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Evaluating Mobile Games for Diabetes Education

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Abstract: Mobile games can be effective, evidence-based, and motivating tools for the promotion of children's health. Traditional method for diabetic education relies heavily on written materials and there is only a limited amount of resources targeted at educating diabetic children. In our earlier work, we proposed a novel approach for designing computer games aimed for educating children with diabetes. In this paper, we apply our game design to a mobile Android game (Mario Brothers). We also introduce two heuristics that are specifically designed for evaluating the mobile game, by adapting traditional usability heuristics. The results of a preliminary evaluation study, conducted for a week, showed that the children found the game engaging and believed that it would have added educational value.

Keywords: games, diabetes, game design, evaluation, self-management, mobile health

1. Introduction

In light of the increasing numbers of people with diabetes (estimated to be over 208,000 New Zealanders in 2011, up 9.7% from 2010 and therefore potentially up to 229,000 in 2012[1]), addressing diabetes is a priority for three major reasons: (1) the prevalence is increasing rapidly (between 5-10% each year since 2005); (2) it is the major preventable cause of costly and debilitating renal failure, lower limb amputation, and avoidable blindness; and (3) it is a major contributor to inequalities in life expectancy [1].

Children with diabetes in New Zealand currently receive medical care from a physician-coordinated team of nurses, dieticians, and health psychologists with a special interest in diabetes. This approach is resource-intensive and potentially could benefit from an inexpensive, popular new mode of delivering diabetes health-related education. There has been enough qualitative research to suggest that video games have helped children between the ages of 10-12 make healthier diet and physical activity choices [2]. A systematic review of interactive multimedia interventions to educate children about their health demonstrated potential to improve children's health-related self-efficacy, which could in turn enable them to become more competent on complex topics such as dietary behaviour change discussions [3]. Tablet computers may offer opportunities to engage patients during inactive times between visits to the health care professionals, tests, or treatments by providing interactive health education modules [4].

Playing games with mobile devices is a recent development and has become increasingly popular both in the development of games and in the field of research. A good gaming experience requires a lot from the user interface. It should be convenient, reliable, and usable so that the player can concentrate on playing the game and enjoying it instead of struggling with the user interface. In addition, the game design itself has a huge impact on the gaming experience. If the rules or game world contains implausible features, the players can be easily offended or frustrated and quit playing. In addition, the heuristics for evaluating games in mobile context are qualitatively different from traditional playability heuristics.

[1] New Zealand Ministry of Health, http://www.moh.govt.nz/moh.nsf/indexmh/heha-importance, Accessed in May 2015.

A number of heuristics have been proposed for evaluating digital games in recent years ([6], [7], [8], [9], [10]). Having reviewed the heuristics for the evaluation of video games for the last 20 years, we realised that most of the heuristics proved very generic and valid only for high level issues in the games. In addition, some were not validated. In heuristic validation, each heuristic is evaluated according to its relevance in designating usability problems ([11], [12], [13], [14]). Furthermore, the size of heuristic sets is also an important factor.

Driven by the initiative of the Adult & Paediatric Diabetes Psychology Service of New Zealand, research has been performed to design and develop proactive mechanisms for diabetes education. As widely known by researchers and clinical psychologists, children who are learning about their diabetic condition will need to learn to cope in a variety of different situations. Thus, we decided to focus our research on exploiting interactive features of computer games to deliver education knowledge through immersive and situational learning. We embarked on developing a set of design guidelines for teaching children how to manage their diabetes and applied the proposed design ideas to an open source 2D game (Mario Brothers) [5]. In this paper, we developed a mobile version of the game and conducted a pilot study with 12 children to determine the effects of playing the mobile game on engaging children. We also introduced two heuristics that are specifically designed for evaluating the mobile game, by adapting traditional usability heuristics. We hypothesized that children would find the mobile game engaging with additional educational value.

The remainder of this paper is organised as follows. Section 2 describes the mobile Mario Brothers game and its features. Section 3 presents the proposed heuristics for evaluating the game and reports our initial findings. Section 4 concludes the paper and highlights future research opportunities.

2. Mobile Games for Diabetes Education

Driven by the three design strategies described in our earlier work [5] – i.e. the *Structure Enhancement* (SE), *Feedback Enhancement* (FE), and *Challenge Enhancement* (CE) – modifications were made to incorporate educational features into the mobile Mario Brothers game (see Figure 1).

