A Systematic Mapping of Serious Games for Oral Health

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Abstract: Oral health in the daily lives of individuals allows health promotion and prevention. Oral health literacy is fundamental to enable people to have the knowledge and be aware of its importance, enabling them to process, evaluate and apply information on this topic. Serious games, in the educational domain, can be used to assist in this literacy. This article carries out systematic mapping of these games in the field of oral health. The mapping included work carried out in the last 5 years and indexed in four repositories. As result it was found that there are few serious games for oral health, and few have a well-defined process for learning.

1 INTRODUCTION

Oral health, despite being an important part of physical health, still receives little attention. Kisely (2016) conducted a study and found that serious mental illnesses, affective and eating disorders can be associated with dental problems such as tooth decay and periodontal diseases. These diseases can lead to tooth loss and the problem can be aggravated due to the use of medication.

A bad dentition can lead to problems with chewing which can impair nutritional intake (Kane, 2017). One way to help solve this problem is to provide individuals with Oral Health Literacy (OHL) (Baskaradoss, 2018). Literacy allows understanding and acting on health issues (Sorensen et al., 2012), allowing for a better quality of life (Martins et al., 2015). Ratzan and Parker (2000) report that health literacy promotes the "ability to obtain, process, and understand basic health information and services necessary to make appropriate health decisions". However, how to provide oral health education in a more interactive way in order to provide individuals with their literacy?

Educational or serious games are interactive tools that assist in the development of skills and learning. Their main objective is to consolidate knowledge instead of simply encouraging entertainment. This type of games encompasses three main characteristics: they provide a learning environment or tool, usually based on an interactive media simulation, and are based on game mechanics and elements. The game elements are related to the operating dynamics and mechanics of how the player interacts and progresses through a game. Their components are environments, scenarios, characters or representation of the player (Gunter, Kenny, & Vick, 2008).

Serious games have a dynamic to transmit concepts and situations aligned with work, education, health, safety, sports, among others, which allow simulating recreational experiences closer to reality. However, they are aimed at a particular audience in which specific knowledge concerning the area they are applied (Mello & Zendron, 2015). Bigdeli and Kaufman (2017) proved that the closer a game is to the educational environment or the student's own reality, the more productive learning will be.

Serious games seek to keep at a maximum the ability of a player to solve certain problems, even if it

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is allowed to choose the levels of difficulties or until the player becomes an expert on the challenges of the game. These games are designed to enhance individual skills and improve some aspects of learning (Hägglund, 2012).

The work described in this paper performs a systematic mapping to obtain an overview of the studies already conducted on the theme of serious games in the context of oral health literacy. The mapping was carried out in the time frame from 2015 to 2021 and used the method of Kitchenham and Charters (2007). Four search repositories were considered: ACM, Scopus, IEEE Xplore and SciELO.

2 SERIOUS GAMES

The use of serious games promotes interactive and explicit learning, as knowledge is developed through experiences obtained during interactions and can be transferred to other activities in the real world. These games adopt several strategies to promote cognitive skills in which students learn by performing activities and engaging with appropriate content and contexts (Mello & Zendron, 2015).

Games can be framed as a didactic tool of educational support, in which different contents can be approached in an interactive and efficient way, potentiating the development of knowledge on a certain subject (Ferreira et al., 2018).

Serious games seek to keep players in an interactive learning circle to motivate them in creating and proposing different solutions to solve problems or challenges; otherwise, there will be abandonment in solving the challenges (Eck, 2015).

The classification of serious games is based on the criteria of gameplay, purpose, market, and target audience. However, many games can be categorized on the gameplay criteria due to their complexity, rules, challenges and objectives (Alvarez, Djaouti & Rampnoux, 2020).

In the study by Garmen, Pérez, Redondo, and Veledo (2019) two tools that apply serious games were evaluated: Cuibrain (Studios and Cuicui, 2020a) and Boogies Academy (Studios and Cuicui, 2020b). The first application uses mathematics and literacy to assist in the development of multiple intelligences, such as memorization, concentration, coordination and attention. Boogies Academy, on the other hand, offers several serious games with activities of logic, biology and music, with the objective of improving cognitive skills and also checking the emotional state of the player during interactions.

