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Dental Case, a Brazilian Serious Game for Supporting Decision-making in the Dental Clinic: A Case Study

Camila Huanca, Deise Garrido, Mario Teixeira, Alana Oliveira, Paola Trindade, Ana Emilia Figueiredo and Ana Estela Haddad

ABSTRACT

***Background*: Games are intrinsic to society and are used to represent a wide variety of human activities. Contemporary society has been digitalized, and the habit of playing games has naturally migrated to the digital environment. The use of digital games in education, where they are known as serious games, has given rise to the introduction of new educational approaches for dental students and dentists, which complement traditional approaches. A brief conceptual outline of games can help broaden our understanding thereof in social and educational contexts.**

***Objective*: To report the designing and development of a serious game for decision-making in clinical case management in the field of dentistry, for use as a complementary teaching tool.**

***Method*: The method used was a case study to describe the development of the content and narrative of a Brazilian serious game for decision-making in the dental clinic, called Dental Case. A player in Dental Case takes on the role of a dentist during a consultation, with the mission of completing the steps of anamnesis, clinical examination, complementary examination, diagnosis, and treatment. The clinical cases presented in the game were designed to resemble real-life decision-making situations in the dental clinic of a primary healthcare setting. The content developed was reviewed and validated by specialists, from both a technical and pedagogical point of view, and then included in the game software by an information technology (IT) team.**

***Results*: Dental Case was developed from a set of clinical cases. The game targets dental professionals and students, and its goal is to lend support to the teaching of decision-making in the different stages of clinical care. The game is freely available on the web, and on the Play Store and Apple Store mobile application platforms.**

***Conclusions*: The resources made available by Dental Case constitute a new complementary pedagogical approach, and a tool for the application of educational technologies in dentistry, which can contribute to expanding the scale and reach of educational activities. Future research is warranted to investigate the effectiveness of Dental Case in promoting learning and should include an evaluation of its performance by its users.**

Keywords: clinical decision-making, dentistry, educational technology, permanent education, serious game, video game.

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I. Introduction

Storytelling and playing are closely intertwined actions. Their history developed with that of humanity, and they contribute to structuring our culture. Games allow us to symbolically enact activities that give meaning to our lives, such as work and education [1], [2]. Games can be found in several fields of knowledge, and have long been used to train people, and as a way of developing new perceptions [3]. They provide safe training in simulated environments, for typical activities conducted in real life. As such, they constitute a trial for living life [1], help players develop a sense of self-efficacy, and provide them with the confidence required to exercise newly acquired skills [4].

A. Serious Games for Clinical Decision Making

Clinical decision-making is the process by which a health professional solves a problem using his/her clinical reasoning comprised of practical and theoretical knowledge, skills, and attitudes and all the resources available to overcome uncertainties [5]. Correct diagnosis and treatment depend on obtaining complete, reliable data from the patient through a global assessment, which includes history-taking, clinical examination, radiographs, and laboratory tests [6]. Clinical decision-making is an important part of medical education,

and has been taught using a variety of methods, including computational strategies, cognitive training, and even sociology [7]-[9].

The literature shows that education and training improve clinical-reasoning skills, thus improving diagnostic performance and reducing operational errors. Several cognitive strategies have been proposed to provide better diagnostic decisions. One such strategy is to increase the student's experience by using simulations [10], [11]. Training for biliary tract surgery [12], the emergency care of patients with tachyarrhythmias [13], the home care of patients with chronic obstructive pulmonary disease [14], and trauma triage in an emergency ward [8], [15] are some examples of serious-game content that simulate clinical decision-making.

B. Serious Games in Dentistry

Game technology provides a new and different approach to education at the undergraduate, graduate [16], and continuing professional development [17] levels. However, there are few reports on the use of serious games as auxiliary resources for dental learning [16], [18]–[21]. It is known that the use of serious games is a valid option for dental education; however, serious games remain underused and poorly researched in this area [18]. Researchers have described games only as complementary tools for dental teaching, and have reported deadlocks in their development [16]. In addition, there are few serious games for decision-making in the field of dentistry [21], [22]. Therefore, there is a gap in the available knowledge provided in the literature regarding the use of serious games for this field.

Brazil is the country with the highest absolute number of dentistry courses worldwide, and one of the countries with the highest number of dentists [23]. Thus, the Open University of the Unified Health System and Federal University of Maranhão (UNA-SUS/UFMA), the Graduate Program in Design of the Federal University of Paraná, and the Telehealth Center of the University of São Paulo School of Dentistry, pooled together to develop Dental Case, an innovative project aimed at meeting the educational and training needs of clinical professionals, by using information and communication technologies to expand the scale and reach of educational activities [17]. Dental Case is a serious game created to support the decision-making process in the dental clinic. The game was developed based on the understanding that quality education is achieved not only with traditional approaches, but also with pedagogical, technological, design, and communication innovations, among other interdisciplinarities. Thus, this study reports on a project aimed at developing a decision-making serious game, which introduces a gamified simulation of clinical cases as an innovative method for the education and training of dentists and dental students.

