questionnaire on prior knowledge (pre-test) that will be described later. Then, over the next three sessions, the control group received instruction on the History of Earth and Life through lectures supported by graphic material (displayed in PowerPoint format). The experimental group participated in the gamified experience during the same three sessions. Finally, both groups were given 45 min to complete the final evaluation questionnaire (post-test).

Table 1. Number of sessions of the teaching sequence, duration, and task per group.

Session	Duration (Minutes)	Group 1 (Control): Master Lessons	Group 2 (Experimental): Gamified Lessons
		Task	Task
1st	45	Prior knowledge test (pre-test)	Prior knowledge test (pre-test)
2nd	55	Lecture 1	Escape room about Precambrian and Palaeozoic
3rd	55	Lecture 2	Escape room about Mesozoic
4th	55	Lecture 3	Escape room about Cenozoic
5th	45	Final knowledge test (post-test)	Final knowledge test (post-test)

All the questionnaires were handed out on paper and completed in the regular classroom for both groups, ensuring consistency in administration conditions.

For the second, third, and fourth sessions, the content in both groups was divided into events that occurred in different geological periods, arranged chronologically, as shown in Figure 1. The Precambrian and Palaeozoic periods were covered in the same session because, although the Precambrian occupies almost 90% of the Earth's history, it includes fewer historical events compared to the three subsequent eras. For the design of the escape room, the Precambrian Eon and the Paleozoic, Mesozoic, and Cenozoic Eras were each assigned to separate rooms, with the Precambrian represented as a long corridor (to simulate its proportion on the geological time scale) containing few events. The Palaeozoic, Mesozoic, and Cenozoic periods were enclosed, and consecutive rooms were arranged in chronological order. In each room, students encountered games and challenges to solve, with decorations including posters, drawings, and figures representing the era. The last challenge of each room (era) required opening a chest containing the key to the next era. To illustrate this design, Figure 1 includes a scale map of the rooms used for the escape room, along with photographs of the activity.

2.2. Instruments for Data Collection

To analyse whether students experienced significant improvements in their perception, motivation, and knowledge of the History of Earth and Life, two questionnaires were developed to compare their understanding before and after the experience. Both questionnaires were identical in structure, with the only difference being that the second one included additional questions to assess students' perception and motivation towards the experience. The design of the questionnaires combined structured, closed-ended questions with unstructured, open-ended questions (particularly in the post-test to gather qualitative insights about the experience).

The design was based on the ideas of [Alonso et al. \(2004\)](#), who stressed the importance of meeting two quality criteria: validity and reliability. Consequently, the questionnaires were evaluated by experts in Geology, and validations were conducted by three researchers in experimental science didactics. Additionally, two high school teachers and one secondary school teacher (Biology and Geology) reviewed the questionnaires to ensure their relevance and appropriateness for the high school classroom context, considering both pedagogical and content-related aspects. Finally, to ensure clarity and language suitability for the educational level, the questionnaires were tested with three high school students (who did not participate in the study) who confirmed their comprehensibility.