Garmen et al. (2019) found that from a sample of 372 students from the first to the third grade of elementary education, the use of serious games helped to reduce the level of anxiety during the interactions with the tool. The authors concluded that by using the tool, it is possible to stimulate multiple intelligences even of students who have learning difficulties.

Thus, the application of serious games can improve cognitive skills bringing students closer to real-world activities and experiences.

3 ORAL HEALTH

An individual's well-being is associated to daily activities such as eating, talking, smiling, among others. Oral health is an integral part of this well-being (Baiju, Peter, Varghese, & Sivaram, 2017). For this reason, oral problems can negatively impact the performance of activities and people's quality of life. Oral diseases and their complications can cause deprivation and psychological constraints on the individual (Ju et al., 2017).

Baskaradoss (2018) conducted a study and found that people who have a low level of OHL had worse periodontal health. The author states that improving individuals' OHL can help with their self-management skills and also with overall treatment outcomes.

Sipiyaruk, Gallagher, Hatzipanagos and Reynolds (2018) comment that there is an increase in serious games applied in health education, but the evidence of its impact still isn't very clear. For this reason, they carried out a quick review study on serious games concerning health and dental education, covering the period from 2005 to 2016 and contemplating 10 repositories. Its purpose was to find evidence by means of systematic reviews and meta-analyzes of the impacts of serious games on health education and to explore the impacts of serious games on dental education. The result of the review found that serious games are effective as a learning tool for improving knowledge and skills and are an option for education in health and dentistry. These games can be a complementary strategy to involve students and improve their motivation.

Morais, Vergara, Brito and Sampaio (2020) conducted a study on integrative review to find works on serious games aimed at education in children's oral hygiene, in addition to looking for apps on the Android® platform available for this domain. The author's review used 8 repositories and Google Scholar over the past 7 years. For the identification of

the applications, IEEE Xplore was used. As a result, it was found that there are few apps for oral hygiene education and most of them are aimed at children. The authors claim that exploiting technological resources (smartphones, tablets, notebooks, E-readers) in this area can help in public health policies.

Mehrotra (2020) carried out a systematic review in order to identify studies that address the inclusion of entertainment in the dental curriculum through animations and games. The review allowed to expose the projects of educational tools designed, presenting their advantages and limitations. It also analyzed the students' perception regarding the adoption of unconventional techniques for teaching and learning in the area. As a result, it was found that entertainment tools such as games, animations, and mimicking provide more fun learning.

As can be seen, the literature review studies in the field of dentistry that covers serious games are related to the identification of evidence of the use of games in the area (Sipiyaruk et al., 2018), a specific audience in the case of oral hygiene for children (Morais et al., 2020) or to verify the inclusion of entertainment in the dentistry curriculum (Mehrotra, 2020). Thus, the review proposed in this article aims to answer the following question: "What is the landscape of serious games on Oral Health?", in order to identify to which audiences they target, which subjects are addressed, what is the learning assessment process, among others that are detailed in the next section.

4 METHODOLOGY

The method used to carry out the systematic mapping was that of Kitchenham and Charters (2007). Studies related to the focus of this research, in the period from 2015 to 2021, which approach learning games on oral health, were identified. This period was defined to relate the most recent studies in the area in question. Figure 1 illustrates the process adopted.

4.1 Repositories and Search Criteria

The extraction of primary studies was performed in 4 (four) digital libraries (ACM, Scopus, IEEE Xplore and SciELO). All searches in these repositories were done covering the period between 2015 and 2021.

Several search terms had already been thought and discussed among the researchers, which facilitated the process of composing the search strings and keywords. The keywords were: Game; Education; Learning; Teaching; Oral; Dental.

