Healthy Gaming – Video Game Design to promote Health

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Keywords

Implementation and deployment, Education, Consumer health, Human-computer interaction, Interfaces and usability, Game design, Educational game design, Instructional design, Pedagogy of gaming, Instructional technology

Summary

Background: There is an increasing interest in health games including simulation tools, games for specific conditions, persuasive games to promote a healthy life style or exergames where physical exercise is used to control the game.
Objective: The objective of the article is to review current literature about available health games and the impact related to game design principles as well as some educational theory aspects.
Methods: Literature from the big databases and known sites with games for health has been searched to find articles about games for health purposes. The focus has been on educational games, persuasive games and exergames as well as articles describing game design principles.
Results: The medical objectives can either be a part of the game theme (intrinsic) or be totally dispatched (extrinsic), and particularly persuasive games seem to use extrinsic game design. Peer support is important, but there is only limited research on multiplayer health games. Evaluation of health games can be both medical and technical, and the focus will depend on the game purpose.
Conclusion: There is still not enough evidence to conclude which design principles work for what purposes since most of the literature in health serious games does not specify design methodologies, but it seems that extrinsic methods work in persuasion. However, when designing health care games it is important to define both the target group and main objective, and then design a game accordingly using sound game design principles, but also utilizing design elements to enhance learning and persuasion. A collaboration with health professionals from an early design stage is necessary both to ensure that the content is valid and to have the game validated from a clinical viewpoint. Patients need to be involved, especially to improve usability. More research should be done on social aspects in health games, both related to learning and persuasion.

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1. Background

The media often voices concern about how playing video games in excess is bad for the health and can have a negative effect on the attitude of the players. However, the scientific evidence is not that clear. Several studies have found positive effects of gaming [1, 2, 3] but also negative [4]. For example, Goldstein et al [3] found that playing computer games for five hours per week during five weeks improved reaction times, self-esteem and the sense of well being of elderly persons.

Only recently have health games become a mass phenomenon, and nowadays it is possible to find games to "enhance" cognitive skills (brain training) or to exercise (e.g. sports games for Wii) in every videogame shop. The research community of serious games for health is growing with venues such as "Games for Health" [5] in its annual 7th edition (2011). In addition, there is an emergence of games designed to persuade users to change their behavior, aka Persuasive Games [6]. For example, in the project "Fish'n'Steps" a community of users keep their "fish" alive in a virtual aquarium by exercising in the real world based on the data captured in their mobile's motion sensors [7].

There are reviews about health games, but not focused on design aspects. Baranowski et al [8] reviewed 27 articles addressing games for behavior change relating to diet, physical exercise, self-management, etc., and they found that most of the studies had positive patient outcomes. They focused on storytelling in videogames particularly directed at children. Adams [9] reviewed 12 health games focusing on the implication for patient treatment and prevention as well as professional use, pointing out that sound educational principles and theories must be used. Lustria et al reviewed 30 computer-tailored interventions delivered over the Internet, some of them included the use of games and quizzes [10]. None of these review articles discussed social games, but Lustria et al [10] refers to several programs with group meetings, personal contact with experts, etc. Many of the reviewed studies showed improved patients outcome; however, the reasons why some studies fail to improve outcomes is not clear.

Despite the growing importance of health games there is a lack of knowledge on aspects related to the design of games. Only a few published articles address design aspects for health games. Lieberman published a short list with design recommendations within a health game competition [11]. Kwok-Chan also reported a study with students who were designing health games [12]. In a recent book about game design six book chapters report study cases of health games [13]. However, there are no publications providing an overview of health game design aspects.

To provide an overview of how game design principles and techniques can be used to make health games is the main objective of this paper. In the following subsection we provide an introduction to game design elements.

1.1 Game Design elements

Design aspects are of key importance to create successful games. Game design principles also apply to health games.

The main purpose of the different design elements varies. Some are mainly for the interaction with the game such as drag-and-drop of game items and timing of game tasks. Others focus on education, such as quests, try-and-fail and repetitions. Other design elements have the main aim to persuade, such as customisation, personal goal-setting, tunnelling and reduction. Below some of the basic principles are described.

