pHealth 2012
B. Blobel et al. (Eds.)
IOS Press, 2012

doi:10.3233/978-1-61499-069-7-85

Gamification and Serious Games for Personalized Health

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Abstract. Computer games are no longer just a trivial activity played by children in arcades. Social networking and casual gaming have broadened the market for, and acceptance of, games. This has coincided with a realization of their power to engage and motivate players. Good computer games are excellent examples of modern educational theory [1]. The military, health providers, governments, and educators, all use computer games. This paper focuses on Games for Health, discussing the range of areas and approaches to developing these games. We extend a taxonomy for Games for Health, describe a case study on games for dementia sufferers, and finally, present some challenges and research opportunities in this area.

Keywords. Gamification, serious games, games for health, game design.

Introduction

Personalized health is about providing personalized interventions focused on the individual needs of the patient. This personalization also provides the user with a sense of control over their healthcare. The increasing use of games and game based approaches to motivate and engage users also expresses an increasing desire for control.

One of the primary motivators in computer games is the sense of control provided by being able to influence the course of events, the tight relationship between your actions, and the outcome of the game. In some games, this can be the ability to save the world from alien invasion, and in others merely the matching of colored patterns to score points. In either case, it is the actions of the player that determine the result.

Traditionally, Western medical treatment has been focused on an expert, matching the symptoms of an individual with a diagnosis. Interventions were performed based on population statistics, generalized information, and treating symptoms in isolation. This happened not because of a desire to ignore the individual, but because of lack of evidence on how individuals respond to interventions. The information age has changed the landscape of healthcare. The Internet of Things, genetic analysis, real-time recording and analysis of health information have created the opportunity for personalizing healthcare.

Computer games and personalized health share the ability to place the individual in the center of the action. Good computer games provide challenges that match the skills of the player. The state of being deeply engaged in a game based on the difficulty

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matching your current ability has been termed "Flow" [2]. Flow shares some characteristics with personalized health. They match the actions of the system with the specific state of the individual. This symmetry means that games for health are a natural fit with the goals and objectives of personalized health.

Games have been used in many areas of healthcare [3], from exergaming, such as the Wii Fit™, through to the use of simulators to train administrators, such as Virtual-U. Given the rapid growth of the use of games in healthcare it is important to organize the field and discover underlying trends and potential interactions.

1. Taxonomy of Games for Health

The Games for Health project [4], which started in 2004, generated a taxonomy for categorizing Games for Health projects (see Table 1 below). This taxonomy provides one way of categorizing the different types of games used in healthcare.

Table 1. The Games for Health Taxonomy developed by the Games for Health Project.

Area of health activity	Personal	Professional practice	Research and academia	Public health
Preventive	"Exergaming" Stress	Patient Communication	Data Collection	Public health Messages
Therapeutic	"Rehabitainment" Disease management	Pain distraction Cyberpsychology Disease management	Virtual humans	First responders
Assessment	Self-ranking	Measurement	Inducement	Interface and visualization
Educational	First Aid Medical information	Skills and training	Recruitment	Management simulations
Informatics	Personal health records	Electronic medical records	Visualization	Epidemiology

Within the taxonomy there are the neologisms Exergaming and Rehabitainment. There has been a succession of such terms used for the general application of computer games and game mechanics to real world problems – edutainment, game-based learning, persuasive games, ulterior motive games and games for health. The two terms that seem to be gaining acceptance to distinguish two different approaches for using games are Serious Game and Gamification.

Gamification and Serious Games are on a different dimension from the above taxonomy. They refer to the way in which the experience has been designed. Is it merely the addition of game elements to an existing activity, or does it require creating a whole new experience to engage the user?

