Multimodal Technologies and Interaction

Article

Kids Save Lives by Learning through a Serious Game

Miriam Mendoza López [1], Petronila Mireia Alcaraz Artero [2,3], Carlos Truque Díaz [4], Manuel Pardo Ríos [2,3,4,*], Juan José Hernández Morante [5] and Rafael Melendreras Ruiz [1]

1 Advanced Telecommunications Research Group (GRITA), UCAM Universidad Católica de Murcia, 30107 Murcia, Spain; mmendoza@ucam.edu (M.M.L.); rmelendreras@ucam.edu (R.M.R.)
2 New Technologies in Health Research Group (NT4H), UCAM Universidad Católica de Murcia, 30107 Murcia, Spain; pmalcazar@ucam.edu
3 Emergency Medical Services 061, Region de Murcia, 30001 Murcia, Spain
4 Facultad de Fisioterapia, Podologia y Terapia Ocupacional, UCAM Universidad Católica San Antonio de Murcia, 30107 Murcia, Spain; ctruque@ucam.edu
5 Eating Disorders Research Unit (UITA), UCAM Universidad Católica de Murcia, 30107 Murcia, Spain; jjhernandez@ucam.edu
* Correspondence: mpardo@ucam.edu

Abstract: This study focuses on the development and assessment of a serious game for health (SGH) aimed at educating children about cardiopulmonary resuscitation (CPR). A video game was created using the Berkeley Snap platform, which uses block programming. Eye-tracking technology was utilized to validate the graphic design. To assess the tool's effectiveness, a pre-post analytical study was conducted with primary education children to measure the knowledge acquired. The study involved 52 participants with a mean age of 9 years. The results from a custom questionnaire used to measure their theoretical CPR knowledge showed significant improvements in CPR knowledge after the use of the videogame, and their emotional responses improved as well. The assessment of the knowledge acquired through the video game obtained an average score of 5.25 out of 6. Ten video segments consisting of 500 frames each (20 s of video per segment) were analyzed. Within these segments, specific areas that captured the most relevant interaction elements were selected to measure the child's attention during game play. The average number of gaze fixations, indicating the points in which the child's attention was placed within the area of interest, was 361.5 out of 500. In conclusion, the utilization of SGH may be an effective method for educating kids about CPR, to provide them with fundamental knowledge relevant to their age group.

Keywords: training; cardiopulmonary resuscitation; serious game; eye tracking; children; videogames

Citation: Mendoza López, M.; Alcaraz Artero, P.M.; Truque Díaz, C.; Pardo Ríos, M.; Hernández Morante, J.J.; Melendreras Ruiz, R. Kids Save Lives by Learning through a Serious Game. *Multimodal Technol. Interact.* **2023**, *7*, 112. https://doi.org/10.3390/mti7120112

Academic Editors: Deborah Richards and Stephan Schlögl

Received: 10 October 2023
Revised: 22 November 2023
Accepted: 24 November 2023
Published: 1 December 2023

1. Introduction

The European Resuscitation Council (ERC) has underlined the need for cardiopulmonary resuscitation (CPR) learning programs directed towards non-health professionals [1]. Scientific dissemination societies have promoted and regulated CPR training in the non-health professional population, with great results due to the achievement of objectives, as well as the acquisition of skills and knowledge of students [2]. As this is a non-health-professional collective, it is necessary for them to re-learn the knowledge acquired after a certain period of time to avoid forgetting, which can lead to inconvenient expenses due to the associated costs [1].

In the past few years in Spain, many initiatives have been implemented to provide non-health professionals with CPR training. These training workshops are performed and supervised by qualified health personnel, and their objective is to prevent situations of risk to the population [3]. Some of these activities are one-time and isolated, and others are better structured and part of education and health policies. This is the case for "Programa Alertante" [4] by the SAMUR in Madrid, or the PROCES [5] program in Barcelona. In both cases, the number of sessions and the contents taught are adapted to the needs of the soliciting center/institution. Likewise, the Spanish Society of Emergency Medicine (SEMES) also provides CPR training to teachers and students through programs deployed in autonomous communities. Recently, these associations beat a record in Vigo (Galicia), by training an entire school, with a student body of almost 2000 students, in order to speak out on the need to teach the population at schools [6].

The World Health Organization (WHO) supports the "Kids Save Lives" (KSL) declaration, pointing out that the most natural way to teach CPR to the population is to integrate it into the mandatory curricula at schools. It has been demonstrated that it is a simple, effective, and cheap way to teach the technique, with only two hours a year deemed enough for training, starting at the age of 12 [7]. Afterwards, in the last update of the ERC, it was indicated that children should be taught at younger ages, starting once they start attending school, by providing at least 1 h a year during the entire schooling stages [8]. Recently, a review of the KSL declaration was published [9], which indicated that the barriers against performing basic life support (BSL) identified by the children were similar to those observed in adults, which included the fear of making mistakes, and other determinant factors (i.e., the sight of blood or vomit).

Presently, we find ourselves with a generation of digital natives who were born at a time in which the use of technology had been implemented in all tasks of daily life, even in the school curricula of many education centers [10]. The aim of serious games for health (SGHs) is to provide education, training, or information, and they have been carefully planned for this [11]. These are considered game-like systems that are designed to achieve specific objectives, and can be found in the shape of board games, video games, escape rooms, etc. [12]. In the last few years, given the multiple benefits they provide for learning [13], they have started to be utilized with other social aims, such as fighting against bullying [14], or social responsibility [15], and have been successfully implemented in some centers as a pedagogical tool. As the main axis of the KSL declaration, we find that motivation for learning CPR must be increased, through the use of SGH, underlining their importance as a powerful education resource equivalent to other resources, such as "face-to-face" training [9].