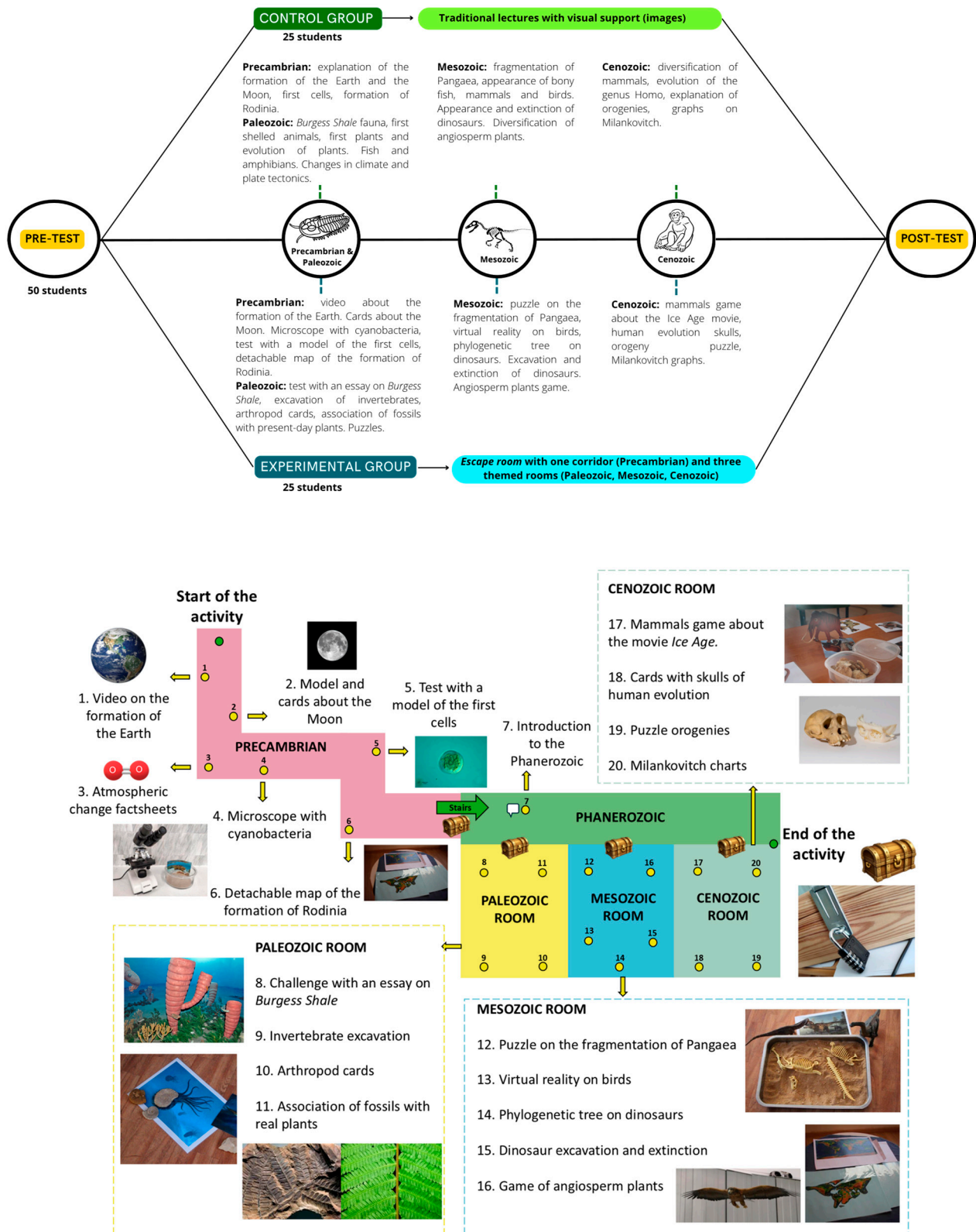


Figure 1. Above: Sequence of work for the control and experimental group sessions. Images used in the figure: trilobite (by heyrrabbiticons), velociraptor (by Puwadol Jaturawutthichai' Images), chimpanzee (by The Ants). Below: Plan of the classrooms where the escape room was designed, including photographs of the different stations and challenges. The *Burgess Shale* image used in the figure is by James St. John, from Flickr.

The questionnaires consisted of forty-seven items, including twenty common questions (Appendix S1), which were answered by each student individually. These questions focused on assessing knowledge related to the History of Earth and Life. Within the questions, there were multiple-choice items, questions requiring table completion or image association, dichotomous (true–false) questions, as well as short-answer questions that required students to respond in their own words.

Table 2 presents the structure of the questionnaires and the scores assigned to the different concepts measured (related to chronology, historical events, dating methods, and fossil recognition) with a maximum score of 47 points if all questions were answered correctly. Scores were assigned according to the importance of each aspect, following the general criterion of giving more relevance (points) to items that required establishing a complex relationship between different elements of the History of Earth and Life, as opposed to those that simply required recalling a specific date or isolated fact.

Table 2. Structure and score distribution for each item of the pre-test and post-test questionnaires *.

