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Um Serious Game para Educação Sobre Saúde Bucal em Bebês.

A Serious Game for Education about Oral Health in Babies.

Un Serious Game para la Educación sobre la Salud Oral en Bebés.

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ABSTRACT: The serious games have been highlighted by the addition of playful aspects to the educational process, motivating and assisting learning through games. In this context, the game intelligence, comprised from decision models, consists of challenging and motivating element for the player. For the present study, it was observed that basic concepts related to health and oral hygiene predominate in serious games for Dentistry and children are the main target audience of these games. The shortage in exploring games with the theme oral health for infant was the focus of the development of a serious game addressed to this theme. The design of the game "Uma Aventura na Floresta da Dentolândia" (An Adventure in the Toothland Forest) allowed verifying the necessity of consider the theme and the target public in the development process of serious games. The research also allowed verifying a wide range of possibilities for the application of serious games in health.

Keywords: games, serious games, Dentistry, pediatric Dentistry, education.

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INTRODUCTION

Interactive digital media reaches most of the spaces in contemporary society at the same time that research shows the effectiveness of computer applications for increased motivation and consolidation of knowledge during the teaching-learning process[1]. In this context, computer games stand out when compared to other media, because they enable a balance between the player's challenge and the involvement during the interaction[2]. Specifically, serious games have as their main feature to provide the learning of specific aspects of disciplines or train operational skills[4]. Kebritchi and Hirumi[1] attribute the success of serious games to a number of factors, including: the use of the action instead of explanation; the creation of a motivation and personal satisfaction; to adapt to various learning styles and skills; the strengthening of skills; and encouragement to the decision-making processes of the player in interactive environments. The first census of the Brazilian industry, released in the year 2014 (with data from the year 2013), pointed out that the serious games corresponded to almost half of the games developed in Brazil (47.8%), and those that specifically target health corresponded to only 4% of the total number of games produced that year [4].

In children from 18 to 60 months of age, it was observed that 21.2 percent of them had at least one baby tooth with dental caries experience[5] while, at 5 years, this percentage amounted to 53.5%[6]. The latest population survey on oral health conditions of the Brazilian population pointed out that such a situation tended to worsen with the passing of age, arriving at 56.5% of 12-year-old children with caries experience and, in adolescents 15 to 19 years, from 76.1%[6]. Such indexes were compounded by an inadequate oral hygiene, by high consumption of fermentable carbohydrates, lack of follow-up and the lack of proper guidance of parents and guardians. In addition, with regard to maternal attitudes front tooth decay involving their children's primary teeth, 93.5% of mothers reported that would lead them to the dentist if their teeth were affected by tooth decay, i.e., seek oral health care if their children show changes, and the child, at this stage, feel pain and require more complex treatments[7]. Despite the improvement in the Brazilian strategies focused on oral health of the baby, even if you understand the need for initiatives and actions about the importance of primary teeth and how to prevent tooth decay from a tender age[8].

In the context of few public policies related to the oral health of infants, especially in the context of the scenario and Brazilian digital media, particularly in the use of serious games focused on the educational processes, the motivation for this work.

The research presented here, dealt with the possibility of use of serious games in the process of information regarding oral hygiene practices. Therefore, they constitute objectives of this work: to identify, through bibliographic research, computer applications developed in the form of serious games for Dentistry and their characteristics; present the planning process and development of a serious game, consisting of an intelligent model of decision making, focused on oral health learning in babies. The decision model, present in the artificial intelligence of the game served

as a challenging and motivating element in the process of learning and information of the target audience.

METHODOLOGY

The development of this work consisted of five steps. The first of these was held an exploratory research to identify computer applications developed in the form of serious games for: Odontology research in scientific papers, selection of commercial games and serious games presented in educational campaigns.

In the first step, the repositories of scientific papers surveyed were: IEEE Xplore, Science Direct, PubMed.gov CAPES Journals, on-line library of SBC and Google Scholar. This phase included the search in 30 journals (20 and 10 multidisciplinary computational) and 9 specific conference proceedings games, from 2005. The surveys were conducted through searches of the following keywords in the repositories highlighted: Health computer games, serious games, interactive computer games, computer games in Dentistry, serious games in Dentistry, serious games, video games, computer games in Dentistry, serious games in Dentistry and pediatric Dentistry games.

In the following step of the survey, the search strategy was restricted to websites of companies related to the development of serious games and games research on search sites such as Google and Bing. Some web sites referred several games developers. The following are listed the repositories and searched researches (links updated at June 10, 2015).

Website: http://jogosdedentista.com

Website: http://www.hospitalgames.co.uk/dentist-games

Website: http://jogosdedentista.com

Website: http://www.hospitalgames.co.uk/dentist-games

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Website: http://www.hospitalgames.co.uk/dentist-games

Ito (2011) [9]

Kolesnikov et al. (2009) [10]

Rodrigues et al. (2014) [11]

The games selected in the survey were analyzed and evaluated in relation to the following features: theme explored, target audience, differential, distribution and display. In this analysis, were discarded the games not related to serious games, i.e., that not linked or transmitted specific information to the player during the interaction.

