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”Mummy, Why Do I Have Diabetes?”: A Tangible Interface For Educating Children With Type-1 Diabetes

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Abstract

This paper presents the stakeholder centred design of an educational game for children, aged 3 to 8 years old, with type-1 diabetes. The novelty of the approach is the multi-stakeholder approach to design and evaluation (diabetes consultants, nurses, parents and children) and the creation of a tangible interface game for interactive learning of diabetes concepts for children aged 3-8.

Author Keywords

Tangible Interface, Diabetes Education, Children.

ACM Classification Keywords

K.3.1 [COMPUTERS AND EDUCATION]: Computer Uses in Education - *Computer-assisted instruction (CAI)*; H.5.m [Group and Organization Interfaces]: Miscellaneous

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Introduction

In the year 2015 the number of children having type-1 diabetes exceeded, for the first time, half a million¹. All those children, living with diabetes, can experience psychological disturbance [13] and periods of struggling to cope with the condition [5], due to the intensity of the diabetes management.

In order to reduce the potentially serious long-term physical and psychological complications that can arise from type-1 diabetes [5], modern health care systems include diabetes education for recently diagnosed children as part of routine care. Nonetheless, children do not always enjoy the conventional diabetes learning methods which are currently employed, since they are often very passive, lack fun and most of the times are not age-appropriate [2, 6].

Industry and research communities have over the years introduced educational video-games as a more attractive and engaging alternative [4]. However, despite the relatively large number of these becoming available, very few are clinically validated and only few of the games satisfy the educational needs of children with type-1 diabetes [4].

This paper presents the stakeholder centred design of an educational game for children, aged 3 to 8 years old, with

¹IDF Diabetes Atlas 2015: <http://www.diabetesatlas.org/>



Figure 1: The first diabetes educational video games, for SNES. Left: *Captain Novolin*-1992. Right: *Paky and Marlon*-1995

★**Constructivism** posits that exploration and problem solving create the context in which learning occurs in the pre-operational children stage.

type-1 diabetes. The novelty of the approach is the multi-stakeholder approach to design and evaluation (diabetes consultants, nurses, parents and children) and the creation of a tangible interface game for interactive learning of diabetes concepts for children aged 3-8. Based on requirements elicited by an initial qualitative research and literature review, the game will:

1. Promote exploratory activity,
2. Promote collaborative learning ,
3. Promote learning through reflection and
4. Will be based on developmental psychology.

Background and Related Work

Diabetes education

Young children have different requirements from adults when it comes to diabetes self-care because they are not capable of solely managing their condition [12]. This is because, diabetes management requires frequent monitoring, insulin dose calculations and decisions by balancing several factors [5]. Diabetes education for this age group (ages 3-8) needs to be age-appropriate and focus more on practical information and skills training [6], in order to help them fundamentally understand the factors that influence their condition and how those interact with each other [1]. These are the essential building blocks upon which a person might be able to later form an effective self-management strategy of their own.

Age-appropriate education

Some theories have been proposed for health promotion such as the *Transtheoretical model*, the *Health Belief Model* and others [8]. To date however, none of these theories are specific to this age group, but instead they see all the patients as a uniform group. Moreover, most of them focus primarily on behaviour change which is inapplicable to children, since they do not self-manage the condition. What

is more important for this age group is the learning of concepts [6] and thus, it is more appropriate for us to use educational theory to develop strategies that will promote and reinforce the required learning for this age group.

For this age group we propose the use of educational theories of cognitive psychology because they are relevant to these ages and have been widely used in other areas of education [9]. The most commonly accepted of these is *constructivism*★, proposed by Piaget [11]. Building upon Piaget's work, Papert promoted the computer as a learning tool. Papert [10] argued that traditional education makes children believe that "learning only happens by being taught" and this is the opposite of empowerment. Constructivism learning theories inspired many researchers who started exploring the educational effects of video games and digitally enhanced toys.

Educational video games

The mass appeal of video-games and the development of their educational aspects, led the researchers and the industry in the creation of video games also for diabetes education. Educational video games can potentially promote hypothesis testing, problem-solving, exploratory learning, reflection upon actions without putting children into harm [15]. All these properties make meaningful connections between events and thereby increase the likelihood that knowledge and skills gained in the game world will be transferred and applied in the real world [15].

