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CHAPTER 16

SERIOUS GAMES IN MEDICAL EDUCATION: STATE OF THE ART

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ABSTRACT

Serious games are games created with the purpose of achieving a specific goal beyond entertainment. To be considered a *serious game*, the game must feature specific challenges, scoring, and design. To carry out this study, we opted for an integrative review. The following databases were research sources: LILACS, IBECS, MEDLINE, Cochran Library, SciELO, PUBMED, and articles in Portuguese and English, published between January 2016 and March 2020. The use of *serious games* in education increases student satisfaction and knowledge gain when compared to methodologies improving the development of practical skills in a safe environment, with progressive degrees of difficulty, leading to interactivity and competition. In this sense, the use of gamification techniques keeps students motivated and engaged in the learning process. Despite the advantages propagated about the use of *serious games* for medical education, their development is complex and there are many obstacles to be overcome. Despite the wide range of objectives of *serious games* for medical education, the quality of these games is still heterogeneous, and it is necessary to create algorithms for their development, validation and distribution.

Keywords: Health education. Virtual learning environments. Medical simulation. Educational techniques.

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INTRODUCTION

Serious games are games created with the purpose of achieving a specific goal beyond entertainment. To be considered a serious game, the game must present specific challenges, scoring, and design (Wang et al., 2016). With the use of new technologies – various types of specific consoles for games, smartphones and tablets – they can take the player/medical professional to environments that challenge their knowledge and cognitive capacity. Initially used for the training of specific skills, these games were aimed at a specific audience.

The popularization of games among "non-adept" people and the development of the aforementioned technologies has led to the emergence of a diversified market for serious games. Currently, games with varying degrees of complexity and realistic simulation are observed, in which the player/student plays the most different roles, ranging from the simplest arcade-type games to games in which the player plays a first-person role in order to achieve a specific learning objective.

It is believed that the use of serious games in education increases student satisfaction and knowledge gain when compared to traditional teaching methodologies (Davids; Chikte; Halperin, 2011; Gleason, 2015). They can be used for the development of practical skills in a safe environment, with progressive degrees of difficulty, leading to interactivity and competition. The use of gamification techniques, therefore, keeps students motivated and engaged in the learning process. In addition, the possibility of playing according to one's own availability, the possibility of repeating the processes and real-time feedback, fundamental principles in adult education theories, are present in such games.

Despite the enthusiasm for the use of serious games in medical education, recent research points to the need to better evaluate its pedagogical bases in the aspects of creation and development, in order to ensure pedagogical effectiveness.

The structuring objective of this integrative review was to evaluate scientific articles published between January 2016 and March 2020, in Portuguese and English, on the use and development of serious games in medical education. The search for articles was carried out in October and November 2020 in the Virtual Health Library (VHL).

THEORETICAL FRAMEWORK

To carry out this study, an integrative review was chosen, and its stages were developed according to the theoretical framework of Souza, Silva and Carvalho (2010), based on five phases. The Population (or Problem), Concept, and Context (PCC) method was used to identify the main data for analysis (Peters et al., 2020): the problem was the

need to create new pedagogical tools that lead to the acquisition of knowledge necessary for good medical practices; The concept was the need to train undergraduate and graduate students in safe environments; Finally, the context was medical education associated with a pedagogical practice, standardizing training and stimulating the acquisition of specific knowledge. Thus, the following guiding question was elaborated: what are the studies of the last four years about the use and development of serious games for medical education?

METHODOLOGY

Through this question, we sought to understand how publications related to the use of these games in medical education develop the theme, listing categories and sub-themes worked on and detailing the scope given to the theme by the literature, in order to understand its use as a pedagogical tool. This review was registered on the Open Science Framework (OFS) platform, and its public record can be consulted at this link.

