Developing a Serious Game for Children with Diabetes

Cecilia Sik-Lanyi\textsuperscript{1}, György Erdős\textsuperscript{1}, and Andras Sik\textsuperscript{2}

\textsuperscript{1} University of Pannonia, Egyetem Str. 10, Veszprem 8200, Hungary
lanyi@almos.uni-pannon.hu
\textsuperscript{2} Prolan Innolab Kft., Szentendrei út 1-3, Budakalasz 2011, Hungary

Abstract. A Serious Game has been developed for preschool-age children who have been newly diagnosed with type 1 diabetes. The name of this game is “for kids with diabetes” the shorter version is “4KidsDiab”. The 4KidsDiab program consists of two parts, an editor and a game part. The editor part is for the parents and they can adjust the game according to their child’s daily allowable carbohydrate meals. Parents can upload pictures and data of meal/food into the game database. The main menu of the game contains four games for children: “True/False quiz”, “Which food has more/fewer carbs”, “Take it to your plate” and the reward game: “Feed the figure” game. This paper shows the design, development and evaluation process of the game. The evaluation process has been based on the System Usability Scale. It is an innovative game because it is useful for children who have multiple diseases e.g. diabetes and gluten or lactose sensitivity.

Keywords: Serious Games · Preschool-age children · Life management · Lactose/gluten sensitivity

1 Introduction

1.1 Background

In the United States, diabetes is increasing in prevalence, and it is now the seventh leading cause of death; if today’s trends continue, by the year 2050, an estimated 48.3 million people in the United States will have type 1 or type 2 diabetes—almost double the current number [1].

The type 1 diabetes disease develops in childhood and the number of patients has tripled in the last thirty years. Currently, the estimated number of children with type 1 diabetes in the world is close to 601,000 [2], and under the age of 15, approximately 80,000 new cases are registered yearly [3]. In Hungary, all six-hundredths of children under the age of 15 are affected, and it is a particularly worrying phenomenon that the incidence of the disease in the youngest (under 6 years) age group increases disproportionately even compared to older children. Type 1 diabetes has become one of the most common chronic childhood diseases these days.

Lifestyle factors do not play a role in the development of type 1 diabetes unlike it is common in type 2 diabetes due to poor eating habits. Type 1 diabetes is an autoimmune
disease caused by a disorder of the immune system. The cause of type 1 diabetes has not been revealed in medicine in recent decades, only predisposing factors are known, such as familial accumulation, cow’s milk consumption under one year of age, and some viral infections. Diagnosis at the earliest possible stage would be extremely important.

Therapeutic options have evolved at a tremendous pace over the past 30 years, there are insulin pumps and sensors, which not only significantly improved patients’ quality of life, but minimized the risk of complications. By 2027 it is predicted that the market for insulin pens alone will be worth some 8.3 billion U.S. dollars.

1.2 Aim of the Development

Despite modern tools, in the case of type 1 diabetes, the lives of children need to be organized on an extremely strict agenda. There is no special diet, the recommendations are in line with the principles of healthy eating, only certain fast-absorbing carbohydrates are on the ban list, but the time, number and amount of meals are predetermined.

The treatment of diabetes is real teamwork, in collaboration between the pediatrician, the educator nurse, the dietitian, the pediatric diabetologist and the psychologist, but civil society also has a prominent role to play [3].

Patients who have type 1 or type 2 diabetes have daily self-management responsibilities that are essential for keeping their blood glucose level under control - such as measuring blood glucose, taking medications or insulin as needed, eating appropriate foods, being aware of symptoms, responding quickly when blood glucose rises too high or falls too low, and adhering in other ways to their individual treatment plan - and poor self-management that fails to control blood glucose adequately, which is a serious problem for many diabetes patients, can lead to severe complications or early death [4].

The lifestyle of diabetic children and their families changes drastically at a glance after the diagnosis. Not only parents but also children need to learn a lot.

To sum it up, a big number of children live with managing type 1 diabetes. Those children need guidance and knowledge near to diagnosis and during ongoing management in order to cope with their condition. It was our motivation to develop a Serious Game to help kids with type 1 diabetes learn the new knowledge they need.

2 Method

Firstly, we have reviewed the literature to find what similar serious games are available.

We have found some video games e.g.:

Lieberman [4] 14 video games, there were released in the period of 1992-2011 but none of them was for preschool-age children.

The game in the Pouw’s thesis at the University of Twente was developed for primary school children [5].

In [6] authors reviewed 18 articles that described the design and evaluation of games for diabetes from technical, methodological, and theoretical perspectives. They undertook searches covering the period 2010 to May 2015. Few of them were
developed for children (not for little children) and some of them were not available in English.