In line with the fundamental principles of role play games, the main character of the game, named Mario, is assumed to have type I diabetes. The health problems faced by Mario become the health problems to be solved by the game player. The ultimate goal of the game is to save a princess who is locked in a castle. To achieve this goal, Mario needs to manage his diabetes and maintain a healthy condition while fighting against a variety of evil guards during multiple stages of the game.

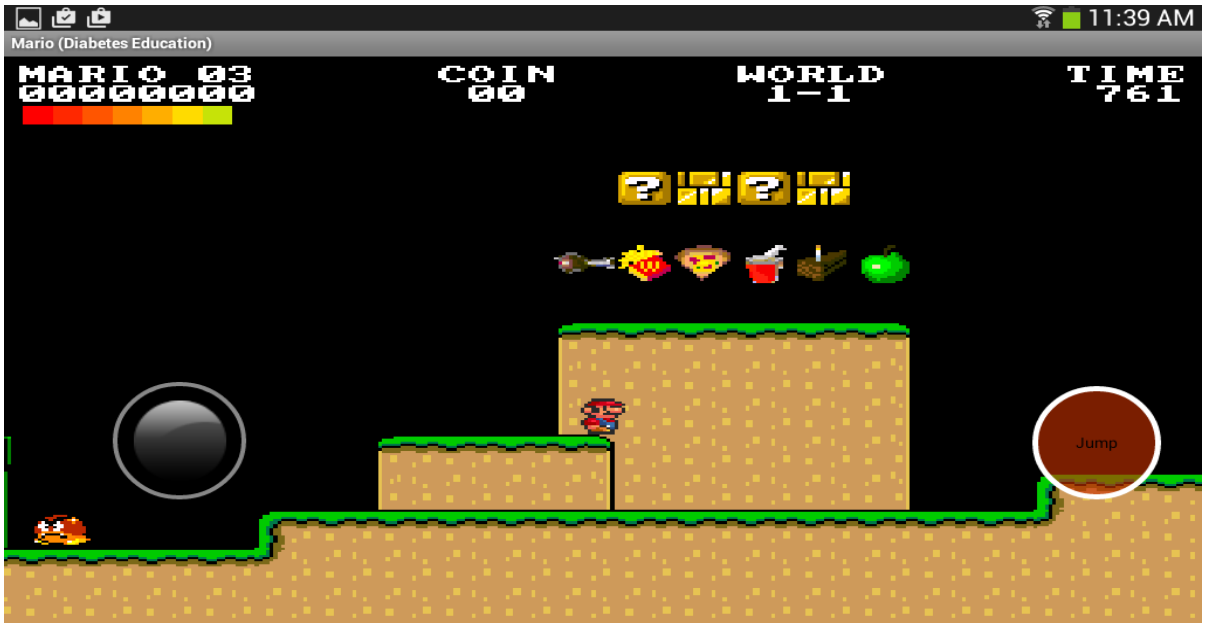

Figure 1. The screenshot of the Android mobile version - Diabetic Mario should maintain his blood sugar level (shown at the top) while trying to save the princess.

It is expected that, as children progress through stages of the game, they will gradually learn the skills to remain healthy by eating healthy food, having regular exercise, and injecting suitable amount of insulin when needed. SE, FE, and CE have been extensively utilized to support effective learning in the game. Below we discuss some representative examples of using the three strategies:

Example 1: Managing Mario's healthy condition, especially his blood sugar level, is designed as a main challenge at every stage of the game. If Mario's blood sugar level goes outside a healthy region, children's effort to rescue the princess will fail. To emphasize the importance of the blood sugar level, an indicator is placed at the top left corner of the game screen. In line with FE, the indicator as shown in figure 1 is designed to change its colour whenever Mario's blood sugar level goes up or drops down. The way that the blood sugar level changes is determined by many factors, including playing time, the amount of exercises Mario had such as walking and jumping, and any food consumed by Mario.

Example 2: The modified Mario Brothers game is designed to help children learn the right skills to cope with their diabetic condition. As illustrated in figure 1, choices regarding food consumption will pop up occasionally when Mario's blood sugar level deviates to a certain degree from the healthy level. According to SE, the options essentially represent fine-grained challenges since children need to make right choices through eating healthy food or injecting suitable amount of insulin in order to continue playing the game. The choice is to be made based on Mario's health condition and the progress of the game. The level of difficulty is adjusted to match the player's diabetes knowledge. In association with CE, at early stage of the game, a small set of recommended food or insulin injection will be provided when Mario has abnormal blood sugar level. At later stages of the game, the challenge increases and children need to choose among a large variety of food and need to decide the right amount of insulin injection.

