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Gamification Tools in Higher Education: Creation and Implementation of an Escape Room Methodology in the Pharmacy Classroom

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Abstract: Educational escape rooms have emerged as an excellent active learning tool to improve student learning, motivation, and engagement. In this work, a methodology to design and develop escape rooms in the classroom has been established and implemented within the general pharmacology, biopharmacy and pharmacokinetics, and pharmaceutical technology disciplines for pharmacy students. Each escape room consisted of three sequential challenges that the students had to solve, and we divided the students into groups of 3–6 participants to complete a mission containing educational questions related to the curriculum of each module. The escape rooms were successfully implemented in all these disciplines, and the activity was positively evaluated by the students (>95% satisfaction). They allowed the students to apply the theoretical learning outcomes of each subject. Moreover, escape rooms promoted teamwork and improved the problem-solving skills of the students. For an escape room to be successful and meet the established learning outcomes, challenges must be adapted to the target students, the time should be precisely set, the tasks of the game master should be well-defined, and final feedback should be included in the session.

Keywords: active learning; escape rooms; game-based learning; gamification tools; health sciences; integral formation in higher education; pharmacy degree; student engagement

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1. Introduction

Teaching methodologies in higher education have undergone a major shift moving from teacher-centred techniques in which students played a completely passive role acting as "mere listeners" of the lessons to active methodologies that imply greater student participation and student involvement in the classroom [1,2]. Many studies have highlighted that the use of blended learning methodologies is a very beneficial tool for student engagement [3]. Implementation of active educational techniques increases motivation, engagement, and student classroom attendance. Additionally, blended learning techniques allow the improvement of students' soft skills, such as critical thinking, problem-solving capacity, creativity, and collaborative competencies among others. All these results translate not only into better academic performance but also into an improvement in the personal life and future employability of the students [4,5].

Gamification is the application of game elements to non-game environments and is one of many blended learning strategies that has been implemented in higher education [6]. Educational staff in higher education are adopting this teaching methodology and incorporating it in different elements of games, such as badges, leaderboards, giftings, quests, points, and ranks, among others, during their lessons [7]. In recent years, a step forward has been taken, and educators have begun to turn classes into "immersive games", developing escape rooms for educational purposes.

The escape rooms are team-based live-action games in which players are challenged to resolve a mission consisting of several enigmas in a specific time. These types of games were first developed in Japan in 2007, but they rapidly spread to other countries and became popular leisure activities in many cities [8,9]. The players, usually 3–6 people per escape room, must collaborate to resolve the challenges. Therefore, these activities promote teamwork and leadership abilities [10]. Escape rooms are used in many companies to facilitate "team building" [11]. Moreover, the enigmas are usually based on cognitive puzzles that include ciphers, encoded messages, and combination locks among others [12], potentiating the logic, creativity, critical thinking, communication skills, and problem-solving capacity of the players. It should be noted that there is always a "game master" that supervises the successful development of the escape room and that provides clues to the players when requested [13]. All this makes escape rooms an excellent teaching tool in higher education to improve student learning [14,15].

However, the successful implementation of educational escape rooms in higher education is complex, and several aspects must be considered before starting. Firstly, it must be clear that unlike the objective of commercial escape rooms is "to have fun", educational escape rooms are focused on student learning. For this, it is necessary to cover a set of learning outcomes to the challenges proposed to the students being aligned to the curricula as well as combining them with fun elements. Secondly, it is key to take into account the target audience of the activity [16]. The audience of commercial escape rooms is broad. However, educational escape rooms are designed for a very specific target group, usually the students of a certain subject [14], and enigmas must be adapted to them. Therefore, for the escape room to be effective, it is essential to have extensive knowledge of the target students, their skills, and their attitudes [17]. Based on these considerations, the implementation of an escape room in the classroom should take place when an important part of the curriculum of the subject has been delivered to the students to enable them to actively apply themselves in the resolution of the challenges [18]. The number of students that will participate in the activity is also essential as it will dictate the number of game masters that will participate during the activity. Third, the available time is also an important aspect as it will determine the number and the complexity of the proposed challenges. The duration of educational escape rooms is limited to the academic timetable and usually lasts between 45 to 90 min. Finally, other aspects being considered are the available space to run the activity, limited to the size of the classroom [14], and the available resources. All of this determines the proposed game environment and challenges [19].

