Evaluating Serious Games for Children with a Chronic Disease

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ABSTRACT
Do children with diabetes, evaluate, value and assess serious games designed for this group differently than children without this disease? In general, what factors determine how children assess serious games? Based on existing evaluation frameworks for serious games from the literature an evaluation method was designed. This method is applied in user evaluations with two groups of children, one group with children with diabetes and another group with children without this disease. Two games are used in the evaluations, one of which is designed for children with diabetes. The results of this research suggest that there are no big differences in evaluation of the games by children with and without diabetes and that evaluation results depends more on personal preferences than on having diabetes or not.

Keywords
Evaluation methods, serious games, educational games, children, user experience testing.

1. INTRODUCTION
According to a research of the NPD group the average time spent playing mobile games by mobile gamers has increased with 57 percent in 2014 compared to 2012. Kids in the age of 2 to 12 spent the most time gaming on a device instead of doing other activities [1] The growth of gaming in general might be the reason why there is a growing interest in serious games as means to educate and train people. [14]

The term “serious game” was already defined long before the digital revolution. Abt (1970) described “serious games” as “games that have an explicit and carefully thought-out educational purpose and are not intended to be played primarily for amusement.” [8]

Serious games could for example be useful for training of soldiers or surgeons, but could also be useful for education at schools. [10] In case of children with a chronic disease, serious games often aim to let these children cope with their disease. The games help them to learn about the disease or experience real-life situations without the real-life consequences. [21] Children with diabetes might face the consequences of skipping a meal or eating food with too many carbohydrates in such a game. [21] The game could also inform these children about their disease or motivated them to document their medical data (more often). [11]

Another term in learning with games is gamification. Although gamification, just like serious games, uses a game element to perceive a non-entertainment goal, gamification uses game elements in real-life settings while serious games make a game of real-life settings.

There already exist some methods for evaluation of serious games. Heuristic Evaluation (EV) compares an interface to a list of established usability heuristics [10] The SG evaluation framework (SG-EF) designed by GALA, the EU network of excellence for serious games, is “a systematic representation of the factors that might concur to determine the learning impact of serious games.” [2]

What makes that children like to play a game? And what makes that children like to play a serious game? When a serious game is designed for diabetes patients do children with diabetes like the game more than children that do not belong to the target group? Does motivation to learn influence the assessment of the serious game?

Currently there is not much information about differences between evaluation of games by children who are chronically ill and children who are not. It is important to find out if there actually are differences, because if there are the design of the serious games for children with diabetes might have to be made different to let these children like the game better and as a result might cope better with their disease.

Therefore, in this paper a method will be set up for evaluation of serious games for chronically ill children by identifying and comparing several evaluation methods for serious games. The eventual method will be tested by performing a case study on children with diabetes and children without this disease.

1.1 Hypothesis and research questions
A serious game for children with diabetes could, for example, be designed to learn children with diabetes about blood sugar or insulin or the consequences of exercise on the blood sugar levels, but the game could also contain information about the carbohydrates in food and aim to learn these children about them. [21] [11]

Because children with diabetes have to be more aware about what they eat every day compared to children without diabetes, these children might like such a game more than the children without diabetes. Therefore the evaluation of the game might be different.

The hypothesis is that children with diabetes will evaluate a serious game designed for children with diabetes different than children who do not have this disease.

This leads to the following research questions:
What makes children with diabetes playing a game different from children without this disease?
To answer this question some other questions have to be answered, namely:
- What is the effect of playing games on the blood sugar levels?
- Are children with diabetes quicker tired playing a game than children without diabetes?
- What is the learning effect of playing the games?
- Also some other questions have to be answered to design an evaluation method.
- What factors for evaluation of games are already used and why?
- What is the difference between evaluation of serious games and evaluation of normal games?

2. BACKGROUND INFORMATION

2.1 Serious games

“A serious game is a game that has an explicit and carefully thought-out educational purpose and is not intended to be played primarily for amusement.” [8]

Although people might also learn from ‘normal’ games, like learning social skills, serious games are specially made for a specific educational purpose.