Diabetes video games

Starting at 1992 a series of educational video-games for children with type-1 diabetes were developed by industry and researchers. These games were released for different consoles (SNES, PC, Smartphones) and some of them were evaluated for their effectiveness. Most of these games were included in a comprehensive systematic review by

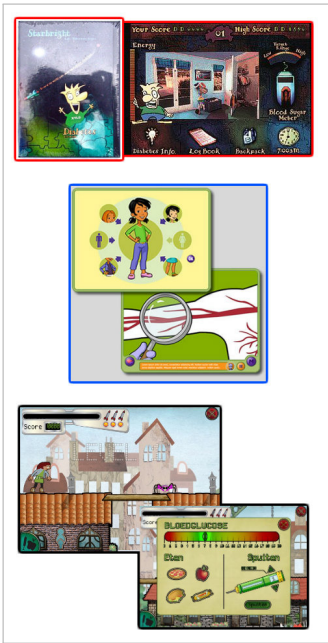


Figure 2: PC games.

Up: *Starbright Life Adventures*- PC CD 1999, Middle: *Dbaza Diabetes Education for Kinds*- PC CD 2003, *Ranj's GRIP*- Online Flash 2008

★Research Questions:

1. How to improve the existing approach of type 1 diabetes education for children?
2. How to educate in a fun, age appropriate, engaging and effective way children with type 1 diabetes?

DeShazo et al. [4]. Some of these games are presented in Figures 1 - 3.

Most of these games have focused on children older than 8 years old with basic literacy and thus are not accessible by younger children. Moreover, such approaches cannot be implemented in a clinical setting, require the possession of a special device by the family, do not inherently promote collaborative learning and may require the over-exposure of the child to the device.

Tangible interfaces games for education

The technology that combines the engagement of the video-games and the learning effects of constructivism is tangible interfaces [9]. Tangibles interface games are proven effective in educating young children and thus have a lot of applications, even in health care [9]. The only example of tangibles interfaces' use for children education with chronic diseases, that came to our attention, is for autism (eg. [3]). Nonetheless, for that condition the children are not being educated for the condition itself, but the games are used to help them overcome some problems the disease introduces, like the inability for pretend play.

Study's Design

Requirements

The basic problem, of younger children with diabetes is the inability to independently access information/educational material, due to illiteracy . In order to investigate how this problem is currently mitigated, a set of interviews with people responsible for the children's education was conducted. The participants were diabetes experts in Yorkhill Children's Hospital in Glasgow, Scottish government staff responsible for diabetes and parents. These requirements interviews allowed us to identify what is the current approach to education for this age group in greater Glasgow, and helped us

formulate our research questions★.

The current approach is twofold:

1. Informal education by parents at home using their own strategies and techniques.
2. Formal education by diabetes clinicians within the clinic with parents and children.

In the first case parents, led by experience, insights and some diabetes knowledge, educate their children on a daily basis while managing the condition .They use whatever techniques and strategies they deem useful (often with the use of age-inappropriate material in leaflets provided by the NHS) to educate their children. Even though learning through experience might be adequate in the longer term, formal diabetes education is also important for the children [5], since it is the corner stone for effective self-management [14] and psychosocial well-being [6].

Formal diabetes education is currently delivered to children in Glasgow through educational sessions with the clinicians in Yorkhill Children's Hospital. During those sessions a diabetes nurse uses a set of plastic food toys and educates the children about food portions, carbohydrates and the potential impact of each food to their condition. The problem with this approach is that it focuses only on one factor (food intake) of the diabetes management. Moreover, the toys are not interactive and thus, do not promote exploration - the key factor that reinforces problem solving [11].

Design decisions

We decided to work with children aged between 3 and 8 years, an age group shares the same cognitive characteristics (pre-operational stage [11]). That group has little or no access to information sources due to the lack of literacy. Moreover, most of the available diabetes educational games target children older than 8 [4].