According to Schell [14] it is important to give users an experience. Games should have rules, problems to solve and a unifying theme. There are different approaches to problem solving, for instance quizzes, drag-and-drop to the right position, role playing games where the player shall chose the right dialogues or actions or adventure games with quests and tasks to solve. It is also possible to use designs that force the player to use their memory, focus their attention and even coordinate actions. Sometimes speed is added to problem solving, giving a limited amount of time. Reward and feedback mechanisms are also of great importance in health games, both rewards and feedback should be given not only on game-play itself, but also on the health related achievements. The instant feedback on behavior is an advantage of games.

It is important to make games relevant and also interesting to repeat. A technique to make the game more interesting is to personalize it based on information from the player or the player char-

acter [15]. Leveling up as the player masters the game is also a common design feature. In persuasive games personal goal-setting is also used.

Gee [16] presents some design elements of particular relevance for learning that can be applied in health care games. One is ″try and fail″ meaning that players do not give up but try again and again until they succeed. Another is ″repetition″ where the player performs the same task to score better. A third is ″take risks″ meaning that the players can try out dangerous behaviors which they cannot try in real life.

Other relevant design elements that were found in the literature are the health belief model [17] and the transtheoretical model [7]. The Health Belief Model (HBM) is a psychological model that attempts to explain and predict health behaviors. This is done by focusing on the attitudes and beliefs of individuals [18]. Kharazzi et al [17] conclude that designing health care games based on behavioral models can increase the usability of the game in order to improve the effectiveness of the game's desired health care outcomes. The Transtheoretical Model of Behavior Change assesses an individual's readiness to act on a new, healthier behavior, and provides strategies, or processes of change to guide the individual through the stages of change to action and maintenance [18]. Analyses of results in [7] using the transtheoretical model suggest that individuals had established new routines that led to healthier patterns of physical activities in their daily lives.

Khaled et al [15] are using something they call reduction – to take away unnecessary information - and tunneling – to force the player through a specific order of events. They found these useful tools for cause-and-effect simulation and story-telling. In social games, we find both competition and collaboration, both synchronous and asynchronous. Also the contents of the game can be both extrinsic, that is detached from the game, and intrinsic, that is a part of the game.

The main purpose of the different design elements varies. Some are mainly for the interaction with the game such as drag-and-drop and timing. Others focus on education, such as quests, try-and-fail and repetitions. And some design elements have the main aim to persuade, such as customization, personal goal-setting, tunnelling and reduction.

2. Objectives

To design games that although entertaining are able to persuade users to change their behavior is not a trivial task. Design aspects are the key to ensure usability and the final successfulness of the games. This paper provides a discussion of how game design principles can be applied for health games in order to enhance their potential benefits. We review the current literature about health games in order to discuss how to apply game design principles as well as some educational theory aspects.

3. Methods/Search Strategies

A non-systematic and non-comprehensive review of literature was performed with the aim to provide an overview of how game design aspects apply to health games. The search was performed in major knowledge databases, such as PubMed, IEEE Explore, ACM Library and specialized web portals and conferences, such as "Health Game Research" [20]. The main key words used were game, educational, serious game, persuasive technology – all combined with health. Games directed at professionals were excluded. The main goal of the research was to find examples of different types of health games to illustrate the design aspects discussed in this paper.

Examples were selected to provide and discuss design principles in health related games across different types of games. The examples, shown in ▶Table 1, were classified into three categories: educational games, exergames and persuasive games. The line between the different categories is not absolute. For instance persuasive games may include educational aspects or even user exercises to control the game. We also discuss the design implications for different age groups: children, adults and seniors.

4. Results

In this section we provide an overview of the main genres of health games: educational games, game to promote physical activity and persuasive games. Within each type we provide some illustrative examples for explaining key design aspects.

4.1 Educational games

Games can be used to learn about different diseases, about food and nutrition and healthy behaviors in general. Health literacy - ability to understand health information and to use that information - has been shown to improve health outcomes [38]. Patients with a chronic condition often need to gain a lot of knowledge about their diseases, such as diabetes. The games that we have studied are designed to increase the knowledge about different health aspects of relevance for the users.

Many health games are designed for children with a newly diagnosed disease requiring much knowledge. For example, the game "Hypos at School" [21], ▶Figure 1, teaches the players how to handle their diet or hypoglycaemic events. The game contains animations, texts and "choose the correct answer" about what to do if you start to feel dizzy at school. The game delivers an important message in a quiz-like way about one theme.