In this sense, began the second stage of that work with a survey of exploratory type for the query to the target audience by the use of a test application. The survey scenario was the Pediatric Dentistry Clinic at the Federal University of Paraíba – Brazil, and the subjects were the mother users of this service. For the research we designed a form consisting of four groups of questions: the mother's relationship with the dentist, the socioeconomic profile, the general knowledge on the subject and the mother's impression of the tested games. The data collection procedure consisted of an interview with mothers by an extended format survey (because of the number of questions). The data obtained in the forms were analyzed descriptively, using absolute values and percentages. From these results, the most appropriate approach was defined for the proposed serious game.

The results of the research with the target audience were used for designing the final script (third stage) and development (fourth stage) of the game serious "Uma Aventura na Floresta da Dentolândia" (An Adventure in the Toothland Forest). In the final step, the game was rated at the same site of the previous survey, in order to identify the acceptance of it, its effectiveness and get suggestions from players.

This research was approved by the Committee of Ethics in Research with Human Beings (CEP) of the University Hospital Lauro Wanderley (HULW) at the Federal University of Paraíba (UFPB), Protocol no 167/09 and FR: 285463. The collection of data relating to the tests, was held at the Pediatric Dentistry Clinic and Integrated Children Clinic belonging to the Federal University of Paraíba. The study received partial funding of Higher Education Personnel Improvement Coordination (CAPES) and the National Scientific and Technological Development Council

(CNPq).

RESULTS

a) Analysis of the Serious Game in Dentistry

In the first stage of research were identified 24 serious games related to oral health, having been observed a predominance of two groups of target audience: Dentistry students and children. In general, the games aimed at children discuss concepts related to nutrition and oral hygiene. Another group of games was directed to students and Dentistry professionals and were based on realism in order to reinforce learning or training skills. We also observed that the existing tools on the market and in the literature, considering the period and analyzed, were limited to four main themes: fundamentals of oral health, oral hygiene of children and adults, trips to the dentist, and professional training.

From the results of the exploratory analysis it was possible to notice the absence of targeted games for the education of mothers and baby caregivers. Unlike games geared to training or professional training, it was noted that the serious games for children aimed at directly affect the health of the player and not a third person, as in the case of babies oral hygiene.

In order to design a serious game for such a purpose, a new planning stage was initiated in order to define and understand the potential target audience of the game.

b) Serious Game Planning

There are no standards set for the planning and development of a serious game focused on health, specifically for Dentistry. However, two factors need to be defined primarily in any game: the target audience and the goal. Only with these two specified points is possible to move on to the next steps of design a serious game for education: pedagogical planning, choice of methodology, definition of the script and elaboration of the challenges. In this sense, this work defined the mothers as target audience and the objective to inform and educate those players about concepts related to the oral health of babies.

During the game serious planning “Uma Aventura na Floresta da Dentolândia”, the meetings of the multidisciplinary team were instrumental in the development of various aspects of the game, including: the relevant pedagogical concepts in the subject and the need for a prior analysis of the view of the audience. The proposal of the final product - a game - not intended to replace the role of health professionals in developing health education actions, but be an extra tool and character assist in the information process or ratification of the concepts related to the oral healthcare of babies.

For didactic reasons, the planning stage of this project was divided into the following subsections: definition of the pedagogical content, ethical aspects of the design and planning of the tests with the target audience. In this project, the definition of the educational content took place under the supervision of a Dental specialist, which has made possible to organize the content covered in the game on eight topics:

1. Aspects related to diet;

2. Oral hygiene techniques in babies;

3. Eruption of deciduous teeth;

4. Risk factors in the development of mammary caries and childhood caries;

5. Trip to the dentist: information about appropriate age to take baby to the dentist and what to expect of the first consultations;

6. Techniques to teach good oral hygiene behaviors to the child;

7. Diseases that the caregiver can pass to the baby through the mouth;

8. Importance of oral health of the mother and her baby.

The process of developing the serious game traveled, generally speaking, the following stages: conceptualization, definition of the Design Bible[2], prototyping, production and implementation of sound/images, testing and finalization of the product. For game planning, this study used a methodology based on the evaluation of the game Communication Approach. The Communication Approach encompasses a number of important elements in the construction of the game, including: concocting, type of narrative, storytelling, plot, environment, interactivity, game genre and game play. Therefore, these are important elements in both stages of conceptualization and definition of Design Bible, since they define how the educational content should be displayed on the screen and explored by the player[12]. The definition of this approach followed the strategy:

- Planning, with the multidisciplinary team, of the Communication Approaches used in the assessment;

- Construction of the prototypes storyboard of the Communication Approaches;

- Meeting with the multidisciplinary team and correction of the storyboard;

- Development of prototypes;

- Tests with the target audience;

- Evaluation of the results.

In order to evaluate which approach more suited to the target audience, we developed two prototypes to test different approaches, so that potential users could test and opine on the prototypes. This information was relevant in the construction of the serious game because influenced directly in drafting the script, challenges, in the making of the messages, in the construction of scenes and in the forms of interaction offered to the player.

The approach prototypes constructed were divided into two types: Formal and Recreational. The conceptual basis explored in the two prototypes was the same, so that the distinctions between the Communication Approaches were explicit.