1.1. Design Approach

Serious Games is a term used to describe the development of games specifically designed to achieve some change in the player. This could be a change in knowledge, attitude, physical ability, cognitive ability, health, or mental wellbeing. This makes the distinction between games that have been designed for entertainment, where changes in

the user are merely side effects, and games where those effects are the purpose of the project. The Olympic Games are a classic example of using games to achieve another purpose. The ancient Olympics were about military training and fitness, while the modern Olympic Games have the goal of:

> "Blending sport with culture and education, Olympism seeks to create a way of life based on the joy of effort, the educational value of good example, social responsibility and respect for universal fundamental ethical principles." [5]

The term Gamification is relatively new, and there is still an open discussion on how to apply the term to the many possible applications of game techniques. The growing consensus is that Gamification refers to:

> "the use of video game elements in non-gaming systems to improve user experience (UX) and user engagement."[6]

The dual references in this definition to user experience and engagement captures part of the motivation for using computer game techniques, engaging the user.

1.2. Target Audience

Identifying the target audience for a health intervention using computer games or game techniques is critical to both designing the experience, and measuring efficacy. Games developed within academic environments tend to focus on both a narrow age range and a specific health objective. This is partly due to the need to measure a specific health outcome, and the nature of targeted funding for research.

Extending the taxonomy above, we can refer to the target audience as either **narrow** or **broad**. Projects focused on a narrow demographic, be it age, gender, race, location, or any other feature, have the advantage of being able to tailor the experience to match the cognitive, emotional, or physical attributes of their users. The broader the audience, the harder it is to design the experience and measure the effect of the intervention.

Games for health have a desired health outcome that can be either **specific** or **general**. Specific health outcomes, such as rehabilitation games, are easier to design and measure, but have a much smaller impact on the general population. General outcomes, such as exercise games (exergames) are much broader in scope and so have the potential for influencing the health of large parts of the population.

2. Personal Games and Health Outcomes

Within the area of personal games in the taxonomy, there are different categories of activities. These focus on the type of change, be it prevention, therapy, or information (assessment, education, informatics). An interesting alternative dimension is the area of health that is being affected. In this section, we discuss the three areas of physical, cognitive, and social/emotional health.

2.1. Games for Physical Health

Traditionally sports have been used as games that promote physical fitness and health. Most sports however were not designed to ensure the physical health of the players, even when governing bodies changed the rules to try to protect the players. Computer

games developed for physical health have the flexibility to define the rules and actions to maximize the benefit for the player, while minimizing risk.

There are already several commercial games that address physical fitness. These commercial off the shelf (COTS) games are successful specifically because they target a market need. Examples include: Wii Fit (43 Million units), Just Dance (30 Mil), Zumba fitness (8.4 Mil), My fitness coach (4.7 Mil), and Kinnect Sports (4.2 Mil) (numbers from VGChartz [2]). Integrated solutions that use mobile devices with GPS to record and promote physical activity have also become popular, including Fitbit, RunKeeper, and Garmin Connect.

The key to developing computer games for physical health is to use sensors that require the user to move. The "Dance Don't Fall" game, and "Text mat" from this pHealth conference are excellent examples of games that promote physical health. These games also promote other areas of health, both social and cognitive.

2.2. Games for Cognitive Health

Games can challenge more than merely a player's physical strength and dexterity. Traditional strategy games such as Chess and Go have been used to try to help develop the strategic and cognitive abilities of the players, with limited success [7]. Recent computer games specifically marketed at cognitive improvement, such as Brain Age (35 Mil [2]) have been extremely successful commercially. Research has shown that these games appeal a wide range of individuals [8], and that they can have a beneficial effect [9].

There is a growing body of research on developing cognitive activities and games specifically for the elderly. Dementia is specifically targeted as it is one of the most significant problems facing social welfare systems in coming decades. Section 3 presents a case study on a game developed with dementia sufferers as a target group. This game is both narrow and specific by the extension of the taxonomy.

Within the area of cognitive improvement, Websites such as Lumocity[3] target cognitive development as their unique selling point. Research using Lumocity has shown improvement in cognitive ability for specific target groups [10]. This result would not be unexpected given that most computer games require the player to think, and much like any exercise, the body will strengthen the parts which are used.

