Chapter

The Use of Serious Games for Learning Cardiopulmonary Resuscitation Procedures: A Systematic Mapping of the Literature

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Abstract

This article presents a systematic mapping, with an analysis of 35 selected works according to established criteria, seeking to connect the points and find relevant information for the following research areas: basic life support, cardiopulmonary resuscitation, serious games, and games for healthcare. Among the main results found, we can mention the representativeness of works by regions and their most productive years, the most common platforms, noting a focus on VR technologies, in addition to identifying the preference for the Unity 3D tool for implementations. It was also possible to show that serious games can be very effective in teaching CPR.

Keywords: cardiopulmonary, resuscitation, CPR, basic life support, BLS, virtual training, virtual reality, VR devices, serious games, VR, systematic mapping, healthcare

1. Introduction

The basis of an electronic game is nothing more than a set of rules to be assimilated and through the repetition of their actions, the player can master the proposed challenges printed in the game mechanics and so advance through the stages, improving your skills, with the objective of winning the final challenge. According to Coelho and Nunes [1], in education, games have two functions: a playful and an educational one.

Playfulness refers to moments of leisure and fun, while education is portrayed through the acquisition of knowledge of the game content and understanding of the player's world. Games also provide the development of social skills, attention, concentration, logical reasoning, and others. The Serious Games (or Serious Games) bring the proposal to evolve and expand the concept of Educational Games. With a

focus on training and management applied through game mechanics, they aim to deal with issues relevant to society, with the aim of generating effects outside the virtual domains, adding value to the player's individual knowledge in the real world.

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Due to this, initiatives such as Games for Health [2, 3] and Games for Change [4] emerged, linked to this end and which also contribute to a promising field in the field of research, Game Studies [5]. With the popularization of digital games and the aging of the generations that grew up playing this product from the entertainment industry, this market trend tends to increase more and more, according to Vasconcellos et al. [6]. It is noteworthy that the theme of Games and Health is relatively new in academic events, such as SBGames—Brazilian Symposium on Games and Digital Entertainment, which at the end of 2022 will reach its 21st edition. Since 2016, a Workshop has been held internally in the area of Health, which last year became an official track for the dissemination of research and the development of games in this area [7]. At an international level, we have the International Conference on Serious Games and Applications for Health—SEGAH, which has been in operation since 2012, is in its 10th edition, and is an event affiliated with the IEEE [8].

According to the document from the Brazilian Archives of Cardiology, by Gonzalez et al. [9], training in Basic Life Support (BLS) generates individual specific skills that can be forgotten in a short time. Due to the lack of opportunities to make use of the procedures, or even the absence of constant practices, this knowledge has an average expiration time of 3–6 months. Therefore, there is a real need to generate maintenance of this knowledge, through simplified training for laypeople, in order to increase the durability of the retention of this knowledge in people's minds. The games can be used at any time, without an appointment, date, or place, just having a computer, a game console, or a mobile device and the willingness to practice. By applying game mechanics that have rules and that, in order to be mastered, need to be repeated in a dedicated way, the use of digital games helps in memorization, fixation, or recall of dormant knowledge. Thus, the union of learning BLS procedures with electronic games is a possibility to help spread this important knowledge, capable of saving many lives.

The motivation for this study comes from the interest of the author in games, together with the possibility of contributing to the research of the doctoral student in Nursing Maicon Nogueira [10], as there is a mutual interest in the union of these areas of research. Thus, this work aimed to analyze the production of academic publications related to health, focused on CPR in the last 5 years from the bases of SBGames, IEEE, Portal da Capes, and Google Academic, in order to identify and analyze the characteristics presented, to get an overview of what has been done in the area.

After this introduction, this chapter is structured where Section 2 brings the theoretical foundation of our objective and its relevance. Section 3 addresses the methodology used to compose this study with the selected articles chosen. Section 4 shows a variety of results that could help us to understand the extension of this theme and how others are approaching it, finally, Section 5 concludes this analysis followed by all the references used in this work.

2. Theoretical foundation

2.1 Serious games

According to Derryberry (2008), what separates serious games from the rest of games is the focus on a specific and intentional learning result to achieve serious, measurable, and continuous performance and behavior changes [11, 12]. The repertoire of computing strategies for medical education is becoming more comprehensive, with the introduction of virtual learning applications (e-learning), based on games, gamification, and via mobile devices. A variety of serious games is being used more often in health education, bearing in mind that health care students are young and technology-savvy. The increased interest in games is evidenced by the growing number of reports and systematic reviews on the use of games in education. According to Bergeron [13], Serious Games is understood as an interactive computer application, with or without a certain connected hardware component, which has a challenging objective, is fun to play, has some scoring concepts, and adds a skill to the user, knowledge or attitude that can be applied in the real world. Games are called serious when they have a pedagogical purpose [14].