II. METHOD

A. The Dental Case Project and Its Development

The method used in this case study was descriptive research into the development of the content and narrative of the Dental Case game, and its interface with the pedagogical and technological dimensions. The project was managed by UNA-SUS/UFMA, and was developed based on the premise adopted by this institution that educational resources should be associated with design, pedagogy, and technology. An interdisciplinary team of about twenty members cooperated with the project and included game designers, managers, pedagogues, instructional designers, information technology (IT) professionals, dental professors from the disciplines of pediatric dentistry, radiology, restorative dentistry, biomaterials, and oral biology, as well as doctoral and post-doctoral dental students experienced in clinical care, the latter being responsible for the content and narrative of the game.

During the development of the Dental Case Project, a series of workshops were held as part of the creative process, in which the entire interdisciplinary team participated actively in the formulation of its main concept, educational content, learning objectives, and branched stages.

Dental students and dentists are the target audience of the Dental Case serious game, which may include people used to playing digital games, as well as people with little or no experience. Players in Dental Case do not interact with other players, i.e. their experience is individual.

The purpose of Dental Case is to test the player's clinical reasoning during dental care, with the ultimate goal of reaching the best possible outcome in terms of the patient's health. The player's knowledge is evaluated during the course of the consultation (comprising the steps of anamnesis, clinical examination, complementary examination, diagnosis, treatment, and patient communication) in relation to his/her ability to make decisions in each step. The player’s ability to analyze test results is scored positively or negatively, depending on whether the game's algorithm judges his/her choices as appropriate or inappropriate, respectively. The player's choices are also scored in relation to humanized care and economic considerations related to the costs incurred by the Unified Health System (SUS). Pedagogical feedback and the corresponding bibliographic references that support it are presented at the end of the game to further contribute to the player's learning experience.

B. Content of Dental Case

Subsequently, this instrument was improved by the IT team, and received the contributions of the pedagogical and content writer teams, ultimately resulting in a clinical-case authoring tool to be used by content writers to speed up the clinical case construction process [24]. The aims of this tool are (1) to guide content writers to structure the content in the steps of anamnesis, clinical examination, complementary examination, diagnosis, treatment, and patient communication; and (2) to set the limits of the narratives included in the game to a pre-defined number of characters. The content of each stage is displayed on the screen of the game.

The content writer team received the input of pedagogues and technical reviewers specializing in the subject matter being addressed in each case, so as to validate and ensure the quality of the content developed for Dental Case. The content included by the content writers using the authoring tool underwent a technical review that determined whether the clinical cases and features of the cases described at each stage were consistent with the best available scientific evidence. This technical review was performed by two dental professors with more than twenty years of experience. The

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content of each case was then either approved or disapproved. If approved, the content would move on to the next step: the pedagogical review. If disapproved, the required adjustments were pointed out by the technical reviewers and forwarded to the content writer to make the necessary corrections. Once the adjustments were completed, the content was sent back to undergo a new technical review, and then to a final pedagogical review.

The IT team then used the approved content to produce the software for the game, comprising the following steps: exporting the content of the cases from the content authoring tool, coding each case in a specific programming language, and incorporating images, audios, and other multimedia resources into the game. After these steps were completed, the game underwent a final phase of testing and internal validation. At this point, a team was formed to assess the quality of the game, and was also invited to play Dental Case freely. The notes made by the validators were then used to make adjustments and improvements to the executable version of the game to be made available at application stores [25].

C. Dental Case Narrative

Overall, the game uses the traditional narrative structure of cinema [26], with specific subdivisions created by the game design team and described below:

Beginning, Act 1 (prologue): the game presents the setting where the narrative takes place between dentist and patient.

Middle, Act 2 (conflict): the patient states his/her complaint, and Act 3 (rising action): the dentist begins the anamnesis and clinical examination; at this stage, unforeseen occurrences or interferences in the dynamics of the game may take place to make it more exciting.

End, Act 4 (falling action): the dentist selects the complementary tests and gives the final diagnosis, and Act 5 (resolution): the chosen treatment or conduct is indicated, and the player receives pedagogical feedback regarding his/her choices.