2.3. Games for Social and Emotional health

Computer games have in the past been criticized as anti-social activities [11]. This attitude has changed because of Massively Multiplayer Online Games (MMOGs), the Nintendo Wii's strong family focus and the development of games on social networking sites. Games on these sites actively encourage the players to link with their friends and both compete and collaborate to achieve their goals. These games can provide the shared experiences and discussion opportunities which enable the development of a sense of community.

Games have successfully been used to counter depression in teenagers [12] and social isolation in the elderly [13]. In this session of pHealth2012, all three games presented include an aspect of improved social interaction as part of the objectives of

[2] http://www.vgchartz.com
[3] http://www.lumosity.com

the games. Multiplayer games and the social spaces around games can be used to increase the social interactions of people who may be normally excluded by non-digitally mediated environments. Games can provide a playful environment to engage socially with a wide range of people. The Nintendo Wii encourages grandparents to play with their grandchildren. Games can also provide a normalizing environment for the players, as one of my players once said: "When using text chat, nobody knows you're quadriplegic".

3. Case Study on Games for Dementia

The main issues related to introducing technology, including computer games, into a healthcare system is that the primary care givers are extremely time poor. There is no time available for training or acting as technology support for the users. Even a small amount of additional workload for nurses is a barrier to implementation of a potentially beneficial game. To address this problem we focused on the development of a tablet based quiz game that could be played independently [14].

3.1. Background

One of the critical issues facing society is how to maintain the cognitive, social and emotional health of our burgeoning elderly population. The improvements in our medical expertise have lengthened life expectancy, without an equivalent improvement in our understanding of the brain and how to maintain mental health [15][16]. This general trend to live longer has increased the need to maintain mental health among the elderly [17].

Computer games may be able to contribute to delaying cognitive degradation and social malaise. However these games need to be tailored to the elderly, in game play, interface, pacing, and objective.

3.2. Design Objectives

The design requirements for the game were to create a reminiscence game for mild dementia sufferers in a rest home setting. Reminiscence has been shown to have a beneficial effect for the elderly [18]. The game was required to run on a tablet, and require minimal input from the nursing staff. It also needed to run natively on the device, rather than as a web-app, as most rest homes in Norway do not have Wi-Fi coverage.

3.3. Iterative Development

The development of the game required multiple cycles of: design, implement, test, and evaluate. The current state of the game has been through six of these cycles using onsite testing in rest homes in two different locations in Norway. This large number of iterations was required given the difficulty of developing an intuitive interface for dementia sufferers on a device that was new to all of the participants [19].

The current implementation of the game is for Android Tablets[4] written in Java using the Android SDK and Eclipse IDE. This combination was selected for ease of development and flexibility in the access to features of the tablet [20].

The initial design of the game included only text instructions, however, after three development iterations, both audio output, and automatic progression were added to the requirements. This iterative updating of the requirements is essential for creating user-centric applications.

In each development iteration we included field tests of the game with the target group. In addition to direct observation and recording of user behavior, we included feedback from nursing home staff, regional care coordination staff, user interface experts, and an expert group in ergonomics in elderly care.

The final assessment was performed using a qualitative analysis with interviews of each participant and one nurse per test. The sample was only six users. This limits the statistical significance of the results, but can still provide feedback for future development and larger studies.

Figure 1: Example of using MasterQuiz on the Galaxy Tab

("What can Dispril help with?")

3.4. The Game

MasterQuiz starts with a lure announcement asking someone to pick it up and play. This is both shown on screen and with audio text-to-speech. Once a player picks up the device (registered by the accelerometer movement), the game gives instructions on how to play. The player can either move forward manually or wait for an automatic progression.

The core of the game is a quiz with an image displayed on the left and text based answers on the right, see Figure 1. The speech bubble represents the audio output. When the user selects an answer, they are either congratulated with text and a cheering sound, or asked to try again with a quiet notification. They can continue to guess until they get the answer right. The game moves to the next question and scores them on number of guesses.