The main objective of this work was to design and develop a methodology for the implementation of educational escape rooms as a teaching strategy to improve student learning and engagement within health science-related disciplines, in particular pharmacy. Escape room games were designed and implemented in three different subjects, (i) biopharmacy and pharmacokinetics, (ii) general pharmacology, and (iii) pharmaceutical technology of the pharmacy degree at the University Complutense of Madrid (Madrid, Spain). Basic considerations to bear in mind during development and implementation were analysed, and student satisfaction was evaluated. Finally, the implemented methodology will be used with a different group of educators in different institutions to evaluate the degree of satisfaction with the training received.

2. Materials and Methods

2.1. Design, Development, and Implementation of Escape Rooms

In this work, educational escape rooms were developed for three different subjects in the pharmacy degree at the Universidad Complutense de Madrid (Spain): biopharmacy and pharmacokinetics, general pharmacology, and pharmaceutical technology.

2.1.1. Knowing the Target Audience

Before starting to design an escape room, it is important to know the target students that will participate. Therefore, it is advisable to implement the escape room either at the

end of the course or when the content of the course is relatively advanced so that students can apply their knowledge and skills during the activity. All the escape rooms developed in this work were carried out on the last day of class of the term, so the students had extensive knowledge of each discipline, enabling them to apply the knowledge and learn during the process.

As a first step, the application of an empathy map is a very useful tool to deepen the knowledge of the participants, which in turn will be reflected in the type of challenges proposed. The empathy maps used in this work were obtained from the tractionwise website (https://www.tractionwise.com/en/magazine/what-customers-want/ (accessed on 20 August 2022)), and the questions used were the following:

1. What do the students think and feel? (e.g., students' aspirations)
2. What do the students hear? (e.g., what do influential people say?)
3. What do the students see in their environment?
4. What do the students say and do? How do the students behave? (e.g., poorly or highly engaged with the subject)
5. What efforts do the students make, and what barriers do they encounter? (e.g., low, medium, or high difficulty challenges)
6. What results do the students seek? (e.g., knowledge, skills, or aptitudes that the students want or need to achieve)

Educators should consult these items before creating a new teaching methodology and, in particular, an escape room. For this reason, it is more convenient to implement an escape room at least after a few hours of contact between students and the educator, so the educator understands the essence of what the students are looking for and expecting from such an activity. Knowing the target group will facilitate the setup of the game.

2.1.2. Learning Outcomes

Other aspects that must be considered before designing educational escape rooms are the learning outcomes to be achieved that must be aligned with the curriculum of each discipline.

In the general pharmacology escape room, six key learning outcomes were covered:

1. To understand basic terminology in pharmacology.
2. To understand how drug databases are managed.
3. To understand the mechanism of action of drugs at the molecular level and the main characteristics of the structure and function of receptors.
4. To understand the processes of absorption, distribution, metabolism, and excretion of drugs.
5. To identify and assess different types of adverse reactions associated with pharmacological treatments.
6. To be able to determine the site of absorption of a drug based on the Henderson–Hasselbalch equation.

In the biopharmacy and pharmacokinetic escape room, three key learning outcomes were established:

1. The concept of the plasma drug half-life.
2. The concept of the drug volume of distribution in the body.
3. The concept of relative and absolute drug bioavailability.

In the pharmaceutical technology module, a discipline focused on the design and manufacturing of medicines, the escape room covered three key learning outcomes:

1. The selection of the most suitable administration route for a specific indication.
2. The selection of the most suitable pharmaceutical dosage form for a specific indication.
3. The identification of the properties and characteristics of a drug that can limit its clinical efficacy and safety.

2.1.3. Escape Room Narrative and Challenge Design

Once the objectives of the escape room have been established, it is important to frame the learning objectives within a relevant narrative or story to establish a suitable game environment that can engage the interest of the students. In this work, each escape room consisted of three different sequential enigmas that the students must resolve to complete the mission. The flow chart used during the escape room is illustrated in Figure 1.