Figure 3: Feature phone games. From top to bottom: *Insulot* 2005 - slot game for carbohydrates measuring, *Egg Breeder* 2004 - Breed a diabetic egg until it hatches, *Detective* 2004 - Help a diabetic detective to catch a villain, *Building Blocks* 2004 - Block building game

The concreteness of the plastic food toys, used in Yorkhill, and their depiction of real world objects are the base line for constructivistic “hands-on” learning. According to that, and in order to avoid perturbing the existing ecosystem, we decided not to alter the existing approach but enhance it through technology by adding all the missing features.

According to the benefits of tangible interfaces in learning and their appropriateness for young children [9], we decide to implement the game as a tangible interface game. The game will have four main components which are going to interact with each other as shown in Figure 4:

1. A “diabetic” mannequin with a display in its abdomen.
2. The plastic food toys.
3. A plastic work-out toy (eg bicycle)
4. A plastic toy syringe.

Each component is going to be related with one of the most important factors about diabetes, according to the clinicians who were interviewed; namely, the child’s endocrine system, food intake - carbohydrates, exercise and insulin treatment respectively. Through the gameplay, the child will explore the different factors and how those interact with the condition. Hence, it will get a more holistic idea about the diabetes “equation” and how it is managed. All the latter components, mentioned above, would be able to interact with the “diabetic” mannequin through wireless technologies (RFIDs, Bluetooth). The game will combine multiple feedback channels (audio and visual) and exploratory learning.

Another advantage of this interface is its accessibility to preschool children with little or no literacy, because it will not require literacy skills and will use direct manipulation [9].

Reflection upon actions

One of the key features that will reinforce children’s learning and will help the clinicians understand children’s mis-

conceptions is the feedback from the game [7]. The game will frequently require from the child to stand back from the learning and reflect upon his/her actions. Thus the clinician will have the opportunity to explain something in more detail to the child. Moreover, the game could be played collaboratively. This way children would have the opportunity to see someone else’s perspective, negotiate and be aware of actions in a more objective way.

Narrative game - exploratory game

The game will have a narrative nature and will guide the child through the typical management of the disease. The child will be asked to help the “diabetic” mannequin manage its condition in everyday scenarios (eg. hypoglycaemia in school or sports, meal preparation etc). This way the children would relate to the mannequin and see how their choices (food, insulin and workout) impact the condition without putting themselves into harm.

Next phases

The subsequent next step of this project, is the actual implementation of the game. During its implementation the game is going to pass from a series of usability evaluations in order to ensure its usability. The last steps of the project involve the employment of the game in the clinical setting of Yorkhill Hospital in Glasgow and its evaluation for effectiveness in delivering the diabetes education to children. The specific evaluation parameters would be decided when the game is developed.

Conclusion

This paper presented the design of an educational game for children, aged 3 to 8 years old, with type-1 diabetes. The novelty of the approach is the use of a tangible interface with multiple feedback channels that will potentially empower children with diabetes by educating them more ef-

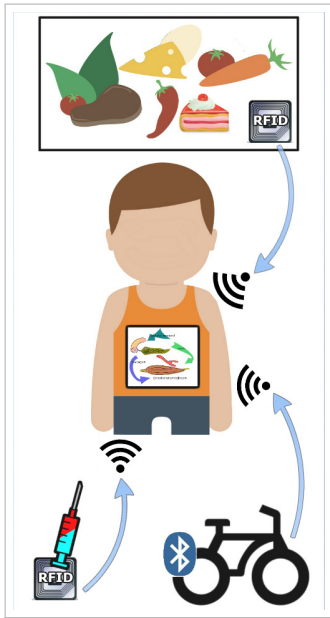


Figure 4: A depiction of how the game would look like. The three input components (food toys, syringe toy, work-out toy) would interact with the “diabetic” mannequin. Audio and visual feedback for the child’s actions would be given from a display in the abdomen and speakers inside the mannequin,

fectively in a more engaging, fun and age-appropriate way. The game will promote exploratory activity, collaborative learning, learning through reflection and will be based on the constructivism theory of developmental psychology. The game will be more accessible to this age group and will be situated inside the clinical setting, without perturbing the existing ecosystem.

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