The objective of SGH is to improve the motivation, adherence, and/or adhesion of students in the learning experience [16]. Historically, SGHs have been used with adults or adolescents but not for teaching children. The aim of this study was to design and analyze a SGH, the aim of which was to teach children aged between 9 and 10 years old about CPR. The secondary objectives were to analyze the fear and security perceived by the schoolchildren.

2. Materials and Methods

A comparative analytical study was conducted, with a pre-and post-intervention assessment, consisting of the acquisition of CPR competencies through a SGH developed as a videogame-based teaching resource.

2.1. Study Population

Students were voluntarily recruited from both classrooms that were part of the 4th year of primary education at the San Vicente Paul del Palmar school (Murcia, Spain), for a total of 52 children. The study was approved by the Ethics Committee from the Universidad Católica of Murcia (UCAM), registration number 7.986, and the parents/tutors provided their consent for the participation of the underage children.

2.2. Design and Development of the Videogame

For the intervention, a videogame was developed with open-source platform Snap®, with an expanded implementation of Scratch®, developed in Berkeley, CA, USA, which was based on a block-based coding language, which is ideal for the creation of interactive applications and games [17]. To guide the player during the experience, two main characters were designed, a female student and a stuffed bear, with the aim of creating a conducive and familiar environment for the child. Throughout all the phases of each scenario, these characters are accompanied by other secondary characters and objects with which they will be able to interact (Appendix A Table A1). Given the type of content and design, the recommended ages for the videogame were between 6 and 11 years old. Although it included a listening aid (voice over), it was necessary for the child to be able to read and write. It can be played in different platforms: PC, tablet, and mobile phone. The structure of the videogame consists of four levels and a final test. The contents and competences were supervised by health professionals with experience in CPR training, and education professionals who taught the participating children at this schooling stage. Technical development was performed by a telecommunications engineer, given the complexity of developing a scoring system and data storage.

2.3. Assessment of the CPR Competencies

As there is no validated questionnaire to assess CPR knowledge and competencies at these ages, an ad hoc survey was created. The student had to provide answers to different issues, and given the decision, the videogame provided feedback to the player as a type of re-enforcement, to ensure that the concepts were correctly assimilated. In the case of wrong answers, the participants were invited to rectify them, until arriving at the correct answer. Thus, aside from the assessment obtained, what was important was for the student to complete the 4 phases and receive CPR training. From these data, a new variable composed of the sum of correctly answered items was determined, which was considered a measure of general knowledge about CPR.

2.4. Eye Tracking System

For the pedagogical and visual validation of the SGH, functional tests (white testing) were conducted with a sample of 10 volunteer children (Figure 1). The purpose of this test was to verify that in each phase and scenario, their attention was focused on the appropriate characters and relevant areas of the screen. For this, an eye-tracking system was employed, specifically Tobii® goggles (Danderyd, Sweden). The data collected from the goggles were meticulously analyzed using software developed in Matlab® (version R2021b) by UCAM researchers [18]. This tool allows for the selection of different regions of an image and the specific identification of gaze fixations within them, simply referred to as “fixations” (Figure 1B). The objective of using the eye-tracking tool was to measure the children’s attention to the most significant game elements and scenes. The aim of this was to enhance the design and, consequently, the experience to facilitate increased learning about CPR. Ten video segments were analyzed, each consisting of 500 frames (20 s of video per segment). In these segments, specific areas were chosen to capture the most relevant interactive elements, to measure the child’s attention during gameplay. The criteria for selecting both the scenes and the areas of interest within these scenes were primarily based on those in which the attention given to the characters teaching the player the CPR protocol could be measured.

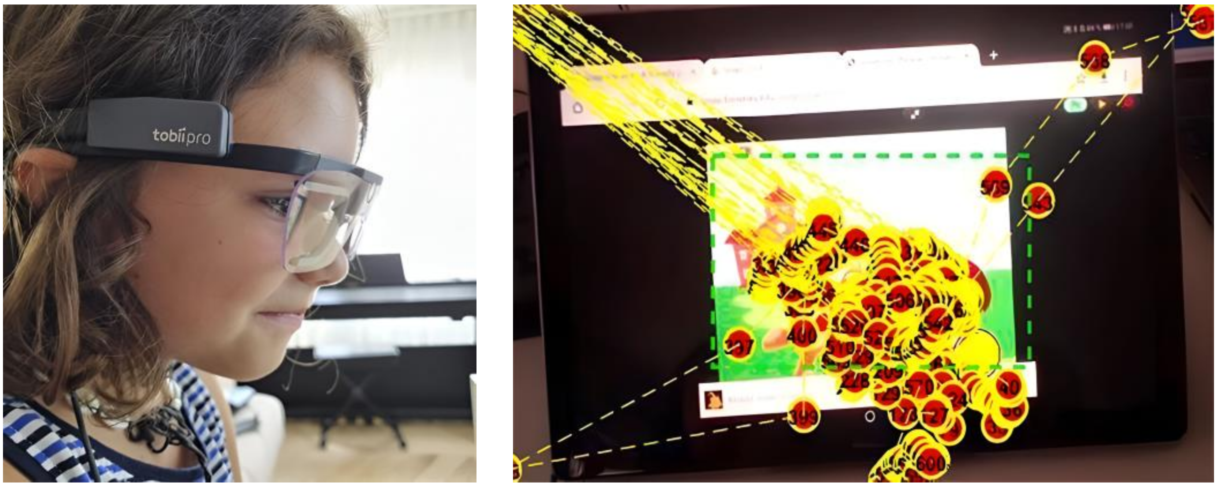
2.5. Intervention

The experiment consisted of two work sessions with the volunteers. In the first session, two activities were performed, which consisted of the following:

- A preliminary assessment (Pre) on the knowledge about the action protocol for performing CPR. For this, a scene was recreated in the classroom, composed of a CPR manikin in the supine position and a telephone close to the victim (manikin). The recreated scenario consists of the child being at the home of a family member, and the family member being unconscious on the floor. From this point on, the child is asked to act.
- The educational intervention took place after the preliminary assessment. Each child was invited to play the game, going through each of the 4 levels of its structure with assistance. The platform utilized was a computer with a mouse. A supervisor, in the

role of assistant, ensured that each phase was satisfactorily completed, until arriving to the end of the game.

