Original Article

Construction of serious games for adolescents with type 1 diabetes *mellitus*

Construção de *serious games* para adolescentes com diabetes *mellitus* tipo 1

Elaboración de *serious games* para adolescentes con diabetes *mellitus* tipo 1

Andréia Régia Rodrigues de Matos Serafim[1]
Amanda Newle Sousa Silva[1]
Caroline Magalhães de Alcântara[1]
Maria Veraci Oliveira Queiroz[1]

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Pediatric nursing; Diabetes mellitus, type 1; Video games; Adolescent; Health education

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Descriptores
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Abstract

Objective: To construct serious educational games for adolescents with type 1 diabetes *mellitus*.
Methods: Methodological research, based on patient-centered design, conducted in three steps: literature review and subjects' involvement; design and production of the prototype; usability assessment.
Results: The production of serious games was based on scientific literature and suggestions of adolescents. The educational content was presented by the *Didi* character, about habits of daily living: waking up, personal hygiene, monitoring of capillary glycemia, and insulin administration. In this sequence, the player observes therapeutic actions, including healthy food choices. In the usability assessment, the adolescents considered the requirements of gameplay, content, and design to be satisfying.
Conclusion: The usability test resulted in positive validation, and the suggestions contributed to improvement of the quality of the functions and interactions, favoring the achievement of the goals of the game. Thus, the technology has properties to improve the care of adolescents with type 1 diabetes *mellitus*.

Resumo

Objetivo: Construir *serious games* educativo para adolescentes com diabetes *mellitus* tipo 1.
Métodos: Pesquisa metodológica, fundamentado no *design* centrado no usuário e efetivado em três etapas: revisão de literatura e envolvimento dos sujeitos; concepção e produção do protótipo; avaliação da usabilidade.
Resultados: a produção do *serious games* foi pautada em literatura científica e sugestões de adolescentes. O conteúdo educativo foi apresentado pelo personagem Didi sobre hábitos de vida diária: acordar, realizar higiene pessoal, monitorização da glicemia capilar e aplicação de insulina. Neste percurso, o jogador observa ações terapêuticas incluindo escolhas de alimentos saudáveis. Na avaliação de usabilidade, os adolescentes consideraram satisfatórios os requisitos de jogabilidade, conteúdo e *design*.
Conclusão: o teste de usabilidade teve validação positiva e as sugestões contribuíram para melhoria da qualidade das funções e interação, favorecendo o alcance das metas do jogo. Assim, a tecnologia apresenta propriedades para melhorar os cuidados dos adolescentes com diabetes *mellitus* tipo 1.

Resumen

Objetivo: construir *serious games* educativos para adolescentes con diabetes *mellitus* tipo 1.
Métodos: investigación metodológica, con fundamento en el diseño centrado en el usuario y realizado en tres etapas: revisión de la literatura y participación de los sujetos, concepción y producción de prototipo, evaluación de usabilidad.
Resultados: la producción del *serious game* se realizó de acuerdo con literatura científica y sugerencias de adolescentes. El contenido educativo fue presentado por el personaje Didi sobre hábitos de la vida cotidiana: despertarse, realizar aseo personal, monitoreo de glucemia capilar y aplicación de insulina. En ese trayecto, el jugador observa acciones terapéuticas, que incluye la elección de alimentos saludables. En la evaluación de usabilidad, los adolescentes consideraron satisfactorios los requisitos de jugabilidad, contenido y diseño.
Conclusión: la prueba de usabilidad tuvo validación positiva y las sugerencias contribuyeron para mejorar la calidad de las funciones de interacción, lo que favoreció el cumplimiento de los objetivos del juego. De esta forma, la tecnología presenta propiedades para mejorar los cuidados de los adolescentes con diabetes *mellitus* tipo 1.

Corresponding author
Amanda Newle Sousa Silva
http://orcid.org/0000-0001-5728-847X
E-mail: amanda.newle@aluno.uece.br

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[1]Universidade Estadual do Ceará, Fortaleza, CE, Brazil.
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Introduction

Type 1 diabetes *mellitus* is one of the most common chronic diseases in childhood, whose incidence continues to increase world wide.[1-3] Among the countries with the highest number of cases are the United States of America, India, and Brazil, which is ranked third.[3,4]

Some impacts to the social and economic life are caused by diabetes,[5] and the experience of adolescents with type 1 diabetes is permeated by confrontations and difficulties related to restrictions in habits, and the routine of intensive care, including a diet plan, glycemic tests, and insulin therapy, which, at times, limits their social life.[6]

Care is guided by a specialized health team, and involves educational interventions that should motivate the therapeutic adherence of the adolescent, and help him to face the challenge of metabolic control.[7] The literature review indicated types of technologies produced for health education of adolescents with type 1 diabetes; however, in the proposal of digital technology integrating the central care, no scientific evidence was found at the national level.