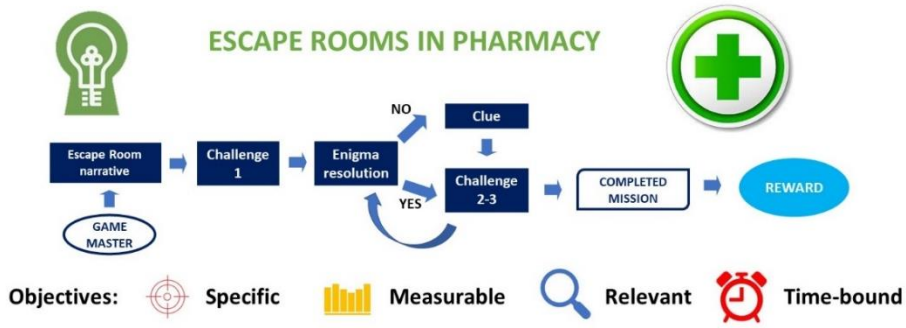

Figure 1. Flowchart used in the escape rooms implemented.

The pharmacology escape room focused on a 2-year-old patient admitted to a paediatric intensive care unit (ICU) with suspected poisoning. In this scenario, the patient accidentally ingested a specific drug to relieve the symptoms of allergies. The students had to solve three challenges based on pictograms, a crossword puzzle, and short answer-based questions to find the drug responsible for this intoxication and the antidote necessary to save the patient.

In the biopharmacy and pharmacokinetic escape room, the narrative consisted of an anthrax outbreak. At the beginning of the game, students received a letter warning them about them being potentially intoxicated with anthrax spores. Students had to solve three numerical challenges to decipher the half-life of the contaminant in the body, the dose of antidote requested, and the relative bioavailability of the antidote in the body.

In the pharmaceutical technology escape room, an outbreak produced by a toxin was contextualised. The story was focused on a highly lethal toxin spread throughout Europe, and the researcher in charge had disappeared before finding the cure. The students had to find and prepare the antidote against the toxin by deciphering a set of pictograms, crossword puzzles, and short answer-based questions.

2.1.4. Playing the Escape Rooms

All the escape rooms took place in the usual classrooms where each module was usually taught. Before each game, the educator responsible for each module acted as the "game-master" and prepared the room accordingly, setting all of the clues (lockers and puzzles) at their corresponding positions. The students then entered the room and were distributed into groups of 3–6 students. Students were studying pharmacy degrees at the Complutense University of Madrid during the academic year 2020–2021. In Table 1, the main characteristics of the three games are summarised.

Table 1. Main characteristics of the escape rooms implemented in this work.

Characteristics	Pharmacology	Biopharmacy and Pharmacokinetics	Pharmaceutical Technology
Number of Participants	16	27	13
Number of Groups/game	4	6	4
Number of challenges	3	3	3
Duration	45 min	45 min	45 min

Once the students were organised into groups and distributed throughout the class, the "game-master" explained the rules necessary to perform each escape room (e.g., all the clues have only one use and are distributed in the classroom at the player's fingertips) and the narrative and mission of each activity. Then, the students had 45 min to resolve all three challenges proposed to complete the mission. It should be noted that the educators were in the classroom during all the games to provide support to the students and provide them with the necessary clues. In Figure 2, several examples of the enigmas and clues proposed during the escape room are illustrated.