There are also many games about food and nutrition for the young population. On the site "Playnourmous" [22] we find several games for children about food (e.g. Pyramid Pile up, Lunch Crunch and Juice Jumble). In Lunch Crunch the aim is to fill lunch trays with fruits and vegetables and trash unhealthy food. Important design elements here are speed and drag-and-drop, and many of these games have several levels and scoreboards, so that you can compete with either by yourself or with others. "Trigger happy" [24] is another educational game designed to teach and warn players about the risk of "triggers" that can lead to poor eating choices when dieting. There are also games targeting the adult and senior population. "Heart Sense" [23, ▶Figure 2] is a role playing game designed by the University of Pennsylvania to educate the players about the risk of heart attacks and also how to help people suffering an attack. Here the player has the role of someone who must help a sick person, and choose the correct dialogues as well as actions through the game.

For seniors there are many games targeting "mental exercising". The games from "Dakim Brain-Fitness" [26] are designed to slow down the development of dementia, offering 150 games with cognitive stimulation, among them memory. They use personalization and also positive feedback and are designed to focus the players' attention, including timing and coordination between memory and action. The game "Inside and Outside" [27] is designed to test the player's ability to concentrate and focus their attention, and the game "Birdwatching" [25] is aiming to improve the players' attention and sharpen their ability to process visual information".

4.2 Games to enhance physical activity

Overweight and obesity are an epidemic in many countries. In the USA more than one third of the population is obese [39]. In Norway more than 10% of 13-year-old teenagers are overweight [40]. This epidemic is increasing the interest for games requiring the users to exercise instead of sitting in front of a PC. The movements are tracked with a set of sensors embedded in devices, handheld controllers, mats or by using video cameras. Recently the American Heart Association endorsed the Wii Nintendo exergames with the "healthy product" label as they have done before with healthy food [41].

There are many studies showing that exergames result in exercising. Unnithan, Houser, & Fernhall [42] tried out "Dance Dance revolution" both on overweight and non-overweight children and adolescents. They found that for both groups the level of exercising gave above the minimum recommended heart rate intensity for developing and maintaining cardio-respiratory fitness. Haddock et al [43] have also found that adding an active video game component (car race) to standard stationary biking led to a modest increase in energy expenditure in overweight children. Playing at least some exergames results in enough energy expenditure to be considered exercise also for young adults [44].

Dancing exergames, such as "Dance Dance Revolution" [32] where the players have to follow dancing steps on a special mat, are very popular amongst the young. Another example of games for children using the Wii mat is "Active Life Outdoor Challenge" [28] which "offers several fast-paced events in both a fun and challenging way". "Froggers Hop, Skip & Jumpin' Fun" from Konami [29] is another example where a control mat is used. "SmartCycle" [30] is yet another game aimed at children. Here, gamers are on a stationary bike while playing a learning video game about spelling, counting, shapes, etc. Many of these games use extrinsic design methods – i.e. game points are earned by doing things that are not related to the main aim (exercising). In addition many of the games use competition between players.

For adults we found e.g. the game "Eyetoy: Kinetic Combat" [31] where players are immersed in Kung Fu and must fight their way to getting into shape. In that game the movements are tracked using a camera.

We have so far not found any exergames particularly designed for the elderly, but several have been tried on this demographical group. Neufeldt [45] tried playing Wii sport with elderly people in a residential home. Even though the inhabitants met regularly to exercise, playing Wii together had a positive social effect and in some cases improved coordination. However, they faced usability problems related to physical coordination (e.g. pressing buttons in the right moment), confusion with menus, etc. One of Neufeldt's conclusions is that playing video games is not as easy for the elderly as often asserted, and the level of difficulty depends on the mental and physical situation of the elderly.

4.3 Persuasive games, games made to influence habits

Persuasion is often involved in health prevention. This particularly applies to changing habits. The main goal of persuasive games is not to educate or to increase physical exercise, but to persuade the users to modify their behavior.