- A posterior assessment (Post); this session took place a month after the first session, and consisted of repeating the assessment on the protocol and CPR (Post), and using the same scenario and the same rubric for its assessment.



(**a**) (**b**)

Figure 1. (**a**) Child with eye-tracking goggles during the experiment. (**b**) Number of impacts during the viewing of the screen.

2.6. *Statistical Analysis*

The variables analyzed were composed as 10 first-aid questions for the lay participants. Questions from one to eight assessed theoretical and physical skills, while questions nine and ten referred to the feelings the children described as having during that situation and after receiving the training. Another variable measured was the amount of time needed by the student to resolve the emergency situation recreated. Once all the study variables were collected, considering the nominal nature of the data, the chi-square and McNemar tests were employed to evaluate changes in paired variables before and after the intervention. In addition, to compare the global effect of the intervention, the Wilcoxon matched pairs signed rank test was used to analyze possible differences in the mean values of the global CPR knowledge score (sum of correct items) of the final values as compared to the initial values. Basic descriptive analysis (mean, variance, standard deviation, etc.) were also performed. All statistical procedures were carried out with the SPSS software (version 27.0, IBM SPSS Software). The statistical threshold for significance was established at $p < 0.050$.

3. Results

This section provides a comprehensive overview of the study's results, including participant characteristics, changes in CPR knowledge, emotional responses, completion times, performance in the videogame exam, and eye tracking analysis outcomes. These findings will be further discussed and interpreted in the following sections.

3.1. *Participant Characteristics*

The final sample was composed of 52 participants, of which 31 were girls, and 21 were boys. The mean age of the participants was 9 y-o. The results obtained in questions 1 through 8, which measured the theoretical knowledge on CPR, are shown in Figure 2.

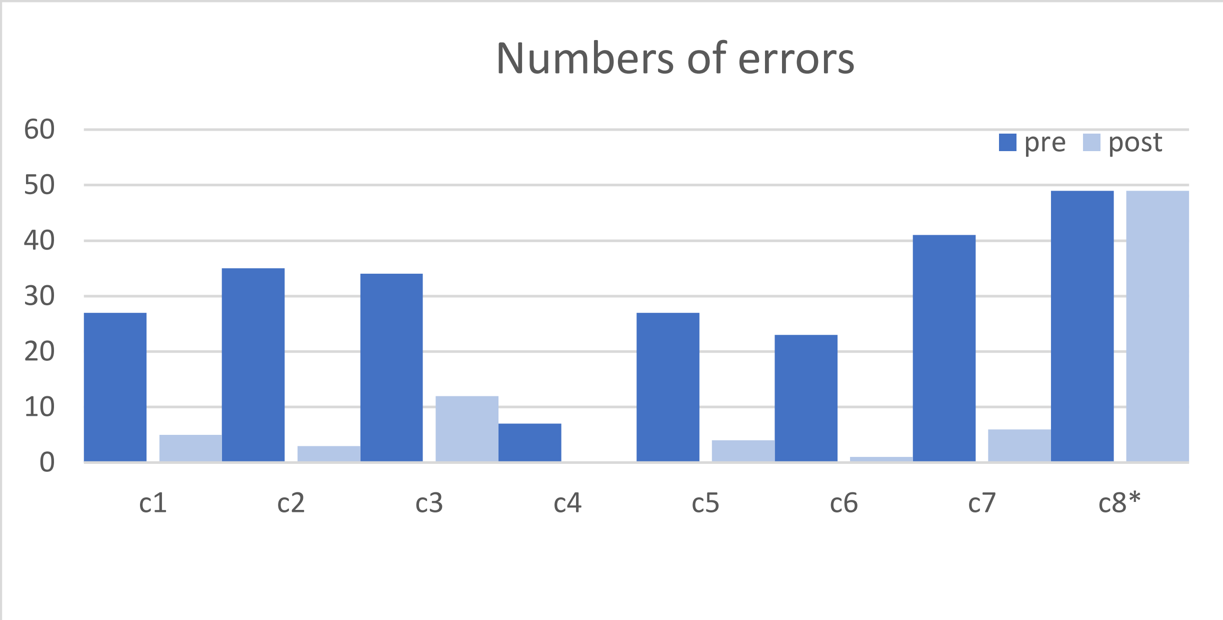


Figure 2. Results of the number of mistakes before and after the intervention. c: competence; * this item, referring to the defibrillator (AED), is not an indispensable example of competency for this age range [1].

3.2. Knowledge on CPR (Questions 1–8)

The information regarding changes in CPR knowledge are shown in Table 1. Before the intervention, for item I1, 46% (24/52) obtained the right answer in the pre-test as compared to 91% (47/52) in the post-test, with statistically significant differences ($p < 0.0001$). For item I2, 32% (17/52) of the students obtained the right answer in the pre-test, as compared to 95% (49/52) in the post-test. For item I3, the correct answers were obtained by 31% (16/52) of the students, as compared to 77% (40/52) in the post-test. Both results were statistically significant ($p < 0.0001$). Item I4 did not obtain statistically significant differences; in the pre-test, the percentage of students with correct answers was 91% (47/52), and in the post-test, it was 100% (52/52). For item I5, 48% (25/52) obtained the right answer before the intervention, while after the intervention, this ascended to 93% (48/52). For item I6, 56% obtained the correct answer before the intervention (29/52), as compared to 98% after it (51/52). In item I7, 21% (11/52) of the students answered correctly before the intervention, and 89% (46/52) did so in the post-test. In these last three items, the statistical difference was significant ($p < 0.0001$). With respect to item I8, for both the pre- and post-test, the percentage was 4%, with $p = 1.000$. This item, which referred to knowledge about the automated external defibrillator (AED), could be ignored, as it is not part of the basic learning results for the age of the participants.