Learning must be meaningful, that is, incorporating content that adds to adolescents' previous knowledge, and thus favoring reflections and healthy behaviors with autonomy and independence.[8] Therefore, in order to reach this population, it is important to create interactive and motivating strategies, which promote health information about daily care.

In this sense, the expansion of information technology enabled the Internet, cell phones, social networks (Twitter and Facebook), electronic games, online education programs, tablets and other devices to include adolescents as the main users of these communication technologies.[9,10] In the digital context, the "serious game", understood as a serious game focused on health education,[11] that can provide adolescents with type 1 diabetes incentives for daily care. These technologies are present in their daily lives[9], therefore, they are tools of utility for educational practices regarding chronic illness situations.

The game is a space for learning, and provides playful, attractive, and innovative activity. Serious games are characterized by enabling the integration of the subject into the game from an educational perspective, stimulating adolescents in health care.[9,11,12] Another peculiarity of the game is the involvement of young people in the search to discover the virtual world,[10] promoting the link between play and learning, permitting the learning of rules, and encouraging health care.[11,13]

From this perspective, a "serious game" was developed with the purpose of promoting meaningful learning,[8] arousing the interest and involvement of adolescents in their health care. Given the above, the study aimed to construct serious educational games for adolescents with type 1 diabetes *mellitus*.

Methods

This was methodological research, which investigates, organizes and analyzes data to construct and validate instruments and research techniques.[14] The construction of the game was based on a pedagogical reference of significant learning,[8] with its design centered on the individual,[15] and was conducted between January and May of 2018, whose three steps of construction were: literature review and involvement of individuals in the field research; design and production; usability testing for prototype refinement.

In the first step, the review study was guided by the question: what educational technologies are developed for adolescents with type 1 diabetes *mellitus*? The databases researched were: National Library of Medicine (PUBMED), Cumulative Index of Nursing and Allied Health Literature (CINAHL), and the Database of Nursing (BDENF), using the descriptors, pediatric nursing, type 1 diabetes *mellitus*, video games, adolescents and health education. This resulted in 14 articles, which signaled the types of technologies produced for adolescent health education with type 1 diabetes, and the gap in serious games technologies. The results of this review, the manuals of the Brazilian Society of Diabetes,[4] and those of the American Association of Diabetes

Educators,[16] contributed to the design and content development, to include specific care for adolescents with type 1 diabetes.

The field research occurred in a reference center for the care of patients with type 1 diabetes, and aimed to understand their needs, and to involve these individuals. In this case, questions using a semi-structured script were answered by 16 adolescents, aged 10 to 19 years, and six care professionals: a physician, a nutritionist, a physiotherapist, and three nurses. The script included needs and interests, use of digital technologies, and suggestions on the presentation of the potential technology, such as colors, language, and sounds.

The second step was the development of the pre-production plan, based on the analysis of the previous steps: review of the literature and the involvement of individuals and professionals.[15,17] The prototype of the game was constructed in a software model using simulations and tests for improvement, ensuring good gameplay.

In the third step of the usability test, the game was adapted and improved,[18,19] and administered with five adolescents between 12 and 17 years of age, chosen by convenience sampling, performed at the same reference center for the care of patients with diabetes, in Fortaleza-CE, Brazil.

The evaluation of usability involved these adolescents in gameplay, and the test was administered in the waiting room, individually, when the game and the commands for use were presented on the computer. Each teenager had interaction with the technology for a mean time of 20 minutes. At the end of this time, a questionnaire was administered, which contained items and their scores, to identify if the game met its purpose, the effectiveness of the gameplay, and suggestions for improvement.

The questionnaire for usability analysis was adapted,[20] and included items about: attention, relevance, confidence, and satisfaction, seeking to observe the stimuli and in some way, the motivation aroused by the educational game, the individual expectations regarding the technology, engagement, and gameplay. Scores were applied on a Likert scale, with a score of 1 to 5 (unsatisfactory) and 6 to 10 (satisfactory).

The suggestions indicated by the adolescents during the evaluation of the game's usability were incorporated into the educational technology, with the help of a computer professional who made the proposed changes. This led to the revision and improvement of the identified dysfunctions.