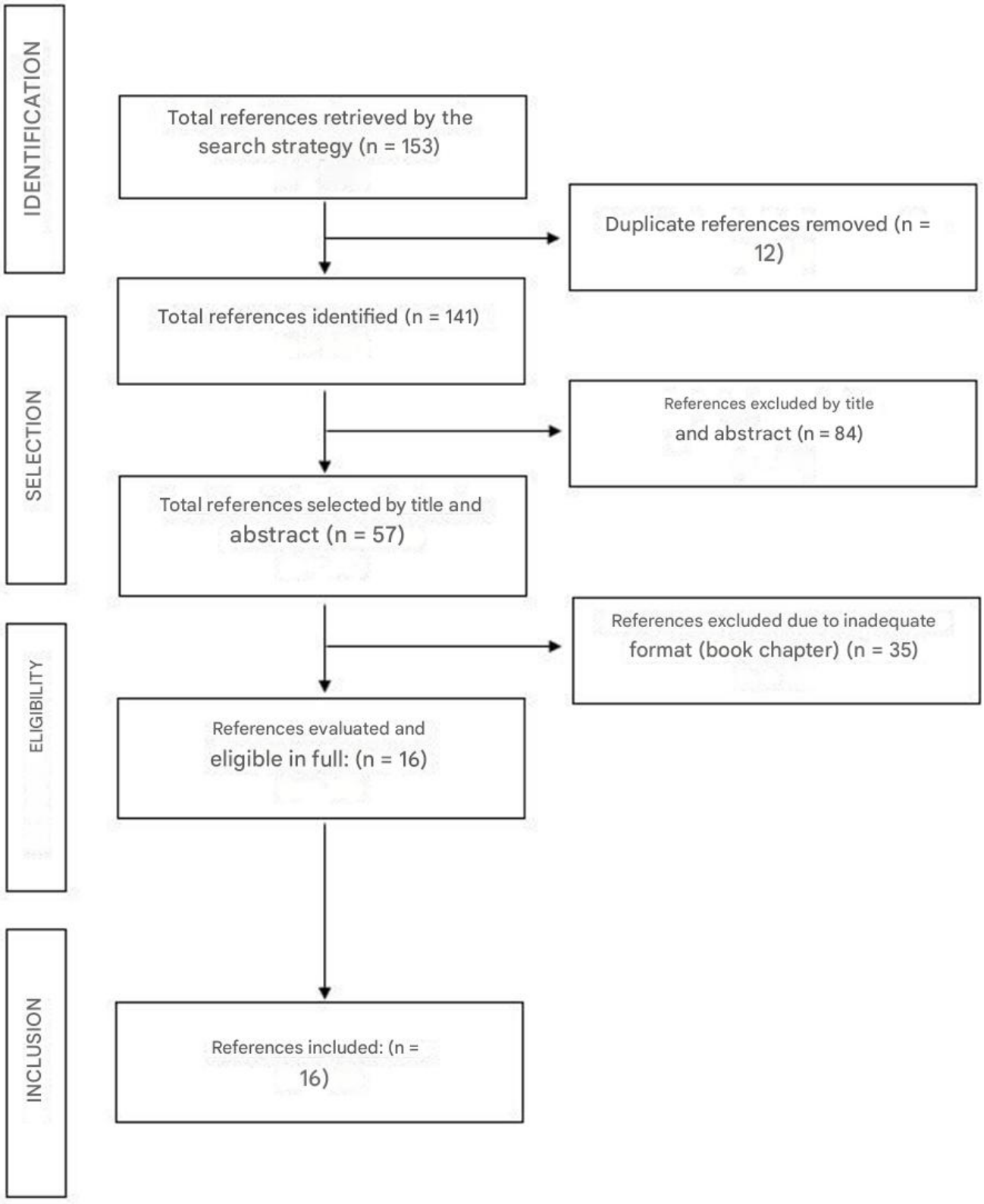
The inclusion criteria for this study were as follows: full articles related to the topic, available in Portuguese and English and published between January 2016 and March 2020. The exclusion criteria, in turn, are: theses and dissertations; articles in languages other than Portuguese and English; articles published before 2016 and after March 2020; redundancies and content not related to the theme.

The search for articles was carried out between October and November 2020 in the Virtual Health Library (VHL), a specialized center of the Pan American Health Organization (PAHO). Established in Brazil since 1967, the library brings together the following databases: Latin American and Caribbean Literature on Health Sciences (LILACS), Spanish Bibliographic Index of Health Sciences (IBECS), International Literature on Health Sciences (MEDLINE), Cochrane Library and Scientific Electronic Library Online (SciELO). Another database consulted is PUBMED, from the National Library of Medicine (National Center for Biotechnology Information) of the United States, which includes more than 30 million citations of biomedical literature and MEDLINE publications, as well as non-indexed scientific journals and online books. To search for articles, the following broad descriptors were used: "serious games", "medical education", "serious games" and "medical education".

A total of 153 references were found; Among these, 12 were removed for duplicity, leaving 141 references identified. Then, 84 were excluded from the title and abstract, with 57 documents duly meeting the inclusion criteria for this review. In the next stage, 35 were excluded due to the inadequacy of the format. Finally, 16 articles were fully evaluated by the research team, with the survey of categories in order to seek the points of convergence

between the various authors, as shown in Figure 1 (Flowchart of research design) and Chart 1 (Articles selected for the 2nd phase: detailed reading).

Figure 1. Survey Drawing Flowchart



Source: prepared by the authors.

Table 1. Articles selected for the 2nd phase: detailed reading.

