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ESCAPE-CARDIO: GAMIFICATION IN CARDIOVASCULAR PHYSIOTHERAPY. AN OBSERVATIONAL STUDY.

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Response to Reviewers:	<p>Response to Reviewer 1 Comments</p> <p>Dear Reviewer 1, We really wish to thank you for your constructive comments in this second round of review. We have proceeded to review each mentioned point, and made consequent changes to the manuscript, as we try to summarize here under:</p> <p>SECTION: MATERIAL AND METHODS (DESIGN AND INTERVENTION) QUESTION 1</p>

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Highlights:

- *Escape rooms expose students to simulated situations where team building is essential*
- *This study evaluates both quantitative and qualitative assessment in physiotherapy*
- *Gamification activities can increase mass media impact for universities*
- *The applied strategy can be transferred to other subjects or health-related degrees*

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INTRODUCTION

The learning process at University is changing in recent years. In contrast to a classic model, focused on the professor, new methodologies of acquiring knowledge have appeared. These methods encourage the students to reach a more active learning process that can generate greater motivation and commitment,¹ such as problem-based activities,² flipped-learning³ and gamification, which include Escape Rooms (ERs).⁴

ERs are live-action team-based games in which players encounter challenges to complete a mission in a limited amount of time.⁵ It is a space where a group of people work together to solve tasks and riddles, with the scope of leaving the room. Within this game, which promotes cooperation and problem-solving abilities, Educational Escape Rooms (EERs) are gaining popularity at schools and universities.⁶

Among the characteristics of an EERs, the introduction in a simulated space based on teaching content is an important one. The student is the main component, taking decisions during events, with interactions between realism and fiction, and turning error into a challenge, with the aim of learning.⁷ The story must connect all the elements of the room, inspiring to continue until the end. Furthermore, there are different

levels of complexity: the basic level features beginner learning and only one story ending, while the advanced level can incorporate gameplay element changes, alternative endings, or even new elements in the room flow.⁸

Every step in the EERs must have a different space that gives meaning to the story.⁹ So, this activity must necessarily contain four main rooms:

- Pre-game room: it is the space where the storyline is introduced. In the EERs, this room should be the one where the presentation of the activity takes place: the padlocks and mechanisms, the security elements, the rules that must be followed and the students' questions about the activity.
- Game room: this is where the activity is carried out. It is the centrepiece of the experience, where the students are the main characters of the story for educational purposes. It can be a mix of physical rooms, a single-space with walls and doors, a virtual room with tasks on a computer, or an artificially created room with different locations within the classroom.
- Monitoring room: it is the space where the monitor can control the EERs and give support if necessary. Monitoring the process requires communication channels with people in the room, such as cameras and microphones.
- Debriefing room: this last space has the purpose of understanding what has happened in the room and assembles what has been learned. Here the teacher and the students can make an objective assessment of the process. This room is a differentiating element of the EERs because shared learning and evaluation of knowledge, skills and attitudes are carried out.⁵

In addition to all the benefits that an EERs can bring to the student in terms of knowledge, this type of gamification could be more important in health-related professions, since they can be used to teach and reinforce clinical skills, due to immersion of the activity.¹⁰

Despite the benefits of this type of gamification in terms of satisfaction, motivation, teamwork and learning, there is a limited number of studies which use this game with students and/or health professionals,¹¹⁻¹⁴ and few of them have directly evaluated the learning from the sessions.^{15,16}

Based on all these premises, we created Escape-Cardio, a gamification room by the Department of Physiotherapy, at the University Cardenal Herrera CEU. The primary aim of the study was to evaluate if this gamification activity led to better knowledge acquisition by the students, improving performance in their final exam. As a secondary objective, we surveyed the satisfaction of the students participating in the EERs of this health-related degree.

MATERIAL AND METHODS

TRIAL DESIGN AND SAMPLE SELECTION

An observational study of cases and controls was carried out. Escape-Cardio was proposed as a voluntary activity included in the schedule of a compulsory subject during 2019-2020 academic year of Physiotherapy degree.

The following inclusion criteria were established: students of 3rd and 4th year of Degree in Physiotherapy who agreed to participate voluntarily in the activity proposed, and who signed the consent for recording and transfer of images. As exclusion criteria, it was established that the 3rd course students were in the subject first exam call.

DESIGN AND INTERVENTION

Three communicating classrooms were necessary. They were equipped with cameras and microphones, so the activity instructor could control the process from the monitoring room. A fourth room was proposed for the pre-game meeting. The material employed included locks of different types, a cryptex, test tubes, books, markers and ultraviolet flashlights and blood bags, among others. Finally, an introductory video was created by the CEU Audio-visual Media service. These videos are common in the ERs, and their purpose is to introduce participants to the story of the activity, achieving greater gamification and immersion in it. The students who accepted to participate were divided into groups of two or three people, to put different nationalities and academic courses students together.