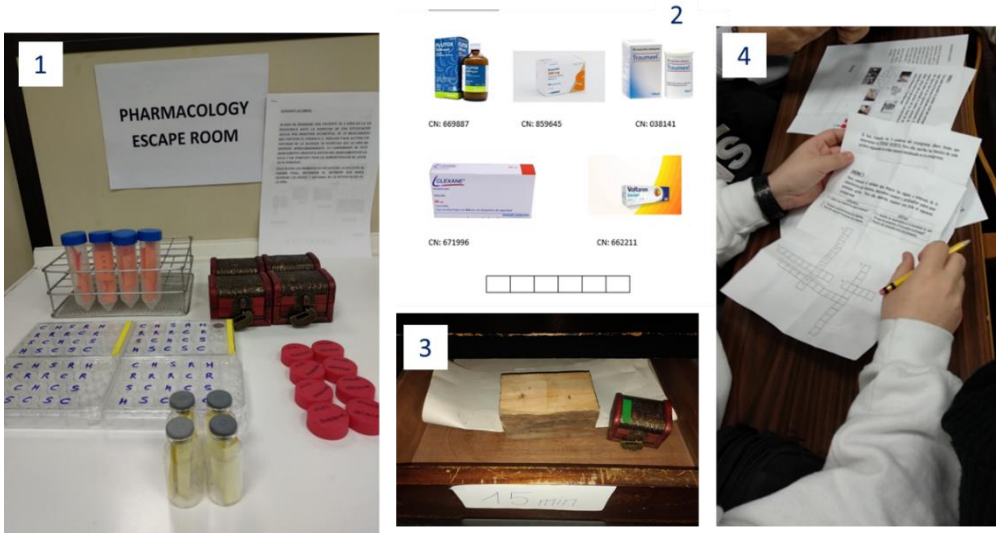

Figure 2. Examples of the challenges and game elements used in the escape rooms: (**1**) Game base elements used in the pharmacology escape room. (**2**) Pictogram used in one of the enigmas of the pharmaceutical technology escape room. (**3**) A chest used in the biopharmacy and pharmacokinetic escape room. (**4**) Students solving one of the enigmas of the pharmacology escape room.

All the escape rooms lasted 60 min. The following scheme was followed: 5 min for the organisation of the students in groups and the explanation of the rules and narrative of the activity, 45 min for the students to solve all the challenges and complete the mission, and 10 min to summarise the activity.

2.1.5. Questionnaire

After each escape room, students filled out an online questionnaire using "google forms" to measure their degree of satisfaction and learning engagement with the activities. The questions were based on a questionnaire used in a previous study [20]:

1. Do you think gamification activities should be implemented in the classroom to improve student learning?
2. Do you think you have learned while playing escape room?
3. What did you like most about the escape room?
4. What did you like the least about the escape room?

Questions 1 and 2 were multiple choice with the following possible answers: "No", "Yes—a little bit", or "Yes—a lot", while questions 3 and 4 were written answer questions to collect as much information as possible about the student's perceptions.

2.2. Training Other Educators to Develop Escape Rooms in Other Disciplines

"Master Class" sessions were developed to share the knowledge acquired with educators from other institutions, such as the Lithuanian University of Health Sciences. This Master Class was delivered online using the google meet platform for over 45 min, followed by a 15 min discussion. An online questionnaire consisting of 4 multiple-choice questions (yes or no) was sent to the attendees to find out their feedback on the activity and their

willingness to create and implement their own escape rooms. Google forms were used. The following questions were evaluated:

(1) Do you consider that the implementation of game-based learning approaches in the classroom has benefits for students?
(2) Have you ever implemented game-based learning approaches in the classroom? If yes, what approaches have you implemented?
(3) Do you consider that the development of escape rooms in the classroom may have benefits for students?
(4) Do you consider that a similar training as the one received has helped you in implementing escape rooms?

2.3. Ethical Considerations

Participation in the escape rooms developed for this project was voluntary. The answers collected from the questionnaires were anonymous.

3. Results

3.1. Data Collected from Escape Rooms

As shown in Figure 3, a total of 56 students participated in the escape rooms: 16 in the pharmacology escape room, 27 in the biopharmacy and pharmacokinetic escape room, and 13 in the pharmaceutical technology escape room. The questionnaire was completed by 36 participants, representing a response rate of 62.5%. It is interesting to note that 35 questionnaire respondents (97%) considered the use of gamification tools in the classroom as a way of improving student learning. Thirteen students (36.1%) showed positive feedback for the game, indicating that it enhanced their learning process, while twenty-two students (61.1%) considered that the game significantly allowed them to improve their learning process. One student (2.8%) did not show positive learning satisfaction with the game.

In the open question, "What did you like the most?", most students considered that the escape rooms allowed them to learn in a fun way and improve their problem-solving skills. Some students highlighted the importance of team building to solve most challenges, considering that the escape room promotes teamwork. In contrast, in the question "What did you like the least?", a great majority of the students considered that the escape rooms were too short in time and the number of challenges proposed was too small. Table 2 shows all student responses to these questions. Data were organised into categories, and the number of answers in each category was quantified.

Table 2. The most and least likeable items of the escape rooms pointed out by the students.

What Did You Like the Most? (*n* = Number of Answers in Each Category)	What Did You Like the Least? (*n* = Number of Answers in Each Category)
You can learn in a fun way (*n* = 13)	Short-lived activity (*n* = 11)
You can apply the theoretical concepts learned in the classroom (*n* = 6)	The number of enigmas to solve was too little (*n* = 10)
Dynamic activity (*n* = 9)	Nothing (*n* = 11)
Teamwork (*n* = 8)	Few participants (*n* = 4)

3.2. Data Collected from Master Class

A total of 18 professors from the Lithuanian University of Health Sciences attended the Master class. The questionnaire was completed by eight participants. All of them answered that they have never developed gamification activities in the classroom but have considered that its implementation (including escape rooms) is beneficial for student learning. In total, 75% of the educators considered that escape rooms have great potential for higher education. Regarding the feasibility of implementing and developing escape rooms in the classroom, most participants agree (75%) that it is feasible, while the remaining showed some concerns regarding their implementation, especially lack of time in the curriculum. All participants

agree that training, such as the one received, is required and very useful to help in the implementation of this type of gamification technique in higher education. All participants highlighted the need to receive further training (Figure 4).