2.2 Chronically ill children

A child is considered to be chronically ill if:
- “The diagnosis of the disease is based on medical scientific knowledge and can be established using reproducible and valid methods or instruments according to professional standards.” [17]
- “The disease is not (yet) curable or, for mental health conditions, if it is highly resistant to treatment.” [17]
- “The disease has been present for longer than three months or it will, very probably, last longer than three months, or it has occurred three times or more during the past year and will probably reoccur.” [17]

In the case of this study the focus will lie on children with diabetes. Most of the children with diabetes have type 1 diabetes, also called diabetes mellitus type 1. This type of diabetes results from the body’s failure to produce enough insulin. [3]

3. RELATED WORK

3.1 Game evaluation

There are several evaluation methods that are used to evaluate games. Some comparisons between these methods are also made. For example the comparison between the Structured Expert Heuristic Evaluation Method (SEEM) and the Combined Heuristic Evaluation (HE) mentioned in the introduction chapter. [6] The results of this research is that the thoroughness and validity from SEEM are higher than those of HE. [6]

3.1.1 CEGEQ

An example of an questionnaire for game evaluation is the Core Elements of the Gaming Experience Questionnaire (CEGEQ). This questionnaire is based on a theory which describes elements that provide a positive user experience while playing games. The questionnaire consists of 38 questions, divided in categories, and has a Cronbach alpha of 0.794[7]

3.1.2 Pre-MEGa

Pre-MEGa is proposed framework for the design and evaluation of preschoolers mobile educational games. It consists of 15 categories of guidelines and is based on several (heuristic) evaluation methods. [20]

3.1.3 SG evaluation method

The SG (serious games) evaluation framework designed by GALA as mentioned in the introduction paragraph consists of several factors that might contribute to the players learning impact in a game. These factors are related to the participant, the context, and the impact of the game. In each category different features are mentioned which could contribute to the learning experience. [2]

3.1.4 Types of players

Bartle stated that there are four types of players: Achievers, Socializers, Killers and Explorer. Each type of player has his own reason(s) to play a game. A player can also be a combination of types, like a Killer and an Achiever. Some type of player might not like a certain type of game. [4]

Yee used the Bartle’s idea to find motivations for gaming. The resulting components where grouped into three overarching components, which are achievement, social and immersion. [5, 23]

Because different players have different characteristics, some games might be more in favor of a player than another game.

3.1.5 Game characteristics

Garis et al. describe six categories in which game characteristics can be described, namely fantasy, rules/games, sensory stimuli, challenge, mystery, and control. [9] Some of these characteristics were already mentioned by Malone, who distinguishes between intrinsic and extrinsic motivation. With intrinsic motivation no external reward is given for doing an activity. He says that intrinsic motivation of people have to be increased, because people are more likely to keep playing a game when no reward (from someone else) is given compared to children who received an award at first. The categories for intrinsic motivation he describes are challenge, fantasy and curiosity. [15] In another research Malone found that there seems to be a difference between boys and girls. Although boys like to have intrinsic fantasy in the game Darts, girls seems to dislike it. [16]

3.2 Diabetes and gaming

According to Valdes, a diabetes nurse clinician, when you play games you get excited and your body responds by increasing output of certain stress hormones, including adrenaline. In turn adrenaline triggers the liver to release stored glycogen for use as glucose. As a consequence people with diabetes can have high blood sugar.

A study by Phan-Hug et al. suggests that “playing videogames could induce a state of excitation sufficient to activate the sympathetic system and alter the course of glycaemia.” [18]

In other words the blood sugar of children with diabetes type 1 will increase while playing games.

Also a research by Wang and Perry reports that “playing video games results in the increase of various metabolic and physiologic variables in young children.” [22]

When blood sugar levels are too high tiredness can occur. [13]
3.3 Games designed for children with diabetes

There already exists several games designed for children with diabetes. A few of them will be described below.

The “Diabetic dog game” is a game in which, the name suggests it already, a player has to take care of a dog with diabetes. The player can feed or pet the dog, walk with the dog or give him insulin. When the blood sugar levels are too low or too high, the dog will get sad or even worse, he will be rushed to the hospital.[12]

“Equalize” is a Swedish platform game where a character with diabetes has to save his friends from sugar monsters. The character has to keep track of his blood sugar levels while playing. If the level increases the player has to eat food or decrease it by using its insulin.

On the site aboutkidshalth.ca are three games for children with diabetes for different age groups. Two of the games contain a story in which the player has to answer questions to help the character. In the other game, the carb count game, the player has to make a meal with a certain amount of carbohydrates out of different types of food.

On the site lenny-diabetes.com there are also several games where the player has to know the carbs in different types of food. The “Build a meal” game looks like the carb count game, but it is a little harder for the player, because the carb values are not given. In the other games the player has to guess how much food contains carb or not (“carb or not”), which type of food contains more carbs (“compare the carbs”) or guess how many carbs a certain type of food contains (“guess the carbs”).

“Monster Manor” is an application for children in the age of 6 to 13 years old. It encourages children to enter their blood sugar information. This game uses gamification, since it gives points or prices after sending in the information via the BlueLoop application.