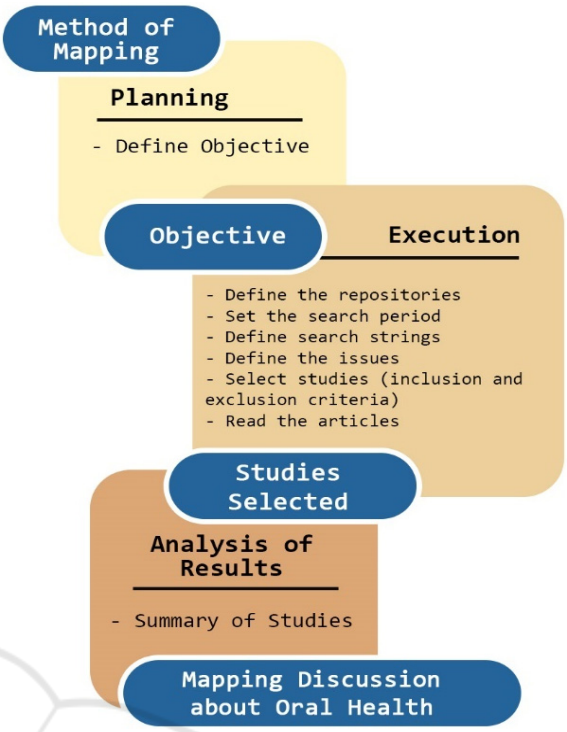

Figure 1: Methodology overview.

The search string used was: TITLE-ABS-KEY (game AND (education OR learning OR teaching) AND (oral OR dental)).

4.2 Selection of Studies

The researchers who carried out the mapping were the evaluators of the collected primary works. The inclusion and exclusion criteria were then defined. The inclusion criteria are:

- Articles written in English
- Open access articles
- Articles with relevance to the addressed topic
- Articles published from 2015

The exclusion criteria are listed below:

- Duplicate articles
- Conference papers
- Articles with title and abstract out of the scope

Selected articles must answer the following research questions:

Q1. What subjects are covered in the games? Which audience are they for?
Q2. How does the game work?
Q3. What technologies were used to build the game?
Q4. How does learning assessment occur?

Table 1 presents the preliminary results per research database for the chosen string.

Table 1: Number of works per repository.

Repositories	
ACM	2
Scopus	76
IEEE Xplore	10
SciELO	0
Total	88

From the search results, a selection procedure was performed using the inclusion and exclusion criteria for choosing the articles. Altogether, at the end of the selection procedure, approximately 89.77% of the included studies were eliminated by the exclusion criteria. Figure 2 shows the result of the process of executing the exclusion criteria.

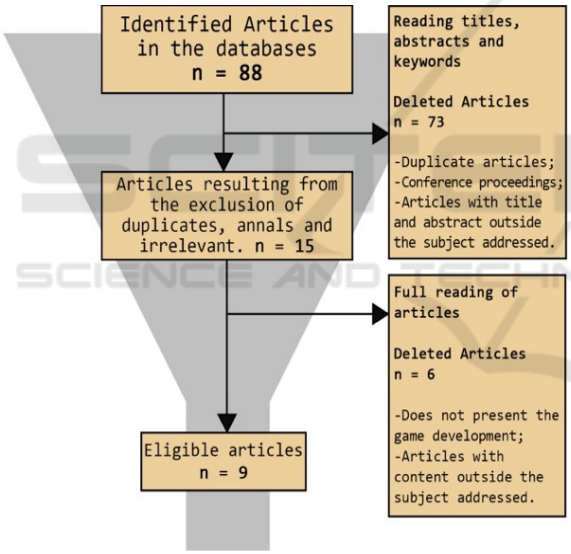

Figure 2: Results of the sorting process.

5 RESULTS

From the criteria established for the search, and from all sorting stages, the research resulted in 9 (nine) articles. After a new analysis, three were excluded because they were review articles (Sipiyaruk et al. (2018); Morais et al. (2020); Mehrotra (2020)) in the area. They were discussed in Section 3 of this paper.

Table 2 presents the selected studies and each was identified with a unique number (ID).

Table 2: Selected articles.