The assessment of emotions was conducted through an analysis of the behavior and the reaction of the child, through a rubric shown in Table 1.

3.3. Emotional Responses (Questions 9–10)

Results for item I9, measuring the calmness of the child, showed an increase from 21% (11/52) in the pre-test to 52% (27/52) in the post-test; $p = 0.004$. Item I10, assessing how secure the child felt, increased from 35% (18/52) in the pre-test to 81% (42/52) in the post-test; $p < 0.0001$ (Figure 3).

Table 1. Changes in CPR knowledge after the intervention. Data show the frequency of individuals that correctly answered the item. Considering the paired nature of the data, McNemar's test was employed to evaluated changes in CPR knowledge as a consequence of the intervention. I: items. As there were no changes, it was not possible to estimate a chi-square on item 4.

Question	Number of Participants with Correct Answer		X^2	p (Sig.)
	Pre-Test	Post-Test		
I1. Talk or call the victim loudly	1	23	1.747	<0.0001
I2. Move the shoulders of the victim vigorously	0	32	1.546	<0.0001
I3. Verifies that the victim is not breathing	2	24	2.220	<0.001
I4. Asks for the phone	45	45	-	>1.000
I5. Does he or she know the number to call?	0	23	4.012	<0.0001
I6. Start CPR maneuvers	0	22	1.286	<0.0001
I7. Places the arms and hands correctly	0	35	1.820	<0.0001
I8. Asks for an AED	0	2	51.000	1.000
I9. How did you feel during the situation? (Right answer: calm)	3	11	5.450	0.004
I10. How did you feel during the situation? (Right answer: secure)	17	25	3.315	<0.0001

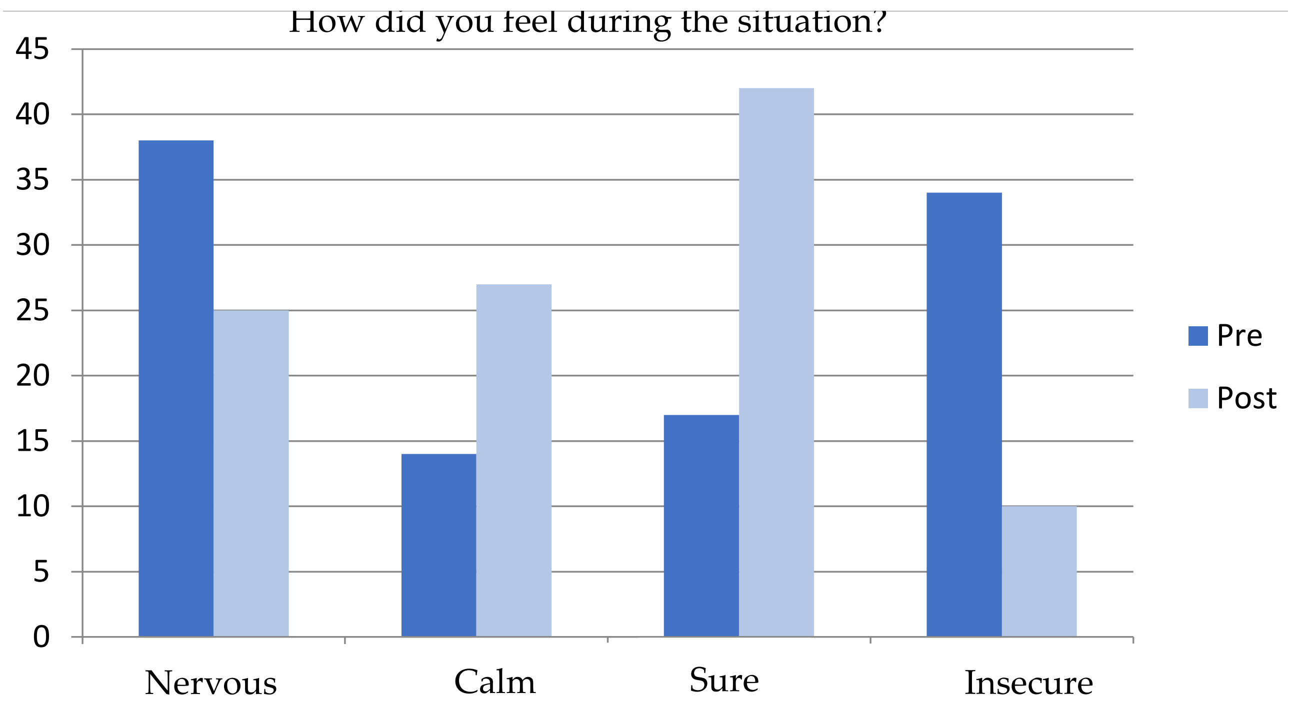


Figure 3. Results of the emotions expressed by the participants before and after using the serious game.

3.4. Overall CRP Knowledge

To evaluate the overall improvement in CPR knowledge, the sum of correct items before and after the intervention was analyzed. In this regard, items 9 and 10 were also included, considering a calm and secure feeling as correct answers. The inclusion of these variables did not modify Cronbach's α value of the test (α = 0.625 with eight items and α = 0.598 including mood items). The data obtained indicated a clear improvement in general CPR knowledge after the intervention (Figure 4).