“Mission T1D” is a game developed to inform children about type 1 diabetes. I think this game could be compared to “Equalize”, but in “Mission T1D” also a quiz element is included.

Unfortunately all of these games are not in Dutch, they are either in English or in Swedish. Since the target group is between the ages of 8 and 12 the language could be of influence on their gaming experience.

There however is a Dutch game for diabetic patients called GRIP, but this game uses personal information out of the patient records. Since the game uses this information throughout the game, the gaming experience might be influenced if this information is not available. [12]

Isaac Pouw, a master student at the University of Twente, also made a game for Dutch children with diabetes called “Carb Counter”. The game he made is comparable to the “Build a meal” game. It is a match-three game where tree products with a certain amount of carbohydrates have to be selected to obtain the goal score (Dutch: Doel). See image 1. The game consists of five levels and for each level three different products are used.

In level 1 the products are bananas (30 carbohydrates), tomatoes (2 carbohydrates) and eggs (0 carbohydrates). When the goal score is 2, for example, two eggs and one tomato has to be selected (in case difficulty level is easy) or swiped in a row (in case difficulty level is hard). [19]

4. METHOD

4.1 Overview

Several evaluations methods (and also existing comparisons) were issued and compared in the previous chapter. With this comparison an questionnaire was made which could be used in the case study. In this case study a game designed for children with diabetes will be tested among children with diabetes and children without diabetes using the designed evaluation method. From the results of this case study there will be information about the difference between children with diabetes and children without diabetes.

4.1.1 Participants

The participants without diabetes were found by contacting schools, out-of-school cures, sport associations and Scoutings via e-mail and phone contact. The participants with diabetes where found via e-mail contact with hospitals.

We initially wanted to select children with a minimum age of 8 years and a maximum age of 12 years, because if they were younger they might not like the game because their mathematics skills might not be good enough. Also the reading of the questionnaire might be too hard.

4.1.2 Questionnaire

The whole questionnaire is in Dutch because the research took place in the Netherlands. Initially the questionnaire was a paper questionnaire, but this questionnaire was made into an online questionnaire with Qualtrics. The questionnaire consists of two parts.

4.1.2.1 Questionnaire part 1

The first part of the questionnaire is used to acquire information about the age of the respondent and the knowledge children already have about carbohydrates. Some of the knowledge questions are order questions; children have to order the products from lowest amount of carbohydrates (1) to the highest amount of carbohydrates (3) by swiping the products to the right place. The images of the products were made from screenshots of the game Carb Counter. See Appendix A1 for an example of this type of question.

After the children are finished doing an ordering question children have to answer how sure they are about the answer they have given on a scale with five options ranging from ‘It was a guess’ to ‘Very sure’. Other questions in this part of the questionnaire are multiple choice questions about the amount of carbohydrates in a certain products. See Appendix A2 for an example of this question.
4.1.2.2 Questionnaire part 2
The second part of the questionnaire, which the children have to fill in after they played the two games, consists of questions to acquire information about what kind of player the child is, what the child has learned from playing the games and what he/she liked and disliked about the games they played.

The first questions ask which of the games the child likes the most and why he/she feels that way.

Then the child is asked whether he/she likes the course mathematics at school and if he/she liked mathematics in the Carb Counter game.

Then the child is asked what he/she has learned from both games.

After this question children are asked to select what they like about playing games to find out what type of player the child is. The questions are based on Bartle’s Four player types. [4]

This question can be found in Appendix A.3.

Then there are two questions with statements about the two games where the children can select an answer on a 7-point Likert scale from totally disagree (1) to totally agree (7) to find out what the children liked and disliked about the game. The questions used for these evaluation questions were some of the questions out of the CEGEQ. Because this questionnaire has far too much questions to ask the children we only picked a few of them.

The last questions in the questionnaire are some of the ordering questions and multiple choice questions which were used in the first part of the questionnaire. These questions are to find out what the child has learned from playing the game. Therefore, the ordering and multiple choice questions will be based on the level(s) the child has played. So if the child has played level 1 which has the products bananas, tomatoes and eggs, the child gets questions about these products.

4.1.3 Game
The game we used to do the case study with were Carb Counter (see previous chapter) and Candy Crush Saga, which is also a match-three game, just like Pouw’s game. See image 2. The main difference is, that children can select all ‘products’ instead of picking certain products to obtain the goal score. Also some extra challenges are built in the game, like jelly which has to be removed. Furthermore the game gives the player special items when four or more products in a row are removed.