The narrative of each clinical case was developed to stimulate player involvement, so that he/she remains focused on the objective of the game. To this end, and guided by the protocol specifications, the content team detailed several aspects of the central narrative of the patient's complaint. Accordingly, the dental chair stage received virtual patients whose characteristics were consistent with the clinical case detailed by the content writer, and the illustrators were able to capture the patient's profile and translate it into realistic illustrations, containing relevant data for decision-making. Some of the physical aspects specified were age group, ethnicity, color, gender, and body mass index (BMI), as well as specifics related to occasional deficiencies (hearing, cognitive, motor and/or visual) and their severity. Each patient was personified, by including a medical record containing his/her health history, family health history, and data regarding age, sex, BMI, number of pregnancies, type of delivery, gender expression, marital status, level of education, work activity, family income, and area of residence. The content writer then created a tree of possibilities based on the previously conceived personification.

D. Structuring a Tree of Possibilities

The main challenge for the player is to meet the patient's demands and solve his/her case. In order to accomplish this task, the player makes choices during the care stages. The choices available in the game are part of a tree of possibilities included in the protocol.

The tree of possibilities provides three types of alternatives for decision making: appropriate, plausible, and inappropriate alternatives. The more correct the player's choices, the better his/her score. The different types of alternatives presented in the game make it more challenging, since they render decision-making more difficult for the player. Furthermore, the game may offer more than one option for each type of alternative (Fig. 1).

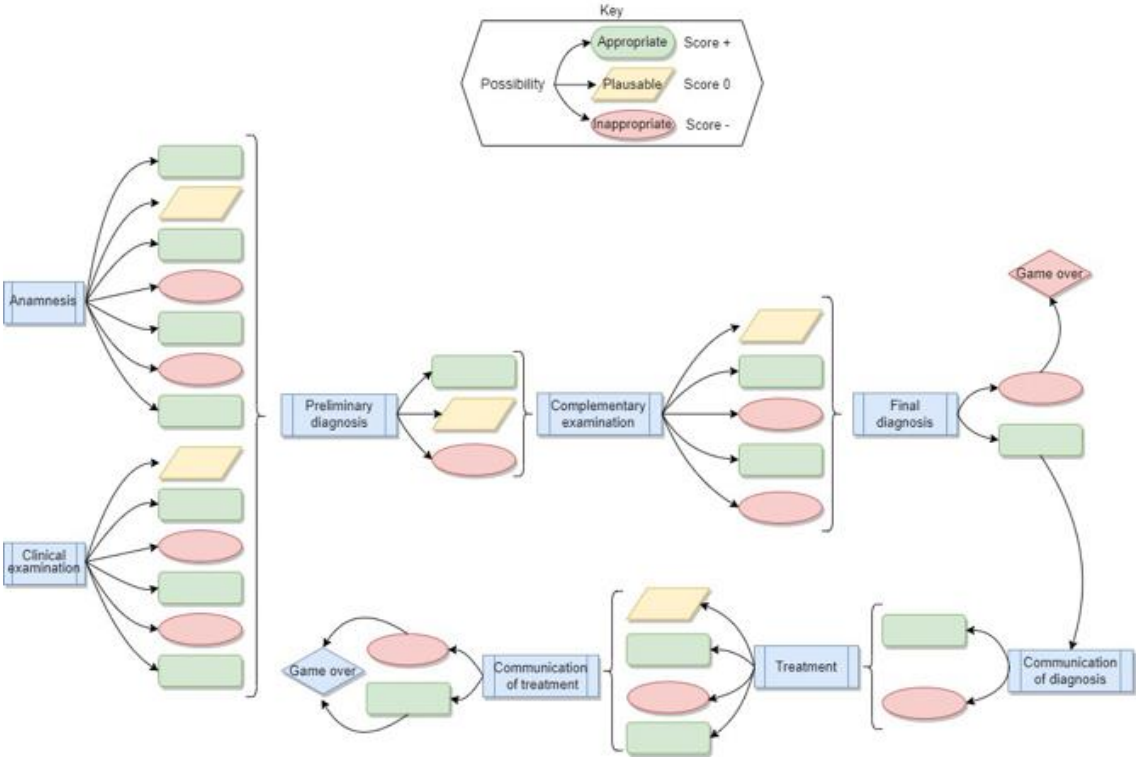

Fig. 1. Tree of possibilities.

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Unusual situations that might occur in consultations at a basic health unit were also included in the game. Thus, the narrator included situations causing the consultation to be interrupted, such as the ringing of a cell phone, external noises, a power outage, or the lack of patient cooperation, as an additional challenge to test the player's decision-making skills. The tact required of the dentist when asking questions and communicating the diagnosis and treatment to the patient is also contemplated in the game narrative formulated by the content writer; accordingly, humanized care features are included in the alternatives available to the player.

After managing the patient's clinical case, the player receives pedagogical feedback containing didactic contributions to the development of his/her knowledge with respect to each stage of the care-giving process.