2.2 BLS and cardiopulmonary resuscitation

Basic Life Support (BLS) consists of a set of steps and maneuvers performed sequentially, which include immediate assessment and intervention in each phase of Cardiopulmonary Resuscitation (CPR), identified as follows: C—circulation (evaluation of signs of circulation and performance chest compressions), A—airway opening (assessment and correct positioning of the airways), B—breathing (assessment of respiratory movements and performance of ventilation), and D—early defibrillation. These recommendations are based on the guidelines of the International Liaison Committee on Resuscitation (ILCOR) and the international scientific consensus of the American Heart Association (AHA) [10].

3. Methodology

Carrying out systematic mapping of the literature, according to Kitchenham and Charters [15], requires the creation and completion of a protocol, which consists of detailed planning, which comes with the collection of all the necessary data to conduct the construction of the review. The steps to be performed are these:

- Define research questions
- Define search keywords
- Define the sources (bases) to be consulted
- Define the types of works that will be part of the research
- Define work languages
- Define the quality criteria for primary studies

- Define the search string
- Define inclusion and exclusion criteria
- List included and excluded articles
- Start the process of filling out the data extraction form, which will be carried out for each of the selected articles
- Conduct analysis of results: grouping, comparing, and critically discussing related works
- Define the existing indicators, metrics, criteria, and gaps

In addition to creating the protocol file, a tool to support the management of literature reviews was used. The chosen one was the national START (State of the Art through Systematic Review), authored by UFSCar/LAPES, in version 3.0.3 beta [16].

3.1 Survey questions

Following Kitchenham and Charters's study [15], and in order to find material related to the proposed topic, the following research questions were created:

- Q1: How have serious games been used to teach CPR protocols?
- Q2: How effective are serious games in teaching CPR?
- Q3: What is the state of the art of serious health-focused games for teaching CPR?
- Q4: What platforms are used to experience the games?

3.2 Strategies used in search engines

To continue the research procedure and obtain the answers to the questions, the keywords listed below were defined:

Keyword	Synonym
Serious games	
CPR	
Resuscitation cardiopulmonary	Cardiopulmonary resuscitation
BLS	

Based on these keywords, the following search string was defined at first: "serious games" OR "serious games" AND "RCP" OR "cardiopulmonary resuscitation" As the search return appeared to be too broad (187 items in the Google Scholar and 221 in Capes Journals), in addition to presenting several articles not related to the research interest, the string was redone.

The new string took the following form: ("serious games" OR "serious games") AND ("RCP" OR "cardiopulmonary resuscitation" OR "Cardiopulmonary Resuscitation" OR "CPR") AND ("SBV" OR "basic life support" OR "BLS" OR "Basic life support"), returning 110 items in Google Scholar.

On the Capes Journal Portal, the string had to be adapted, as it presented incompatibility with the previous format, obtaining the following form: (serious games) OR (serious games) AND CPR OR BLS OR ((Cardiopulmonary Resuscitation) AND (basic life support)), returning 176 items. After some observations in the listed articles, it was noticed that certain terms should be excluded from the string, as they have the same acronym of BSL and CPR, they were integrated in the search result.

Then, after a new adjustment to the string, this format was agreed to: (serious games) OR (serious games) AND CPR OR BLS OR ((Cardiopulmonary Resuscitation) AND (NOT (Common-Pool Resource)) AND (NOT (biomedical laboratory) science))), with the option to return only peer-reviewed journals, which resulted in 76 items.

The databases that returned in the search performed within the Capes Portal were PubMed, Scopus, Advanced Technologies & Aerospace Database, Directory of Open Access Journals—DOAJ, Web of Science, SpringerLink, Sage Journals, ERIC, and ACM Digital Library.

A private search was also performed in the IEEE database, which returned 21 items with the adapted string: ("All Metadata": "serious games") AND ("All Metadata": "Cardiopulmonary Resuscitation") OR ("All Metadata": "CPR training") OR ("All Metadata": "basic life support").

Finally, in the SBGames repository, which are the Annals of the Symposium, the search was performed manually, having found four items that included the chosen keywords. And this result was manually entered into START. BIBTEX files were also generated with the results of each search performed in the databases (Portal da Capes, Google Academic, and IEEE) to be inserted in an automated way in the support tool for the management of systematic literature reviews.