Total time of sessions was 90 minutes, divided as follows: In the first 15 minutes, the welcome and the pre-game room meeting took place. Here, the informed consent for the recording was signed, the rules of the activity were explained, and the introductory video was shown. Next, students were received in a room by the instructor, who was part of the game and, **after instructor left the room**, the 60-minute counter was displayed in one of the screens and the escapism activity itself was carried out. Students had to find clues when solving puzzles related to theoretical and practical concepts in the area of cardiorespiratory physiotherapy. Then they could move to another room until the last space, where they finally had to make a physiotherapy diagnosis based on the symptomatology of an advanced simulation mannequin. All the games were based on standardized physiotherapy and nursing interventions,¹⁷ and we chose the design of the puzzles based on a list of most characteristic puzzle types in recreational ERs worldwide.¹⁸ Educational topics, skills demonstration and games related to them are described in Table 1. **Students** were constantly seen and heard by the instructor of the activity who, from the monitoring room, could guide them if they requested for help. After finishing the activity, during the last 15 minutes, the debriefing was done. All the aspects that had been interesting to the students were discussed, focusing on the learning they took from the activity.

STUDY VARIABLES AND DATA COLLECTION

Escape-Cardio was created as a voluntary activity to integrate interested students that have previously studied cardiac rehabilitation contents from the 3rd year onwards. Finally, 37 students from the 3rd course and 21 of the 4th course took part in the activity, forming the complete intervention group (CEERs Group, n=58). Only the 3rd course students in the intervention group (3rd EERs Group, n=37), took the exam of the cardiac rehabilitation subject at the end of the term, as well as their classmates not participating in the activity, forming the control group (3rd NEERs, n=117). Marks obtained during the exam were the primary outcome to compare knowledge of the subject between groups. The 4th course students could not be integrated in this comparison because they have already passed the subject, so they have no right to take the exam. 4th course students only completed the qualitative evaluation of the activity, for it was the only way to assess their game experience, while 3rd course students were assessed by quantitative and qualitative evaluations.

While 3rd course intervention group participated in the EERs, the control group received a manual with the results of the clinical cases shown in the activity. The final exam was divided into two sections (cardiovascular and respiratory), to make a statistical comparison between them.

The CEERs Group (n=58) filled in a self-created survey after the completion of the activity. This survey highlighted different aspects of the project, including learning and applicability of the concepts related to the subject, integration in the teamwork model, assessment of the instructor's work, gamification and activity immersion and overall assessment of the Escape-Cardio. A Likert scale from 1 to 5 was used, being 1 the lowest score and 5 the maximum one. At the end of the survey, we included a free space for the student to comment on the positive and negative aspects of the activity. A content and face validity process was carried out in order to validate the suitability of the survey. Content validity was checked in two different ways. First, we summarized the previous literature about EERs and based our survey in the topics that were evaluated in several studies.^{11,13,15} After that, when the Escape-Cardio's survey was created, the Physiotherapy Department professors, being members as well as not members of the investigation group, approved the items and questions proposed. Face validity was tested by sending a Microsoft® Forms to the students asking if each item question in the survey had a good degree of clarity and comprehension. There was a categorical option of "Yes" and "No", allowing a favourable or unfavourable evaluation to each item.

The study data were collected between October and December 2019.

ETHICS

The study was approved by the ethics committee of the University CEU Cardenal Herrera. All students that participated in the EERs signed the informed consent for recording. Participation was

voluntary, and the decision not to participate or to discontinue participation did not result in any consequences, academic or otherwise.

STATISTICAL ANALYSIS

The described activity was included in the schedule of a compulsory subject of the third course. Results obtained by the students in the final exam are analysed. Marks are divided into two groups of study, those of the third-course students attending to the EERs (3rd EERs Group) and those of their non-participating peers (3rd NEERs Group).

Total marks in the final exam of the subject are categorized as Excellent (10 points), Very Good (9 points), Good (7 to 8 points), Pass, (5 to 6 points), Fail (below 5 points) and Non-submitted in both groups. Each category is presented in percentage for its comparison and total mark mean value and standard deviation are presented for each group.

A U-Mann Whitney test was used to detect differences between groups in the number of correct answers obtained in the cardio-related questions. Also, the number of correct answers of the other exam sections were analysed between groups to avoid bias. Statistical significance was set at p-value <0.05. All the statistical analyses were performed using IBM SPSS for Windows (version 24.0, Armonk, NY. IBM. Corp.).

Finally, the survey results obtained from the CEERs Group are described as mean and standard deviation.

RESULTS

The 58 students of the CEERs Group participated in one of eight different sessions distributed along the term. The percentage of women was 70.3% compared to 29.7% of men, with an average age of 21.2 ± 2 . A convenience group of eight students per session was established due to the facilities, devices and structures of the proposed games. This way, every student could participate actively. The distribution of students in groups can be seen in Figure 1.

Every single student managed to get out of the Escape-Cardio. Of the 60 minutes granted to complete all the challenges, the average time to escape from the rooms was 50 minutes and three seconds, with a minimum time of 38 minutes and 10 seconds, and a maximum time of 59 minutes and 45 seconds. Eleven students (29.7%) had previous experience in escapism rooms, although it was non-healthcare education-related once.

The performance of the students in the third-course subject exam was analysed. Before explaining the data analysis, it is considered necessary to say that none of the riddles, tests or clinical cases of the Escape-Cardio corresponded with questions of the exam. As shown in Figure 2, better performance of

the 37 students in the 3rd EERs Group, compared to the 117 of the 3rd NEERs Group. The highest mark percentage of 3rd EERs Group corresponded to an average grade of "Good" followed by "Pass", compared to the highest mark percentage of "Pass" followed by "Fail" in the 3rd NEERs Group. Only one of the students who participated in the Escape-Cardio failed the final exam (3%), compared to a total of 40 students who failed to pass the course (30%). Likewise, of 11 students that not submitted to the exam (7% of the total), only one corresponded to a student who had completed the activity (3%).