Measured Concept	Question Number	Question Type	Score
Chronology	Question 1	Complete a table	10
	Questions 15 and 16	Order events	6 (3 points each question)
Historical events	Questions 3, 5, 6, 7, 8, 9, 10, 11, 14, and 18	Multiple choice	10
	Questions 4 and 13	Short question	6 (3 points each question)
	Question 12	Short question	2
	Questions 19 and 20	True/False	8
Earth age	Question 2	Multiple choice	1
Fossil recognition	Question 17	Picture matching	4
Total	20		47

* The pre-test and post-test quantitative questionnaire, as presented to the students, is shown in Appendix S1.

The questions were formulated to assess whether students could distinguish between broader concepts and more specific ones.

Some questions aimed to determine whether students could organise geological periods (Question 1) and events; Question 15 was more general, requiring students to complete a table with the three geological eras (Paleozoic, Mesozoic, and Cenozoic) and place five events within the correct era. Question 16, however, was more specific, providing a list of eight events that students had to arrange in the correct chronological order.

Additionally, the questionnaire included items on historical events; Questions 3, 5–11, 14, and 16 were multiple-choice questions, each with four possible answers, of which only one was correct. These were questions such as ‘In which period did Pangaea form?’ or ‘In which period were fern forests abundant? Some questions (4, 12, and 13) required short answers about historical events. For example, ‘What is the name of the extinction that led to the dinosaurs’ disappearance? How many million years ago did it occur? How did it happen?’.

The quiz also included a multiple-choice question about the exact age of the Earth (Question 2) and an image-based task (Question 17) in which students had to identify and name key fossils. Finally, there were two true/false questions (Questions 19 and 20) related to significant historical events.

Although the questions have been described individually here, in the questionnaires, they were interspersed rather than presented in chronological order. This design choice was made to assess whether the students could identify and arrange historical events in the correct sequence.

Regarding the evaluation of the experience and teaching methodologies, the post-test questionnaire included a specific section with three questions for each group (control and experimental). The control group was asked to evaluate the lectures, including questions about any motivational elements that may have been used. The complete post-test questionnaire for the control group can be found in Appendix S2. The experimental group, in addition to providing a general assessment, was asked to compare the experience with traditional lecture-based teaching. They were also invited to reflect on what they had learned from the experience and suggest potential improvements. The full post-test questionnaire for the experimental group can be found in Appendix S3.

2.3. Data Analysis Methodology

The results of the experience have been analysed through the questionnaires with a mixed approach, carrying out a quantitative analysis of the common block of the pre-test and post-test, related to knowledge about the History of the Earth and Life, and a qualitative approach to address the students' assessment of the methodology used and their motivation.

For the analysis of the questionnaire responses to the closed-ended questions (dichotomous and/or multiple-choice), a simple and direct coding was carried out. To analyse the short answers, a detailed reading of all the answers from both questionnaires was conducted, categorising them. The coding was then reviewed by another researcher, and criteria were agreed upon to ensure that the coding was homogeneous and consistent throughout the data analysis, confirming the uniformity of the application of the previously created categories. Appendix S4 shows the analysis grid used.

For the analysis of the responses collected in the exclusive post-test questions related to the evaluation of the experience (motivation and perception), each response was divided into units of meaning, which were then assigned to different categories. Appendix S5 shows the categories for the control group and for the experimental group in relation to the different questions added to the post-test questionnaire.

The experimental design for analysing the results extracted from the questionnaires through the application of the analysis networks is detailed below. The answers to the twenty questions in the questionnaire that students completed before and after the experience were analysed. To ensure anonymity, each student was assigned a number, from 1 to 50, followed by the letter E (student). This identification allowed for the correct conduct of statistical analysis since it is essential to correlate the two pre-test and post-test questionnaires for each participant.

The data passed the Kolmogorov–Smirnov test to ensure the normal distribution of the variable and to justify the use of ANOVA, which is appropriate when the dependent variable is numerical and normally distributed and the independent variables (factors) are nominal.

According to [Theobald and Freeman \(2014\)](#), the results derived from the pre- and post-tests can be analysed in several ways to determine whether there has been an increase in learning. Regarding the quantitative part of the research, the analysis of variance (ANOVA) is one of the most common parametric statistical tests used in this type of study (e.g., [Martin et al., 2007](#); [Ozogul et al., 2019](#)), and it was the method used in this paper. The ANOVA tests whether the improvement in students' scores in the grade where the educational intervention takes place is greater from pre-test to post-test than the improvement in the control group.