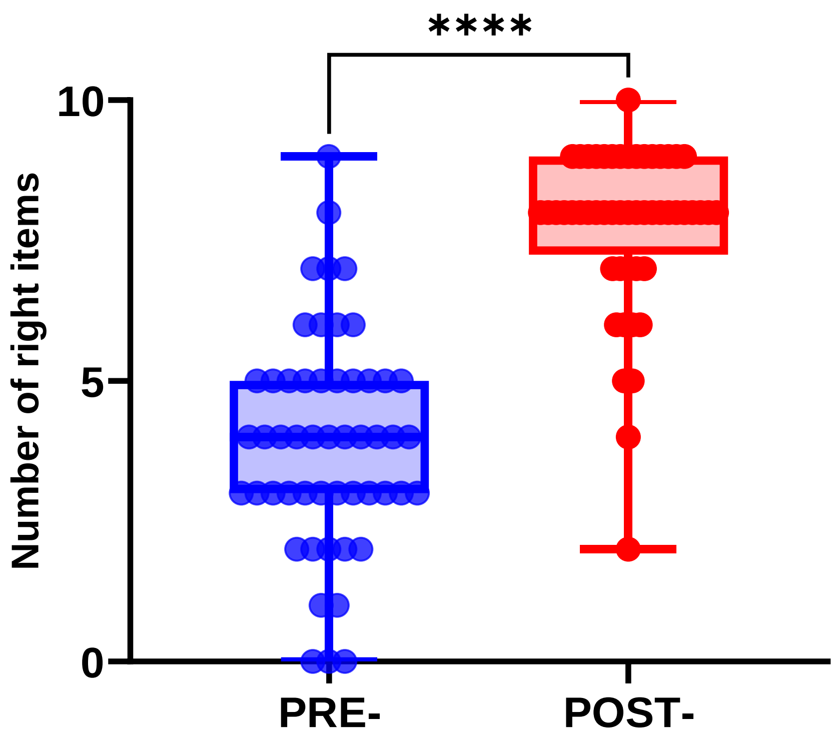


Figure 4. Box plot of the number of right items in the CRP knowledge survey carried out in the present work. The dots show the individual score of the participants. Differences were analyzed via a Wilcoxon matched-pairs signed rank test; ****: p-value < 0.0001.

The completion time of the videogame was also significantly reduced after the intervention (108.54 ± 26.527 s before and 56.65 ± 15.285 s after the intervention). The differences regarding mean resolution times before and after the intervention were statistically significant with $p < 0.0001$.

3.5. Videogame Exam

With respect to the exam on the last screen of the videogame, which was not part of the pre-post questionnaire of the intervention, the mean score obtained was 5.25 out of 6. The figure shows the exam score as compared to the time needed to finish the game (Table 2).

Table 2. Scores obtained in the test as compared to the mean total play time. A greater percentage of students obtained a higher score on the test and less time was needed for each turn.

Test Score	Mean Game Playing Time (s)	% Students
2 (minimum)	417.5	3.8
4	375.24	32.7
6 (maximum)	350.5	63.5

3.6. Eye Tracking Analysis

In the eye tracking analysis, 10 scenarios consisting of 500 frames each (20 s per scenario) were analyzed in a subsample of 10 participating subjects to evaluate the quality of resources, counting one fixation per frame. The average number of fixations across the 10 scenarios with regard to gaze fixations, which denoted the points where the child's attention was observed within the area of interest, was 361.5 out of 500. This accounted for 72% of fixations within the designated area of interest, which indicates a significantly high level of attention (Figure 5). The research team analyzed the results of eye tracking and adjusted the resources that received less attention, by modifying colors, shapes, and/or sounds.

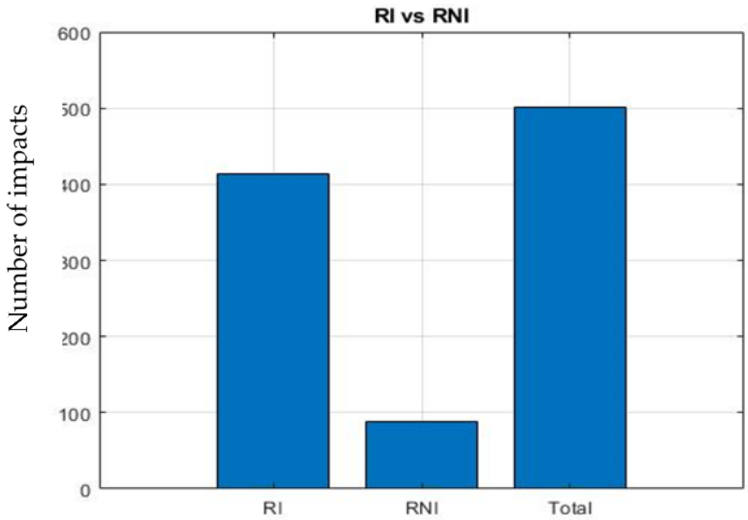


Figure 5. Plot diagram of the impact path sequence, at level 3 of the serious game. RI: region of interest vs. RNI: region out of interest.

4. Discussion

In the results obtained, it was observed that the simulation environment of this game favored controlled learning, in which users can manipulate their own learning curve, being able to improve each time the game was played (with a better score and shorter time as the game was played more often). In the study by Eugenio Marchiori et al. [18], the authors already addressed the inclusion of educational games at schools as a new tool for the CPR training of adolescents. Our post-intervention results support the usefulness of incorporating technological tools with an educational purpose, such as serious games, as a support for traditional methodologies. Also, our studies broaden the age range to children younger than 12 years old. In the research by Cristina Cerezo Espinosa et al. [19], conducted on adolescents, which used audiovisual materials as a tool for providing training on basic life support, the authors concluded that there were no differences between traditional teaching, in which an instructor teaches a course using a face-to-face methodology, and non-face-to-face learning, in which the students are not taught by a teacher in person, just as in our study. However, in our case, as the subjects were younger than 12 years old, we saw the need to use a supervisor, just as with any other activity in which technology is utilized with children [20].