N.	TÍTULO	AUTORES	ASSUNTO	PERIÓDICO
1	Making Learning Fun:Gaming in Radiology Education	Awan *et al.*	Uso de games na residência deradio, tipos de games usados, uso de IA. Desafio do uso de games.	*Radiology Research Alliance*
2	Game-Based Learning in Virtual Worlds: A Multiuser Online Game for Medical UndergraduateRadiology Education with Second Life	Lorenzo-Alvarez *et al.*	Desenvolvimento de game paraensino de anatomia radiológicae sinais radiológicos. Avaliação da eficácia.	*American Association for Anatomy*
3	Transfer of Clinical Reasoning Trained With aSerious Game to Comparable Clinical Problems	Middeke *et al.*	Uso de *serious game* para treinamento clínico com pacientes virtuais. Avaliação da eficácia.	*Society for Simulation in Healthcare*
4	A serious virtual realitygame to train spatial cognition for medical ultrasound	Byl, B.; Sunckxen, M.; Teistler, M.	Uso de *serious game* para ensino de resolução espacialpara ultrassom médico num contexto não médico.	*Institute of Elstric and Eletronics Engineers*
5	Efficacy of educational video game versus traditional educational apps at improving physi- cian decision making in trauma triage: randomized controlled trial	Mohan, D. *et al.*	Uso de *serious game* X APPpara ensino de condutas na triagem de trauma.	*BMJ*
6	Serious Games in SurgicalMedical Education: Virtual Emergency Department as a Tool for Teaching Clinical Reasoning to Medical Students	Chon, S-H. *et al.*	Eficácia de um *serious game* (EMERGE) para treinamento de estudantes em emergência eavaliação da satisfação.	*JMIR Serious Games*
7	Serious Games as an educational strategy for management and leadership development inpost-graduate medical education	Busari, J. O.; Yaldiz,H.; Verstegen, D.	Investiga opiniões de residentes sobre *serious games*para treinamento de habilidades gerencias e liderança.	*Advances in Medical Education and Practice*
8	Serious Games for health:three steps forwards	Drummond, D.; Hadchouel, A.; Tesnière, A.	Desenvolvimento, estratégias para aumento da eficácia, avaliação dos *serious games* naeducação médica.	*Advances in Simulation*
9	A low-fidelity Serious Game for medical-basedcultural competence education	Khan, Z.; Kapralos, B.	Desenvolvimento de um *serious game* para educaçãomédica priorizando a diferenças culturais dos pacientes.	*Health Informatics Journal*
10	Diagnostic Markers of User Experience, Play, andLearning for Digital Serious Games: A Conceptual Framework Study	Tan, J. W.; Zary, N.	Critérios para classificação deum jogo como *serious game*.	*JMIR Serious Games*
11	Evaluation of App-Based Serious Gaming as a Training Method in Tea- ching Chest Tube Insertion to Medical Students: Ran-domized Controlled Trial	Haubruck, P. *et al.*.	Avaliação da eficácia de um*serious game* no ensino de drenagem de tórax para estudantes de medicina.	*J Med Internet Res*
12	AntibioGame®: A SeriousGame for teaching medical students about antibioticuse	Tsopra, R. *et al.*	Desenvolvimento e avaliação da usabili- dade e jogabilidade de *serious game* no ensino deprescrição ATB.	*International Journal Medical Informatics*
13	InsuOnline, an ElectronicGame for Medical Education on Insulin Therapy: A Randomized Controlled Trial With Primary Care Physicians	Diehl, L. *et al.*	Avaliação da eficácia de um *serious game* para educação médica de não endocri- nologistas a respeito do uso de insulina.	*J Med Internet Res.*
14	Creating GridlockED: A Serious Game for Teaching multiple patients management	Tsoy, D. *et al.*	Desenvolvimento de um *serious game* para ensino demúltiplos pacientes simultaneamente.	*Academic Medicine*
15	Serious Game versus online course for pre training medical students before a simulation-based mastery learning course on cardio- pulmonaryresuscitation	Drummond, D. *et al.*	Comparação entre a eficácia douso de *serious game* e a aula online antes do curso presencial de manejo de PCR.	*Eur J Anaesthesiol.*
16	Development and Evaluation of a Serious Game for Teaching ICD-10 Diagnosis Coding to Medical Students	Agudelo-Londoño, S. *et al.*	Avaliação da eficácia pedagógica de um *serious game* (CODIFICO) no ensinodo CID-10 para estudantes de medicina.	*Games For Health Journal*

Source: prepared by the authors.