Amongst extrinsic persuasive technology for children we found "Didget" [33], ▶Figure 3, a blood glucose meter for children with Type 1 Diabetes. The meter can be used together with Nintendo DS. In the videogames coming with the meter the player earns game points when testing the blood glucose level, and gets extra points (rewards) when the readings are good. This is a way to persuade kids not only to perform life-saving measurements, but also to strive for stable blood sugar levels. Many games aimed at persuading do this by educating, though. "Rex Ronan: Experimental Surgeon" [34] educates about the dangers of smoking. The game takes place inside the body of a man who is dying of lung cancer. Also taking place inside a body is a game against obesity called "Escape from Obeez City" [35].

For adults we found games aimed at helping smokers to quit their habit, such as "My Stop Smoking Coach with Allen Carr" [36]. For adults with Diabetes Type 2 struggling with their diet, we have the game "Escape from Diab" [37] both intrinsic, the latter more adventure-like.

Many elements are involved when creating persuasive games. Goal setting is one important factor. Consolvo et al [46] have been investigating how goal setting can be an effective strategy for changing behavior. In their "UbiFit" system information about physical activities was sent to the system and results according to predefined goals were displayed as flowers on the player's mobile phone [46]. Just as in [33] points are earned in a game by doing something that is not related (exercise versus getting flowers). A social game on Facebook for diabetes prevention, "HealthSeeker" [47], also uses goal setting. This game is very concrete when it comes to food and exercise, and even if the players set their own goals, they have to choose between meals and tasks that do not necessarily suit everybody.

Also the interaction with the game such as identification with the avatar and rewards, are important. If the player is doing well in approaching the goal, this should be visible, for instance in a stronger avatar. Barr et al [48] found that the upgrading of the player's avatar should represent an improvement in well-being in the game, and that this has value for persuasive games aimed at human well being.

Later the same group made a prototype of a game meant to persuade people to quit smoking [15] using a simulation game. They look at several perspectives for persuasive games, amongst them managing the players' attention, identity and target audience. They show how important it is for the

player to identify with their game avatar, and feel that the message in the game is aimed at them personally. They use methods like "reduction" and "tunneling" to achieve desired effects. They also use "customization" providing users with personally relevant information to increase the interest for the game.

Lin et al [7] used a transtheoretical model to assess the effects of their "fish bowl" experiment. The game "created initial excitement, increased participants' awareness of their level of physical activity and it improved motivation". They also found that a significant number of the participants developed a certain emotional attachment to their virtual pet. Towards the end of the experiment, the game was perceived as increasingly repetitive, but it was considered to have had the expected effects; a temporary means of assisting the participants in advancing along the steps of behavioral change.

5. Discussion

Basic game design principles such as game rules, problems to solve, feedback reward mechanisms also apply when creating games for health purposes, and are found in the games we have studied, but in addition one has to consider how to get the message through and yet make the game fun. We have studied many examples of games for health purposes with different aims and different target groups. We will now look at design issues that are being used or could be used in educational and persuasive games as well as in exergames to see if any can enhance the health purpose they aim to solve. Designing entertainment video games is a complex task. Adding an educational or persuasive dimension does not make tasks easier. A multidisciplinary team is behind most game designs, and this group has to be extended with both didactical competence and knowledge in the field in question [49].

5.1 Design for education

In games one can learn from the contents, for instance about healthy eating, one can learn skills, such as how to calculate insulin doses or one can learn system thinking, for instance how changing eating and life style can influence health in the long run.

Most educational games that we have found are intrinsic, meaning that the learning material is a part of the game contents. Many of the education games are small games or mini-games using elements like drag-and-drop, speed, and memory. The games will normally be perceived as boring after a few times, and they sometimes use levels both to be able to meet players with different background knowledge and to give new challenges to players. Aoiki et al [50] created three small games for initial diabetes education. The games were viewed as both useful and fun, but the players would have liked more individualized and more thorough information as well. The authors point out that if the game has too much fun without appropriate contents, it cannot be called a learning tool, but on the other side it will not have appeal if the education is emphasized too much.

Simulation games are also common in education. One type of simulation is found in educational role-playing games where the players have to envision themselves in different roles, and choose the correct actions and dialogues to solve a task, for instance helping someone with a heart attack [23]. In role-playing games it is also possible to try out risky behavior. We have only found single player role-playing games, but this is a type of game that has a great potential as a tool for collaborative learning.

Games with public scoreboards also have a social element, using competition as a design element.

5.2 Design for persuasion

The persuasive contents can either be intrinsic or extrinsic. Persuasive games about smoking or obesity going on inside the body are examples of the first.