ID	Title	Author (Year)
1	A 3D Serious Game for Dental Learning in Higher Education	Rodrígez-Andrés, Juan, Mollá, and Méndez-López (2017)
2	ToothPIC: An Interactive Application for Teaching Oral Anatomy	Javaid, Ashrafi, Žefran and Steinberg (2016)
3	Development of web-based dental health ladder snake game for public elementary school students in Indonesia	Rikawarastuti, Ngatemi and Yusro (2018)
4	Development and Evaluation of a Mobile Oral Health Application for Preschoolers	Campos et al. (2019)
5	Using Augmented Reality to Motivate Oral Hygiene Practice in Children: Protocol for the Development of a Serious Game	Amantini et al. (2020)
6	Gamification as a learning strategy in a simulation of dental anesthesia	Ribeiro, Corrêa and Nunes (2017)

Below are the answers to each question.

5.1 Q1: What Subjects Are Covered in the Games? Which Audience Are They for?

Considering the selected studies, 2 serious games are intended for students of higher education in dentistry (Rodrigez-Andres et al. (2017); Javaid et al. (2016)), 2 for children (Campos et al. (2019); Amantini et al. (2020)), 1 for dental professionals (Ribeiro et al. (2017)) and 1 for elementary education (Rikawarastuti et al. (2018)). The subjects covered in the games are tooth morphology, tooth decay, among others. Figure 3 shows the results for Q1.

Oral health issues such as: promotion, prevention and control of oral diseases; guidance from groups and people, among others, still need to be explored in serious games in order to allow the individual to obtain their oral health literacy. An individual who is literate in oral health will have the ability to understand the information and make the right decisions. In turn, an individual with low literacy can favor the occurrence of chronic diseases such as periodontal diseases (Wehmeyer, Corwin, Guthmiller, & Lee, 2011).

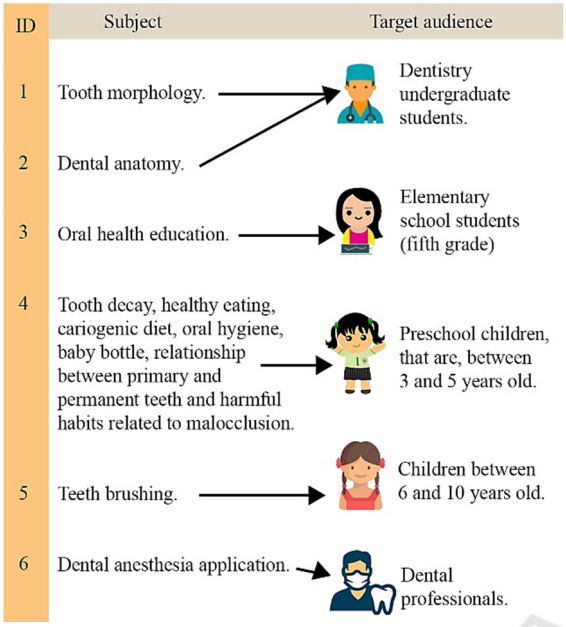

Figure 3: Answers to Q1.

5.2 Q2: How Does the Game Work?

Javaid et al. (2016) created a game where students can remove a tooth (upper or lower) from a group of randomized teeth, in a 3D virtual scene, and position it in its location and correct orientation in the empty arch, in addition to naming and numbering the selected tooth. Once the student places the tooth in what they think is the correct place, they can verify the answer and proceed to the remaining teeth.

Rodrigez-Andres et al. (2017) developed a game in which the individual can observe each tooth in order to know its morphology. In the first phase, through gestures, the student is able to approach and rotate the teeth to analyze it. In the second phase, a jaw is presented with holes for the student to fit the correct teeth in their respective positions.

Ribeiro et al. (2017) created a game that uses Virtual Reality (VR) techniques to simulate and get closer to the reality of performing anesthetic procedures through the reproduction of virtual tasks necessary for learning. Gamification techniques were applied to make the game more attractive, such as scoring, difficulty levels, sounds, achievements, and ranking. The game scenario takes place in a dental office and a patient model in which it is necessary to use a syringe, positioning it in the correct place to perform the anesthetic procedure. The location of the syringe insertion is represented by an object in the shape of a sphere where the player can measure the contact of the needle in the patient's gums for proper application. When performing the procedure, the player must use the mouse buttons to position the syringe needle at an appropriate angle as well as its depth, in addition to the keyboard to move the syringe position in a Cartesian coordinate system. The angle and depth have tolerance values, which are calculated to indicate the player's successes and errors.