In addition to the results previously exposed, it could be observed that the average assessment mark of the exam in the 3rd EERs Group was 7.03 ± 1.3 out of a maximum of 10, compared to an average qualification of 5.61 ± 1.6 points of the students in the 3rd NEERs Group. Regarding the total number of correct questions on the exam, within the specific cardiac area, out of a maximum of 14 questions, the students who performed the Escape-Cardio correctly answered an average of 10.8 ± 2.1 questions, compared to 8.2 ± 3.3 correct questions in the control group, with an increase of more than two questions on average.

According to the number of correct answers analysis, the U-Mann Whitney test showed a statistically significant difference between groups in the cardio-related section of the exam ($p= 0.00$), since it was not for the other exam section ($p= 3.00$). Results are shown in Table 2.

Finally, regarding a qualitative evaluation, the CEERs Group received a survey to evaluate the activity. Each student answered this survey, and all of them scored unanimously each item with the maximum value of 5 ± 0 points, aiming for 100% satisfaction. Questions, items evaluated and results are presented in Table 3. Within the free text fields, most of the comments emphasized the applicability of the concepts that had been seen, the great immersion of the activity and the excellent group work, both with peers from their academic year and with students from another year. As negative aspects, it was only highlighted that it should not be a voluntary activity but integrated into the annual teaching plan. Face validity of the subject was checked by the results of the Microsoft® Forms sent to the students. All of them answered positively to the clarity and comprehension of the survey items.

DISCUSSION

All innovations proposed in the Escape-Cardio project started from gamification as part of the physiotherapy student's learning process, working on different transferable skills with a lateral thinking methodology. Besides, peer-to-peer learning strategies were promoted between different academic courses, and the promotion of internationalization, since the proposed activity required continuous communication from the group during its course.

The main objective of the project was to provide students with an engaging authentic learning experience with the additional pressure of working as a group and having a time limit. The evidence of the level of

learning achieved by using the Escape-Cardio learning activity was measured in a summative way in the final exam of the subject.

To our knowledge, this is the first scientific study of these characteristics in the field of physiotherapy, which has also evaluated results in the cardiovascular area. Our results include a better final score on the exam in the group that joined the Escape-Cardio activity. Furthermore, we observed a decrease in the rate of students who did not take or failed the final exam of the subject, and a statistically significant difference in their assessment mark compared to the control group.

A recent Meta-analysis showed that the role of the university teacher is complex, since the students easily lose attention and motivation in the subjects taught.¹⁹ The incorporation of learning methodologies through games, such as online question platforms, have managed to update the vision of university education, specifically in Health Sciences, students rate positively activities that include exposure to real clinical situations where team-building is essential, highlighting the simulation.^{20,21} Combine simulation with ERs has been considered unfeasible in the scientific literature, due to the added complexity in the project design.¹¹ However, we developed authentic clinically based simulation activities mixed with EERs, to take the physiotherapy student closer to clinical environments related to the cardiovascular area.

In the EERS, players need to transfer from their real-life context into the game context. That's why the immersion of players during gameplay is truly important, as this is the process by which participants are lured into a story or a particular problem.⁵ Immersion perceived, essential in health-related learning, was also evaluated in the survey that all the students completed after the Escape-Cardio activity. Results of the presented study were a maximum score of all the items in the survey.

Finally, to achieve visibility of the project, given its innovative nature, it was possible to carry out internal and external dissemination, since different national media published press notes in their online media. Furthermore, an audio-visual media showed interest in attending the recording of one of the sessions, interviewing both the instructor and different students who participated. This medium was the television of the *Consejo de Enfermería de la Comunidad Valenciana* (CECOVA-Tv). Currently, physiotherapists do not have its own audio-visual media so, since many double-degree nursing and physiotherapy students participated in the activity (specifically 15 students in 3rd course, and 9 in 4th course), CECOVA-Tv was chosen to further record the project. The video, published on its channel and the online platform *Youtube*, can be viewed at this link: <https://www.youtube.com/watch?v=Dxq0CEdR6R8&t=19s>.

This pilot study has a series of limitations necessary to mention. Firstly, it could be considered that the sample of 58 students, of whom only 37 were included in the statistical analysis, may be low. However, the project wanted to prioritize the quality of the sessions, limiting the maximum number to eight students so that all of them could participate actively. It was not possible to propose more than 8 sessions

due to lack of availability of schedules. Another aspect to mention, given the voluntary nature of the activity, would be that it is plausible to assume that more motivated students or with better academic performance could have participated in the Escape-Cardio. Even though randomization of the students may have diminished this bias, it was considered that the motivational factor was important to face the activity, so this voluntariness was maintained. To try to minimize this bias, a statistical analysis that differentiated the two parts of the exam, both cardiovascular and respiratory area, even though the sample was the same in the two cases, only statistically significant changes were found in the first one. Future studies are necessary to confirm the effectiveness of gamification in this very specific, and sometimes complex, area of physiotherapy. However, the results of our study seem to confirm the importance of establishing new methodologies to promote student learning. The participants must be thanked for both their effort and enthusiasm, as well as all the positive comments they made after completing the activity. Also, above all, we have to thank for their predisposition to something that none of us, both students and teachers, should ever lose: learning through play.