The study was approved by the Research Ethics Committee of the State University of Ceará, receiving CAAE 74169617.7.0000 and opinion no. 2,468,749. The research followed the ethical precepts of human research, and the Terms of Free and Informed Assent Form was reviewed and signed by the adolescents and the Terms of Free and Informed Consent Form was signed by responsible adults; all the steps had the participation of these subjects.[21]

Results

The development of serious games is presented descriptively, from its inception and construction, to the usability test that was conducted with questions posed to the adolescents. Answers were compiled, with the individual notes and the mean, for confirmation of the validation test.

In the first step of the study, all articles from the international scope showed benefits in the use of technology for education of adolescents with type 1 diabetes. Counseling programs, text messaging systems, forums, blogs, social networking tools, applications, and online training programs with specific focuses, such as: reproductive education, glycemic control, feeding, insulin therapy, resolving self-management, and coping skills for diabetes. However, none of these studies, in the planned scope, was developed in the Brazilian context.

The adolescents emphasized their interest in using digital technologies, aspects that are present in their daily lives, namely: digital games and their access, through smartphones, tablets and computers, and the importance of illustrative materials and short sentences. The professionals pointed out the advantages of the use of technology, as they attend playful aspects of learning, and are present in the daily life of this population. They talked about lan-

guage, dynamic presentation with strong colors and sounds to motivate adolescents for daily care.

In the second step, prototype planning, the researchers met to draw strategies, discuss concepts, and to aggregate information from the literature reviewed and the field research. Eight meetings with information technology professionals and graphic designers were necessary, so that they understood the content and the context to be reached in the technological construction.

The operational phases of construction of the technology consisted of elaborating the Game Design Document, detailed report, artistic conceptualization, and gameplay and interface definitions of the game. The contents enclosed in the serious games, called "Battle of the Didi", had the purpose of awakening in the player autonomy for care, using the virtual world, associated to experiences in the real world.

The main character, named *Didi,* was the same on the website (www.diabetesemfoco.com) developed by the Child and Adolescent and Nursing Health Care Research Group (GEPCCA).

The game interface, shown in figure 1, has four options: play, ranking (with scores of each player), help (presents the objectives and tutorial of the game), and restart. The educational game is compatible with android and windows, dimension format (2D), using the Make Game Studio 1.4 engine. For the operation of the game and individual and computer interaction, we chose to use the keyboard.

The serious games consisted of five periods, which began with the *Didi* character waking up and performing his activities of daily living, predisposing himself to choices for self-care activities. Then, in the second stage, the adolescent checks the capillary glycemia, administers insulin, and gets the morning meal with healthy foods. At the end of this segment, *Didi* meets with the family that represents the primary social support to the sick person.

In the third phase of the game, *Didi* participates in physical activity, and makes decisions regarding the provision of healthy foods, or not; the adolescent will make choices in which, when opting for nutritious foods, he earn points. In the fourth phase, at the end of the class, *Didi* returns home

Figure 1. Presentation of the serious game, "Battle of *Didi*"

and goes to the market. At this point, he makes food choices that will comprise his diet, stimulating his food preferences, gaining points with healthier choices. In the fifth phase, it is time to go home, so he skateboards and takes some healthy food to consume later.

In these phases, synthesized in figure 2, obstacles and difficulties in the daily care routine experienced by adolescents with type 1 diabetes were inserted, which are represented by the characters (auxiliary avatars), that is, "demotivation" and "sadness". It is necessary that *Didi* avoid these barriers and overcome those agents which are often faced in the real world of daily care and treatment. If the player chooses to ignore the virtual obstacles and faces *Didi*, with the barriers imposed by "demotivation" and "sadness", the player loses points, and can reach the "game over" status, which means, literally, end of game; in other words, he has failed to complete the proposed challenge.

The virtual world represents challenges faced by adolescents with type 1 diabetes, which they have to face and overcome in everyday life, with the support of their social network, including family and health professionals.

Serious games, as well, have audible alert features, such as a wake-up call and the dub voice command, so the player can understand the rules and operation. Music was included to motivate the period when *Didi* performs physical activity, such as cycling and skateboarding, enabling the player to simulate the real world.