The analysis of the results showed that 80% of the items assessed obtained a very high significance value ($p < 0.0001$). Other studies, in which technologies were utilized (i.e., virtual reality) for learning CPR, also obtained significant results, which reinforces their use [20,21].

With respect to item 5, which referred to the emergency telephone number, it is important to point out that 50% of the students utilized 911 and not the Spanish 112. This was not learned at school or from health professionals. This could be due to the consumption of series and movies, most of which are American, through diverse platforms (i.e., Netflix, HBO, YouTube, etc.). After the interventions, the percentage of participants who interiorized the correct number increased to 85%. Item 6, which alluded to the knowledge on the use of an AED, can be considered irrelevant, as it is not considered to be a learning objective for these ages, according to the ERC [1].

The children responded to the situation presented with greater security, more than twice, which had an effect on the time it took them to resolve the situation (Figure 4). This time decreased by 48% in the students who felt more secure. Despite the level of calmness not being as important, it did not incapacitate the users in the acquisition of competences.

Another interesting result was that the participants who took less time to finish the videogame obtained a higher score on the test. This could be due to a greater understanding of the material. The mean test score was high (5.25/6), and 63.5% obtained the highest score.

One of the strengths of the use of this technology is that it favors the learning of basic yet indispensable aspects of emergencies. We can mainly highlight that the child learned how to become aware and manage the situation, by identifying the scenario, learning to call 112, and even a learning about chest compressions (rhythm, hand and body positioning, area of compression, etc.). Thanks to the use of eye tracking technology, the graphic design of each scenario of the videogame was validated, to optimize the degree of attention and interaction of the subjects. Regarding the game design, the data analyzed in Matlab collected from the eye tracking software indicated that the level of attention to the selected elements was high. As demonstrated by the study conducted by Alvarado et al. [22], eye tracking glasses are a valuable technological tool for measuring attention and even for the detection of certain pathologies.

The availability of this type of tool at schools allows us to not only provide training during school hours, but it can also adapt to the needs of any student, and can even be used in flipped classroom methodologies [23] or as a reinforcement to avoid a steep forgetting curve.

In addition, as it is a software product, other conditions arise. This resource is useful, as it is easy to update (due to changes in regulations, different regulations between countries, etc.), it is very accessible (multi-platform), it is always available (always online), and the development and maintenance costs dissipate as the number of users grows [24–26]. Despite the benefits described, with respect to practical knowledge, a CPR manikin could serve as support, for becoming aware about the force needed for the compressions, the real speed they must use, etc.

Basic life support (BLS) education for schoolchildren has emerged as a crucial initiative to boost the rates of bystander CPR. The strategy recommended for teaching schoolchildren, by the International Liaison Committee on Resuscitation, involves a straightforward algorithm known as CHECK-CALL-COMPRESS [25]. In recent years, there has been a rise in the use of virtual reality (VR), augmented reality, smartphone applications, and social media for BLS instruction. Despite the potential of these innovative, technology-enhanced learning tools for children who are growing up in a digital world, their effectiveness is often underappreciated, particularly regarding the most effective digital learning strategies. "Serious games" are digital games designed for educational purposes. Studies have indicated that using serious games in teaching schoolchildren can be as effective as traditional, instructor-led face-to-face teaching [26]. Moreover, fostering competition among students can significantly heighten their engagement [27]. Most apps are aimed at young children over the age of 4 and are developed as animated tutorials, simulations, or interactive virtual worlds. The majority of these apps focus on teaching hands-only CPR, although some also cover ventilation techniques. Only one app includes BLS training with an automated external defibrillator (AED). Skills such as checking the airway, requesting an AED, and using the AED are significantly better after instructor-led courses as compared to after app-based learning. Blended learning courses in BLS and defibrillation are increasingly prevalent and yield results comparable to those from traditional BLS training programs. Serious games also hold the potential to enhance awareness about the importance of BLS. Training schoolchildren in basic life support has the capacity to educate entire generations on how to respond to cardiac arrests and to improve survival rates following out-of-hospital cardiac arrests. Comprehensive legislation, curricula, and scientific assessment are essential to further advance the education of schoolchildren in basic life support.

5. Limitations, Future Work and Conclusions

The main limitation of our study is the small sample size and the assessment of only some aspects of CRP and SGH. Eye tracking technology allows us to adapt the design of educational resources, promoting designs that better capture attention. The use of these resources should be incorporated in a balanced way with other training actions, as indicated by philosophies such as blended learning. Future lines of work must focus on adapting the material according to age and condition, to be able to integrate children with special needs, and to also design experiences in which the child teaches individuals in a family setting, to promote hybrid methodologies that combine traditional learning with ICT, and even to compare the efficiency between different technologies. On the other hand, it would be necessary to encourage collaborations between educators, health professionals, technologists, and game designers to create BLS educational materials that are both educational and engaging. Lastly, we believe it is important to conduct long-term studies to evaluate the effectiveness of different BLS teaching methods in skill retention and readiness to act in a real emergency.

The main novelty of our research is that we have used SGH for teaching children. The main conclusion of our work is that gamification and the use of serious games for health (SGH) is an efficient method for the CPR training of children, adapting to the language and skills appropriate for their age.