Searches were carried out between February and July 2021, through the academic registration valid on the CAPES portal and the mapping database, extracted during this period, and the final selection of chosen studies was systematized through MS Excel spreadsheet, which later also contributes to the elaboration of the graphs for this work. Also, during this period, learning the technique of Systematic Mapping was contemplated, through the subject of Scientific Methodology, which was administered by Professor Viviane Santos, collaborator of this work.

3.3 Inclusion and exclusion criteria

This item was also developed based on Kitchenham and Charters [15] with the formulation of the following definitions below, presented in **Table 1**:

In order to exclude erroneous terms that would invalidate the search results within the consulted databases, this list of criteria was created. In particular, the terms Common-Pool Resource/Cascaded Pose Regression (CPR) and Biomedical Laboratory Science (BLS) were included because they have the same abbreviation as the terms Cardiopulmonary Resuscitation (CPR) and Basic Life Support (BLS), respectively.

3.4 Criteria for selection of studies and identification of qualities

To obtain the works that contained the object of study of interest to the researchers in this review, the criteria were as follows: (a) whether the study uses volunteers to test

Criteria	Results
Being within the time frame of the last 5 years (2016–2021)	IC-01
Belonging to the disciplines of nursing, computer science, and medicine (specifically on the Capes Portal)	IC-02
Contain relationship with cardiopulmonary resuscitation (CPR)	IC-03
Academic works in English and Brazilian Portuguese	IC-04
Be from the physical sports spectrum (games)	EC-01
Contain the term Common-Pool Resource or Cascaded Pose Regression (CPR)	EC-02
Contain biomedical laboratory science (BLS)	EC-03
Not be a gamified implementation (digital game)	EC-04

Table 1.
List of chosen criteria.

the software's teaching efficiency; (b) whether the study is specifically about basic life support with a focus on CPR; and (c) if there are details on how the software was built, with information such as platform, the tool used, as well as additional hardware.

Two researchers from this study were delegated to do the peer review, in the final choice. In addition to the complete reading of the individual selected, the researchers discussed each article, with the aim of both being in agreement on the fulfillment of the established criteria.

Figure 1, which is the PRISMA flow above, shows all stages of the study selection process until reaching the definition of the chosen works, which were 35 and are listed in **Table 2**:

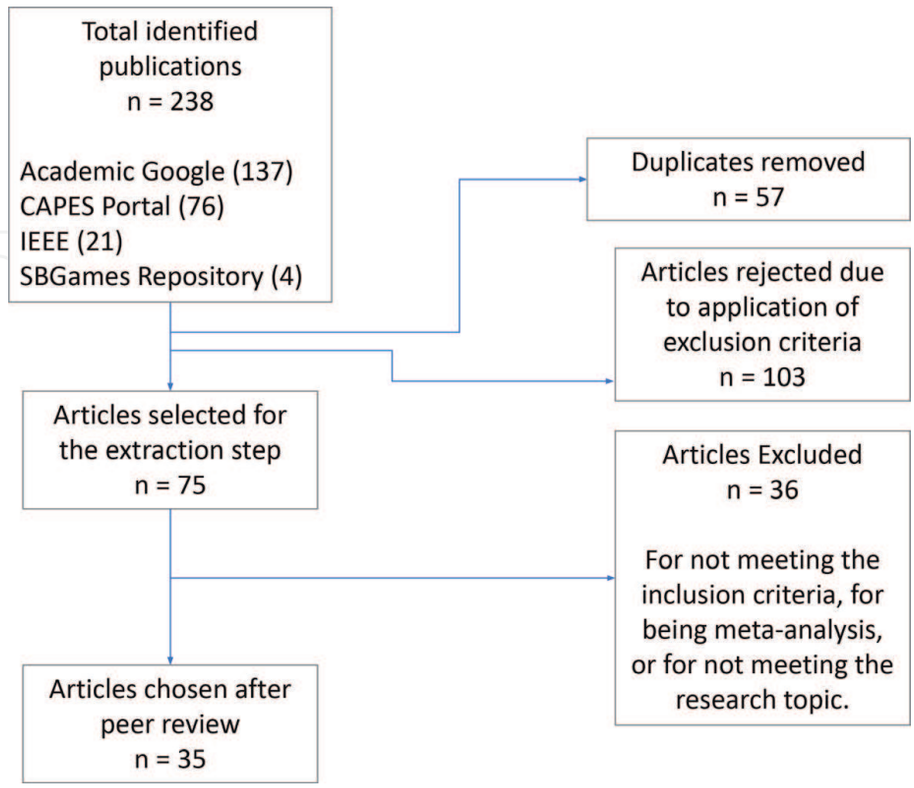

Figure 1.
Chapter selection process (prepared by the authors).