CONCLUSIONS

After the data analysis presented above, and the perception of the activity by the students, it can be concluded by stating that Escape-Cardio: gamification in cardiorespiratory physiotherapy, reached the established aims of the project since the students who participated improved their qualifications in the cardiovascular physiotherapy area in a statistically significant way. Besides, an excellent qualitative evaluation was achieved by the students, as a remarkable degree of dissemination of the gamification activity.

ABBREVIATIONS AND ACRONYMS

CECOVA = *Consejo de Enfermería de la Comunidad Valenciana*; CPET = cardiopulmonary exercise testing; CPR = cardiopulmonary resuscitation; ECG = electrocardiogram; ERs = escape room; EERs = educational escape room.

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- Debriefing room: this last space has the purpose of understanding what has happened in the room and assembles what has been learned. Here the teacher and the students can make an objective assessment of the process. This room is a differentiating element of the EERs because shared learning and evaluation of knowledge, skills and attitudes are carried out.⁵

In addition to all the benefits that an EERs can bring to the student in terms of knowledge, this type of gamification could be more important in health-related professions, since they can be used to teach and reinforce clinical skills, due to immersion of the activity.¹⁰

Despite the benefits of this type of gamification in terms of satisfaction, motivation, teamwork and learning, there is a limited number of studies which use this game with students and/or health professionals,¹¹⁻¹⁴ and few of them have directly evaluated the learning from the sessions.^{15,16}

Based on all these premises, we created Escape-Cardio, a gamification room by the Department of Physiotherapy, at the University Cardenal Herrera CEU. The primary aim of the study was to evaluate if this gamification activity led to better knowledge acquisition by the students, improving performance in their final exam. As a secondary objective, we surveyed the satisfaction of the students participating in the EERs of this health-related degree.

MATERIAL AND METHODS

TRIAL DESIGN AND SAMPLE SELECTION

An observational study of cases and controls was carried out. Escape-Cardio was proposed as a voluntary activity included in the schedule of a compulsory subject during 2019-2020 academic year of Physiotherapy degree.

The following inclusion criteria were established: students of 3rd and 4th year of Degree in Physiotherapy who agreed to participate voluntarily in the activity proposed, and who signed the consent for recording and transfer of images. As exclusion criteria, it was established that the 3rd course students were in the subject first exam call.

DESIGN AND INTERVENTION

Three communicating classrooms were necessary. They were equipped with cameras and microphones, so the activity instructor could control the process from the monitoring room. A fourth room was proposed for the pre-game meeting. The material employed included locks of different types, a cryptex, test tubes, books, markers and ultraviolet flashlights and blood bags, among others. Finally, an introductory video was created by the CEU Audio-visual Media service. These videos are common in the ERs, and their purpose is to introduce participants to the story of the activity, achieving greater gamification and immersion in it. The students who accepted to participate were divided into groups of two or three people, to put different nationalities and academic courses students together.

Total time of sessions was 90 minutes, divided as follows: In the first 15 minutes, the welcome and the pre-game room meeting took place. Here, the informed consent for the recording was signed, the rules of the activity were explained, and the introductory video was shown. Next, students were received in a room by the instructor, who was part of the game and, after instructor left the room, the 60-minute counter was displayed in one of the screens and the escapism activity itself was carried out. Students had to find clues when solving puzzles related to theoretical and practical concepts in the area of cardiorespiratory physiotherapy. Then they could move to another room until the last space, where they finally had to make a physiotherapy diagnosis based on the symptomatology of an advanced simulation mannequin. All the games were based on standardized physiotherapy and nursing interventions,¹⁷ and we chose the design of the puzzles based on a list of most characteristic puzzle types in recreational ERs worldwide.¹⁸ Educational topics, skills demonstration and games related to them are described in Table 1. Students were constantly seen and heard by the instructor of the activity who, from the monitoring room, could guide them if they requested for help. After finishing the activity, during the last 15 minutes, the debriefing was done. All the aspects that had been interesting to the students were discussed, focusing on the learning they took from the activity.

STUDY VARIABLES AND DATA COLLECTION

Escape-Cardio was created as a voluntary activity to integrate interested students that have previously studied cardiac rehabilitation contents from the 3rd year onwards. Finally, 37 students from the 3rd course and 21 of the 4th course took part in the activity, forming the complete intervention group (CEERs Group, n=58). Only the 3rd course students in the intervention group (3rd EERs Group, n=37), took the exam of the cardiac rehabilitation subject at the end of the term, as well as their classmates not participating in the activity, forming the control group (3rd NEERs, n=117). Marks obtained during the exam were the primary outcome to compare knowledge of the subject between groups. The 4th course students could not be integrated in this comparison because they have already passed the subject, so they have no right to take the exam. 4th course students only completed the qualitative evaluation of the activity, for it was the only way to assess their game experience, while 3rd course students were assessed by quantitative and qualitative evaluations.

While 3rd course intervention group participated in the EERs, the control group received a manual with the results of the clinical cases shown in the activity. The final exam was divided into two sections (cardiovascular and respiratory), to make a statistical comparison between them.