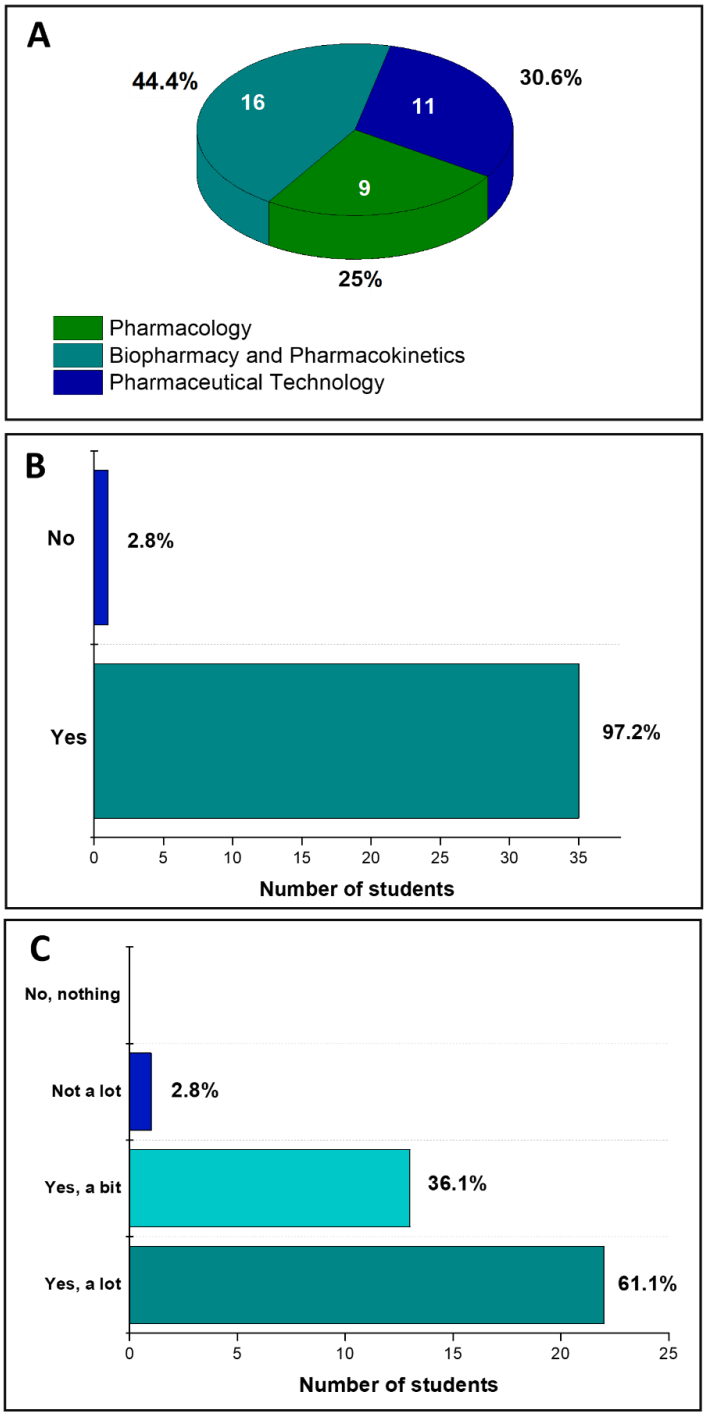

Figure 3. Student responses to the escape game questionnaire. (**A**) Distribution of the total students that completed the questionnaire in the different escape rooms. (**B**) Recorded answers to the questions "Do you think gamification activities should be implemented in the classroom to improve student learning?" and (**C**) "Do you think you have learned while playing Escape Room?".