III. Result

The serious game presented in this report is a gamified simulation of clinical cases. The content writers developed the script, prepared the clinical cases, selected and included the results of the radiographic and other relevant complementary examinations (with information in the form of texts and images), and built the pedagogical feedback reports. The game's narrative takes place in a basic unit of the SUS, and the player selects an avatar among six existing configurations of a dentist about to start his/her clinical workday. The game unfolds from the perspective of the avatar-dentist. The dentist chooses among the many patients available for treatment, each one presenting with complaints and symptoms that are then investigated by the professional, using the most appropriate selection of history-taking questions, clinical tests, and complementary tests to diagnose and treat correctly. The cases are similar to real-life dental situations commonly found in the context of primary healthcare, and were designed with the goal of contributing to the training of SUS professionals.

Dental Case has recently been launched in its beta version and was programmed using the Unity game engine (Unity Technologies). The game took approximately two years to develop from its conception to the current version but is still under development to incorporate new features. Content writers continue to feed the authoring tool with new clinical cases to be added to the 20 cases included so far. The IT team is playing and testing the cases to detect and fix any problems and has already produced a Dental Case version using web technologies, namely the React JS development framework [27]. This version allows the game to be ported more easily to a variety of browsers and mobile devices based on the Android and iOS platforms.

The authoring tool created by the IT team to allow the development of a narrative, avatars, and an image database of characters, environments, and equipment has systematized the work of the content writer, pedagogue, and technical reviewer teams, as documented in the Dental Case development meeting reports. In addition to this authoring tool, other products related to the development of the game were created and registered at the National Institute of Industrial Property (INPI) under the following names and registration numbers: SAITE Image Pack Dental-Case Scenarios / BR512019002777-9, SAITE Image Pack Dental-Case Characters / BR512019002778-7, SAITE Dental Cases (iOS) / BR512019002775-2, and SAITE Dental Cases (Android) / BR512019002773.

It is an open-access game, and freely available on the web and at Google Play and Apple Store for mobile devices, in Brazilian Portuguese, English and Spanish, in that the last two were automatically translated by the Google Translator API. Player interaction with Dental Case can be made by mouse on the web, or by touching the screen of a mobile device. Some illustrations of the game are shown below (Figs. 2–4, representing screenshots from Dental Case).

Fig. 2. Choosing a clinical case.

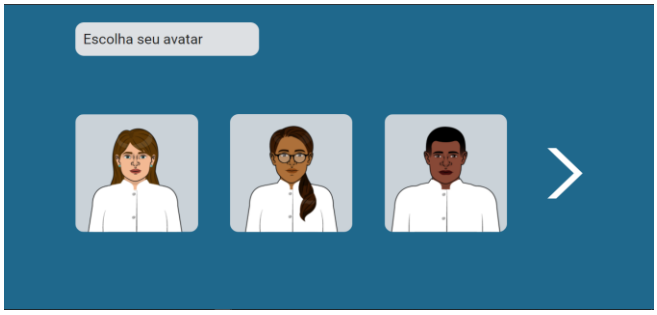

Fig. 3. Choosing an avatar.

Fig. 4. Dentist receiving the patient.

IV. Discussion

Digital technologies have caused a permanent change in both society and the individual toward the way people live, work, and entertain themselves. According to McLuhan, games translate experiences and give new forms to already known situations [3].

The present case report describes not only a project that involves the building up of interdisciplinary knowledge but also the production of a serious game for decision-making in the dental clinic, both of which are innovative. After conducting a review of the related literature, a few serious games devised for this purpose were found in the field of dentistry. The literature search found only one serious game

about tooth caries and tooth pulpitis [21], and another serious game developed about dental public health education [22]. Therefore, the serious game described herein can be presumed to be one of the few games for decision-making targeting the dental public.

Dental Case is a serious game designed to contribute interactively to the honing of the decision-making skills of dental students and dentists, providing them with a significant learning experience through the simulated care of patients in several different situations occurring in a primary healthcare setting. The goal was to present players with several dental clinical cases that would enable them to enhance their experience, and encourage them to identify gaps in their knowledge in order to develop their data collection skills, to name just one aspect. The ongoing pandemic at the time this report was published caused many students to miss many hours of clinical training, as a result of the restrictions imposed on in-person care [28]–[30]. Although Dental Case cannot replace this practice entirely, the game constitutes a complementary mode of training for the management of clinical cases that professionals and students were kept from managing during the pandemic. By enabling the practice of clinical decision-making in a digital, controlled, and secure environment, the game provides clinical training without involving any risk to the health of real patients, as reported by Graafland *et al.* in a systematic review of serious games [4].