The games connected to a blood glucose meter [33] are examples of the latter. Other examples of this "detachment" are the Fish'n Steps [7] where exercise keeps fish in a virtual aquarium alive.

Other examples are car-racing games controlled by user input from stationary bikes [38]. We have so far seen no conclusions as to which of these mechanics work the best in motivation, but at least when it comes to persuading people to exercise harder it seems like extrinsic methodology works the best [43]. For children, the Didget blood glucose monitoring system [33] works well, and the possibility to change games and still use the same equipment and methods seams like an attractive methodology. When the players grow older or get bored of one game, they can still earn game points and keep up the good habits.

But changing behavior is not straightforward, and also other methods are used. Kharrazi, Faiola and Defazio J. [17] for instance used the Health Belief Model (HBM) to design a game aimed at adolescents with Type 1 diabetes. HBM outlines that an individual's intention to engage in a healthy behavior is determined by general health values, specific health beliefs about vulnerability to a particular health threat, and beliefs about the consequences of the health problem. They point out that one also has to consider empowerment, compliance and behavioral change when planning game elements. Another example is the transtheoretical model using tunneling and reduction, but also focusing on personalization.

Goal-setting involving the players is another principle in motivation and persuasion [45, 46]. The goal setting must be personal, but the players must get help not to set the goals too low. Peer pressure in social games can also be used in persuasion, and also to help set high enough goals. Both competition and co-operation are seen in multiplayer games, so it would have been interesting to see more research on multiplayer social games. It is well known that social networks play a role in health behaviors [51].

5.3 Design for exercising

Exergames shall not only be about moving but also about having fun. Exergames are in a way persuasive games, since they persuade the players to exercise more. It has been found that physical games which only aim to increase excercise, soon become boring, but games with a story engage the players for longer [8]. Thus the challenge is to design games that are engaging for different target groups and that provide varied exercises.

Competition is an important factor for engagement in these games, and they can both be turn-based or played in a team (double tennis for instance). Exergames for elderly or people with different disabilities must be adapted to the physical conditions of the players.

The Wii remote, and other remotes for that matter, do not require much movement for game action, but the players' involvement often ensures more exercise than required to play the game. Users forget they are exercising and may thus exercise for longer periods of time [43]. Maybe more videogames can be played with accelerometers or other equipment that will force the players to move a bit more.

Some "brain games" can also be classified as exergames, since their main aim is to keep the brain active. They often use game elements that require the players to use their memory, coordination or even speed.

5.4 Games and target group

Different target groups have different requirements and approaches to games and digital tools. Therefore, the target group is of great importance when designing games. Noisanen & Kankaanranta [52] found that children like rich designs with lots of information and numerous alternative actions [52]. They also like playing together either sitting together or meeting in a game, and they want easy access to compare scores and be able to monitor their status.

For elderly people it is the opposite; they prefer simple screens with little information, and plenty of time to get an overview. Aoki et al [50] states that interface design for elderly should minimize the burden on spatial and working memory, visual functions or motor ability. Interfaces should also be adaptable to compensate their age-related limitations. According to Ijsselsteijn, Nap & de Kort [53] "digital games hold a significant promise for enhancing the lives of seniors, potentially improving their mental and physical well being, enhancing their social connectedness, and generally offering an enjoyable way of spending time." However, they also conclude that many of the games

they tried were either not enjoyable or were unsuitable because of a challenging interface such as small size of objects, too rapid movement or reaction time required. Both functional limitations and a simple lack of technological experiences mean that seniors suffer more from usability problems than young people. Adults are all age groups in between, and we suggest that they gradually move from one end of the scale to the other, depending both on age and how accustomed they are with this type of tool. With a careful design it should be possible to design games that cover larger groups by for instance using personalization elements such as different levels, and also letting the users choose whether for instance speed shall be used, change font size, etc.

5.5 Evaluation

Evaluation is an important aspect of any project or product. The evaluation of health games is crucial in order to determine whether it has any impact on the users, otherwise health games may lead to a waste of limited healthcare resources. In addition, the evaluation of health games is the only way to build knowledge on which characteristics make health games effective. Unfortunately, many health games reach the market without any evaluation on their positive or negative effects.