Image 2: Candy Crush Saga

4.2 Procedure
At first participants have to fill in the first part of the questionnaire. After they filled this in, the children had to play the Carb Counter game. The participants were allowed to choose whether they wanted to play either level 1 or level 2 and they could also decide at which difficulty level (easy or hard) they wanted to play the level. After they finished the level the participants were allowed to play another level if they would like to do that. If they were done playing Carb Counter, the participants had to play Candy Crush. The participants could pick any level they wanted to play. When they were finished playing both games, the participants had to fill in the seconds part of the questionnaire.

The games were played on a Windows tablet with an android emulator. The questionnaire was also filled in on this tablet or on a laptop.

The sport associations and the hospital gave permission to do the research at their location. The case study was carried out with parental permission and willingness of the participant.

Participants could ask questions during the whole case study. If they did not understand something, I helped them to understand it better.

I was sitting next to the children during the entire research.

5. RESULTS
5.1 Participants
The questionnaire was filled in by 10 participants, of which 6 females and 4 males.

All participants are from the Netherlands. The participants are between 8 and 12 years old. (Mean=10.2 and Standard Deviation=1.033). Three of the participants have diabetes.

From one questionnaire only the first part was useful, because the participant was in a hurry and did not look at the second part of the questions but just filled something in.

5.3 Questionnaire results
5.3.1 Learning results
5.3.1.1 Carb Counter
Three participants mentioned that they did not learn anything from Carb Counter. One participant learned to remember things. The other six participants learned about the amount of carbohydrates in products and learned to count with it.

Before they played the game, all participants with diabetes where right about the amount of carbohydrates in an egg, which is 0 grams, while all participants without diabetes filled in the wrong answer.

Afterwards, of the participants who played level 1 (seven participants) six selected the right answer for the amount of carbohydrates in a tomato and all seven selected the right answer for the amount of carbohydrates in an egg. Of the participants who played level 2, which were four participants, all of the participants filled in the right answer for the amount of carbohydrates in an apple.

The order question for level 1 was filled in correctly by six out of seven participants. The participant who answered this question wrong, was not the same participant who answered the multiple choice question wrong afterwards.
5.3.1.2 Candy Crush
All but one participant mentioned that they did not learn anything or that they hardly learned a thing from Candy Crush Saga. The one that learned something, said she learned to think smart.

5.3.2 Game evaluation
Six out of ten participants preferred Carb Counter over Candy Crush Saga. Two participants with diabetes liked it better because they thought it was well conceived or because you have to count carbohydrates. The other participants (without diabetes) mentioned that they love to do mathematics, just liked it or that it is a game they never had played before. One participant had no idea why she liked it. Two participants (without diabetes) preferred to play Candy Crush, because they have played it more often or because you only have to pick the same candy and do not have to know the exact numbers. One participant (with diabetes) did not like both of the games. He disliked Carb Counter because it is too much thinking and he thinks Candy Crush Saga is boring. One other participant did not prefer Carb Counter over Candy Crush Saga because he thought Carb Counter was something new and you get to know something about carbohydrates. But he thinks it might get a little boring, just like Candy Crush Saga.

In table 1 and 2 the results of the game evaluation questions are displayed. The participants without diabetes seem to like the Carb Counter game better than the participants with diabetes. But there has to be mentioned that one of the participants with diabetes really disliked the game, while the other two participants seemed to like the game according the questionnaire results. All participants seem to prefer Carb Counter over Candy Crush Saga, because Carb Counter scored better on the “I enjoyed playing the game” and “I would play the game again” questions. But the rules of Carb Counter are less clear to the participants. Also the looks of the game are in favor of Candy Crush Saga.

5.3.2.1 Type of gamers
Eight out of ten participants play games to earn points and to finish levels. Three participants like to play games because they can learn something from it. Four participants like to play games because you can play it with someone else. Five participants (four of them are females) like to play games to beat other players.

The participants who like to play games because they like to learn something from it, liked Carb Counter but they liked Candy Crush Saga as well.

5.3.3 Observations
5.3.3.1 Carb Counter
We noticed that all the participants who played Carb Counter did not understand the rules properly. Some of them did not understand what they had to do at all. The biggest problem was that the participants did not understand that they had to select three products and not less (or more).

One participant thought he first had to undo the minus score he had received and afterwards select the products for the goal score.

Another problem that occurred was that the participants did not notice that the goal value was changing. This occurred more when the first goal value was the same as the second

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<th>Table 1: Results evaluation questions Carb Counter</th>
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<td>I enjoyed playing the game.</td>
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<td>I knew what I was supposed to do to win the game.</td>
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<td>I liked the way the game looked.</td>
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<td>The game was unfair.</td>
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<td>I understood the rules of the game.</td>
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<td>The game was too difficult.</td>
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<td>I got bored playing this game.</td>
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<th>Table 2: Results evaluation questions Candy Crush</th>
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<td>I enjoyed playing the game.</td>
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Some participants got frustrated when they thought they selected the right answer but it was not right. At one point one participant struggled with the mathematics in the game and other kids who were watching started to help him.