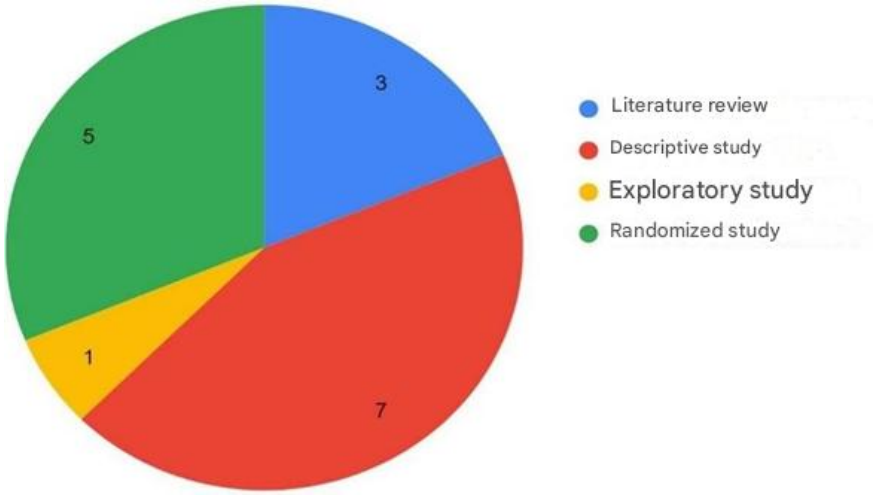
As shown in Chart 1, 16 articles advanced to the final phase, based on the analysis of the categories, considering the following division based on the period of publication: all

were published between January 2016 and March 2020; Of these, 5 articles are from 2017, 3 from 2018, 8 from 2019 and, finally, 1 from 2020.

Todos os artigos foram redigidos em inglês e publicados nas seguintes revistas internacionais indexadas: *Radiology Research Alliance*; *American Association for Anatomy*; *Society for Simulation in Healthcare*; *Institute of Eletric and Eletronics Engineers*; *BMJ*; *JMIR Serious Games*; *Advances in Medical Education and Practice*; *Institute of Medical Education Research Rotterdam*; *Advances in Simulation*; *PNAS Proceedings of the National Academy of Sciences of the United States of America*; *Health Informatics Journal*; *Games for Health Journal*; *Journal of Medical Internet Research*; *International Journal of Medical Informatics*; *Academic Medicine*; *European Journal of Anaesthesiology*.

Graph 1 shows the classification of the analyzed articles in relation to the methodologies used, categorized as follows: descriptive research, exploratory research, randomized study and literature review.

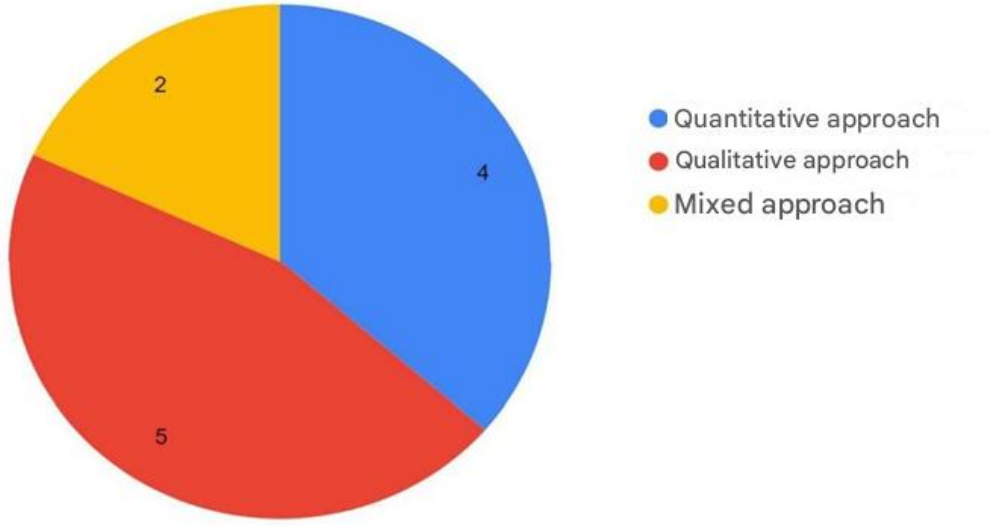
Graph 1. Classification of articles in relation to methodology.



Source: prepared by the authors.

The approach to the articles was divided into three categories, as shown in Graph 2: quantitative, qualitative, and mixed. Of the articles chosen, five used the qualitative approach to assess the effectiveness of *serious games* in the learning process; four used the quantitative approach, and these focused on the evaluation of the user's perception (physician/medical student); finally, two of them used the mixed approach, gauging both the effectiveness of *serious games* and the user's perception in relation to their use.

Graph 2. Classification of articles in relation to approach.



Source: prepared by the authors.

The articles selected in the third phase were read in full, and the evaluation forms were filled out in order to record the data and the main topics addressed in these articles, which are the topics listed below:

a) gamification and classification of a game as a serious game;
b) development of devices;
c) measurement of the effectiveness of the serious game as a tool for learning;
d) comparison of the effectiveness of the use of serious games in relation to other teaching methods.

Table 2. Description of the categories emerging from the analysis of the articles.