Year of publication	Amount	Published works
2021	01	A16—[17] "Comparative Effectiveness of Simulation versus Serious…"
2020	10	A07—[18] "Hands 2 Help: Educational "Serious Game" for teaching…" A08—[19] "Use of the serious game as an innovative educational strategy…" A11—[20] "Comparing Basic Life Support Serious Gaming Scores With…" A12—[21] "Developing a virtual simulation game for nursing…" A14—[22] "Precourse Preparation Using a Serious Smartphone Game on…" A19—[23] "A Pilot Study of CPR Quality Comparing an Augmented…" A20—[24] "Immersive Virtual Reality-Based Cardiopulmonary…" A22—[25] "Virtual Reality simulation technology for cardiopulmonary" A33—[26] "A Serious Game on the First-Aid Procedure in…" A34—[27] "Exploring User Needs in the Development…"
2019	10	A03—[28] "Proposal to build a serious game as an instrument for…" A05—[29] "Building a Health Game for Basic Life Support: Teaching…" A13—[30] "FASim: A 3D Serious Game for the First Aid Emergency" A15—[31] "Comparative evaluation of video-based online course versus…" A17—[32] "Virtual Reality Simulation Technology for Cardiopulmonary…" A21—[33] "Feasibility of an augmented reality cardiopulmonary…" A26—[34] "Holo-BLSD—A Holographic Tool" A29—[35] "Gamifying autonomous CPR training" A30—[36] "Comparing the effects on learning outcomes" A35—[37] "From experiencing to critical thinking: a contextual…"
2018	03	A04—[38] "Developing a Digital Game for Building First Aid Basics" A09—[39] "CPRforblind: A video game to introduce cardiopulmonary…" A31—[40] "Data analytics of mobile serious games"
2017	05	A06—[41] "Simulators for teaching cardiopulmonary resuscitation:…" A23—[42] "Affordable Hi-fidelity VR based CPR simulator" A24—[43] "Development and Evaluation of a Corrective" A28—[44] "A Serious Game For cardiopulmonary" A32—[45] "Designing an Engaging and Informative Application…"
2016	06	A01—[6] "Health in Academic Gaming Literature: an analysis…" A02—[46] "Serious Game developed in Health: Integrative Literature…" A10—[47] "Cardiopulmonary Resuscitation Training by Avatars:…" A18—[48] "Success factors for serious games to enhance learning:…" A25—[49] "Relieve A markless Assistant" A27—[50] "A Game Designed to Promote the Cardiopulmonary"

Table 2.
Number of articles per publication year.

3.5 Data extraction and synthesis

The process of filling out the protocol generated an extensive file, of more than 100 pages, the result of data collection carried out with the START tool [16], cataloging information such as title, abstract, authors, keywords, journal, year, publication link, and others comments. After the complete reading, the comprehension of the selected works is also included.

A synthesized document was built in Microsoft Excel to solidify the information of interest to this study, found in the reading of each article. These were the items: (1) if there is the identification of the application of artificial intelligence techniques (yes or no); (2) year of publication of the material; (3) platform used (PC, mobile devices, virtual or augmented reality glasses and other peripherals); (4) existence of volunteers in the study (yes or no); and (5) country that carried out the survey. There

Figure 2.
Cloud of words by the title of selected works.

was space for extra information such as type of peripheral, manufacturer, and tool/language used to create the software.

Due to the use of a tool to support the management of systematic reviews (START), it was possible to obtain the word cloud graph according to the chosen studies, with a sampling of the words that were most present in the titles (**Figure 2**).

In the following section of results and analysis, it is possible to check the graphs that were generated with this information. Out of curiosity, it is worth mentioning that among the excluded works, even with the generated search string, there were themes a little out of contexts, such as a study on fictions such as "Boys Love" [51] and collective consciousness [52].

4. Results and analysis

When analyzing the relationship between the origin of publications and quantity, **Figure 3** shows that most of the selected works are of European origin.

Another interesting observation is the representation by region, with 11 works from Europe (Denmark, Spain, Netherlands, England, Italy, Portugal, and Sweden), six in Asia (India, Japan, Pakistan, Thailand, and Taiwan), four in North America (Canada, United States), three in the Middle East (Iran and Turkey), two in Africa (South Africa and Algeria) and, finally, one work in Oceania (Australia), respectively. Brazil is the only representative of South America, with nine works highlighted.