The CEERs Group (n=58) filled in a self-created survey after the completion of the activity. This survey highlighted different aspects of the project, including learning and applicability of the concepts related to the subject, integration in the teamwork model, assessment of the instructor's work, gamification and activity immersion and overall assessment of the Escape-Cardio. A Likert scale from 1 to 5 was used, being 1 the lowest score and 5 the maximum one. At the end of the survey, we included a free space for the student to comment on the positive and negative aspects of the activity. A content and face validity process was carried out in order to validate the suitability of the survey. Content validity was checked in two different ways. First, we summarized the previous literature about EERs and based our survey in the topics that were evaluated in several studies.^{11,13,15} After that, when the Escape-Cardio's survey was created, the Physiotherapy Department professors, being members as well as not members of the investigation group, approved the items and questions proposed. Face validity was tested by sending a Microsoft® Forms to the students asking if each item question in the survey had a good degree of clarity and comprehension. There was a categorical option of "Yes" and "No", allowing a favourable or unfavourable evaluation to each item.

The study data were collected between October and December 2019.

ETHICS

The study was approved by the ethics committee of the University CEU Cardenal Herrera. All students that participated in the EERs signed the informed consent for recording. Participation was

voluntary, and the decision not to participate or to discontinue participation did not result in any consequences, academic or otherwise.

STATISTICAL ANALYSIS

The described activity was included in the schedule of a compulsory subject of the third course. Results obtained by the students in the final exam are analysed. Marks are divided into two groups of study, those of the third-course students attending to the EERs (3rd EERs Group) and those of their non-participating peers (3rd NEERs Group).

Total marks in the final exam of the subject are categorized as Excellent (10 points), Very Good (9 points), Good (7 to 8 points), Pass, (5 to 6 points), Fail (below 5 points) and Non-submitted in both groups. Each category is presented in percentage for its comparison and total mark mean value and standard deviation are presented for each group.

A U-Mann Whitney test was used to detect differences between groups in the number of correct answers obtained in the cardio-related questions. Also, the number of correct answers of the other exam sections were analysed between groups to avoid bias. Statistical significance was set at p-value <0.05. All the statistical analyses were performed using IBM SPSS for Windows (version 24.0, Armonk, NY. IBM. Corp.).

Finally, the survey results obtained from the CEERs Group are described as mean and standard deviation.

RESULTS

The 58 students of the CEERs Group participated in one of eight different sessions distributed along the term. The percentage of women was 70.3% compared to 29.7% of men, with an average age of 21.2 ± 2 . A convenience group of eight students per session was established due to the facilities, devices and structures of the proposed games. This way, every student could participate actively. The distribution of students in groups can be seen in Figure 1.

Every single student managed to get out of the Escape-Cardio. Of the 60 minutes granted to complete all the challenges, the average time to escape from the rooms was 50 minutes and three seconds, with a minimum time of 38 minutes and 10 seconds, and a maximum time of 59 minutes and 45 seconds. Eleven students (29.7%) had previous experience in escapism rooms, although it was non-healthcare education-related once.

The performance of the students in the third-course subject exam was analysed. Before explaining the data analysis, it is considered necessary to say that none of the riddles, tests or clinical cases of the Escape-Cardio corresponded with questions of the exam. As shown in Figure 2, better performance of

the 37 students in the 3rd EERs Group, compared to the 117 of the 3rd NEERs Group. The highest mark percentage of 3rd EERs Group corresponded to an average grade of "Good" followed by "Pass", compared to the highest mark percentage of "Pass" followed by "Fail" in the 3rd NEERs Group. Only one of the students who participated in the Escape-Cardio failed the final exam (3%), compared to a total of 40 students who failed to pass the course (30%). Likewise, of 11 students that not submitted to the exam (7% of the total), only one corresponded to a student who had completed the activity (3%).

In addition to the results previously exposed, it could be observed that the average assessment mark of the exam in the 3rd EERs Group was 7.03 ± 1.3 out of a maximum of 10, compared to an average qualification of 5.61 ± 1.6 points of the students in the 3rd NEERs Group. Regarding the total number of correct questions on the exam, within the specific cardiac area, out of a maximum of 14 questions, the students who performed the Escape-Cardio correctly answered an average of 10.8 ± 2.1 questions, compared to 8.2 ± 3.3 correct questions in the control group, with an increase of more than two questions on average.

According to the number of correct answers analysis, the U-Mann Whitney test showed a statistically significant difference between groups in the cardio-related section of the exam ($p= 0.00$), since it was not for the other exam section ($p= 3.00$). Results are shown in Table 2.

Finally, regarding a qualitative evaluation, the CEERs Group received a survey to evaluate the activity. Each student answered this survey, and all of them scored unanimously each item with the maximum value of 5 ± 0 points, aiming for 100% satisfaction. Questions, items evaluated and results are presented in Table 3. Within the free text fields, most of the comments emphasized the applicability of the concepts that had been seen, the great immersion of the activity and the excellent group work, both with peers from their academic year and with students from another year. As negative aspects, it was only highlighted that it should not be a voluntary activity but integrated into the annual teaching plan. Face validity of the subject was checked by the results of the Microsoft® Forms sent to the students. All of them answered positively to the clarity and comprehension of the survey items.