Carb Counting with Lenny [7] game is downloadable from the AppStore. In spite of the fact that the developers recommend it for age rating 4+ the screens contain several text pieces of information and it is available only in English, moreover the overall rating is 2.9 out of 5.

MyDiabetic game [8] is a very complex game, however, this complexity can be a disadvantage for our target audience. The game tries to cover as many aspects of diabetes as possible. The game is a result of three years of research. Unfortunately, this game is not available in Hungarian either.

Then we have realized the lack of age-appropriate education for younger children with type 1 diabetes. We have followed a user-centered design approach. Therefore, we have consulted pediatric dietitian on how to educate newly diagnosed children with type 1 diabetes. The consultations have helped in formulating the scope and we have defined the functional requirements which can be summarised as follows:

- The program can be run on as many platforms as possible, but the two most important are Android and Windows.
- The game should be designed so that it can be easily upgraded to other platforms.
- The controls of the game should be clear and simple so that anyone who uses it can handle it without any difficulty.
- Age group would be preschool children who do not have literacy skills and thus cannot access written information.
- The game would be based inside the clinical setting, in order for the clinicians and parents to be involved as well in the process.
- The game will focus on four mini-games for children and an editor program for parents and pediatric dietitians, which can be used to expand the game’s database.

Since young children of this age are not able to set their own learning goals, feedback from those who are educating them is very important. Hence, care professionals, teachers, parents, and staff healthcare had been interviewed. The knowledge and experiences of the participants uncover the health, education and lifestyle needs of the children with diabetes. Those needs have been thereafter translated into the requirements for the game. Those requirements consist of all the non-functional goals which are related to education about the disease.

3 Discussion

The 4KidsDiab program consists of two parts, an editor and a game part. The two parts have different constraints and functional functions, so we have chosen development tools that better specialize in the tasks. The editor is QT Creator, the game has been created in a development environment called Game Maker Studio.

QT Creator is a C++ based development environment. We have chosen it because it’s easy to create a user interface, and the editor itself is well documented, making it easier to fix bugs.
Game Maker Studio is a popular game development engine that uses its own language, GML. Game Maker Studio specializes specifically in the development of two-dimensional games, which is a big advantage in this case. It has a built-in graphics creator/editor, which is also a great help during development. Using Game Maker Studio we are able to develop new games on many platforms. It can develop for Windows, Android, IOS, and Ubuntu, among others.

3.1 4KidsDiabGame

The game part contains four games: “True/False quiz”, “Which food has more/fewer carbs”, “Take it to your plate” and the reward game: “Feed the figure” game.

The task in the “True/False quiz” (Fig. 1) is to choose the right answer for the question. It means that the statement of the question is true or false. E.g.:

- It is important that I exercise a lot, drink enough water. (True)
- My blood sugar levels can go up from a lot of movement. (False)
- A lot of movement can drop my blood sugar level. (True)
- I always have to have some carbs with me. (True)
- I have to drink at least 2 dl of milk every morning. (False)
- Milk should not just be drunk; it should be calculated. (True)
- Honey should not be eaten. (True)

These sentences and instructions are read by children’s voices in the game.

![Fig. 1. A screenshot of the “True/False quiz”.

The photos of two foods are on the screen in the “Which food has more/fewer carbs” game (Fig. 2). Children have to choose the picture based on the right answer to the question.
Children have to choose food for a meal in the “Take it to your plate” game (Fig. 3). They can choose foods for breakfast, lunch dinner, etc. from the database. The carbohydrate is calculated based on their allowable value which had been uploaded by their parents in the editor mode. It is a very hard game for little kids.

The fourth, reward game is the “Feed the figure” game (Fig. 4). It is a traditional snake game. If the child gives a portion of good food for the snake the snake will be longer. If the child gives bad food for the snake, it will be shorter and sick.
3.2 Editor for Parents

Parents can upload pictures and data of meal/food into the game database. These data are (Fig. 5):

- Name of the food
- Category of the food (fruit, meat, vegetables, baked goods, etc.),
- The carbohydrate content of the food
- The food is usually serviced for (breakfast, lunch, snack, dinner, supplementary dinner),
- It contains fast or slow absorbing carbohydrate,
- It is allowed to eat anytime, it is forbidden to eat, children can eat but parents have to calculate its carbohydrate content
- Does it contain gluten or lactose?