CATEGORY	CATEGORY DESCRIPTION
Gamification and classification of a game as *serious game*	Definition of the requirements necessary for the categorization of an analog or electronic device as a *serious game*
Device development	Description of the process and the programs and software used for the development of the games
Measurement of the effectiveness of the use of *serious games* as a learning tool	Use of pre and post-test to assess *serious games* as a learning tool
Comparison of the effectiveness of the use of serious *games* compared to other teaching methods	Evaluation of the effectiveness of the use of *serious games* as a teaching tool in comparison with other methods such as simulation

Source: prepared by the authors.

RESULTS AND DISCUSSIONS

CATEGORY I: GAMIFICATION AND CLASSIFICATION OF A GAME AS SERIOUS GAMES

The first category identified in the review addressed the basic principles and requirements necessary for the definition of an analog or digital device as a serious game. According to the articles addressed, there are some criteria that must be observed for the correct categorization in this sense, including: a specific learning objective (goal); the

presence of rules (determine the norms, restrictions and actions allowed to the player in the game process); feedback (the player receives a response to their actions, either through a scoring system or by allowing passage to the next stages); and the freedom to participate or not in the game (voluntary participation). Of the 16 selected articles, 5 address the gamification process.

Awan et al. (2019) (Article n. 1, Radiology Research Alliance),[5] cite the work, carried out at the MIND Research Institute[6], which described the five basic principles of gamification (Karou, 2018). In this article, the authors summarize and adapt the basic principles for creating a game focused on education: interactivity with informative feedback; specific objectives; feeling of improvement with the possibility of achieving the proposed objectives; sense of security (possibility of failing in a safe environment, free of punishment and engagement).

The study by Alvarez et al. (2019) (Article n. 2, journal of the American Association for Anatomy) conceptualizes gamification as the application of game design elements in a non-playful context (Brigham, 2015; Dichev; Dicheva, 2017; Van Roy; Zaman, 2017), with the aim of bringing students a sense of fulfillment of duty when learning specific content and success through feedback (Brigham, 2017).

Drummond, Hadchouel and Tesniere (2017) (Article n. 8, Advances in Simulation) describe the difficulty of developing a serious game for the medical field, showing that the use of these games should be more effective for the group of students classified as extrinsically motivated, according to Ryan and Deci's (2000) Self-Determination Theory. In addition, the authors suggest ways to develop serious games based on the four pillars of learning according to cognitivism: attention, active participation in learning, feedback, and consolidation of knowledge (Petersen; Posner, 2012).

Tan and Zary (2019) (Article n. 10, JMIR Serious Games) establish criteria that must be observed in a game for it to be considered a serious game –: player experience, gameplay, and learning objective – and evaluate the presence of these criteria in three serious games established in the medical field: Touch Surgery, Dr. Game, Surgeon Trouble, and Staying Alive. This article uses the eight-step categorization system proposed by Jabareen (2009) for the proper classification of a game as a serious game.

Haubruck et al. (2018) (Article n. 11, Journal of Medical Internet Research) cite the first formal definition of serious games, made by Abt (1987) in 1970. On that occasion, they were defined as games created for education. The authors of the article report that, since

[5] The articles will be identified according to the order of presentation in Chart 1 and the source of their publication.
[6] Non-profit institution created to improve the teaching of mathematics. It is located in Irvine, California (USA).

then, multiple classifications, both based on the market and the purpose of the game, have been proposed. In this sense, Sawyer (2002) redefined serious games based on the connection between a serious purpose of knowledge and video game technology. Years later, Djaouti and Jessel (2011) established a new comprehensive classification, which combined the analysis of the "serious" and "game" dimensions into a gameplay/purpose/scope model. Using the classification proposed by Djaouti (2011), the authors of the article classified Touch Surgery as a serious game that can be used in the training of medical students in performing chest drainage.

CATEGORY II: DEVELOPMENT OF THE DEVICE

The second category dealt with the development process of Serious Games. Among the 17 selected articles, 8 discussed this topic.

Awan et al. (2019) (Article n. 1) highlight the importance of the interaction of the medical team (clinical and specialized knowledge on the topics to be addressed) with information technology professionals and programmers who will be responsible for the broad functioning of the serious game. As it is an application with a specific purpose, the development of a game of this type requires the involvement of professionals in the area addressed. Considering that the games analyzed are aimed at medical education, the participation of medical professionals in the development team is essential. These should help in the delineation of the scope of the game, as well as point out the most appropriate ways to approach the contents (Munro; Clark, 2013).

Lorenzo-Alvarez et al. (2019) (Article n. 2) cite the three basic theories of human learning – behaviorism, cognitivism, and constructivism – (Williamson et al., 2004) and the role of each of them in the process of creating the League of Rays Game, created for the teaching of anatomy and radiological signs to medical students through a previously existing virtual reality scenario already used for medical education, Second Life, launched by Linden Research Inc. in 2003.