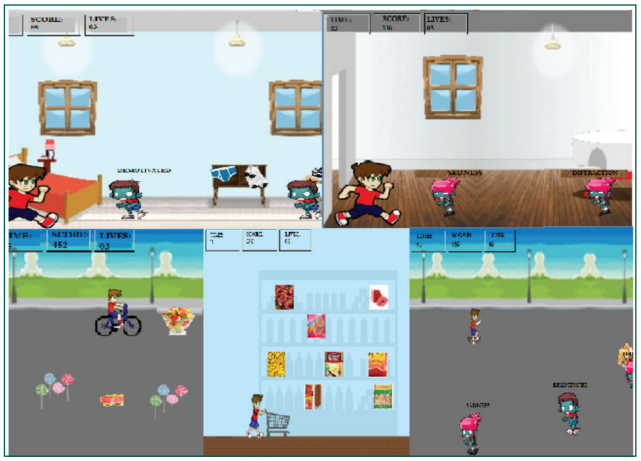

Figure 2. Serious game phases: "*Didi* battle "

The images used were designed by a graphic designer, along with other professional experts, who comprised the group of researchers mentioned. The purpose was to develop cheerful environments, strong and vibrant colors, and to be motivating, playful and provide familiar scenarios. The physical activities were practiced by *Didi* in urban settings.

In relation to the usability test, the evaluation criteria for educational games were presented, using the following dimensions: attention, relevance, confidence, and satisfaction. The adolescents made suggestions, and among them, was to improve the illustrations of the last phase, because the size of the figures was too small, which made it difficult to visualize and choose the foods integrated into the food plan. At the end, in the fourth phase, after the usability tests, the revision phase was performed, with all the suggestions accepted and modified by the programmer, a participant in the serious games construction team.

Discussion

Results were shown, related to the number of adolescents who participated in the gameplay test, and because they occurred in the office waiting room, their availability was reduced because their family showed haste in completing the task. However, adolescents immersed themselves in the gameplay proposal, demonstrating confirmation of interest in the game.

Thus, the possibility of contribution to nursing practice can be observed, especially in the development of educational interventions involving adolescents with type 1 diabetes. It is envisaged that the validation of this game will continue to increase the reliability and effectiveness of educational actions, enabling incorporation into the nurse's clinical care.

The script, or narrative, of the game presented a simulation of the daily life of adolescents with type 1 diabetes, encouraging them to make decisions in the virtual world, observing the routine of care and self-care behaviors.[16] Serious games as digital technology constitute a playfulness resource, which provides relaxation, interactivity, and possible educational actions, considering their acceptance and use are increasingly present in the daily life of adolescents, facilitating care for those with type 1 diabetes. In order to use the game, a computer, smartphone or similar tool is needed.

The technology has sought to provide health education by means of the web. The choice of the name of the game, "*Did* battle", occurred during the field research with the adolescents, seeking to represent daily challenges, interconnecting the virtual fictional identity with the real world lived with the condition of illness.[22]

The literature indicates that serious games impress virtual qualities that arouse the interest and adherence of adolescents, so that they learn and enjoy themselves, simultaneously.[12,13] Currently, they coexist with a multitude of information and technological resources that make them more and more autonomous and participative in the educational processes.[13] It is, therefore, recommended to involve them from the development phase, and in the process of functionality, expanding the possibilities of reaching the desired results.[15]

The constructed game enables players to achieve points, such as reward and interaction, in a simple and natural way, associating them with the routine of care, and thus serving this purpose. Educational technologies are necessary to facilitate nursing education and the practice of caregiving, as they raise the level of knowledge and motivate care.[11,23] Thus, it addressed the seven main behaviors of self-care from the American Association of Diabetes

Educators: healthy eating, glycemic monitoring, safe medication use, physical activity, problem solving, healthy coping, and risk reduction.[4,16]

From this perspective, challenges are shown, represented by the escorting avatars symbolized the feelings of discouragement and sadness, which are present in the literature.[4,24] These reactions compromise the therapeutic adherence and quality of life of the affected individuals. The reward mode in the educational game occurs through making the right choices, based on the knowledge focused on adhering to treatment, gaining points and motivating the participant to win each phase, and complete the game.

Thus, digital technologies, such as serious games, are considered to be a means of providing health education, a strategy that can stimulate care, as they are, often, challenging for adolescents.[20,22,25,26] This technology considers activities of the daily life of adolescents, with practices common to all, such as dressing, feeding, physical activity, and going to school. The participation of the health professionals helped with the development and facilitated the adequacy of the content, approaching the daily life of the individual.[27]

The study demonstrated the daily care activities of adolescents with type 1 diabetes, resulting from the continuous treatment that often starts during childhood. Health professionals and the family can substantially collaborate, in order to understand the need to comply with the daily routine and to avoid acute decompensations, such as diabetic ketoacidosis, among others, so that this adolescent cares for himself and has a healthy life that approximates, as much as possible, the life of those without diabetes.[15]

The first and second phase of the game represent self-management of daily care, such as hygiene habits, dressing, feeding and going to school, which are indispensable for the adolescent's development.[27] The game stimulates the adolescent regarding insulin administration and glycemic verification, because each therapeutic action accumulates points, and this will motivate him to achieve responsibility and greater autonomy in care.[25]

These activities, including healthy eating and insulin replacement, are critical to metabolic control. This therapeutic control blocks lipolysis and hepatic glucose production, whereas periods without insulin are causes of wide glycemic oscillations, adding insulin resistance factor which is provided by hyperglycemia itself.[4] Therefore, these aspects were stimulated in the game as a care priority for adolescents with type 1 diabetes.