Rikawarastuti et al. (2018) created a game based on Snakes and Ladders, whose goal is to be the first player to reach the end, moving across the board, according to the number that appears on the dice. Each "square" on the board has an image referring to oral health. In addition, there are stairs and snakes superimposed on the squares. When a user falls into a square that contains the base of the stairs, they are automatically taken to the square at the opposite end, in the same way, when the user falls into a square where they have the head of the snake, they "slip" and are taken to the square where the snake's tail begins. In both cases, a pop-up is presented with: i) an image of the initial position; ii) an image of the player's final position after the event, iii) a text relating the two images.

Campos et al. (2019) created a game for mobile devices, available for Android and IOS, however, the author did not describe the operation of the game, emphasizing only the performance of users.

Amantini et al. (2020) created a game to teach the brushing technique, which is available in the game for children to perform the movement in a virtual environment in order to stimulate oral hygiene and proper brushing. The game is available on interactive and immersive virtual panels and uses Kinect to capture the movements of players and assess whether the brushing was performed correctly.

Figure 4 illustrates the main objects used for the operation of the games that were analyzed in this article.

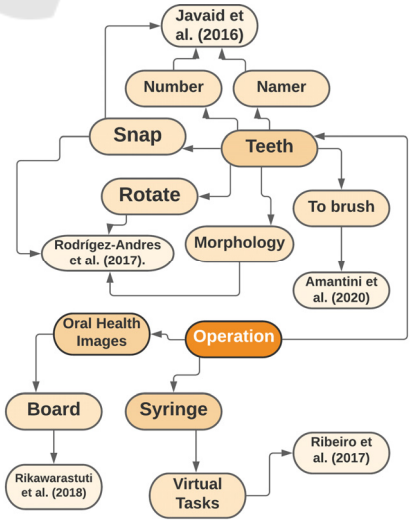

Figure 4: Main Object of Operation in the Game.

It is noted that the main object/concept for 3 of the studies was the tooth (Javaid et al. (2016); Rodrigez-Andres et al. (2017); Amantini et al. (2020)), used so that the student can learn to fit it in the correct place, to number it, to identify its name, to practice brushing and to understand its morphology. One of the studies teaches the correct application of anesthesia using a syringe (Ribeiro et al. (2017)) and the other study uses images on a board to teach oral health (Rikawarastuti et al. (2018)).

5.3 Q3: What Technologies Were Used to Build the Game?

Considering the studies, 3 (Rodrígez-Andres et al. (2017); Amantini et al. (2020); Ribeiro et al. (2017)) used the Microsoft Kinect device for motion detection, along with the game development platform Unity 3D and the C# programming language. In addition, Ribeiro et al. (2017) used an autostereoscopic display to improve the 3D perception and the concepts of Natural User Interfaces (INU), which allowed a greater level of immersion in the game, controlled only by gestures.

Only 1 of the games was developed for the web (Rikawarastuti et al. (2018)). The advantage in this case is the possibility of games being multiplayer. In 1 of the studies the authors (Campos et al. (2019)) developed an app for mobile devices, however, it was not clear what technologies were used, only that it was developed for Android and iOS. Finally, 1 article (Javaid et al. (2016)) used Python programming language with the Numpy library and the H3DAPI development platform to deal with 3D graphics. Table 3 shows the results for Q3.

Table 3: Answers to Q3.

ID	Technologies
1	Natural user interfaces (NUI); Autostereoscopic display; Microsoft Kinect; Unity 3D platform / C# language.
2	Python programming language; NumPy library; H3DAPI platform.
3	Apache2 server; PHP programming language; JavaScript programming language; MySQL database; CodeIgniter 3 framework.
4	Did not explain the technologies used.
5	Microsoft Kinect; Unity 3D platform/ C# language.
6	Blender 3D; Microsoft Kinect; Unity 3D platform/ C# language.