In Formal prototype, was built a script closer to the reality of mothers, based on a board game. To win, the player should respond to everyday issues related to oral health of the baby, and in some moments also get tips on the theme explored. The game defied the mother to reach the end of the board and solve all the challenges. In this context, the messages were directed to the adult audience, using technical terms at times, besides being formed by phrases and simple sentences, but with a more serious language. The speeches were direct and targeted to the user during the interaction. Completing this scenario, environments and the prototype screens were composed by routine, as images: children brushing their teeth and a familiar routine. The environment was a motivating element and was not allowed for the player to interact with it. In this prototype were explored concepts related to generalized information about the oral health of the baby. The interaction with this prototype occurred through the keyboard, in simplified form. On construction of an interactive narrative, was taken into consideration the concept of unity, that is, a narrative with beginning, middle and end. Therefore, it was necessary to react to the player interactions not only aesthetic but also in certain respects in particular pattern that allows the player to understand, learn and eventually master the game. In both approaches, an attempt was made to which such element was present.

The Playful approach was characterized by the presence of a script and a narrative full of fun elements without losing the theoretical basis that subsidizes the serious games. In this prototype the adopted script was the following: in a land far away there was a king and a queen who just had a daughter. Child birth was cursed by the witch Tartar so that if the Princess has a dental problem all of the Kingdom will be with sad smiles and rotten teeth. So that this doesn't happen, the player was stimulated to help the King and the Queen to prevent such a curse. The speeches were prepared based on the plot, so it had as interlocutors magical teeth who talked with the mother throughout the interaction. During the making of the environment and the screens it was possible to explore imaginary elements such as speaking teeth, the wizard and the enchantment. After being offered the challenge in the game, the audience should start a search to the magical teeth in one of the royal halls of the castle. If the mother can solve the problem situations exposed the game, receive the title of royal heroine. The content exploited in this approach were the same Formal approach, with the

difference present in the form of presenting such information to players.

Prototypes related to Communication Approaches have been tested at the Pediatric Dentistry Clinic of the Federal University of Paraíba. The clinic is frequented by low-income mothers who seek free and quality dental care for their children. The sample was evaluated by mothers between 25 and 35 years of age, being the most literate and averaging 2 to 3 children. However, the familiarity of this population with informatics was unknown. Initially, the mothers interacted with the prototype related to the Playful approach and then with the Formal. After playing the two test prototypes, the form of assessment was applied in the form of interview and the data were recorded by the interviewer. This testing stage evaluated the opinion of 20 mothers and occurred from October to November of 2010.

The average time to play the two prototypes and respond to the form was 35 minutes for each mother. In order to optimize the time during interviews, a strategy for addressing the mothers was adopted. The steps adopted in this strategy were:

- Present the research proposals and goals in the clinical waiting environment, directed to mothers who are awaiting service;
- Invite mothers to individually test and present the prototypes;
- If the mother would accept the invitation, the informed consent was presented, clarifying the proposal for data confidentiality;
- From that moment, the mother interacted with the Communication Approach prototypes;
- The form was applied, acknowledgments made and research finalized.

In general, the mothers had found it easy to play the prototype approaches. Most were afraid when receiving the notebook (in their hands), for fear of breaking or perform some action that could break the machine. At this point, it was stated verbally that it was not necessary to fear because the interviewer would be there to help them in case of any doubt. The exclusion criteria adopted in this stage of the research were: parents, women who are not mothers, illiterate mothers and children.

The predominant age group in the test was of mothers over 38 years, corresponding to 60% of the interviewed. Other interesting information is that 65% of the mothers said they have computer knowledge. However, such limitation didn't affect their performance and motivation during the games. In general, mothers found interesting the idea of making a game geared towards them about this issue. The importance of a serious game for the intended purpose became clear to find a reality in which more than 80% of the mothers interviewed had not received any guidance related to oral hygiene. In this group of mothers, were found cases of some who brought their children to treat early childhood caries due to a bad oral hygiene during lactation phase. Misleading information

about oral hygiene were proven in this sample.

The distinctions between the approaches were noted by the mothers during the interactions. However, the most relevant differences, according to them, were the narratives. This fact was evidenced by the understanding of the messages in the two approaches. The interviewer's diaries recorded that mothers were more attentive to issues in the Playful Approach and they usually had a better performance in this approach, because of greater involvement caused by plot and by the script.

When assessing the motivation element in both approaches, we noticed a small percentage difference between them. In the Playful approach, mothers who stated feeling some kind of motivation have reached 90% of the interviewed, these 35% claimed to be very motivated, 95% of the Formal approach opposed, with 30% saying they were very motivated. However, the interviewer diary reported that mothers showed greater willingness to finish the Playful Approach because they wanted to "save the princess". Another criterion assessed in this work was the standard note attributed by the mothers of each of the approaches. The grades were given within a range of multiple choice, from 1 to 5. At the end of the testing stage, the playful prototype achieved an average score of 4.6 contrasting the 4.4 obtained by the formal prototype. Again, the results observed in the application of playful approach suggested a better performance than the formal approach[13,14].