In **Figure 4**, which shows the number of publications per year, it is possible to note that the years 2019 and 2020 were the most productive for the topic, with a total of 20 works, eight of which for mobile devices. Perhaps because studies on games are increasingly in evidence, accompanied by the popularization of smartphones, which favors and encourages the emergence of new applications. According to an annual study by the company NewZoo, released in May this year, the number of active users on this device specifically reached the amount of 3.8 billion around the world, with a growth of 6% compared to the previous year. And a 56% share of that audience is found in the Asia-Pacific region [53].

It was possible to observe that in **Figure 5**, referring to the platforms used in the selected studies, there is almost a tie between the option of implementation on PC and on mobile devices (smartphones and tablets). One of the chances that the PC is

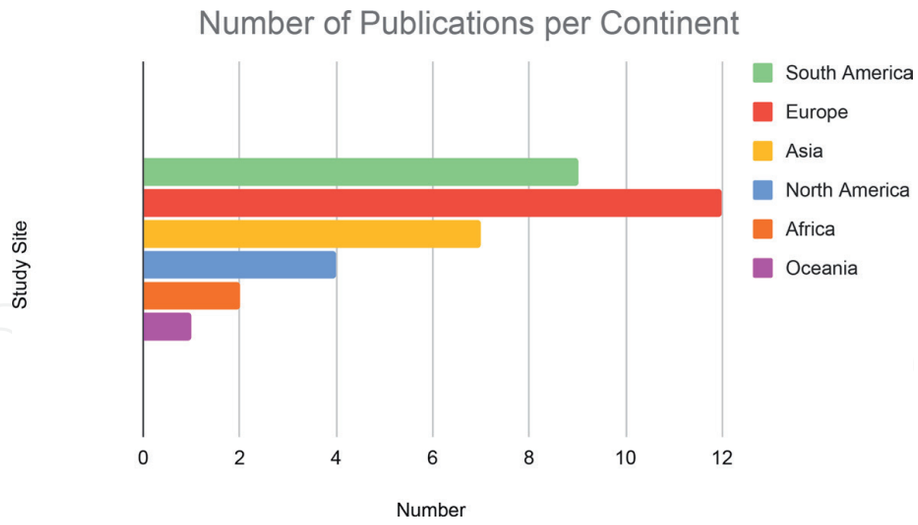

Figure 3.
Number of publications by continent.

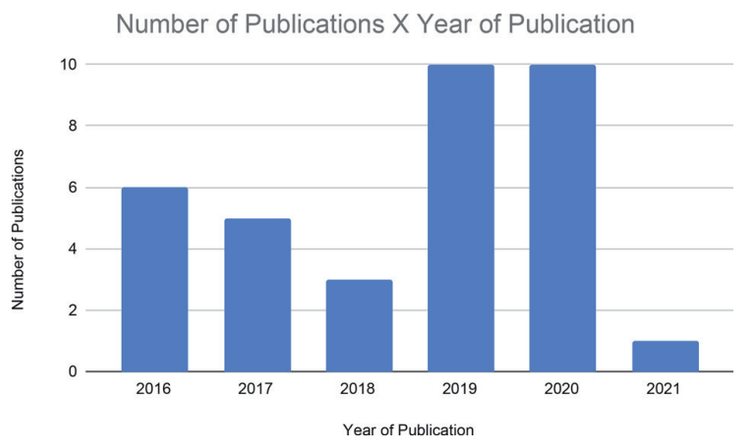

Figure 4.
Number of publications per year.