It is noted that most games were developed in three-dimensional environments with the Unity 3D platform and the Microsoft Kinect device; this is due to the inccreasing popularization and accessibility to such technologies and devices. It was also found that the games have mainly, simulation environments.

5.4 Q4: How Does Learning Assessment Occur?

For this question, it was identified the way the game was evaluated by the user. Only one of the studies (Rodrigez-Andres et al. (2017)), refer a comparison between learning before and after its execution, through the application of questionnaires that measured the difference in learning. In addition, an opinion and progression questionnaire was used during the game.

The evaluation method of the other games was based on performances obtained during the execution of the games (real-time feedback, scoring, and progression). For these, users' opinion questionnaires were applied concerning the game, except in one of the studies (Rikawarastuti et al. (2018)) that did not collect any feedback. Table 4 shows the results for Q4.

Table 4: Answers to Q4.

ID	Assessment Process
1	Game progression; Before and after questionnaire and comparison; Users' feedback.
2	Game progression; Users' feedback.
3	Game progression.
4	Game progression; Users' feedback.
5	Game progression; Users' feedback.
6	Game progression; Users' feedback.

It is noted that, from the analysis of the studies, it is necessary the development of research that evaluate the effective contribution of the users' learning from the games.

6 DISCUSSION

This study found that in the literature there is the need for the creation of interactive and reliable tools to assist and evaluate functional and conceptual literacy in oral health, corroborating the finding made in the work of Martins et al. (2015).

Serious games are an alternative that can be adopted for education in oral health, which promotes the literacy of the individual. Serious games, according to Mello and Zendron (2015), promote cognitive skills in which individuals learn in an interactive and attractive way. In this way, serious games in oral health can be used as an instrument to

assist in the prevention and control of oral diseases reaching various audiences, among them those who have serious mental issues.

Assessment is an important element in any knowledge development process. Therefore, pedagogical criteria are necessary in order to obtain a good learning response. Araújo et al. (2013) explains that Bloom's Taxonomy is an instrument that supports the identification of a hierarchical structure with well-defined objectives, supported by cognitive domain categories, which help in the elaboration of questions for the assessment and perception of the acquired skills and knowledge. Thus, it was found that the selected studies need a knowledge-building process that implements assessment methods.

Another aspect that was observed is the lack of techniques to keep the user motivated and engaged during the game. Reis, Oliveira, and Pio (2017) explain that the level of interest of the student in learning can affect their academic life, and propose the use of a motivation model called ARCS (Attention, Relevance, Confidence and Satisfaction) for the automatic adjustment of the level of difficulty of a game using an Artificial Neural Network (ANN) algorithm. In this way, it is possible to keep players more engaged and consequently the level of success of the game is achieved.

7 CONCLUSION

This article presented a systematic mapping to identify serious games for learning about oral health. These games can promote oral health education and consequently assist in the individual's literacy in oral health.

During the analysis of the selected studies, it was found that the target audience are undergraduate students in Dentistry, professionals in the field, and children. The subjects covered are directed to oral hygiene, morphology and anesthesia.

Some technologies used for game development are Unity 3D and Microsoft Kinect. Machado (2014) justifies the use of Kinect because it is a low-cost device and very efficient in recognizing movements, in addition, the equipment developer (Microsoft) provides a development kit to be used in third-party software. Carvalho (2012), on the other hand, explains that the great advantage of using Unity is the fact that it is multiplatform, with games developed for desktops, mobile, and web changing simple configurations. In relation to learning assessment, it was observed that there is a way to measure through questionnaires; however, the use of learning assessment methods needs to be explored.

Another finding is that the games do not include Artificial Intelligence techniques, which could make them offer an individualized learning environment and greater motivation.

The serious games presented in the oral health domain have simulation characteristics. The use of entertainment elements can make them more attractive, allowing greater interaction and motivation by the user during their learning.

As future work, it is suggested to explore methods of learning assessment and domains of oral health in order to propose a game in oral health that allows the individual they literacy.

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