![Fig. 5. A screenshot of the editor mode.](image)

Parents can upload questions for “True/False quiz” game e.g.:

- I can drink milk at any time. (False)
- I can never drink milk. (False)
- I can drink milk when there is a meal and mom/dad calculate the carbohydrate content. (True)
- I can drink tea made with sweetener at any time. (True)
- I can get a teaspoon of honey at any time. (False)
- If my blood sugar is low, I can safely eat chocolate. (False)
Parents can upload pictures and food date for the “Which food has more/fewer carbs” and “Take it to your plate” games. The necessary and eatable carbohydrate is adjustable based on the children needs by the parents in the editor mode.

3.3 Evaluation

The “4KidsDiab” serious game is under evaluation. We have asked little preschool-age children and their parents and pediatric dietitians to test our game.

For testing, System Usability Scale (SUS) [9], more precisely a modified version was used in the Google Form. The questionnaire asks questions that are alternately positive and then negative statements. Users have had to answer the questions on a Likert scale of 1 (strongly disagree) to 5 (strongly agree). In our modified SUS questionnaire, there are 15 instead of 10 questions. Moreover, it is further divided, the first 10 questions of the test are for parents and the remaining 5 questions (questions 11–15) are for children. The first 5 questions are interested in the editing program, while all the others are opinions on the game:

1. The operation of the editing program is simple and straightforward.
2. The editing program is unnecessarily overcomplicated.
3. Managing the editing program is easy to learn.
4. I need the help of an expert to be able to manage the editing program.
5. Using the editor is fast and problem-free.
6. The user interface of the game does not correspond to a child’s play.
7. The game is useful for young children.
8. The sub-games are too complicated.
9. Game management is easy to learn.
10. The game is difficult to use.
11. I will play the game often.
12. The game is too simple.
13. I can learn a lot from the game.
14. I don’t like the game.
15. I can play the game alone.

The modified SUS questionnaire was filled by 10 users (7 adults and 3 children). The results’ evaluation based on the SUS Interpreting Scores. The maximum scores are 100. In our case, the parents’ score was 81.25 and the children’s score was 80.5. So we can state that both the parents’ and children’s scores are “Excellent” based on the SUS [9] evaluation. (SUS score above 80.3, the letter grade is “A”, the adjective rating is “Excellent”).

4 Conclusion

A Serious Game has been developed for preschool-age children who have been newly diagnosed with type 1 diabetes. The game has been designed on the children’s needs and conceptions and implemented based on the knowledge of pediatric dietitians. It contains a database with photos and data of several foods and meals. Finally, it has
been evaluated for its learning effectiveness and usability. Our game is an innovative game not only because it is for preschool-age children, but it contains allergic information for children who have gluten or lactose intolerance.

**Acknowledgements.** The authors would like to thank Dóra Henn, Anna Mesterházi-Kövecses and Márta Molnár-Nemes, dietitians of the Ferenc Csolnoky Hospital in Veszprém for their professional advice.

**References**

1. Hayes, B.M., Aspray, W. (eds.) Health Informatics: A Patient-Centered Approach. MIT press, Cambridge (2010): https://books.google.hu/books?hl=hu&lr=&id=GCd5qAVxLMC&oi=fnd&pg=PR5&ots=VwHnBqS18O&sig=I2G01PWP0gUD4GE3ZFbA8wFj2ts&redir_esc=y#v=onepage&q&f=false
2. Elflein, J.: Children and type 1 diabetes worldwide – key facts (2019). https://www.statista.com/statistics/241818/key-facts-on-children-and-type-1-diabetes-worldwide/
3. Semmelweis’s news: The number of children with type 1 diabetes is increasing year by year (in Hungarian). http://semmelweis.hu/hirek/2019/01/09/evrol-evre-tobb-az-ovodaskoru-1-es-tipusu-diabeteszes/
4. Liebarman, D.A.: Video games for diabetes self-management: examples and design strategies. J. Diabetes Sci. Technol. 6(4), 802–806 (2012). https://doi.org/10.1177/193229681200600410
5. Pounds, I.H.: You are what you eat: serious gaming for type 1 diabetic persons. Student thesis at the University of Twente (2015). https://essay.utwente.nl/68139/
6. Lazem, S., Webster, M., Holmes, W., Wolf, M.: Games and diabetes: a review investigating theoretical frameworks, evaluation methodologies, and opportunities for design grounded in learning theories. J. Diabetes Sci. Technol. 10(2), 447–452 (2016). https://doi.org/10.1177/1932296815604634
7. Carb Counting with Lenny. https://apps.apple.com/us/app/carb-counting-with-lenny/id516080517
8. MyDiabetic game. http://my-diabetic.cz/en/index.html
9. System Usability Scale. https://www.usability.gov/how-to-and-tools/methods/system-usability-scale.html