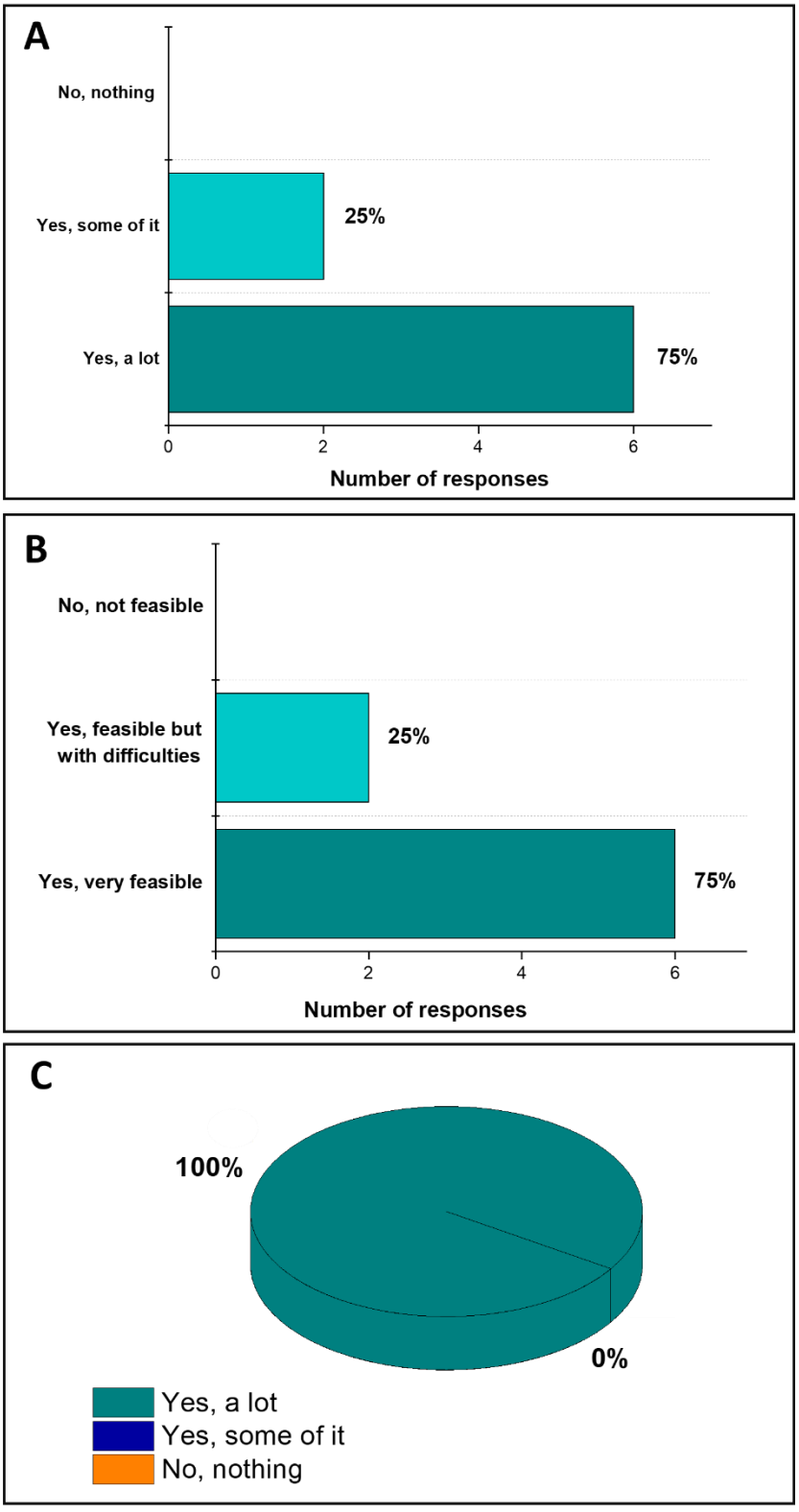

Figure 4. Student responses to the escape game questionnaire. (**A**) Distribution of the total students that completed the questionnaire in the different escape rooms implemented. (**B**) Recorded answers to the questions "Do you think gamification activities should be implemented in the classroom to improve student learning?" and (**C**) "Do you think you have learned while playing Escape Room?".