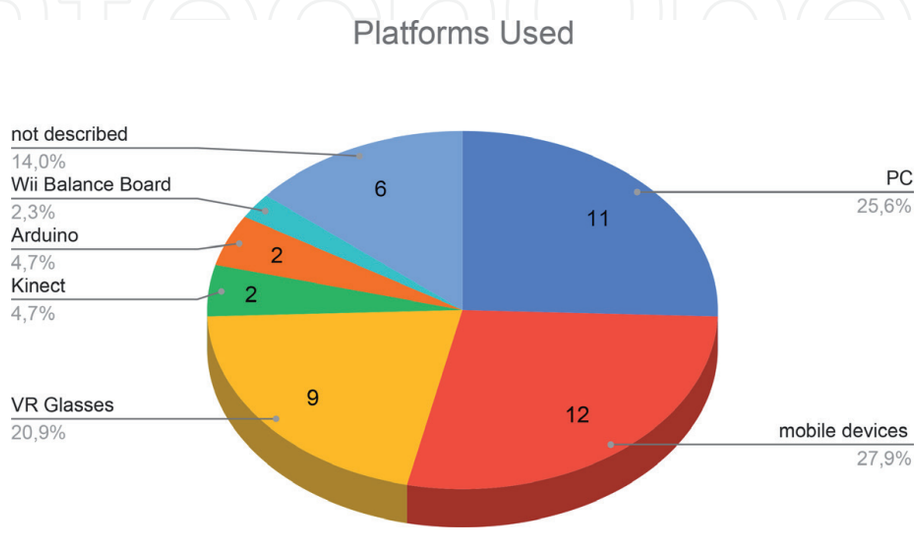

Figure 5.
Platforms used in selected studies.

Figure 6.
HTC Vive Kit [12] with Trackers [59].

among the most chosen is due to the convenience of generating builds in the default configuration of most game development tools. Mobile devices, on the other hand, follow slightly in the lead as they are the platform with the greatest ease of access among users, even game development tools do not offer build generation by default. And according to another study by NewZoo, the global gaming market is dominated by mobile devices, with 52% of revenue [54].

In third place, there are the Virtual Reality Glasses (VR), with nine studies, representing almost 21%. They appear to be gaining in popularity, particularly in the European, Asian, and North American regions. The models that appeared in this selection were HTC Vive [55], Rift Glasses, and Go Glasses [56]. There were also three studies with the MS HoloLens [57], which makes use of mixed reality. These are modern and very interesting technologies, but they have a high market value, increasing costs, and access for the vast majority of users.

Anyway, it's worth opening a parenthesis here to detail VR devices, head-mounted displays (HMDs). The HTC Vive was used in the works A17—Canada [32] and A22—Italy [25]. Both also made use of complementary peripherals, the HTC Trackers [58], to improve the experiment's effectiveness, as shown in **Figure 6** below. Just like the Unity3D software [60] was chosen for the development of the applications.

HTC Vive has a total of 70 sensors spread out in its set (glasses and controls), allowing the user to perform fluid and high-precision movements. However, for good functioning, the device needs to be calibrated for each new user, especially if there is a difference in height. It is classified as PC VR (tethered VR) as it is dependent on a rugged computer for its operation [61, 62]. It is still possible to expand the number of sensors, by inserting HTC Trackers in the set [58].

The model used in both studies (A17—**Figure 7**/A22—**Figure 8**) was the first version from 2016, which arose from a partnership between North American Valve and Taiwanese HTC. Currently, the manufacturer already has other models on the market, such as Vive Flow, Vive Pro, Vive Focus, and Vive Cosmos [55].

Following the details of the models found in the selection of studies, we have two variants of Facebook property: the Oculus Rift, which was used in study A23—India [42];

Figure 7.
HTC vive kit and trackers used on study A17 [32].

Figure 8.
Study A22 [25] uses the HTC vive kit with their software. Figure (A) is related to the measurement of the individual's carotid pulse. The figure (B) is related to cardiac compressions. Both on VR and on real life.

and the Oculus Go, in study A34—Australia [27]. The Rift model was the manufacturer's debut product, having been launched in 2016. It is a tethered VR type, comes with a sensor called Constellation, which needs to be placed in front of the user to enable tracking of the position, both sitting and sitting foot. Optionally, it can be used together with two peripherals for inserting hands in the environment, called Oculus Touch. It also has native Xbox console controller support for Windows only [63]. In study A23, only the HMD was used, with no complementary accessories.

In contrast, the other model, the Oculus Go used in study A34, is classified as an all-in-one (standalone VR) type. It does not need a powerful computer to work, as it is self-sufficient: it contains all the hardware components required to work, without the need for additional accessories, such as the aforementioned trackers [62]. But it has hand controls (Oculus Go hand controllers) for handling menus and other interactions.

The Unreal Game Engine [64] was chosen for the development of the application in the A34 study, as it allows the use of textures, has editing capacity, great customization power, in addition to providing a final product with high visual and realistic quality [27]. According to Hillman (2019), the development environment in this software has support for the most important VR platforms, with a unified set of tools that uses consistent procedures for the interaction between components [65].