DISCUSSION

All innovations proposed in the Escape-Cardio project started from gamification as part of the physiotherapy student's learning process, working on different transferable skills with a lateral thinking methodology. Besides, peer-to-peer learning strategies were promoted between different academic courses, and the promotion of internationalization, since the proposed activity required continuous communication from the group during its course.

The main objective of the project was to provide students with an engaging authentic learning experience with the additional pressure of working as a group and having a time limit. The evidence of the level of

learning achieved by using the Escape-Cardio learning activity was measured in a summative way in the final exam of the subject.

To our knowledge, this is the first scientific study of these characteristics in the field of physiotherapy, which has also evaluated results in the cardiovascular area. Our results include a better final score on the exam in the group that joined the Escape-Cardio activity. Furthermore, we observed a decrease in the rate of students who did not take or failed the final exam of the subject, and a statistically significant difference in their assessment mark compared to the control group.

A recent Meta-analysis showed that the role of the university teacher is complex, since the students easily lose attention and motivation in the subjects taught.¹⁹ The incorporation of learning methodologies through games, such as online question platforms, have managed to update the vision of university education, specifically in Health Sciences, students rate positively activities that include exposure to real clinical situations where team-building is essential, highlighting the simulation.^{20,21} Combine simulation with ERs has been considered unfeasible in the scientific literature, due to the added complexity in the project design.¹¹ However, we developed authentic clinically based simulation activities mixed with EERs, to take the physiotherapy student closer to clinical environments related to the cardiovascular area.

In the EERS, players need to transfer from their real-life context into the game context. That's why the immersion of players during gameplay is truly important, as this is the process by which participants are lured into a story or a particular problem.⁵ Immersion perceived, essential in health-related learning, was also evaluated in the survey that all the students completed after the Escape-Cardio activity. Results of the presented study were a maximum score of all the items in the survey.

Finally, to achieve visibility of the project, given its innovative nature, it was possible to carry out internal and external dissemination, since different national media published press notes in their online media. Furthermore, an audio-visual media showed interest in attending the recording of one of the sessions, interviewing both the instructor and different students who participated. This medium was the television of the *Consejo de Enfermería de la Comunidad Valenciana* (CECOVA-Tv). Currently, physiotherapists do not have its own audio-visual media so, since many double-degree nursing and physiotherapy students participated in the activity (specifically 15 students in 3rd course, and 9 in 4th course), CECOVA-Tv was chosen to further record the project. The video, published on its channel and the online platform *Youtube*, can be viewed at this link: <https://www.youtube.com/watch?v=Dxq0CEdR6R8&t=19s>.

This pilot study has a series of limitations necessary to mention. Firstly, it could be considered that the sample of 58 students, of whom only 37 were included in the statistical analysis, may be low. However, the project wanted to prioritize the quality of the sessions, limiting the maximum number to eight students so that all of them could participate actively. It was not possible to propose more than 8 sessions

due to lack of availability of schedules. Another aspect to mention, given the voluntary nature of the activity, would be that it is plausible to assume that more motivated students or with better academic performance could have participated in the Escape-Cardio. Even though randomization of the students may have diminished this bias, it was considered that the motivational factor was important to face the activity, so this voluntariness was maintained. To try to minimize this bias, a statistical analysis that differentiated the two parts of the exam, both cardiovascular and respiratory area, even though the sample was the same in the two cases, only statistically significant changes were found in the first one. Future studies are necessary to confirm the effectiveness of gamification in this very specific, and sometimes complex, area of physiotherapy. However, the results of our study seem to confirm the importance of establishing new methodologies to promote student learning. The participants must be thanked for both their effort and enthusiasm, as well as all the positive comments they made after completing the activity. Also, above all, we have to thank for their predisposition to something that none of us, both students and teachers, should ever lose: learning through play.

CONCLUSIONS

After the data analysis presented above, and the perception of the activity by the students, it can be concluded by stating that Escape-Cardio: gamification in cardiorespiratory physiotherapy, reached the established aims of the project since the students who participated improved their qualifications in the cardiovascular physiotherapy area in a statistically significant way. Besides, an excellent qualitative evaluation was achieved by the students, as a remarkable degree of dissemination of the gamification activity.

ABBREVIATIONS AND ACRONYMS

CECOVA = *Consejo de Enfermería de la Comunidad Valenciana*; CPET = cardiopulmonary exercise testing; CPR = cardiopulmonary resuscitation; ECG = electrocardiogram; ERs = escape room; EERs = educational escape room.

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FIGURE 2. From left to right, summary of assessment marks in the final exam of the subject of intervention group (3rd EERs Group, n=37) and control group (3rd NEERs Group, n=117). Marks are presented in percentage. Own source.