The evaluation of health games comprises technical and health-related aspects depending on the context of the application. Not all the games have the same clinical significance and therefore evaluation requirements. A game to increase the awareness among teenagers needs to be attractive to reach as many as possible. On the other hand, an exergame for brain stroke rehabilitation may require a complete clinical evaluation (e.g. clinical trials) and cost-effectiveness analysis to be introduced in clinical practice. Exergames will typically measure weight changes or the amount of exercise. Games trying to inform or modify behaviors will typically use standardized questionnaires to capture information about habits and acquired knowledge.

Clinical evaluation is very complex, and even if the patient outcome is positive, it does not mean that the health game has had any effect since the placebo effect may occur. Therefore, it is a common practice to use randomization and control groups to determine how much of the improvement is really caused by the health game. The design of the clinical evaluation needs to be done during the game design phase and involves the collaboration of healthcare personnel. For example, the game has to be designed to acquire the necessary data to evaluate the efficacy of the game (e.g. quizzes with standardized questionnaires).

A well-designed game from a health point of view can fail if the game is not attractive to the users, meaning that all the principles from a game design point of view need to be taken into consideration. Human factors are even more important than in a standard game since many of the users may have limitations by their health status. In the case of elderly users these aspects are of key importance since their cognitive abilities may be impaired due to neurodegenerative disease (e.g. dementia).

6. Conclusions

According to research [e.g. 6, 7, 9, 10], many games aimed at health promotion do work, but still there is not enough evidence to conclude definitely what kind of design principles work for what purposes. Traditionally the research literature in health games does not describe which game design methodologies were used.

When designing health-related games, one should define both the target group and main purpose, and then design a game accordingly using sound game design principles, but also utilizing design elements and learning principles to enhance learning and persuasion for change of life style. While children may like “rich” games with a lot of contents and information as well as playing together, the elderly may prefer simple games to learn. Adults will likely move from the preferences of children to the preferences of the elderly as they get older.

Feedback is important in games. In real life, most feedback connected to a disease is negative. In games it is possible to give positive feedback when you do things right, and also game rewards can make people solve tasks that otherwise are considered boring.

The main content of games can either be intrinsic or extrinsic. The latter at least seems to work in persuasion while the first is more common in learning. There is a need for further research into this as well as into how social aspects in games work in persuasion, for instance how co-operation or competition influence the players. Even though the evidence shows that smoking is dangerous, to quit smoking is not a trivial task. It is uncertain that a game, however well designed, will be better in persuasion than other mechanisms, and more research is also needed to understand whether gaming can establish long-lasting changes in habits or daily (medical) routines.

6.1. Implications of results for practitioners and consumers

There have been many studies and reviews [e.g. 6, 4, 9, 10] where health games have been found to be a successful tool for health education. Design aspects are a key part for success, which in most of the literature is overlooked. This review outlines the main aspects that need to be taken into account when designing health games for health promotion and education.

Conflict of Interest

The authors declare that they have no conflicts of interest in the research. The article did not involve research on human subjects.

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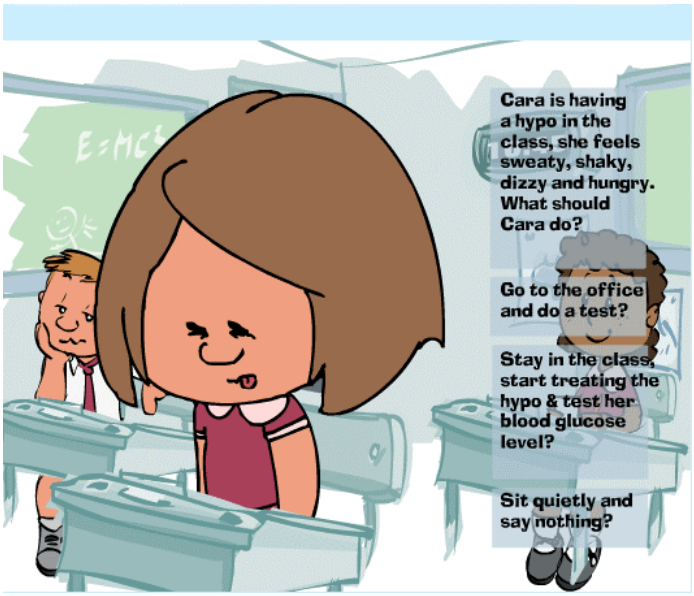