Research conducted with serious games as a means of training or acquiring experiences to improve decision-making skills have shown that these simulations are effective in promoting positive changes in the participants' performance [8], [15]. The main findings of one such study confirm the validity of using serious game technology to study physicians' decision making, considering that the pattern of decisions made while playing seemed consistent with the patterns found in real-life practice [31]. In addition, players have reported a sense of responsibility in decision-making [13], have considered cases clinically relevant [14], [32], and have perceived the fun involved in the act of playing [12], [13]

Developing a game to better qualify students and dentists is in line with the literature that shows that serious games have been widely used in the field of medical education, owing to the positive results obtained by medical students toward learning and participation [13], [33]. Accordingly, researchers have encouraged the use of this type of application [16], [20].

The making of Dental Case was only possible due to the robust contribution of the different teams involved. Its construction and development were complex tasks, which required the simultaneous and cross action of an interdisciplinary team, as reported by Novak with respect to the development of commercial games [26]. The goal of the Dental Case project is to promote learning through the game process, which includes the posing of challenges, performance assessment, and the possibility of repeating tasks, in addition to providing pedagogical feedback in the form of commentaries—and accompanying bibliographic reference—to the alternatives chosen by the player during the game. By presenting a range of appropriate, plausible, and inappropriate alternatives, the game allows the player's score to rise or fall as his/her choices switch between more or less appropriate. The player can monitor his/her performance immediately, by observing his/her partial score displayed on a bar on the screen pertaining to each stage of the care being provided. This game mechanism contributes to expanding the player's knowledge, and refining the accuracy of his/her choices, as reported in the research conducted by Mohan *et al.* [15].

Text The main concern of developers when designing serious games is to maintain a balance between their two most important components: content and entertainment [4], [5]. However, some researchers argue that content is the central aspect of a serious game [34], whereas others argue that it is entertainment, i.e., that education should be subordinated to narrative [35]. This contradiction found in serious games is known as the “edutainment paradox” [36], [37]. The present case study on the Dental Case Project describes the concern of the team of content writers in developing an educational resource that is faithful to real-life dental situations, but that does not sacrifice fun or engagement. This same understanding guided Diehl *et al.* when developing a serious game on insulin therapy focusing on continuing medical education [38]. The concern of the Dental Case developers was to engage the player through the game's narrative, scoring system, and unexpected situations, elements also used by Danilicheva *et al.* [37]. These elements create an enjoyable experience, and increase the player's intrinsic motivation.

A compelling narrative also contributes positively to the game, as reported by Mohan *et al.* [15]. However, the restriction to the number of characters allowed by the clinical case protocol of the game's authoring tool proved to be a limitation to the accuracy of the game in reproducing real life, since it sometimes entails constructing overly succinct questions and answers. On the other hand, the authoring tool allowed a significant reduction in the time needed to create clinical cases. During the meetings, there were positive reports about the perception by content writers of their experience in developing clinical cases, as well as the perception by technical and pedagogical reviewers about theirs in evaluating the content before and after creation of the authoring tool. The tool was classified as useful and capable of streamlining the teams' work process.

Supporting elements of the content are no less necessary, and are also present in Dental Case. They allow the player to view the patient's records containing health history, family history, and demographic data. According to Johnsen *et al.*, these data are important to help the player understand the clinical case, and detect relevant clues to resolve the patient's condition [14]. Some articles in the healthcare field report the importance of designing games that are as realistic as possible, and no less accurate in reproducing the studied context, considering that the goal of using serious games is to promote behavioral changes related to the continuing education of a large number of professionals [39].

The significant learning experience sought by the developers of Dental Case is in line with the literature that highlights the importance of clinically relevant content consistent with learning objectives and clinical practice [14], [40]. This is because its goal is to increase the player's ability to make appropriate decisions, care for the patient in a humanized way, and make the most appropriate and relevant

choices of complementary exams, for both the patient and SUS, economically speaking.

According to Johnsen *et al.*, playing is a way of stimulating active learning [14]. Accordingly, the interdisciplinary team of Dental Case defined the main concept of the game as an encouragement to develop decision-making skills, and sought to inspire players to apply, analyze, and synthesize knowledge to make the most appropriate choices. In this scenario, we agree with the statement by Pereira and Walmsley that game technology and its application in the field of dentistry have enormous potential [16].

Other positive features of the project are its open and free access, and its availability both on the web and in the form of an application for mobile devices. Therefore, the objectives outlined by previous research of reaching a large number of people interested in continuing education [5], [17] and expanding the reach of educational resources using mobile technology [17] are both enabled by Dental Case. This focus on the goal of increasing scale and reach reflects an awareness of the management team toward a particular feature of Brazilian reality: the existence of a very large number of current and future dentists in the country [23].

It is noteworthy that UFMA is one of the pioneering institutions of the network of universities comprising the UNA-SUS, a successful government strategy that promotes the offering of free distance learning courses for continuing education in healthcare [41]. By offering continuous education, UNA-SUS/UFMA provides its students with a virtual learning environment (VLE) that allows integration of Dental Case into the existing set of courses offered on the web.