Within the types of ANOVA, a mixed ANOVA was selected, including a between-subjects factor, which distinguishes the participants in the control group from those in the

experimental group, and a within-subjects factor, since these measures are repeated (i.e., paired data).

To study the students' degree of motivation and perception of the experience regarding the methodology used, a qualitative analysis was carried out of the answers to the exclusive questions in the post-test questionnaire, both for the control and experimental groups. The students' responses were segmented into units of meaning within the categories established in the section on methodological design for the control group and for the experimental group.

3. Results

Fifty responses were collected from students in the first year of high school before the didactic intervention, providing an initial insight into the knowledge of students finishing compulsory secondary education in Spain regarding the History of Earth and Life. The analysis of the initial results (pre-test) revealed significant deficiencies in students' knowledge. Based on these deficiencies, the educational intervention was designed, and the effects are detailed below.

Box plots (Figure 2) have been created to visually represent the dispersion and symmetry of the data. It is evident that the mean in the pre-test is similar in the two groups, although in the experimental methodology, the sample shows greater dispersion. Regarding the post-test, the mean score in the experimental methodology increased significantly compared to the control methodology.

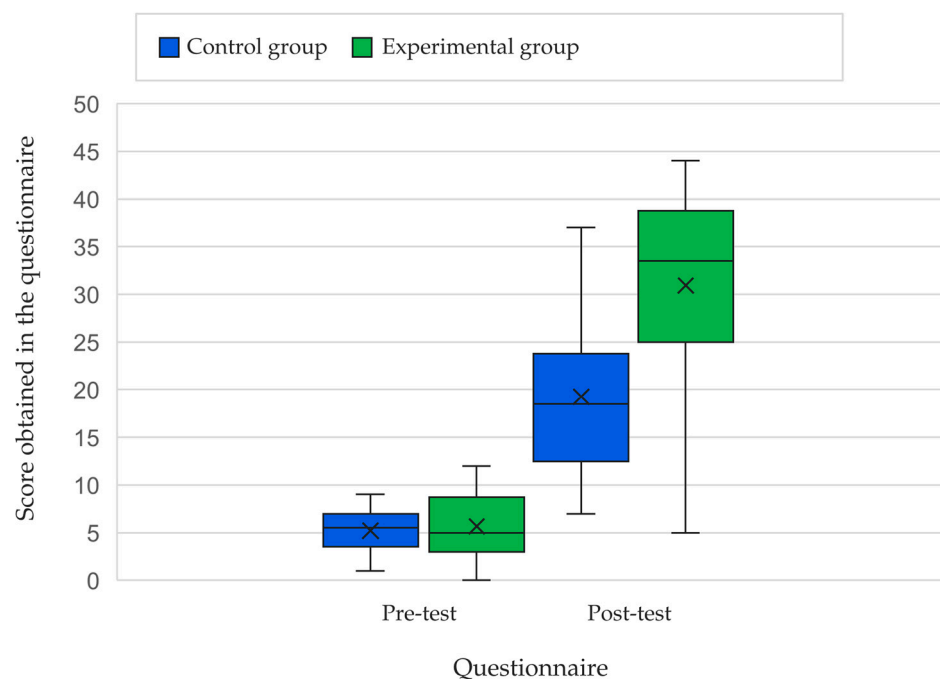


Figure 2. Box plots of the control and experimental methodologies with respect to the pre-test and post-test, generated using Excel. The X-axis represents the time of assessment (pre and post), while the Y-axis represents the scores obtained in these questionnaires.

As shown in Table 3, the raw numerical data reflect an improvement in learning with both methodologies, as the average score increases considerably. However, the experimental methodology appears to show a greater improvement.

Table 3. Categories for the qualitative questions of the control and experimental group.

		N	Mean	Standard Deviation
Control Methodology	Pre-test	25	5.22	2.19
	Post-test	25	18.5	8.03
Experimental Methodology	Pre-test	25	5.00	3.30
	Post-test	25	33.5	9.85

Once the data trend was identified, statistical tests were performed in greater depth on the comparative results obtained between the pre-test and post-test of both methodologies. A repeated measures mixed ANOVA was applied, including one within-subject factor (pre-test/post-test) (Table 4) and one between-subject factor (control methodology/experimental methodology) (Table 5).