Byl, Suncksen and Teistler (2018) (Article n. 4, journal of the Institute of Electric and Electronic Engineers) describe the development of a serious game in a virtual environment with emphasis on the process of manipulating the transducer of the ultrasound device and on the understanding of the spatial relationships in the formation of the ultrasound image. In this article, technical aspects of the game's development are described, such as the software used (Unity 3D) and the device used to run it (HTC Vive). It also describes the environment in which the game's actions are developed (toy store), its objective (locating

lost toy boxes and giving them a correct destination, in a given time) and the forms of punishment (end of the game after three mistakes) or reward (score).

Mohan et al. (2017) (Article n. 5, The BMJ) describe the development of Night Shift, a serious game that aims to recalibrate the decision-making process immediately (heuristics) in the triage of trauma patients in non-specialized services. Its goal is to reduce the underestimation of injury severity by utilizing an engaged storytelling approach. The game is based on a behaviorist concept and considers that the physician initially evaluates the severity of the injury and later considers the respective treatment possibilities (Kahneman; Tversky, 2003; Sanfey et al., 2006). It also understands that the recognition of the pattern of injury and its conduction is directly related to the concept of archetypes, through which patients who meet certain widely known criteria will be considered severe, while patients who are victims of less common injuries are underestimated in relation to the severity of their clinical condition.

Khan and Kapralos (2017) (Article n. 9, Health Informatics Journal), describe the development of a serious simulation-type game, Fydlyty, aimed at teaching cultural competence for the practice of medicine. Its objective is to develop the ability of the professional and medical organizations to understand and integrate the values, beliefs and behavior of each patient. These, in turn, are determined by several factors – race, ethnicity, nationality, language, social class – and must be understood for the best management of the patient's treatment. The game, created using the open source framework Django, uses the Model View Controler software and consists of simulated dialogues between the doctor and the virtual patient, who have different characteristics and moods. The article also highlights the concept described by Gee (2003), according to which the initial levels of a game are like "hidden tutorials", through which players learn how to use the game, with better results expected as the levels progress.

Tsopra et al. (2019) (Article n. 12, International Journal of Medical Informatics) describe the process of creating a serious game developed for the training of medical students in the field of antibiotic prescription in primary care. The game was developed using gamification techniques (scoring, awards and sequential phases) and cartoon design, since the game has a superhero who helps students with actions when necessary. The user interface occurs through cartoon characters that react to actions according to the user's level of accuracy. The game is based on clinical cases to be conducted by the player.

Tsoy et al. (2019) (Article n. 14, Academic Medicine) describe the process of developing and creating the serious game GridlockEd, which aims to teach how to drive multiple patients in a hospital emergency setting. The article describes the stages of this

development (research, initial development, and improvement of the quality of the game) and the particularities of each of these stages.

Agudelo-Londoño et al. (2019) (Article n. 16, Games for Health Journal) describe the process of creating and developing a serious game, CODIFICO, whose pedagogical objective is to teach undergraduate medical students the use of ICD 10, a textbook on coding pathologies. The authors are based on humanist proposals, which focus on learning in the student, and constructivist, since the game proposes the resolution of a real-life problem as a strategy for the discovery of knowledge (Wu, 2011).

CATEGORY III: ASSESSMENT OF THE EFFECTIVENESS OF THE USE OF SERIOUS GAMES AS A LEARNING TOOL

The third category defined addressed the evaluation of the effectiveness of the serious games developed in the learning process. Of the 16 articles selected, 15 addressed this theme. In the quantitative approach, most of the articles used the application of pre- and post-tests as a tool to assess learning.

Lorenzo-Alvarez et al. (2019) (Article 2) selected 197 undergraduate medical students and divided them into two groups. The first had 97 participants, who, in addition to studying through the usual teaching methodologies, were invited to play League of Rays, created for the teaching of anatomy and radiological signs. The second group had 107 participants, who worked on the content with usual methodologies, exclusively. One month after exposure to the game, both groups participated in a review of the contents covered, applying a multiple-choice test on these contents. Then, the results obtained between the two groups were compared and, in addition, the grades obtained at the end of the radiology internship, in order to evaluate the long-term absorption of knowledge.

Middeke et al. (2020) (Article n. 3, journal of the Society for Simulations in Healthcare) demonstrated that serious games can be used as a tool for developing clinical reasoning by repetitive exposure of the player to common clinical cases in emergency services. They also stated that clinical reasoning can be used in the management of similar cases, through the concept of transferable knowledge (Norman, 2005). However, the validity of the study is impaired by the lack of a pre-test for the placement of the participants.