The development of Dental Case for use with mobile technology expands the reach of its educational resources to SUS health professionals. The mobile format of the game made available at the two largest application platforms is meant to meet the demands of expanding mobile networks and digital game usage, a trend also observed in the target audience of Dental Case. Today the use of mobile devices is commonly a part of people's daily lives, who remain in a state of permanent connection. In fact, it is almost unimaginable that a citizen of today's world would not rely on the availability of a smartphone for the tasks of communicating, obtaining information, and requesting services.

The mobile industry celebrated a milestone as the first billion 5G connections were made by the end of 2022 [42]. In Brazil, the digital population is 130 million, and 86.4 million users count exclusively on mobile devices [43]. Digital games are also present in Brazilian society, with 84% people using various electronic devices to play games [44].

Thus, the relevance of mobile devices for education is currently undeniable, a fact that has led to the incorporation of the term mobile learning or m-learning in distance education terminology, confirming the integration of mobile technologies in education, and validating the use of smartphones and tablets as learning channels. The ease of having any sought-after knowledge readily available in the palm of your hand at any time and place through these mobile devices has expanded user autonomy and interest exponentially, maximizing and invigorating the teaching-learning process.

Some of the video games available are meant to be played in groups; Dental Case, in contrast, was pedagogically designed to be an individual game. This decision was made during the game design process, when it was realized that decision-making in clinical dental practice is mostly an individual action. On the other hand, this means that the game fails to offer what many digital games do: social interaction within the virtual space shared by players from different parts of the world [45]. As a result, in the jargon of the entertainment games industry, Dental Case falls into the category of "first-person shooter" games [46]. Evidently not a shooting game, Dental Case is a first-person game in which the “shooter” (dentist) has to make decisions (“shots”) that lead him/her to success or failure in the game.

One limitation of the Dental Case development process is that the content writer requires the assistance of the game-design and IT teams to upload new clinical cases. Nonetheless, a new version is already being developed to give autonomy to content writers in carrying out this task. Another limitation is related to the clinical case structure, in which each phase of care has its own tree of possibilities. As a result, the sequential and linear character of the player's progression through the stages of the game reduces the possibilities of game alternative randomization and combination.

Further investigation is warranted on the educational effectiveness of the game in enhancing the decision-making ability of dental students and dentists in the dental clinic, and also on their experience and satisfaction with Dental Case. The product should also be updated to include a categorization by area of the clinical cases incorporated into the software of the game.

V. Conclusion

The novel complementary pedagogical approaches in the field of dentistry are needed. Dental Case developers are keen to engage the player with appropriate content and narrative to entertain and educate. The resources made available by Dental Case require decision-making at different stages of the dental care process, combined with robust pedagogical, technological, and design support. They constitute a novel tool in the armamentarium of dental educational technologies and can contribute to expanding the scale and reach of educational activities, both at the undergraduate level and in the continuing education of dentists.

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Conflict of Interest

Authors declare that they do not have any conflict of interest.