Table 4. Within-subject repeated-measures ANOVA.

	Sum of Squares	Df *	Quadratic Mean	F	p-Value	η^2 Parcial
Pre-post	9663	1	9662.9	257.4	<0.001	0.843
Pre-post with Methodology	790	1	789.6	21	<0.001	0.305
Residual	1802	48	37.5			

* Df: Degrees of freedom.

Table 5. Between-subject repeated measures ANOVA.

	Sum of Squares	Df *	Quadratic Mean	F	p-Value	η^2 Parcial
Methodology	918	1	918.1	18	<0.001	0.273
Residual	2449	48	51			

* Df: Degrees of freedom.

The main effect of the pre-test factor was significant, meaning that, overall, participants showed a significant increase in their learning between the pre-test and the post-test.

$$(F(1, 48) = 257.4; p < 0.001, \text{partial } \eta^2 = 0.843)$$

This represents a very large effect size, suggesting that the learning gains were highly consistent across participants, regardless of the methodology used.

Furthermore, the interaction between the pre-post and methodology factors was also significant,

$$(F(1, 48) = 21; p < 0.001, \text{partial } \eta^2 = 0.305)$$

indicating that the improvement in test scores was significantly greater for students in the experimental group compared to the control group. The partial eta squared value reflects a large effect size, highlighting the meaningful impact of the teaching approach on student learning outcomes.

In addition, a more exhaustive analysis using questionnaire items showed that in the pre-test, the students showed greater deficiencies in the chronology and historical events sections, while the best results were obtained in the section on the age of the Earth. As for the post-test, the degree of improvement was more significant in chronology than in historical events, although the experimental group excelled especially in the correct location of events within the corresponding eras and periods.

Regarding the evaluation of the methodology used, the qualitative results were categorised into units of meaning, which are presented in Appendix S1. As this was an

open-ended questionnaire, it should be noted that some students provided more detailed opinions, including responses in two or even three categories (e.g., student E08). In these cases, the unit of meaning of interest for that particular category has been underlined.

For the three questions of the control group, all the students' responses can be found in Appendix S6.1, specifically in Tables S1, S2 and S3, respectively. The letter E followed by a number (e.g., E26) refers to the anonymised code of each participating student.

Concerning students' views on the class, almost all participants showed a definite interest in the subject, e.g., "I am very interested in the subject, I have learned a lot" (E03). When inquiring about what they prized most in a lectured based class, students highlighted the clarity of the explanations given, "I appreciate that the content is explained well, calmly and not complicated to understand, and if it is, there are resources to facilitate the level of difficulty" (E06), the incorporation of visual aids, "PowerPoint helps a lot, since it allows us to see things with images, and it is better understood" (E20), and the opportunity for interaction, "I like that you can ask questions" (E02). When questioned about how to enhance the experience's motivation, most students preferred more engaging and interactive activities, including games: "in the middle of the explanation, play a quick game for us to participate" (E13). Nonetheless, a few students favoured the lessons' format with minor improvements.

Next, the answers to the three questions of the experimental group were analysed (Appendix S6.2: specifically in Tables S4, S5 and S6, respectively). All students in the gamified group reported enjoying the experience. The two most frequently cited reasons for preferring this methodology were its effectiveness in enhancing information retention "I think that I retained the information more easily" (E45), "... and also being set in an escape room, you keep more of all the data when you remember the room, or an image that had been pasted, or an object that was to be themed" (E42). The second reason was its dynamic and interactive nature "... it is more dynamic and become very enjoyable" (E45). The main aspect they felt needed improvement was the length of the activity, as they found it too short to complete it optimally: "We did not have enough time to carry out the activity well" (E29). Finally, all the students stated that they had increased their knowledge, attributing this to the spatial representation of geological time (eras and periods) across different rooms, "... the most interesting thing was the layout of the different rooms" (E39), as well as the immersive environment and visual materials used.