Mohan et al. (2017) (Article n. 5) demonstrated the behavioral changes in serious game Night Shift players, represented by the lower number of cases of trauma patients with underestimated injuries. In this article, long-term behavioral change was also evaluated,

with the reevaluation of the participants and the verification of the persistence of behavioral changes.

Chon et al. (2019) (Article n. 6, JMIR Serious Games) evaluated the acquisition of theoretical knowledge by applying a questionnaire before (pre-test) and after (post-test) students had played EMERGE, a serious game in which the student develops actions in a virtual emergency department. In the game, a digital mentor supports the student as they handle the interface and treatment of patients. When starting the simulation, students receive information about the patient referred to the emergency service. The students then perform the physical examination, evaluate the patient's history, ask for complementary tests and, with the data obtained, must make the diagnosis and establish the treatment. The assessment of procedural knowledge (competencies, clinical skills, and attitudes) was carried out through the application of a Structured Objective Clinical Examination (OSCE, a method used to assess clinical competencies by medical students and residents), before and after the game. The results showed that the students who used EMERGE had a gain in theoretical knowledge, but not in procedural knowledge.

Haubruck et al. (2018) (Article n. 12, Journal of Medical Internet Research) evaluated the acquisition of procedural knowledge with the use of the serious game Touch Surgery through an OSCE created specifically for the evaluation of thoracic drainage procedures, observing a satisfactory response to the procedures required for drainage by the students who played Touch Surgery.

Diehl et al. (2017) (Article n. 13, Journal of Medical Internet Research) presented the results obtained after the application of the InsuOnline game, developed for teaching insulin prescription for diabetics to the public of physicians who are not specialists in endocrinology: the game brought a significant increase in correct prescriptions. The evaluation of the accuracy of the prescriptions was carried out in three moments: before the game, immediately after the game and three months after the game. The number of correct answers increased significantly immediately after the game, but fell after three months, remaining higher than the number of correct answers before the intervention.

Agudelo-Londoño et al. (2019) (Article n. 16) evaluated the effectiveness of CODIFICO through the application of pre- and post-tests and did not demonstrate a significant increase in students' knowledge after using the game.

Some articles also addressed serious games in a qualitative way, gauging the students' perception of the experience in the game, the effectiveness in the learning process and the degree of satisfaction with the method.

Byl, Suncksen and Teistler (2018) (Article n. 5) evaluated the developed game only qualitatively, using the User Experience Evaluation Questionnaire (UEQ). The researchers obtained results higher than +0.8 (considered good) in the categories attractiveness, efficiency, stimulation and innovation; Results lower than +0.8 (neutral) occurred in the perspicuity (clarity and comprehension) and reliability categories.

Mohan et al. (Article n. 5) also evaluated the game qualitatively, showing that about 40% of the players found the intervention satisfactory and offered positive feedback about the game, which they considered engaging; those with negative feedback found it cloying.

Chon et al. (Article n. 6) describe, in a qualitative way, the evaluation made by EMERGE students. Through the Likert scale, the results obtained showed satisfaction with the quality, gameplay and design of the game. In addition, the study showed that students have a favorable position on the use of serious games as a pedagogical tool.

Busari, Yaldiz, and Verstegen (2018) (Article n. 7, Advances in Medical Education and Practice) qualitatively evaluated the acceptance by resident physicians of a serious game created for the teaching of managerial, leadership, and negotiation techniques. The authors concluded that residents who already had experience with video games were more excited about the use of serious games as an educational tool. The residents' biggest concerns regarding the development of the game were: it should be realistic, directed and offer variability of situations. In addition, with the data obtained, it was postulated that residents prefer serious games that associate the teaching of management skills with clinical cases.

Drummond, Hadchouel and Tesniere (2017) (Article n. 8) highlighted the scarcity of data related to the use of serious games as a pedagogical tool and the need to classify and evaluate the effectiveness of these games through a structured validation object as proposed by Graafland et al. (2014).

Khan and Kapralos (2017) (Article n. 9) qualitatively evaluated the perception of medical professionals in relation to the usability, engagement, and satisfaction of Fydlyty. The results of this study revealed that serious gaming provided an easy interface even for physicians with little or no experience with video games. Satisfactory results were reported in relation to engagement and satisfaction with the use of the device.

Haubruck et al. (2018) (Article n. 11) evaluated the serious game qualitatively, demonstrating a high degree of user satisfaction with the game, who expressed interest in continuing to use the device for other training. The authors also demonstrated that user satisfaction with the use of serious games was higher than the use of traditional teaching methodologies.

Tsopra et al. (2019) (Article n. 12) qualitatively evaluated the serious game AntibioGame through MEEGA+, an appropriate statistical method for educational game evaluations. This method evaluates both usability and player experience from the learner's perspective, using an explicit scale and evaluating various quality factors, providing an overall score for the game (Djaouti et al., 2011). The results obtained demonstrated broad student satisfaction with AntibioGame.