REFERENCES

[1] Murray J. Hamlet on the Holodeck: The Future of Narrative in Cyberspace. São Paulo: Unesp; 2001.
[2] McGonigal J. Reality is broken: why games make us better and how they can change the world [Internet]. New York: Penguin Press; 2011. Available at: https://educacaofisicaaefcps.files.wordpress.com/2018/07/reality_is_broken.pdfISBN:1-101-46715-0.
[3] McLuhan M. Understanding Media: The Extensions of Man. São Paulo: Editora Cultrix; 1964.
[4] Graafland M, Schraagen JM, Schijven MP. Systematic review of serious games for medical education and surgical skills training. *Br J Surg*. 2012;99(10):1322–1330. doi: 10.1002/bjs.8819.
[5] Faria L, Oliveira-Lima JA de, Almeida-Filho N. Evidence-based medicine: a brief historical analysis of conceptual landmarks and practical goals for care. *Hist Cienc Saude Manguinhos*. 2021;28(1):59–78.
[6] Sonis ST, Fazio RC, Fang L. History, Physical and Laboratory. Principles and Practice of Oral Medicine. São Paulo: Guanabara Koogan S.A.; 1995. p. 491.
[7] Blanié A, Amorim M-A, Meffert A, Perrot C, Dondelli L, Benhamou D. Assessing validity evidence for a serious game dedicated to patient clinical deterioration and communication. *Adv Simul*. 2020;5(1):4. doi: 10.1186/s41077-020-00123-3.
[8] Middeke A, Anders S, Schuelper M, Raupach T, Schuelper N. Training of clinical reasoning with a Serious Game versus small-group problem-based learning: A prospective study. *Ito E, organizador*. *PLoS One* 2018;13(9):e0203851. doi: 10.1371/journal.pone.0203851.
[9] Gamborg ML, Mehlsen M, Paltved C, Tramm G, Musaeus P. Conceptualizations of clinical decision-making: a scoping review in geriatric emergency medicine. *BMC Emerg Med*. 2020;14;20(1):73. doi: 10.1186/s12873-020-00367-2.
[10] Gruppetta M, Mallia M. Clinical reasoning: exploring its characteristics and enhancing its learning. *Br J Hosp Med*. 2020 out 2;81(10):1–9.
[11] Thammasitboon S, Cutrer WB. Diagnostic decision-making and strategies to improve diagnosis. *Curr Probl Pediatr Adolesc Health Care*. 2013. p. 232–241.
[12] Graafland M, Vollebergh MF, Lagarde SM, Van Haperen M, Bemelman WA, Schijven MP. A serious game can be a valid method to train clinical decision-making in surgery. *World J Surg*. 2014;38(12):3056–3062. doi: 10.1007/s00268-014-2743-4.
[13] Kaczmarczyk J, Davidson R, Bryden D, Haselden S, Vivekananda-Schmidt P. Learning decision making through serious games. *Clin Teach*. 2016;13(4):277–282. doi: 10.1111/tct.12426.
[14] British Johnsen HM, Fossum M, Vivekananda-Schmidt P, Fruhling A, Slettebø Å. Teaching clinical reasoning and decision-making skills to nursing students: Design, development, and usability evaluation of a serious game. *Int J Med Inform*. 2016; 94:39–48. doi: 10.1016/j.ijmedinf.2016.06.014.
[15] Mohan D, Farris C, Fischhoff B, Rosengart MR, Angus DC, Yealy DM, *et al*. Efficacy of educational video game versus traditional educational apps at improving physician decision making in trauma triage: randomized controlled trial. *BMJ*. 2017; j5416. doi: 10.1136/bmj.j5416.
[16] Pereira AC, Walmsley AD. Games in dental education: playing to learn or learning to play? *Br Dent J*. 2019;227(6):459–460.
[17] Oliveira AEF de, França RM, Haddad AE, Brasil LSB, Pinho JRO. Open applications developed in Brazil for distant learning in dentistry: valuable educational resources for academic and professional qualification. *J da Soc Int Telemedicina e eHealth*. 2016;4(10):1–6. https://journals.ukzn.ac.za/index.php/JISfTeH/article/view/142/html.
[18] Sipiyaruk K, Gallagher JE, Hatzipanagos S, Reynolds PA. A rapid review of serious games: From healthcare education to dental education. *Eur J Dent Educ*. 2018;22(4):243–257. doi: 10.1111/eje.12338.
[19] Zaror C, Mariño R, Atala-Acevedo C. Current State of Serious Games in Dentistry: A Scoping Review. *Games Health J*. 2021;10(2):95–108.
[20] Mehrotra P. Edutainment in dental curriculum – A systematic review. *J Oral Biol Craniofacial Res*. 2020;10(4):417–421. doi: 10.1016/j.jobcr.2020.07.016.
[21] Ju-Hui Wu, Je-Kang Du & Chen-Yi Lee. Development and questionnaire-based evaluation of virtual dental clinic: a serious game for training dental students. *Medical Education Online*. 2021; 26:1. https://doi.org/10.1080/10872981.2021.1983927.
[22] Sipiyaruk, K., Gallagher, J.E., Hatzipanagos, S. *et al*. Acquiring critical thinking and decision-making skills: an evaluation of a serious game used by undergraduate dental students in dental public health. *Tech Know Learn*. 2017; 22:209–218. https://doi.org/10.1007/s10758-016-9296-6