4. Discussion

The results of this study support our initial hypothesis that a gamification-based experiential methodology significantly improves student learning compared to traditional lecture-based teaching, as evidenced in the results section. This finding aligns with previous research, such as [Hamari et al. \(2014\)](#), [Dichev and Dicheva \(2017\)](#), and [Dolowitz \(2023\)](#), which has demonstrated the benefits of interactive and engaging educational strategies. Our results corroborate the idea that gamification can enhance academic performance by making the learning process more engaging and effective ([Macías-Guillén et al., 2021](#)). In line with similar research, such as that conducted by [Su and Cheng \(2015\)](#), our results suggest that gamified methodologies not only increase motivation but also promote better retention of information and understanding of content. We agree with [Lázaro \(2019\)](#) on the importance of careful task design to ensure alignment with the educational context. In our case, it was the regular classroom teacher who finalised the gamification and implemented the escape room.

An innovative aspect of our methodology was the implementation of a thematic escape room where each geological era was represented as a different room (as shown in Figure 1, above). This structure probably helped students organise and retain information more

effectively. Previous studies have suggested that the use of 'knowledge boxes' or mind maps can improve retention by providing a structured framework for learning (Buzan, 2006; Novak & Cañas, 2008). The escape room worked similarly, offering students an immersive experience that facilitated understanding and recall of the geological periods by associating each era with a specific physical space and dynamic activities in these spaces. Furthermore, Pickering et al. (2023) indicated that visual memory helps students recall historical events more effectively; therefore, the thematic design of the rooms supported this process.

The qualitative analysis also revealed significant differences between the two groups in terms of the perception of the methodology used. Students in the experimental group reported that they retained information better and perceived the methodology as more dynamic and interactive, which aligns with previous studies highlighting the importance of active learning and interaction to enhance student engagement (Deterding et al., 2011; Murillo-Zamorano et al., 2021). However, they missed some initial explanations and needed more time to solve the challenges. These aspects have also been noted in other escape room studies (Rodríguez-Rivera et al., 2025).

Conversely, the control group expressed significant interest in the lecture class; however, most students suggested incorporating more motivating and dynamic elements, specifically mentioning games as a potential improvement. This reinforces the idea that traditional lectures, while effective to a degree, could benefit from integrating interactive components to foster student interest and participation (Huang & Soman, 2013).

Future research should address the limitations identified in this study, such as time management. To maximise the benefits of gamification, it is crucial to design activities that fit appropriately within the time available or to allocate additional time if necessary. In addition, longitudinal studies could provide a more comprehensive understanding of the long-term impact of gamification on academic performance and skill development. Another limitation is the sample size; based on this pilot study, future research could expand the sample, incorporating the improvements mentioned above. Additionally, integrating digital tools could enhance the experience, as previous studies have shown positive results (Brusi & Cornellà, 2020; Rodríguez-Rivera et al., 2025). This would also facilitate its implementation in multiple secondary schools, making the approach more scalable and accessible.

5. Conclusions

This study has shown that the implementation of a gamification-based educational methodology is significantly more effective for student learning compared to the traditional lecture-based approach. Quantitative results indicated that participants in the experimental group showed a greater increase in their learning, as evidenced by significant improvements between the pre-test and post-test scores. Additionally, qualitative data revealed a more positive perception of the gamified methodology, highlighting its dynamic, interactive, and motivating characteristics, as well as its ability to foster collaboration and active participation among students.

These results align with previous research on the benefits of gamification in the educational context, suggesting that the incorporation of playful and dynamic elements can not only enhance student motivation and engagement but also promote deeper learning through experiential and contextualised activities. Moreover, the findings support the idea that gamification can contribute to the development of key competencies such as problem-solving, teamwork, and critical thinking, making it a valuable tool beyond content memorisation. However, it is important to note that the success of gamification depends on factors such as appropriate time management, the alignment of game mechanics with

educational objectives, and the personalisation of activities to address student diversity. The feedback received from the experimental group underlines the need for the careful design of gamified activities to ensure that they are well adapted to the time available and the specific needs of the students while also maintaining a balance between engagement and cognitive demand to maximise learning outcomes.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/educsci15040485/s1>, Questionnaire as the students received it.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Ethics Committee of University of Valencia (Application Reference 2024-MAGPED-3610455, date of approval: 22 October 2024).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

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