Finally, among the HMDs devices, we have the Microsoft HoloLens, having been used in three of the selected studies: A19 [23] and A21 [33], both of American origin (USA); and in the European A26—Italy [34]. This device was introduced to the market in March 2016. But it acts a little differently from its competitors, making use of augmented reality (AR), by projecting for the user through the glasses on the device, information, and 3D digital graphics, overlaid on the image viewed in the real world [57].

And here comes the concept of mixed reality (MxR). He appears to be somewhat confused at first, but Bekele (2021) presents a study that details the nuances between these definitions [66]. The HoloLens is also considered a wearable device, as it allows the user to use it as a complementary accessory: as smart glasses, being called Augmented Reality Smart Glasses (ARSGs) [67].

Studies A19 and A21 only mention the use of the device, without providing further details about its application. By contrast, study A26 details his experiment, serious game modeling, and application in detail. It is also the only one who mentions the tool used for development, which was Unity3D. A common detail for the three studies was the use of a mannequin to assist in immersing the simulation for the user.

Following the analysis of peripherals used in the selected studies, Microsoft's motion sensor, Kinect [68], remains tied with Arduino, with two incidences each. Probably because of the difficulty of access and the cost involved. To use Kinect, you must have an Xbox 360 console [69] or an XOne. It is also possible to perform implementations on the PC, but it has the extra cost of acquiring the device [43, 49].

Arduino [59] is hardware with the characteristic of open source and low cost to implement. Provides great freedom for the developer. In the studies mentioned, it was used together with VR, mobile, and PC devices [24, 25].

The Nintendo Wii Balance Board [70] was used in one studies of Japanese origin. The implementation was in conjunction with MS Kinect and the PC [43]. And finally, the option without platform registration/citation, with six incidences.

Figure 9 clearly shows the number of studies that have the participation of volunteers in order to validate the experiment: 74% yes and 25% no. This was one of the criteria for selection of studies and identification of qualities, item (a) of Section 3.4 this work. Therefore, the importance of this criterion for validating the software developed for any study is noted.

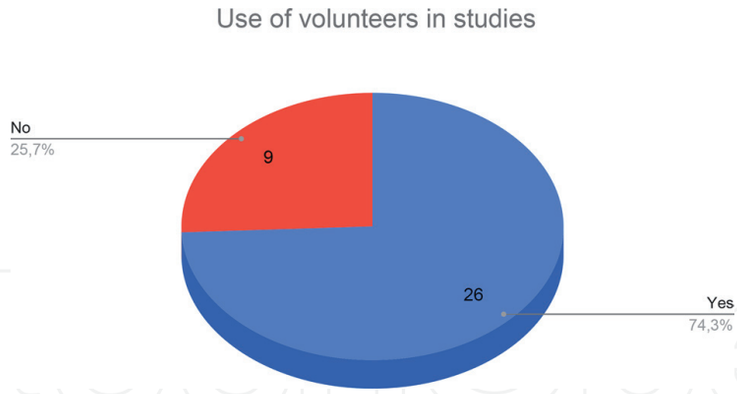

Figure 9.
Presence of volunteers in the study.

4.1 Quality assessment result

As listed in Section 3.4 (criteria for selection of studies and identification of qualities) of this chapter, three quality criteria were defined. The first refers to letter (a) if the study uses volunteers to test the efficiency of teaching the software. **Figure 6** shown in the previous item brings this answer and 26 articles make use of this guideline. The second refers to letter (b) if the study is specifically about basic life support with a focus on CPR. Yes, the 35 selected studies deal specifically with this theme, and only five of them are indirect, presenting different approaches, but still, the CPR theme is present. The third refers to letter (c) if there are details on how the software was built, with information such as platform, the tool used, as well as additional hardware. Yes, these data were included, and it is possible to check the information generated in the figures and graphs in this article.

Another interesting information raised was that eight studies [22, 24, 25, 32, 34, 44, 45, 50] explained in their texts the use of the Unity3D game engine [60], a well-known tool as a game engine and quite popular among game developers.

There were also mentions of other technologies such as MS Visual Studio [43, 71] for programming in the C# language, the use of the Japanese RPG Maker VX game engine [37, 72], and the robust Unreal Game Engine [64], software owned by Epic Games.

4.2 Critical comparisons

Some articles presented simulators as a serious gaming resource. Define the difference between simulators and serious games, what is a simulator and what is a game. If it's a simulator, is it considered a game too?

Other articles addressed the competition of learning using online videos and serious games, where the effectiveness was greater when using videos, but volunteers reinforced that learning with games was more interesting. But games are software that uses multimedia resources (audio, video, and images), there is even a genre that applies this resource in the game: the visual novels. The popularization of games focused on RCP, which is of this genre, would not be more interesting for the target audience? [73].