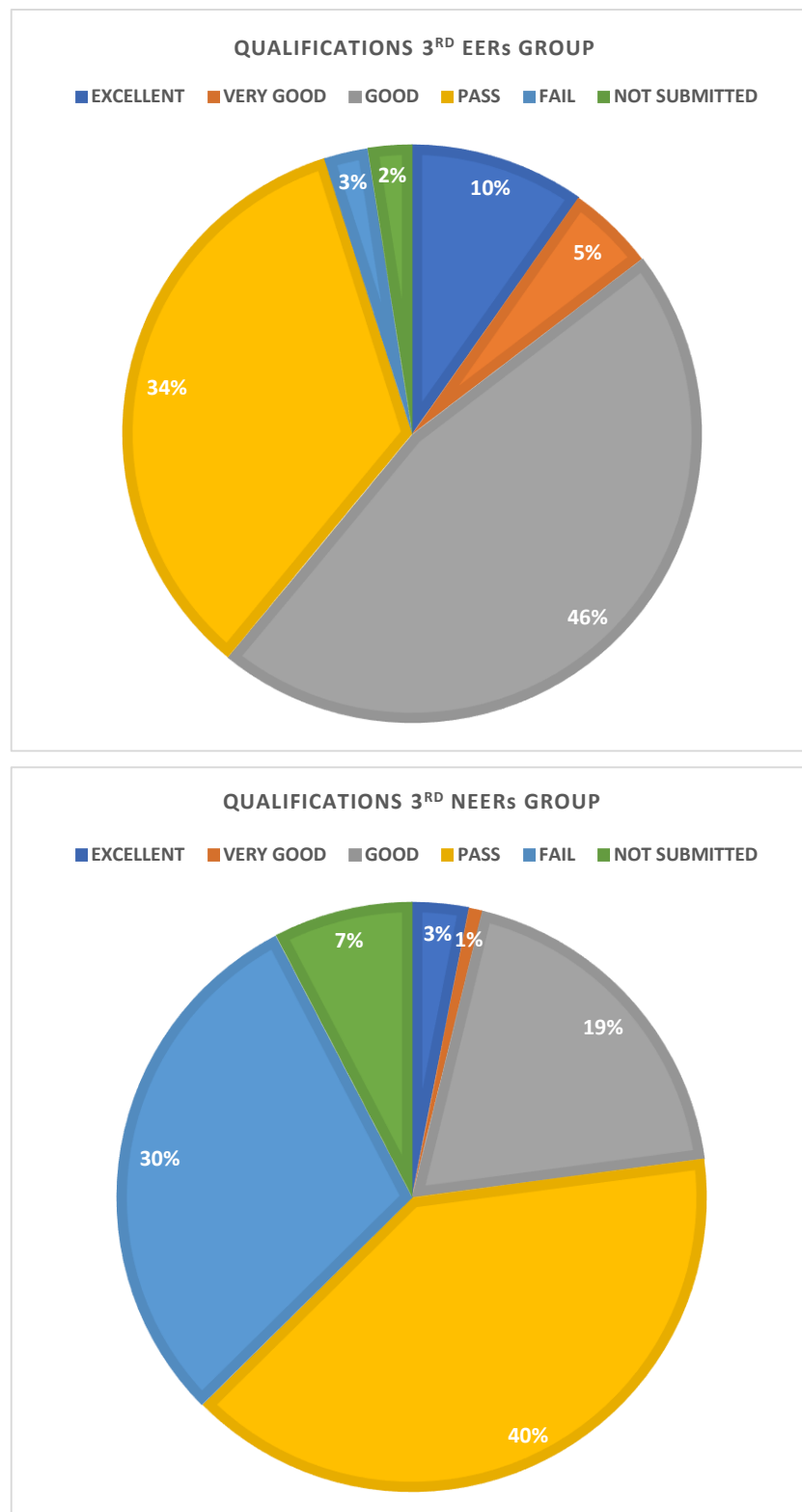


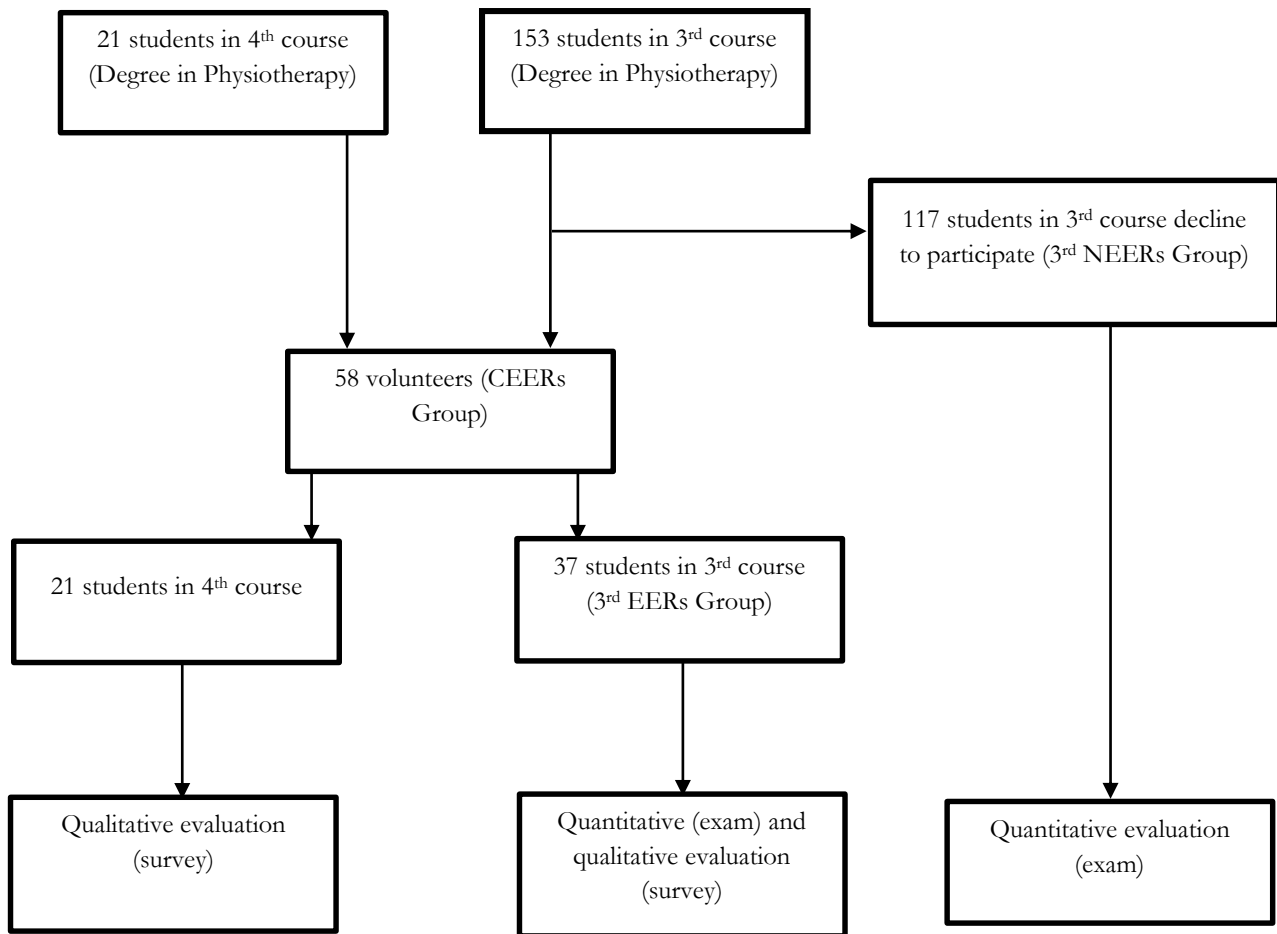
FIGURE 1. *Flow-chart of students' selection. Own source.*

TABLE 1. *Summary of topics carried out and evaluated in Escape-Cardio sessions. Own source.*

<i>Educational topic</i>	<i>Skill demonstration</i>	<i>Game tasking</i>
Cardiovascular risk factors	Identification of modifiable and non-modifiable risk factors	To find bags with risk factors, and to calculate the exact weight of them
Pharmacology	Association of medicines and illnesses	To create a code with medicines for 4 clinic situations
Cardiopulmonary exercise testing (CPET)	Recognition of usual parameters in CPET	To achieve a submaximal heart rate in a ergometer
Electrocardiogram (ECG)	Identification of abnormalities in ECG	To get puzzle pieces and find the specific abnormal ECG
Cardiovascular anatomy	Review of theoretical concepts of anatomy	To answer in a correct way questions in a maze box, getting a key at the end of the game
Cardiopulmonary resuscitation (CPR)	Setting CPR algorithm	To perform a CPR to a high-fidelity simulated manikin, with feedback device
Cardiovascular patient assessment	Training in cardiopulmonary auscultation	To achieve a code when a correct auscultation is done
Cardiovascular diseases	Physiotherapy diagnosis	To obtain a diagnosis in a high-fidelity simulation manikin, based on symptoms and complementary tests

TABLE 3. *Qualitative assessment of the activity. Ad Hoc survey items and results by the complete intervention group (CEERs Group). Likert Scale 1 to 5.*

<i>CEERs Group (n=58)</i>	