For the purpose of behavioural analysis, children need to login with their user name in order to play the game. Password is not required as this might pose problem to some children, especially those at very young age. Many game-playing activities, such as the amount of food consumed, the amount of insulin injection, and the amount of exercises, will be recorded in the system log. The log will help us find out whether children's skill of managing blood sugar levels will improve after playing the game for some time.

3. Preliminary Evaluation

A pilot study was conducted with the modified mobile version of Mario Brothers in February & March 2015. The main objectives of this study were to determine the effects of playing the mobile game on engaging children and on enhancing their knowledge of healthy diet and lifestyle.

To take part in the study, 12 children aged 9-13 years were recruited in the greater Auckland area. The study was approved by the University of Auckland Human Participants Ethics Committee. Participation in the study was entirely voluntary. The participants filled out a health-related questionnaire about diet, exercises and lifestyle choices. They then borrowed a tablet for one week so they could play the mobile game in their free time if/when they wanted to. The game automatically logged all the interactions, including when and for how long they played each time, which choices they made, how much feedback they received etc. At the end of the week, we collected the tablets and asked them to fill out the health-related questionnaire again, followed by a survey about what they thought of the game.

To determine how engaging the game was, we studied different factors. Educability was an important factor for this study, however, one cannot achieve that, if the game does not meet other requirements such as usability. We, therefore, chose two heuristics, *Usability*, and *Educability*, from the study of literature to evaluate the game prototype.

The *usability* aspect of the heuristics covers such factors as audio-visual elements, screen layout, terminology used in the content, navigation, controls offered, feedback management and the help features.

Table 1: Heuristics used for Usability of the game

Usability	GU1	Audio-visual representation supports the game
	GU2	Screen layout is efficient and visually pleasing
	GU3	The player understands the terminology
	GU4	Navigation is consistent, logical, and minimalist
	GU5	Control keys are consistent and follow standard conventions
	GU6	The game gives feedback on the player's actions
	GU7	The player cannot make irreversible errors
	GU8	The player does not have to memorize things unnecessarily
	GU9	The game contains help

The effectiveness of the game mainly depended on how engaging and educational it was. Figure 2a shows the responses to the *usability* factors. In addition to audio-visual features that support, they expected visually pleasing screen in terms of colour, lay out and the resolution of the animations. There wasn't any terminology used as the game provides the visual representations. The players found the navigation to be consistent, logical, and minimalist. However, any small error meant starting the game right from the beginning, which attracted most criticism. As a result the scores for items GU6 & GU7 were relatively low (see Figure 2a). Some players suggested that there should be new ways to control game characters such as voice interaction with game characters.