All participants where really wiling to finish the game and some wanted to play another level. One participant only wanted to play other levels to find out which recipes grandma will receive out of the products of the level. (The recipes did not make much sense to him)

When some of the participants saw they only received one star they were a little disappointed.

Most of the participants without diabetes were surprised that cheese did not contain any carbohydrates at all.

5.3.3.2 Candy Crush
From the seven participants without diabetes only one did not knew Candy Crush at all and one only knew the game by name. The others where familiar with the game.

Some participants thought they had to reach the target score (which is the high score) while the goal was to reach one star or more.

Some of the participants seemed more eager to receive the ‘special candy’, with which they for example can move a complete row away or delete all candies of one type, than to get to receive the goal.

5.4 Other interesting comments
5.4.1 General comments
Afterward he was done playing the games and filling in the questionnaire, one participant told me he thought he would prefer Candy Crush Saga to play later on because this game has more challenges like jelly that has to be removed to finish a level or candy that is stuck in a rock.

5.4.2 Comments during the questionnaire
One participant with diabetes said he was sure that eggs and cheese do not contain any carbohydrates, because his mother told him he could eat as many of these products he wanted.

Some participants said that they liked Carb Counter better because it was a new game to them and they knew Candy Crush already, but they did not fill this in in the questionnaire.

5.4.3 Comments on Carb Counter
One of the parents of a child with diabetes said she thought the Carb Counter game could also be useful for her to learn about the amount of carbohydrates in products.

A medical specialist at the hospital told me she thought bananas contain less carbohydrates than the amount of carbohydrates the bananas were given in the game.

6. DISCUSSION
Although it seemed from the results of the questionnaire that the participants liked Carb Counter over Candy Crush, no conclusion can be drawn from these results, because the research population is too small to draw conclusions. Only three participants with diabetes is not enough to draw conclusions for all children with diabetes, which were according to the International Diabetes Federation around the 440000 children (in 2007) worldwide. Furthermore during the game phase participants did not understand the rules of the Carb Counter game, but in the questionnaire the mean of the answer indicates that they agreed on understanding the rules. Also some comments made about the game being new and therefore more appealing might suggest that the participant might not like the game as much as suggested by the questionnaire.

Also different player types did not show different evaluation results. For example the participants who like to play games because they can learn something from it, also liked Candy Crush (in which you do not learn anything specific).

7. CONCLUSION
To answer this main question of this research some other questions have to be answered first, namely:

What is the effect of playing games on the blood sugar levels?
The effect of playing games is that the body produces adrenaline which stimulates the liver to subtract glucose to the blood. This will lead to an increase of the blood sugar levels.

Are children with diabetes quicker tired playing a game than children without diabetes?
Children with diabetes are quicker tired because their body is unable to produce insulin against the high blood sugar levels.

What is the learning effect of playing the games?
After playing the two games most of the children seem to have remembered the amount of carbohydrates in the products that were used in Carb Counter.

Also some other questions have to be answered to design an evaluation method.

What factors for evaluation of games are already used and why?
There are several evaluation methods which have several factors for evaluation. Evaluation can be based on type of player, but also on user experience.

What is the difference between evaluation of serious games and evaluation of normal games
Because Serious Games have an carefully thought-out educational purpose, the focus of these games lies on the educational part of the game. Therefore in the evaluation of the game the learning effect has to be taken in consideration. For normal games this is not the main purpose of a game.

The main question of this research was “What makes children with diabetes playing a game different from children without this disease?”
Children with type 1 diabetes will get tired quicker compared to children without diabetes playing a game, because of their body’s failure to produce insulin.

In the case study no significant differences in evaluation of the games were found, therefore on the gaming experience no conclusions can be made about differences between children with and without diabetes.

7.1 Future work
Because the case study was done with only ten participants, the research population was not very high and therefore results might be unreliable. To find out more about this subject more research has to be done.

Because one of the parents of a child with diabetes mentioned that the Carb Counter game might also be useful for her, the game could also be tested on parents instead of children. Also because one of the participants with diabetes said he knew the amount of carbohydrates in a product from his parents.
8. REFERENCES

APPENDIX

A. Questionnaire

A.1 Order-question

Example of order-question

A.2 Multiple-choice question

Example of multiple-choice question

A.3 TYPE OF PLAYER QUESTION

Type of player question 1