Author Contributions: Conceptualization, M.P.R. and R.M.R.; methodology, M.M.L. and C.T.D.; software, M.M.L.; validation, P.M.A.A.; formal analysis, M.M.L.; investigation, M.M.L.; resources, M.P.R.; data curation, J.J.H.M. and M.M.L.; writing—original draft preparation, M.M.L.; writing—review and editing, M.P.R.; visualization, R.M.R.; supervision, R.M.R.; project administration, M.P.R.; funding acquisition, M.P.R. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by PMAFI-09-2021, granted by the UCAM to the project "Innovación docente y recursos didácticos inclusivos para el aprendizaje de Reanimación Cardiopulmonar y Primeros Auxilios en niños en edad escolar", and by the Ignacio H. Larramendi Research Support granted by the Mapfre foundation in 2022 for the research project PECES (Programa de Educación en Competencias de Emergencia Sanitaria), to the UCAM Universidad Católica de Murcia, to Dr. Manuel Pardo Ríos and his research team.

Institutional Review Board Statement: The study was approved by the Ethics Committee from the Universidad Catholic of Murcia (UCAM), registration number 7.986.

Informed Consent Statement: The parents/tutors provided their consent for the participation of the underage children.

Data Availability Statement: Data is contained within the article.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Summary table of the videogame levels, objectives, and scores.

Level	Scenario	Objectives	Learning Results	Score
1	Forest with interactive characters	Familiarize the player with the device and the characters	Knowledge of the environment	+10 If the character is found
2	Pantry with healthy and non-healthy foods	Feed the bear	Become responsible. Distinguish healthy food	+2 Healthy foods +1 Less healthy foods Maximum of 4 foods
3	Phase 1: Video Phase 2: Game	Learn about first aid	Instructions on the technique *in the following order*: 1. VERIFY 2. CALL 3. COMPRESS	Total of 25 points: 8 questions Correct answer add +2 and +5 Incorrect substract −1
4	The bear suffers a cardiac arrest	Know the CPR technique	Correctly execute the position and rhythm of compressions Call from a mobile phone without the need to unlock it	Total of 36 points Correct placement +1

References

1. Koster, R.W.; Baubin, M.A.; Bossaert, L.L.; Caballero, A.; Cassan, P.; Castrén, M. European Resuscitation Council Guidelines for Resuscitation 2010 Section 2. Adult basic life support and use of automated external defibrillators. *Resuscitation* **2010**, *81*, 1277–1292. [CrossRef] [PubMed]
2. Escalada, X.; Fabrega, X.; Diaz, N.; Sanclemente, G.; Gómez, X.; Villena, O. Programa de Reanimación Cardiopulmonar Orientado a Centros de Enseñanza Secundaria (PROCES): Conclusiones tras 5 años de experiencia. *Emerg. Rev. Soc. Española Med. Urgenc. Emerg.* **2008**, *20*, 229–236.
3. Sesma, J.; Miró, Ò. Urgencias y emergencias: Al servicio del ciudadano. *An. Sist. Sanit. Navar.* **2010**, *33*, 5–6. [CrossRef]
4. SAMUR—Protección Civil—Formación a la ciudadanía: Alertante y Primer Respondiente—Ayuntamiento de Madrid [Internet]. Available online: https://www.madrid.es/portales/munimadrid/es/Samur/SAMUR-Proteccion-Civil/?vgnextfmt=default&vgnextoid=c88fcdb1bfffa010VgnVCM100000d90ca8c0RCRD&vgnextchannel=84516c77e7d2f010VgnVCM1000000b205a0aRCRD&idCapitulo=10276015 (accessed on 7 September 2023).
5. Miró, Ò.; Díaz, N.; Escalada, X.; Pérez Pueyo, F.J.; Sánchez, M. Revisión de las iniciativas llevadas a cabo en España para implementar la enseñanza de la reanimación cardiopulmonar básica en las escuelas. *An. Sist. Sanit. Navar.* **2012**, *35*, 477–486. [CrossRef]
6. SEMES XCN. En 2022. Available online: https://www.semes.org/vigo-batira-el-record-en-formacion-de-ninos-en-rcp-en-el-congreso-nacional-de-medicina-de-urgencias-y-emergencias/ (accessed on 10 October 2023).
7. Greif, C.; Lockey, A.; Conaghan, P.; Lippert, A.; Vries, W.; Monsieurs, K. European Resuscitation Council Guidelines for Resuscitation 2015: Section 10. Education and implementation of resuscitation. *Resuscitation* **2015**, *95*, 288–301. [CrossRef] [PubMed]
8. Greif, R.; Lockey, A.; Breckwoldt, J.; Carmona, F.; Conaghan, P.; Kuzovlev, A.; Pflanzl-Knizacek, L.; Sari, F.; Shammet, S.; Scapigliati, A.; et al. European Resuscitation Council Guidelines 2021: Education for resuscitation. *Resuscitation* **2021**, *161*, 388–407. [CrossRef] [PubMed]
9. Semeraro, F.; Monesi, A.; Gordini, G.; Del Giudice, D.; Imbriaco, G. Kids Save Lives: A blended learning approach to improve engagement of schoolchildren. *Resuscitation* **2023**, *182*, 109675. [CrossRef] [PubMed]
10. Iglesias, A.; Martín, Y.; Hernández, A. Evaluación de la competencia digital del alumnado de Educación Primaria. *Rev. De Investig. Educ.* **2023**, *41*, 33–50. [CrossRef]
11. Tomala-Gonzales, J.; Guaman-Quinche, J.; Guaman-Quinche, E.; Chamba-Zaragocin, W.; Mendoza-Betancourt, S. Serious Games: Review of methodologies and Games engines for their development. In Proceedings of the 15th Iberian Conference on Information Systems and Technologies (CISTI), Sevilla, Spain, 4–27 June 2020; pp. 1–6.
12. Nacke, L.E.; Drachen, A.; Goebel, S. Methods for Evaluating Gameplay Experience in a Serious Gaming Context. IACSS [Internet]. 2010; Volume 9. Available online: https://research.cbs.dk/en/publications/methods-for-evaluating-gameplay-experience-in-a-serious-gaming-co (accessed on 10 October 2023).
13. Botto-Tobar, M.; Zambrano Vizuete, M.; Montes León, S.; Torres-Carrión, P.; Durakovic, B. Applied Technologies. In Proceedings of the 4th International Conference, ICAT 2022, Quito, Ecuador, 23–25 November 2022; Revised Selected Papers, Part I [Internet]; Springer Nature: Cham, Switzerland, 2023. (Communications in Computer and Information Science; Vol. 1755). Available online: https://link.springer.com/10.1007/978-3-031-24985-3 (accessed on 10 October 2023).
14. Noboa Carrasco, G.N. Diseño de un Serious Game Para Concientizar a Niños de Educación Básica Sobre el Bullying [Internet] [Bachelorthesis]. Riobamba. 2021. Available online: http://dspace.unach.edu.ec/handle/51000/7790 (accessed on 10 October 2023).
15. Rodríguez Carranza, Y.V. Diseño de Serious Game para la enseñanza de la Responsabilidad Social en la Educación Superior. *Docencia Univ.* **2018**, 156–175. [CrossRef]
16. CarrerasPlanas, C. Del Homo Ludens a lagamificación. Quaderns de Filosofia [Internet]. 21 de mayo de 2017. Volume 4. Available online: https://ojs.uv.es/index.php/qfilosofia/article/view/9461 (accessed on 10 October 2023).
17. Newley, A.; Deniz, H.; Kaya, E.; Yesilyurt, E. Engaging Elementary and Middle School Students in Robotics through Hummingbird Kit with Snap! Visual Programming Language. *Joltida* **2016**, *2016*, 20–26.
18. Marchiori, E.; Ferrer, G.; Fernández Manjón, B.; Povar Marco, J.; Suberviola González, J.F.; Giménez Valverde, A. Instrucción en maniobras de soporte vital básico mediante videojuegos a escolares: Comparación de resultados frente a un grupo control. *Emerg. Rev. Soc. Española Med. Urgenc. Y Emerg.* **2012**, *24*, 433–437.
19. Espinosa, C.C.; Caballero, S.N.; Rodríguez, L.J.; Castejón-Mochón, J.F.; Melgarejo, F.S.; Martínez, C.M.S.; López, C.A.L.; Ríos, M.P. Estudio Aleatorizado de Formación en Reanimación Cardiopulmonar en 2.225 Alumnos: ¿Se Pueden Sustituir las Clases por Videos? EMERGENCIAS [Internet]. 22 de Diciembre de 2017; Volume 30. Available online: https://emergenciasojs.portalsemes.org/index.php/emergencias/article/view/524 (accessed on 10 October 2023).
20. Marín Díaz, V.; García Fernández, M.D. Los Videojuegos su Capacidad Didáctico-Formativa. Video Games and Their Didactic-Formative Capacity [Internet]. 2005. Available online: https://idus.us.es/handle/11441/45606 (accessed on 10 October 2023).
21. Pérez Rubio, M.T.; González Ortiz, J.J.; López Guardiola, P.; Alcázar Artero, P.M.; Soto Castellón, M.B.; Ocampo Cervantes, A.B.; Ríos, M.P. Realidad Virtual para Enseñar Reanimación Cardiopulmonar en el Grado de Educación Primaria: Estudio comparativo. RIED Revista Iberoamericana de Educación a Distancia [Internet]. 2023. Available online: https://redined.educacion.gob.es/xmlui/handle/11162/252752 (accessed on 10 October 2023).