c) Development of the Serious Game

Once completed the planning phase and after meetings with the multidisciplinary team, the adopted storytelling of the game was: "Once upon a time there was a mother who never took care of the oral health of her newborn child. Seeing such carelessness, the Tooth Fairy decided to test her, because she saw that the mother loved his baby, but did not know that their oral hygiene was important for their well-being and health. Then the Tooth Fairy made a magic and led the mother to an enchanted forest, dominated by the Toothless Witch. To return from this dream the mother (player) must prove their knowledge related to the oral health of babies. For this, she must solve challenges, find tips and find the keys to open an enchanted chest, where is the map for the lair of the Toothless Witch and the Magic Brush to release the imprisoned babies. To get to the treasure chest, the mother needs to address the challenges and issues and achieve the bonus to receive chest key parts. The challenges proposed by the Fairy will involve topics related to infant oral health. In the Toothland Forest, the mother meets enchanted beings, keys, tips and challenges to reach the enchanted object. The mother can only get to the last challenge if she achieves the previous ones and will only free the babies if she has enough strength to overcome the Witch.". Therefore, the game features four main characters: the mother (player), the Toothless Witch, the Tooth Fairy and the enchanted rabbits. The vision of the game is in First Person and is through the mother character that the player explores the Toothland Forest. The Tooth Fairy helps the audience to break the

existing spell in bonuses and enchanted rabbits provide the clues. The magical tools were hidden by the Toothless Witch and she presents the challenges to break the spell of the tools.

The interaction with the serious game occurs through the mouse and keyboard, since the game's target audience is a very heterogeneous group with respect to computer skills. This serious game falls into the category of clues game, as the player must find the magic tools through the clues received for each correct challenge. They only win the game if they get all the tools and get enough points to destroy the Toothless Witch, saving the babies. The game features three main scenarios: The Toothland Forest, the Toothless Witch's house and the Witch's lair. The last two scenarios are only released throughout the levels. The forest has four differentiated regions where the player navigates through most of the interaction. The navigation menu will lead the audience to the next steps.

In this phase of development, the pedagogical script was outlined. However, the issues related to the oral health of the baby needed to be defined. For this, it was necessary to outline the types of questions that appear during the game. In this context, three groups were designed: the bonus, the tips and the challenges. Each of them is required at specific times of the serious game. For example: bonuses are activated when the user tries to get enchanted brushes; the tips appear when the user interacts with the magic smiles; and the challenges are presented when the user has all the magic brushes and find the magic level tool. Another relevant difference between these groups is the goal of each one of them. While existing questions in tips exploit the true-false dynamic in the answers, the questions of bonuses and challenges using contextualized answers to routine baby care. In addition, the difference between the bonuses and the challenges is the complexity of the issues, because the challenges contain the assertions with higher levels of difficulty.

Once the logic database handling was sketched, we felt the need to prepare a data stream outline for the serious game "Uma Avntura na Floresta da Dentolândia" This activity was relevant in the context of multidisciplinary work, because it allowed the team kind of like on the dynamics of the tool. The use of diagrams to clarify the game flow was important for the next stages of the project, such as construction of the decision tree and choose the artificial Intelligence methodology, among others.

d) Decision model of the Artificial Intelligence

The decision-making process is an action performed naturally by man. This capability is important for the growth, learning or just for the course of life. People decide based on odds constantly calculated and stored in their heads. The brain continuously accumulates portions of visual and auditory information as someone observes a scene, eventually gathering enough to take what you believe to be a decision needs[15]. Incorporate the power of decision to the universe of