Twenty-nine (29) works mentioned the platform used. A tie-in incidences between the PC and mobile devices was registered. What will be the ideal platform to implement serious health games? Each platform has its own advantages and

disadvantages, including in-game features and mechanics. Or would the focus be on reaching all of them? But the more cross-platform the game is, the higher production costs will be involved, which can make the creation of the software unfeasible.

It is worth mentioning that Pavkov et al. (2017) present a comparison between five game engines, aimed at the development of serious games. With the advantages and disadvantages of each, the study proposes a criterion in order to facilitate the choice of the tool by the future developer [74]. In contrast, Cowan and Kapralos (2017) argue that it is common for educators to need to hire well-skilled developers to assist in programming serious game projects [75]. The authors even recommend other game engines not identified here in this study, for those who aspire to develop games but lack programming knowledge.

Another interesting observation is that nine studies were registered that present games aimed at VR devices. It shows an interesting trend, but for developing countries with scarce financial resources for research (aka Brazil), unfortunately, this is a difficult trend to follow here. In addition to limiting the target audience too much, VR devices have a high market value compared to other platforms such as PC or smartphones, which makes production even more impossible.

On the other hand, studies that mentioned the use of Microsoft Kinect and Nintendo Balance Board devices (A24 and A25) may become meaningless, as both peripherals left the manufacturing line, no longer being marketed [76].

4.3 Existing gaps

Conducting this systematic mapping raised some interesting points to be mentioned. One was to note that there is no academically validated research regarding existing commercial implementations of serious CPR-focused games. A quick search of game app stores such as Steam for PC and Google Play for Android mobile devices reveals a plethora of health-oriented games (Heath Games). Some even had great commercial success, with millions of units sold.

It is remarkable the fact that a commercial game has a greater appeal for playfulness/entertainment, dispensing with realistic educational rigor, with concepts to be worked on and solidified. But it is an undeniable fact that they are much more popular among the general consumer public, compared to serious games, mostly with academic backgrounds.

Another interesting perception for future works would be a literary, integrative, or systematic review focused on some of the platforms identified in the research, such as only mobile devices, only consoles, VR devices, or PC.

It was also possible to notice the need for curation of games available in digital stores. In order to get a guide or perhaps a list of health game recommendations. Not just with a commercial view, but with academic validation.

Finally, it was noted the need for more systematic reviews and mappings within the area, not only focused on CPR, but on other aspects that Health Games may have examples.

5. Conclusion

The selected works were of great value for the understanding of this study, of how a systematic mapping is developed, with all its detailed and careful process that must be carried out.

Next, the answers for each research question mentioned in item 3.1 follow:

- Q1: How have serious games been used to teach CPR protocols? In carrying out this work, it was possible to verify that serious games have been used with different approaches, such as through PCs, mobile devices, and HDMs. Auxiliary peripherals (MS Kinect, Nintendo Balance Board, and Arduino) were also used to obtain better results for the user in immersing the simulations.

- Q2: How effective are serious games in teaching CPR? In the 26 studies (74.3%) that used volunteers to validate the results, it was possible to notice that the use of games for learning generates engagement, providing a deepening in thinking (deep thinking), as can be seen in the reports of the consulted students to validate the A35 job, for example. Because games have the characteristic of playfulness, being "playing" to carry out the activity, in a virtual environment controlled by rules, the involvement in the activity to achieve the best result, undoubtedly generates an increase in interest among users. And the studies that used VR as the main device have the potential to be even more immersive, due to the characteristics of the device.

- Q3: What is the state of the art of serious health-focused games for teaching CPR? It is believed that this work made a portion of contribution to the academic community in trying to potentially answer this question.

- Q4: What platforms are used to experience the games? This detail can be seen in its entirety in item 4.

To improve this work, the evaluation criteria must be revised, listing weights for each one, in order to have numerical data to define the quality of the selected articles. Review some criteria and perhaps define further details between them. Also expand the number of databases searched, for those who know how to find more jobs in the South American region.

It was also possible to notice that the area of the Serious Games focused on health is relatively new when observing the age of the relevant events in the area: SBGames will complete 20 editions by the end of this year, but only 5 years ago it has a track dedicated to the theme; SEGAH is reaching its 9th edition. This fact opens up great possibilities for studies and research that have not yet been carried out, as the field is relatively new.

It was also possible to note that there is still a lot of room for research using new technologies, such as VR glasses, Microsoft Kinect, which have only one study each.

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