22. Creutzfeldt, J.; Hedman, L.; Heinrichs, L.; Youngblood, P.; Felländer-Tsai, L. Cardiopulmonary resuscitation training in high school using avatars in virtual worlds: An international feasibility study. *J. Med. Internet Res.* **2013**, *15*, e9. [CrossRef] [PubMed]
23. Mendoza López, M.; Pérez Rubio, M.T.; Truque Díaz, C.; Pardo Ruiz, M. Enfermera Comunitaria Escolar e Innovación Docente para Enseñar Reanimación Cardiopulmonar en la Escuela a Través de una Flipped Classroom. Aten Primaria [Internet]. 1 de Junio de 2023. Volume 55. Available online: https://www.elsevier.es/es-revista-atencion-primaria-27-articulo-enfermera-comunitaria-escolar-e-innovacion-S0212656723000872 (accessed on 10 October 2023).
24. López Raventós, C. El videojuego como herramienta educativa. Posibilidades y problemáticas acerca de los serious games. *Apert. Rev. Innovación Educ.* **2016**, *8*, 136–151.
25. Semeraro, F.; Greif, R.; Böttiger, B.W.; Burkart, R.; Cimpoesu, D.; Georgiou, M.; Yeung, J.; Lippert, F.; Lockey, A.S.; Olasveengen, T.M.; et al. European Resuscitation Council Guidelines 2021: Systems saving lives. *Resuscitation* **2021**, *161*, 80–97. [CrossRef] [PubMed]
26. Semeraro, F.; Frisoli, A.; Ristagno, G.; Loconsole, C.; Marchetti, L.; Scapigliati, A.; Pellis, T.; Grieco, N.; Cerchiari, E.L. Relive: A serious game to learn how to save lives. *Resuscitation* **2014**, *85*, e109–e110. [CrossRef] [PubMed]
27. Schroeder, D.C.; Semeraro, F.; Greif, R.; Bray, J.; Morley, P.; Parr, M.; Nakagawa, N.K.; Iwami, T.; Finke, S.-R.; Hansen, C.M.; et al. KIDS SAVE LIVES: Basic Life Support Education for Schoolchildren: A Narrative Review and Scientific Statement From the International Liaison Committee on Resuscitation. *Resuscitation* **2023**, *188*, 109772. [CrossRef] [PubMed]