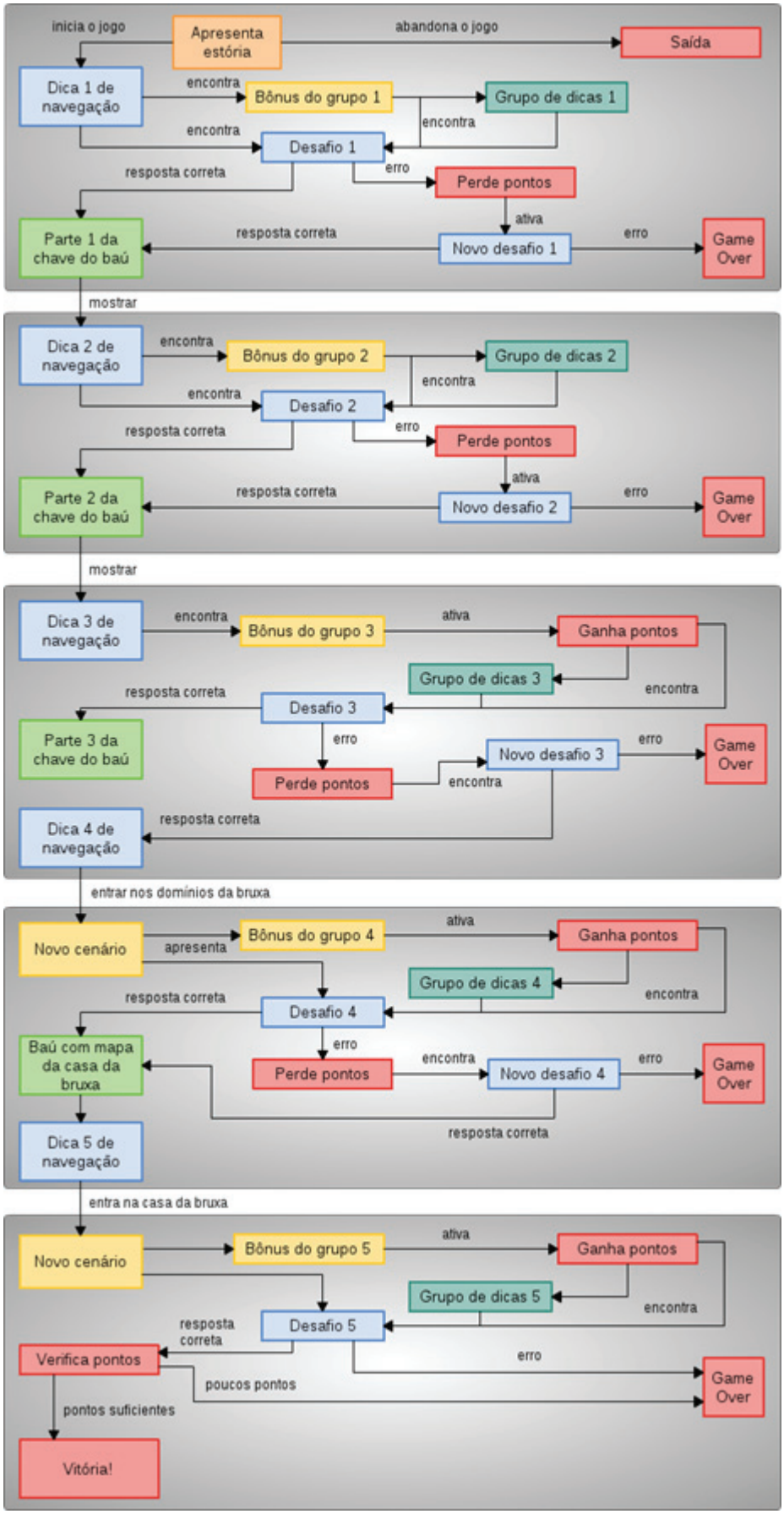
serious games allows the enrichment of pedagogical practice, allowing the free trial, the challenge, the simultaneous operation of several senses and the motivation of the learning process.

The partnership between the decision-making process and the serious games happens by means of Artificial Intelligence (AI). It is embedded in games in order to deal with the player's decisions and react automatically. This reaction is given by the artificial intelligence of the game, which can be based on decision models.

The AI is usually incorporated into the designs of games as a separate module that interfaces with the game engine. These can act in different ways and with different objectives, highlighting: control opponents, assessment of decision-making processes of the player, control the levels of difficulty, action planning, forecasting trajectories of characters and changing states. In addition to these, Bourg and Seeman[16] also consider drive algorithms and collision between elements as important parts of it. The choice of type of AI and the area of expertise in serious game is set in the planning stage. In this context, various techniques and methodologies are referenced in the literature, including: state machines, neural networks, Bayesian networks, fuzzy logic, rule-based systems, search algorithms and genetic algorithms. This paper adopts the term AI to refer to machine decision-making. Millington[17] states that in serious games the AI can act on different levels, such as: moving, decision-making and strategy.

From the detailing of the game flow, it was possible to structure and develop the related aspects of the game. In this process, some steps needed to be considered: the decision tree construction of the game, the development of a graph of events and, ultimately, the choice of AI methodology adopted. Set the central theme and the direction of the script throughout the game, it was possible to describe the actions and events that will occur in accordance with the decision-making process of the target audience. With these data, we built up the project's decision tree[18] (shown in Figure 1). This diagram allows visualizing the consequences of the player's decisions and related random events. Decision trees fit the problems easily representable by the attribute-value pair. However, another approach to this problem was to use a pre-built tree, which is only consulted in the course of the game. In multidisciplinary projects, this methodology is widely used because it allows all the components of the team talk about the consequences of a decision. This fact can be justified by the clarity and simplicity of these diagrams.

Figure 1: Decision tree of "Uma Aventura na Floresta da Dentolândia".



Another important diagram for the game was the event graph. It was built to facilitate the analysis related to the choice of the AI, showing in details the events and their transitions according to the dynamics of the game. Its construction used information taken from the decision tree and the Game Bible project. Each event featured in this diagram should present only one input and one output according to its definition.