[23] Morita MC, Uriarte Neto M, Fontanella VRC, Haddad AE. The unplanned and unequal expansion of Dentistry courses in Brazil from 1856 to 2020. *Braz Oral Res*. 2021;35:1–10.
[24] GameCase. GameCase admin [Internet]. 2020. Available at: https://gamecase.adm.br/
[25] Lemos AF, Nascimento EN, Passos MFD, Oliveira AEF de, Veiga C de C, Salgado Filho N. Experiências exitosas da rede UNASUS 10 anos [Successful experiences of the UNASUS network 10 years]. São Luís: EDUFMA; 2020. Portuguese.
[26] Novak J. Game development. Cengage Learn. São Paulo; 2010.
[27] Facebook.com. React – A JavaScript library for creating user interfaces [Internet]. *React*. 2021. Available at: https://pt-br.reactjs.org/.
[28] Klaassen H, Ashida S, Comnick CL, Xie XJ, Smith BM, Tabrizi M, *et al*. COVID-19 pandemic and its impact on dental students: A multi-institutional survey. *J Dent Educ*. 2021;85(7):1280–1286.
[29] Farrokhi F, Mohebbi SZ, Farrokhi F, Khami MR. Impact of COVID-19 on dental education - a scoping review. *BMC Med Educ*. 2021;21(1):1–12.
[30] Chang TY, Hong G, Paganelli C, Phantumvanit P, Chang WJ, Shieh YS, *et al*. Innovation of dental education during COVID-19 pandemic. *J Dent Sci*. 2021;16(1):15-20. doi: 10.1016/j.jds.2020.07.011.
[31] Mohan D, Angus DC, Ricketts D, Farris C, Fischhoff B, Rosengart MR, *et al*. Assessing the validity of using serious game technology to analyze physician decision making. *PLoS*. 2014;9(8).
[32] Diehl LA, Souza RM, Gordan PA, Esteves RZ, Coelho ICM. InsuOnline, an electronic game for medical education on insulin therapy: A randomized controlled trial with primary care physicians. *J Med Internet Res*. 2017;19(3).
[33] Zhonggen Y. A Meta-Analysis of Use of Serious Games in Education over a Decade. *Int J Comput Games Technol*. Hindawi Limited; 2019. doi: 10.1155/2019/4797032.
[34] de Freitas S, Oliver M. How can exploratory learning with games and simulations within the curriculum be most effectively evaluated? *Comput Educ*. 2006; 46:249–264.
[35] Zyda M. From visual simulation to virtual reality to games. *IEEE Comput Soc*. 2005;38(9):25–32. doi: 10.1109/MC.2005.297.
[36] Sobral D, Machado I, Paiva A. Machiavellian characters and the edutainment Paradox. Lect Notes Artif Intell. *Subseries Lect Notes Comput Sci*. 2003. p. 333–340. doi: 10.1007/978-3-540-39396-2_55.
[37] Danilicheva P, Klimenko S, Baturin Y, Serebrov A. Education in virtual worlds: virtual storytelling. *2009 Int Conf CyberWorlds*. *IEEE*. 2009. p. 333–338. doi: 10.1109/CW.2009.57.
[38] Diehl LA, Souza RM, Alves JB, Gordan PA, Esteves RZ, Jorge MLSG, *et al*. InsuOnline, a serious game to teach insulin therapy to primary care physicians: design of the game and a randomized controlled trial for educational validation. *JMIR Res Protoc*. 2013;2(1): e5. doi: 10.2196/resprot.2431.
[39] Barnabè F, Giorgino MC, Guercini J, Bianciardi C, Mezzatesta V. Engaging professionals with serious games: the Lean Healthcare Lab at Siena University Hospital. *Dev Learn Organ Emerald Group Publishing Ltd.*; 2017;31(3):7–10. doi: 10.1108/DLO-06-2016-0051.
[40] Hummel HGK, Nadolski RJ, Eshuis J, Slootmaker A, Storm J. Serious game in introductory psychology for professional awareness: Optimal learner control and authenticity. *Br J Educ Technol*. 2020. doi: 10.1111/bjet.12960.
[41] Ministry of Health, UNA-SUS, Secretariat of Labor Management and Health Education, FIOCRUZ. The net UNA-SUS | UNA-SUS [Internet]. [cited in Oct 9th, 2017]. Available at: https://www.unasus.gov.br/page/una-sus/rede-una-sus.
[42] GSMA. GSMA | About the GSMA - Represents the interests of mobile operators worldwide [Internet]. GSM Assoc. 2023 [cited 2023 Jun 5]; Available at: https://www.gsma.com/newsroom/blog/gsma-mwc-barcelona-trend-watch-what-comes-after-one-billion-5g-connections-the-2nd-wave-of-5g/.
[43] ComScore. State of Gaming – 2023 [Internet]. ComScore. 2023. [cited 2023 Jun 5]; Available at: https://www.comscore.com/por/Insights/Apresentacoes-e-documentos/2023/Tendencias-Digitais-e-Lancamentos-2023.
[44] Sioux Group. Research Brazil Game 2022 [Internet]. PGB 2022. [cited 2023 Jun 5]; Available at: https://www.pesquisagamebrasil.com.br/pt/ebooks/.
[45] Seo Y, Dolan R, Buchanan-Oliver M. Playing games: advancing research on online and mobile gaming consumption. Internet Res. Emerald Group Publishing Ltd.; 2019. p. 289–292. doi: 10.1108/INTR-04-2019-542.
[46] Therrien C. Game studies – inspecting video game historiography through critical lens: etymology of the first-person shooter genre. *Games Stud - Int J Comput game Re*. 2015;15(2). Available at: http://gamestudies.org/1502/articles/therrien.