Diehl et al. (2017) (Article n. 13) qualitatively evaluated factors such as usability and engagement with the game. Using the Likert Scale, the group submitted to the serious game was compared to the control group (submitted to an online activity on the same theme), with more satisfactory results in the former.

The evaluation of criteria such as usability, fidelity, acceptability, and applicability was described by Tsoy et al. (2019) (Article n. 14) in relation to the GridlockED game. This evaluation was carried out qualitatively immediately after the intervention, and the results obtained were promising: the players described broad satisfaction with the game and stated that they would recommend its use for educational purposes.

CATEGORY IV: COMPARISON OF THE USE OF SERIOUS GAMES WITH OTHER TEACHING METHODS

Awan et al. (2019) (Article n. 1) pointed out that, despite the increase in the use of serious games in medical education, there are still few publications that discuss the pedagogical results of these tools. The authors cite a study conducted with business students evaluated with pre- and post-tests that shows the beneficial pedagogical effects in terms of content acquisition with the use of serious games (Van Staalduinen, 2010), but emphasize the scarcity of specific data on the effectiveness of the use of these games in medical education, especially in the area of radiology.

Mohan et al. (2017) (Article n. 5) compared the behavior change required to reduce the underestimation of traumatic injuries in non-trauma service professionals between a group of physicians who played the proposed serious game and another composed of physicians submitted to the use of a traditional didactic application. The authors demonstrated better results in both the short and long term in the group that used the serious game.

Haubruck et al. (2018) (Article n. 11) compared the knowledge acquired with the use of the serious game Touch Surgery in performing chest drainage with a control group submitted only to standard theoretical classes. The method used in this comparison was an

OSCE created exclusively to evaluate the performance of students in this procedure, observing better performance in students who used the game.

Diehl et al. (2017) (Article n. 13) described the increase in the number of correct insulin prescriptions by physicians who are not specialists in endocrinology in two distinct groups. One was submitted to a game designed specifically for this purpose (InsuOnline); the other was submitted to an online activity on the same topic included in the Continuing Education Program. The authors observed similar results in both groups in relation to the data collected immediately after the interventions, but there were more correct answers in the group submitted to the game in the evaluation carried out three months later.

Drummond et al. (Article n. 15) compared the efficacy criterion between a serious game developed for pre-simulation training in a cardiorespiratory arrest situation (Staying Alive) and an online training on the same topic, with recorded classes. The article did not demonstrate the superiority of the serious game in relation to the classes in terms of skill acquisition in the situation addressed.

CONCLUSION

The articles selected in this integrative review show that the use of serious games in education increases student satisfaction and knowledge gain when compared to traditional teaching methodologies (Davids; Chikte; Halperin, 2011; Gleason, 2015). Serious games can be used to develop practical skills in a safe environment, with progressive degrees of difficulty, leading to interactivity and competition (Cook et al., 2011; Roberts; Newman; Schwartzstein, 2012; Morris et al., 2013). The use of gamification techniques keeps students motivated and engaged in the learning process. In addition, the possibility of playing according to one's own availability, the possibility of repeating processes and real-time feedback, fundamental principles in adult education theories, are present in serious games. Despite the enthusiasm for the use of these games in education, the evaluated articles point to the need to better evaluate the pedagogical bases related to their creation. Thus, a theoretical foundation regarding the pedagogical principles used for the creation of serious games is of fundamental importance for their validation.

Studies indicate that the educational effects of serious games can be explained from different pedagogical perspectives, as presented below:

a) the behaviorist proposal: learning occurs by performing tasks, with the transmission of knowledge;

b) cognitive proposal: students absorb and transform the information that needs to be understood;

c) humanistic proposal: the learning process is person-centered based on values and intentions with the active participation of the student;
d) constructivist proposal: the acquisition of knowledge through problem solving and social interaction.

It is worth noting, however, that the real connection between the pedagogical proposals and the process of creating the games is still little studied.

The use of serious games as educational platforms meets numerous learning objectives in Health Sciences. In this sense, they share the same advantages of using simulators for student training, allowing practice in safe environments and without exposing patients to risks, standardizing training, and stimulating the acquisition of specific knowledge in a more economical way and with greater reach (Wang et al., 2016).

Despite the advantages propagated about the use of serious games for medical education, their development is complex and there are many obstacles to be overcome. The development of a serious game for medical education requires knowledge in the areas of medicine, education and information technology, meeting the basic requirements of a game: modeling, specific design and scoring system (Olszewski; Wolbrink., 2016).

In addition, a systematic review conducted by Wang et al. (2016) showed that, despite the wide range of objectives to be achieved with the use of serious games in the context of medical education, the quality of these games – considering pedagogical principles, design and development – is still heterogeneous, requiring the creation of algorithms for their development, validation and distribution.

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