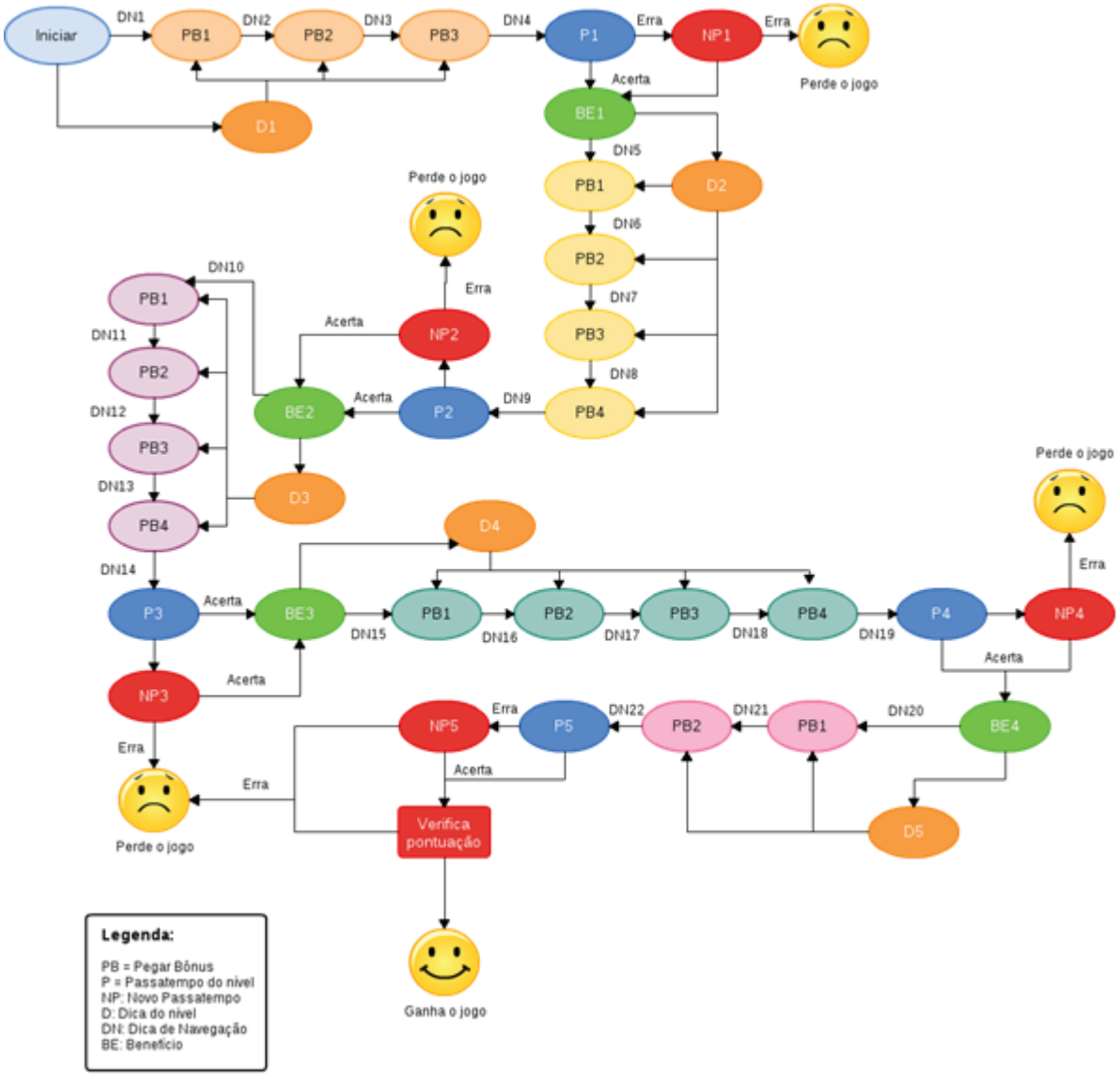
The event graph in the context of the serious game "Uma Aventura na Floresta da Dentolândia" (Figure 2) shows the sequence of events according to the presentation of bonuses, tips and challenges throughout the levels.

When starting the game, the graph shows that the user must solve all the existing bonus in brushes delighted to turn the challenge level and thus get the magic tool. For this, the player receives navigation tips in order to get to the enchanted brushes and tools. However, they should still worry about activating existing magical smiles throughout the environment because they give extra force points in the case of a correct answer. These points are checked on the last level to evaluate if the user holds sufficient knowledge to fight against the Toothless Witch and save the babies. The magical smiles earn teeth throughout the levels and simulate the baby's mouth. If the user does not activate the smiles and only gets the brushes, the game activates extra questions to assess their knowledge.

In a way, the graphs of events present information given by the decision tree, but in a more detailed and sequentially manner. This type of display was important during the analysis of the nature of the events that the serious game AI should address.

When analyzing the events chart and decision tree of the game, it was realized that it was possible to map all states and events handled by the AI during the interaction with the player. Therefore, deterministic AI methodologies were considered for this project. However, to better understand the dynamics of this serious game, the states were divided in three distinct entities: the tools, the player and challenges. For each entity, were modeled states and the events that occasioned the change between them. After the mapping of the states it was possible to affirm that the use of the Machine State was essential for the proper operation of the game. After the analysis of the types of machines and their characteristics, it was necessary to reach some conclusions related to the AI choices and their possibilities[16]. Initially, the events were defined as finite and deterministic, so it was possible to work with nearly all types of state machines, except those composed by: Concurrent states, associated with neural networks and Bayesian networks; Hierarchical states with Bayesian network; and Finite states, related to Bayesian networks.

Figure 2: The game serious events graph “An Adventure in the Toothland Forest”.



Other relevant information is the variable type of the serious game developed. In this case, the game input variables do not belong to the group of fuzzy variables, which deal with uncertain values. This fact excludes another group of techniques: Fuzzy state machines and Fuzzy hierarchical machines because such methodologies deal with indeterminate or uncertain states, characteristic of fuzzy logic. Finally, the methodology chosen for this serious game was the use of Finite state machine based on classical logic, because this method deals with finite and deterministic events, in addition to perfectly associating with classical logic. Another advantage is the low use of processor (CPU) resources. In computer games this concern is relevant because the graphics processes consume much of the hardware processing.