Question	Mean Score Obtained (Mean ± SD)
Have you applied the concepts that we have been working in the subject? <i>(Evaluated item: Learning and applicability of concepts related to the subject)</i>	5 ± 0
Have you felt integrated in the teamwork? <i>(Evaluated item: Integration in the teamwork model)</i>	5 ± 0
From 1 to 5, how would you rate the instructor's implication in the activity? <i>(Evaluated item: Assessment of instructor's work)</i>	5 ± 0
From 1 to 5, how would you rate the setting and the immersion of the session? <i>(Evaluated item: Gamification and activity immersion)</i>	5 ± 0
What is your global satisfaction with the Escape-Cardio? <i>(Evaluated item: Overall assessment of the Escape-Cardio)</i>	5 ± 0
Total Survey Results	5 ± 0

TABLE 2. *Statistical Analysis. U-Mann Whitney mean correct answers comparison between groups, intervention (3rd EERs group, n=37) and control group (3rd NEERs group, n=117).*

Exam section	3rd EERs group Students correct answers	3rd NEERs group Students correct answers	Signification (p-value< 0.05)
Cardio-related questions	10.8±2.1	8.2±3.3	0.000
Non Cardio-related questions	9.1±2.4	7.6±2.6	3.000

Author Contributions: Conceptualization, FJFS, NVG; methodology, FJFS, NVG; student selection and recruitment, FJFS, NVG; measures and data acquisition, FJFS, NVG; software and statistical analysis, PEKB, MCF, GRS; writing (original draft preparation), FJFS, NVG; writing (review and editing), PEKB, MCF, GRS; resources, JAGD, FJMD.

All authors have read and agreed to the published version of the manuscript.



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