Fig. 1 From the game "Hypos at school" [21]

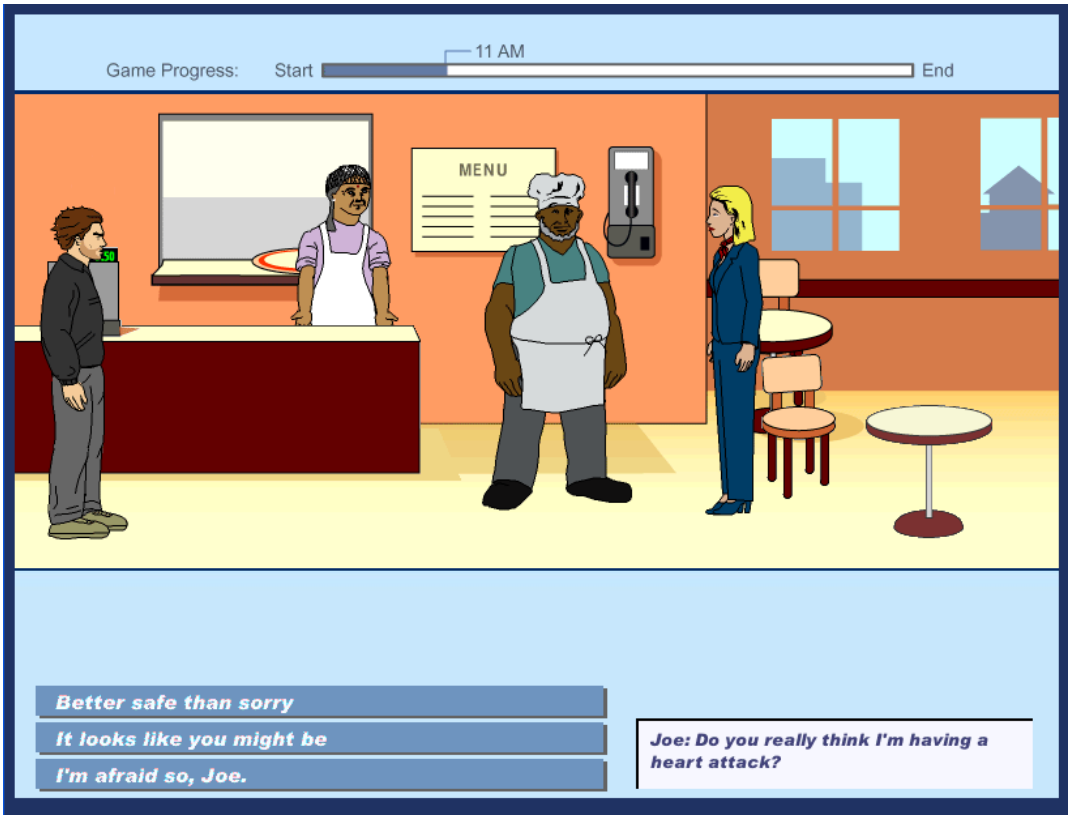

Fig. 2 Scene from the game "Heart Sense" for heart attack prevention with possible replies [23].

Fig. 3 The Nintendo DS with the blood sugar meter "Didget" from Bayer [33]

Table 1 Games mentioned in the paper. Edu = educational games, exer = exergames, persu = persuasive games.

	edu	exer	persu	child	adult	senior
Fish'n'Steps [7]		x	x		x	
Hypos at school [21]	x			x		
Lunch Crunch [22]	x			x		
Heart Sense [23]	x				x	x
Trigger happy [24]	x				x	
Birdwatching [25]	x				x	
Dakim Brain Fitness [26]	x					x
Inside and outside [27]	x					x
Nintendo Wii sport [28]		x		x	x	
Wii Active Life Outdoor challenge [28]		x		x		
Froggers Hop, Skip & Jumpin' Fun [29]		x		x		
SmartCycle [30]	x	x		x		
Eyetoy: Kinetic Combat [31]		x			x	
Dance Dance revolution [32]		x		x		
Didget [33]			x	x		
Rex Ronan: Experimental Surgeon [34]	x		x	x		
Escape from Obeez City [35]	x		x	x		
My Stop Smoking Coach with Allen Carr [36]			x		x	
Escape from Diab [37]		x	x		x	

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