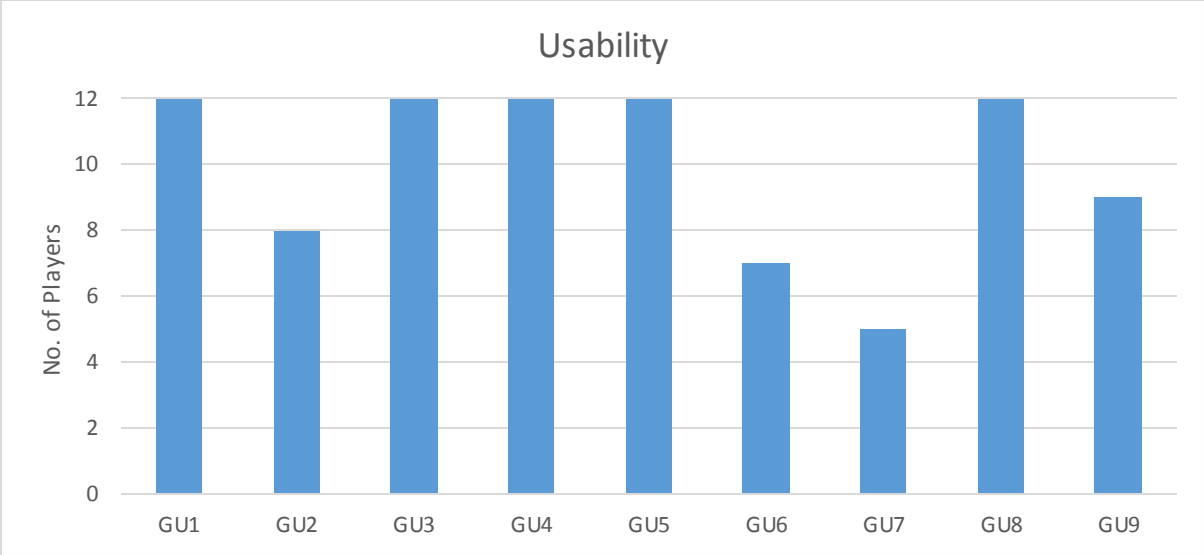

Figure 2a. Responses to the *Usability* heuristics

The *educability* aspect takes care of how much of learning has taken place, though domain specific. This is evaluated in terms of several display mechanisms (e.g. the blood-sugar indicator), confidence achieved (e.g. easy to control the blood-sugar levels) and application of the knowledge (e.g. managing one's own diet as a result)

Table 2: Heuristics used for Educability of the game

Educability	ED1	The blood-sugar indicator easy to understand
	ED2	Easy to control the blood-sugar level
	ED3	Seeing Mario going through the blood-sugar level changes, you feel confident about managing your own diet
	ED4	The game helped understand how blood-sugar level changes

Based on the results of the study (Figures 2a-2b) and current literature (e.g. [7]) a game should have the following characteristics for any educability:

- The content of the game should be accurate, graphically detailed and predictable.
- The players should feel that they are in total control of the game
- The game should respond to players' actions in a consistent, immediate, challenging and exciting way.
- Transmit different stimuli to activate and engage players during playing time.
- The game should make players feel that they are part of a creative and dynamic community.
- It should accelerate learning times and focus on reinforcement of players' skills and experience.
- It should increase players' retention levels.
- It should present suitable and effective content for players of all levels.

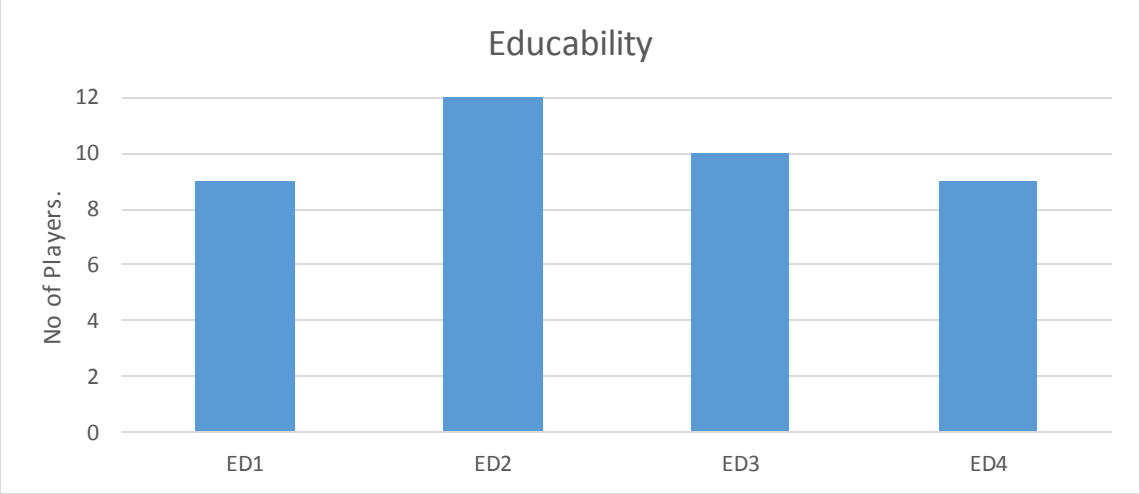

Figure 2b. Responses to the *Educability* heuristics

4. Conclusions & Future Work

A novel mobile game was developed for teaching children how to manage their diabetes using the proposed design strategies. We then chose two heuristics, *Usability*, and *Educability*, from the study of literature to evaluate the game prototype. The initial results from an evaluation study showed that the participants enjoyed playing the game and believed that it would have added educational value.

The results thus far are encouraging. Further work includes: 1) addressing the feedback received from the pilot study to enhance the game prototype, 2) analysing the health questionnaire to find out if/to what extent the players' knowledge of healthy diet and lifestyle is enhanced 3) analysing the interaction data logged on the tablets which would allow us to gauge the extent to which the game

design successfully embeds enjoyable experiences and meaningful learning outcomes, 4) personalising the game according to players preferences and abilities, and 5) evaluating the effectiveness of the proposed game with the target population (children with diabetes) for long-term behavioural changes and increased knowledge of diabetes. We believe, our research paves the way for the systematic design and development of full-fledged computer games dedicated to diabetes education in the future.

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