4. Discussion

In recent years, escape rooms have emerged as an attractive, active teaching methodology to improve student learning and engagement in higher education [21]. It should be noted that Health Science education represents one of the areas where more escape rooms have been implemented, especially in nursing but also medicine, dentistry, and pharmacy. The development of this activity allows students to better reproduce situations that they may find in their future professional life, allowing them to apply theoretical concepts in practice [22]. The objective of this work was to design and develop a methodology for the implementation of educational escape rooms as a teaching methodology to improve the learning and engagement of students in health science-related disciplines, in particular, pharmacy.

It should be noted that escape rooms are generally very well accepted by students. Very positive feedback (97% student satisfaction) was obtained in all three escape rooms, considering that the development of this kind of activity in the classroom is beneficial for the students as it allows them to learn in a fun way. This methodology contributes to promoting student motivation and engagement [23]. The implementation of escape rooms in health sciences-related disciplines allows the application of the theoretical concepts learned in the classroom to real scenarios that the students will find in their professional future [22]. This is highly beneficial for their professional development. In fact, it has been perceived by most of the students as one of the most positive aspects of the escape rooms implemented in this work.

Another positive point highlighted by many of our students is that escape rooms promote teamwork. Students are organised into different groups and must collaborate to resolve the challenges and complete the mission allowing them to increase their social and communicative skills, as well as offering the opportunity to train their leadership skills. In fact, Baker and collaborators found that pharmacy students who participated in an escape room considered that this activity strengthened their leadership capacity [24], which is essential for their professional careers.

Concerning the negative aspects perceived by the participants, it should be noted that many students indicated that the escape rooms had a short duration. Precisely, one of the main limitations when developing and implementing this type of activity is that the duration is limited to the academic timetable. For this reason, escape rooms were designed according to the time allocated for each module (60 min). In fact, most of the escape games designed in pharmacy-related disciplines had a similar duration of 30–45 min [12,17,18]. Another aspect perceived negatively by the students was the low number of challenges to solve. In comparison to the escape games designed by other authors, who usually designed four to five challenges in each game, the number of enigmas in our study was three [12,25]. However, it should be noted that in the biopharmacy and pharmacokinetic game, the enigmas were problem-based challenges, and the students needed more time to solve them. Except for one group, the rest of the groups completed the mission satisfactorily within the 45 min allocated to the game, which indicated that the proposed difficulty and number of challenges were adequate for the duration of the escape rooms designed.

The design and implementation of escape rooms in the classroom, although feasible, is complex, and several aspects are especially critical for their success. First, it is critical to know the student profile that will participate in the activity, their degree of knowledge about the module, their skills, and their attitudes to adapt to the difficulty and duration of escape room challenges. Secondly, it is essential to establish learning outcomes aligned with the curriculum. The escape room implemented in this work took place at the end of the semester, but they can be implemented at different times, according to educator perception and needs. Thirdly, it is important to adapt the type and number of the enigmas to the escape room duration, place, and type of students. The students should have enough time to solve all of them but within the time limit allocated for the activity. Finally, it is essential that the educator, who acts as the game master, is available throughout the activity, verifying its correct progress and providing clues and support to the students when needed.

Based on the escape rooms implemented in this work, we suggest the escape rooms should run with one educator per 15 students. For larger groups, the presence of a second educator is highly recommended to ensure students receive appropriate support in a timely manner.

Most of the escape rooms developed in higher education focused on a certain discipline. However, several authors have reported the benefits of implementing interprofessional collaborative escape rooms in health sciences (nursing, pharmacy, medicine, and physical therapy) [26–28]. These activities promote interprofessional socialisation and collaborative skills of the students and may have a positive impact on their professional future as the escape rooms can reproduce situations that the student of all these disciplines will face collaboratively in their future careers. For this reason, the next step planned in this project will be to design, implement, and develop collaborative virtual escape rooms among students from different institutions.

5. Conclusions

The implementation of gamification tools in the classroom is an excellent strategy to improve student learning, motivation, and engagement, with an escape room being an exceptional tool. However, the lack of training in how to implement this methodology in higher education results in a poor number of cases of escape room implementation at this level. Educators in higher education should receive suitable training discussing the key points to bear in mind for a successful design and to mitigate the risk of failure. In this work, we demonstrated that the escape room methodology can be applied successfully to health science-related disciplines, especially pharmacy, with minimal cost. Student satisfaction was 97%, indicating that this methodology is likeable for the students and enhances student awareness and learning as well as team building. These activities allowed the application of theoretical aspects learned in each discipline to real case scenarios.

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

Data Availability Statement: The data that supported the findings of this study can be available from the corresponding author.

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