Of all the AI techniques currently used in games, Finite state machines are the most used, not only because they are easy to understand and program, but also because they are applied to almost all kinds of problems[16]. This technique can be used along with other existing AI techniques such as neural networks or Fuzzy logic, and allows separating each possible behavior of an entity in different logical states. The use of Finite state machines in games, although simple, can produce results in which intelligence is at least apparent, i.e. reaches one of its main goals. Classical logic in computing is based on Boolean logic, working with the verification rules previously established by the specialist and returning true or false. In the case of state machines used in games, this logic is embedded in the rules for the transition states of the entities defined. It's a simple technique to implement, but requires proper planning and states the rules of the game.

As previously mentioned, the Finite state machines can easily be associated with other AI techniques. In this context, in the implementation phase of the intelligence of the serious game occurred the need to control the following situation: monitoring the performance of the mothers during the tips. For this, intelligent agents were used. Lima[19] defines intelligent agents as components that can interact with the environment around them by means of sensors and actuators. In this case, the agents activate special tips for mothers who have low scores or did not open any hint at the level.

The Serious Game "Uma Aventura na Floresta da Dentolândia".

The resulting product was the game "Uma Aventura na Floresta da Dentolândia" (An Adventure in the Toothland Forest) (Figure 3). This application is the result of the analyses carried out on the serious games in dentistry and the practical application of AI methods for informative and educational purposes. It is noted that the construction of the game was based on Playful Communication approach and key elements of the game follows its characteristics.

After starting the game, the player enters the Toothland Forest. To guide them through the levels and challenges there is a navigation menu at the bottom center of the screen that will always show them the next steps that should be performed. However, there are other on-screen graphics that guide the player during the adventure, as can be observed in Figure 3.

Figure 3: Scene of game “Uma Aventura na Floresta da Dentolândia”.

A survey was conducted to assess the opinion of the target audience, which was intended to observe the interactions of users with the game and gather views on various elements of the tool. The form was built with the multidisciplinary team and applied in the Pediatric Dentistry Clinic of the Federal University of Paraíba. The sample was voluntary. The form was divided into the following parts: impressions of the game, relationship with the dentist, general knowledge and socioeconomic profile. In the end, the tests were conducted with a sample of 15 mothers accompanying their babies at the clinic. The average time of interaction was 55 minutes per mother. After using the game, mothers respond the questions on the form, presented by the interviewer.

At first, the target audience opined about their impressions regarding the serious game. In general, the mothers liked the game, and 100% indicated that they believe the fact of these applications helping in learning and, above all, on the acquisition of concepts related to the oral health of the babies. At the end of the interaction, about 87% of the participants surveyed obtained some new knowledge that they intend to pass on to someone they know or a family member. Within the analyzed sample, about 53% of the mothers successfully finished the game. Those who failed to finish the game indicated the lack of time or the end of their child’s appointment at the clinic.

Subsequently, the opinions reported on the form were analyzed on three points: the game in general (beginning-middle-end), the challenges presented and the messages (and the discourses used in the challenges). The reviews were positive in all these aspects. The target audience felt very motivated to interact and successfully complete the application. This motivation helps in the player’s immersion process in the plot, as well as improving their cognitive processes. In this regard, only one of the mothers interviewed felt little motivated with the application. During the

tests, many mothers expressed a willingness to introduce the game to other relatives and suggested adding an avatar to navigate through the forest.

CONCLUSIONS

During the bibliographic survey carried out for this research, we found several serious games related to Dentistry. These applications have well defined characteristics that can be compared with the resulting serious game of this work. The first analysis that must be highlighted is the type of visualization of this game. Amid applications predominantly 2D, the game "Uma Aventura na Floresta da Dentolândia" emerged as a specific 3D tool to inform on concepts related to the execution of oral hygiene since the deciduous dentition.

Two main aspects can be highlighted in the work: the adopted theme (oral health in babies) and the defined target audience (baby caregivers). Confronting the data collection applications, which shows the predominance of topics related to health and oral hygiene to a widespread audience, it should be noted that this work has developed a serious game of unprecedented and relevant theme (considering the analyzed databases).

At the same time, the evolution of the target audience of games deserves attention. Despite the analyses carried out previously in this paper, the final test step resumed a questioning present in the whole game construction process: the expansion of the target audience. This change is natural given the increasing participation of parents in the education and care of babies. This fact was witnessed during the final testing stage, where a large number of parents stood in the waiting room of the Pediatric Dentistry Clinic. In anticipation of these changes, the serious game "Uma Aventura na Floresta da Dentolândia" has been modified to: avoid direct discussions with the mother in the messages throughout the game and use the first-person view to prevent female avatars.

Another particular feature of this serious game is the targeting of information to the public focus. Usually, in serious games with educational purposes, the content is transmitted directly to the target audience. However, when it has focus on babies there is a change in this flow of concepts. That is, the information is transmitted to third parties to affect, in fact, the target subjects.

During the planning and construction of the serious game it was necessary to ensure that the players would find, throughout the levels, all the basic information of the theme, regardless of the paths taken by them, keeping their motivation and interest. Therefore, the decision-making processes of the player were analyzed in a decision tree to define the AI methodology best suited for the problem. In this regard, AI was implemented based on finite state machines associated with reactive agents, encouraging, challenging and assisting the player's route. It is important to note that there is no default AI methodology directed to serious games related to Dentistry and to

the definition of the techniques should be undertaken through studies and analysis of the game intended. Within this category of games, concepts and information transmission must be considered carefully so that no aspect is forgotten.