Another important aspect for the treatment was physical activity, using cycling and skateboarding because they are common sports in this age group, which is important in type 1 diabetes.[4] The practice of regular physical activity reduces insulin resistance, facilitating the peripheral use of glucose, and contributing to improved glycemic control.[4]

In the fourth phase, the adolescent with type 1 diabetes is stimulated to make food choices, essential for treatment.[23] This is demonstrated in our study, when he goes to the market and chooses desired food. Another study showed that, although adolescents have an idea of what healthy eating is, they have difficulty accepting the restrictions, even knowing the consequences. Research indicates that they associate knowledge of healthy eating with what they are exposed to at school, and that this practice is associated with their quality of life. However, many still persist in ingesting non-nutritious snacks, such as fast food and treats. The change in eating behavior is not simple, it is an attitude that requires time, planning, and implementation of continuous educational practices, especially in the school environment, where they spend most of their time.[28]

To represent the difficult daily challenges, avatars were used as symbols, represented by "demotivation" and "sadness",[23] mostly experienced at the beginning of treatment. These are overcome by learning to live with some limitations, and to take care of the indispensable metabolic control. In addition, other negative feelings were stated, such as fear and insecurity about the new reality, permeated by dietary restrictions, physical limitations, and caregiver supervision.[28] Because the game is recreational, and a discovery activity that integrates the subject between the virtual and the real world, it can encourage adolescents to take care of their health.[11,12]

The participation of the target audience, contributing from the conception to the test of gameplay, enabled the contemplation of adolescents' needs, associating its purpose, strategy of teaching based on meaningful learning, and search to promote learning that moved beyond the mechanical or rote methods.[8] This technology, also a creative strategy, can make the adolescent aware of his/her own care, based on in context motivation, interactivity, and the dynamism of the information, proposing moments of relaxation and reflection.[14]

In the evaluation of usability, the adolescents judged the dimensions evaluated as satisfactory, and the indexes of agreement that qualify the game as a friendly interface that is uncomplicated to use, that is, the technological product, in the view of the adolescents, indicates a usability appropriate to the population for whom it is intended. Positive evaluations were therefore considered, according to the adolescents' perception, when they tried to play in a playful way and reached the expectations imposed by the challenge of the game.[29]

The usability evaluation data confirmed the pertinence for using it as an educational tool, because the proposed challenges corresponded to one of the most important aspects in games for this purpose. It needs to be challenging enough, appropriate to the player's cognitive level, and require increasing levels of skill and ability.[16,20]

In addition, the illustrations are strategies used in digital technologies to describe the content and induce meanings, in order to promote learning.[30] The adolescents evaluated the images and the scenario used in the dynamics of the game as satisfactory. It is undeniable that the educational actions, performed by health professionals with adolescents with type 1 diabetes, should be facilitated by educational technologies involving these subjects. Nurses are educated to use therapeutic behavior with patients, providing education and support.[31] The development of the game was based on content found in the literature, prior experience from a previous study, and evaluation made by adolescents about the usability of the game. These stages, developed in conjunction, have enabled us to infer that technology, as an educational proposal, expresses the prior knowledge of adolescents and awakens their spirit, encouraging them in the continuous care for their health.

Conclusion

The development of serious games was finalized, associating experiences and knowledge about the care of adolescents with type 1 diabetes; it brought their daily life, that is, real world situations contextualized in the virtual world, with experiences and obstacles in the course of care daily. This participation, even with few subjects, also materialized in the test of gameplay, which enabled, beyond interaction, improvement in the purposes of the game. Thus, the adolescents judged the proposal of the educational game positively on the observed items, demonstrating ease of use, noting that the rules were clear, and that the graphic presentation was motivating and interactive. The usability test showed a positive response by the adolescents, and their suggestions contributed to improving the quality of the functions and interaction, favoring the achievement of the goals of the game. Thus, the technology has properties to improve the care of adolescents with type 1 diabetes.

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Collaborations

Serafim ARRM, Silva ANS, Alcântara CM and Queiroz MVO declare that they contributed to the design of the study, analysis and interpretation of the data, essay writing, critical review of the intel-

lectual content, and approval of the final version to be published.

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