The results found in this research allowed to verify that the thematic possibilities are broad for serious games. Thus, issues such as oral health in babies, oral hygiene in elderly care, oral hygiene related to the use of dental appliances and oral care in pregnant women are real application possibilities.

REFERENCES

1. Kebritchi M., Hirumi A. Examining the pedagogical foundations of modern educational computer games. Computers & Education. 2008; 51(4): 1729-1743.

2. Moraes RM, Machado LS, Marques FLSN, Costa RMEM. Serious Games and Virtual Reality for Education, Training and Health. In: Maria Manuela Cruz-Cunha (Ed.). Handbook of Research on Serious Games as Educational, Business and Research Tools. IGI Global, 2012. p. 315-336.

3. Machado LS, Moraes RM, Nunes FLS, Costa RMM. Serious Games Baseados em Realidade Virtual para Educação Médica. Revista Brasileira de Educação Médica. 2011; 35(2): 254-262.

4. ABRAGAMES. I Censo da Indústria Brasileira de Jogos Digitais. 57p. Disponível em: http://www.abragames.org/files/downloads/829630556e3acdd35ff.pdf. Acesso em jul/2015.

5. Almeida TF et al. Family context and incidence of dental caries in preschool children living in areas covered by the Family Health Strategy in Salvador, Bahia State, Brazil. Cadernos de Saúde Pública. 2012; 28(6): 1183-1195.

6. Brasil. Ministério da Saúde. Secretaria de Atenção à Saúde. Secretaria de Vigilância em Saúde. SB Brasil 2010: Pesquisa Nacional de Saúde Bucal: resultados principais / Ministério da Saúde. Secretaria de Atenção à Saúde. Secretaria de Vigilância em Saúde. Brasília: Ministério da Saúde, 2012. 116 p.

7. Silveira ER et al. Maternal attitudes towards tooth decay in children aged 12-18 months in Pelotas, Brazil. European Archives of Paediatric Dentistry. 2015; 16(5):383-389.

8. Bueno RE. Protocolo de atenção à saúde bucal por ciclos de vida. Revista Gestão &Saúde. 2010; 1(20): 18-26.

9. Ito C. Uma Alternativa de Conscientização Sobre Prevenção Odontológica: Desenvolvimento e Avaliação do protótipo de um Serious Game [Dissertação]. [São Paulo-Brasil]: Centro Estadual de Educação Tecnológica Paula Souza; 2011. 93 p.

10. Kolesnikov M., Zefran M, Steinberg A, Bashook P. PerioSim: Haptic Virtual Reality Simulator for Sensoriomotor Skill Acquisition in Dentistry. IEEE International Conference on Robotics and Automation (ICRA'09); 2009 May 12-17; Kobe, Japan. p. 689-694.

11. Rodrigues H, Machado , Valença A. Applying Haptic Systems in Serious Games: A Game for Adult's Oral Hygiene Education. SBC J. on Interactive Systems. 2014; 5(1): 16-2

12. Schell J. A Arte de Game Design: o livro original. Rio de Janeiro: Campus. 2011.

13. Morais AM, Rodrigues HF, Machado LS, Valença AMG. Planning Serious games: Adapting Approches for Development. Lecture Notes in Computer Science. 2010; 6249: 385-394.

14. Morais AM, Machado LS, Valença AMG. Definindo a Abordagem de Comunicação no Planejamento de um Serious games Voltado para Saúde Bucal em Bebês. XXX Congresso da Sociedade Brasileira de Computação – X Workshop de Informática Médica, 2010 Jul 20-23; Belo Horizonte/MG, Brazil. p. 1556- 1565.

15. Green CS, Pouget A, Bavelier D. Improved Probabilistic Inference as a General Learning Mechanism with Action Video Games. Current Biology. 2010; 20(17): 1573-1579.

16. Bourg DM, Seeman G. AI for Game Developers. O'Reilly. 2004.

17. Millington I, Funge J. Artificial Intelligence For Games. CRC Press. 2ª edição, 2009.

18. Leite Jr AJM, Severo APA. A Importância da Imagem no Processo de Imersão do Usuário em Jogos Eletrônicos. VII Simpósio Brasileiro de Jogos e Entretenimento Digital (SBGAMES); 2008 Nov. 10-12; Belo Horizonte/MG, Brasil. 10p. Disponível em: http://www.sbgames.org/papers/sbgames08/artanddesign/full/ad1_08.pdf.

19. Lima I, Pinheiro C, Santos F. Inteligência Artificial. Rio de Janeiro: Elsevier, 2014.

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Modelagem do Comportamento Hemodinâmico de um Paciente Virtual Cirúrgico baseado em Sistema Especialista *Fuzzy*.

Hemodynamic behavior modeling of a Virtual Surgical Patient based on a Fuzzy Expert System.

Modelado de comportamiento hemodinámico de un paciente quirúrgico virtual basado en un Sistema Esperto Fuzzy.

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RESUMO:

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