The game settings allow the user to select either generic questions or personalized questions previously uploaded to a web database. The generic questions can be filtered by decade or customizable tags for each of the images such as sports, home, science, arts, etc.

[4] Tested devices included: Galaxy Tab, Hauwei S4, Multicom mPad Z1, Dell Streak 5.0

3.5. Results

The focus of this project was not to analyze the performance of the users on the details of the quiz, but to assess the level of independence while playing. User observations were conducted using a modified Functional Independence Measure (FIM) [21] focused on using the game. Data was also collected from the device, including the number of touches outside of the answer area, time taken to answer questions, and number of incorrect answers.

The most important result was that for the majority of the users it was possible to independently play a game on a mobile device. Just over half (21/40, 52%) of all questions required no interaction from the carer. Only one user required the carer to physically assist for answering a question. The other users showed different profiles of usage and learning. One only asked at the beginning and then played independently, while another only asked when she did not know the quiz answer. One user contributed 87% (21/24) of requests for assistance in answering questions.

There were no problems with the user interface on the device. This is partly due to solving problems identified in the five previous usability sessions at other rest homes. Specifically, the text was easy to read, the audio as clear, the timing on automatic progression was acceptable, the image question was large enough, the tablet was easy to use for 5/6, and logic of the quiz as easy to follow.

3.6. Discussion, Audio and Touch

Working with dementia sufferers is difficult. When conducting post session interviews with the users, some did not remember much, and one user had no memory at all of the game or the device. The users' cognitive abilities were very different, based on their stage of dementia. This poses significant challenges is producing consistent results.

Audio feedback not only improved the ability to answer the questions, but also nature of the interactions with the tablet. When the tablet was silent, the players treated it as a personal item, much like a book. When the device used speech to interact the users changed their approach. It became a social item, more like the television. This encouraged users to interact socially with each other while learning to use, and playing with the device.

Modifying the sensitivity to multi-touch was important in addressing user interface (UI) issues. Many of the users did not understand the concept of multi-touch, and so would rest a thumb or part of a hand on the device. To solve this problem, we had to treat any touch as a potential question answering touch, rather than a multi-touch gestured.

A second objective for the project was to use the users' performance as part of a diagnostic test for cognitive decline. By recording information about the touches (both correct and incorrect), timing, accelerometer shaking, and game performance, we hope to be able to track the users performance over long periods. This would provide a potential alert for signs of cognitive deterioration. This forms an important part of ongoing research using this game in a rest home setting.

4. Challenges for Using Games in Health Research

There is no magic formula for developing successful Serious Games or for Gamifying an activity. Some proponents of Gamificaiton claim that they can effectively engage users simply by applying a formula for adding points, achievements, feedback, social challenges, and leader boards. However, a game is not simply a collection of parts, it is an integrated system which requires these elements to be balanced and tuned [22]. In this section we discuss some of the issues and challenges related to using games as a tool for behavioral change.

4.1. Measuring Effect

Games allow the player to interact with the game environment. Each time a player plays a game the outcome can change. This interactivity is fundamental to the nature of a game, but it also introduces a great deal of noise in correlating game activity with health outcomes. Two different players playing the same game for the same length of time may have very different experiences. Given that many of the social and cognitive benefits rely on the experience of playing the game, this variation could cause many problems in the analysis of results.

The voluntary nature of games is also important for engagement. The experience of playing a game is very different between choosing to play and being forced to play. Some definitions of the term "game" explicitly require that the player voluntarily chooses to play [23]. If we only measure people who want to engage in a particular activity we could easily suffer from "selection bias". A game may only be effective for players who want to use the game in the way it was intended.

4.2. Quality of Games

The primary distinction between an "activity for health" and a "game for health" is related to the motivation and engagement of the participant. If a game is not engaging and enjoyable, then it is hard to call it a game at all, but it becomes merely an activity. Adding points to an activity does not make it a game. The derogatory term coined by Margaret Robertson for this reductionist approach to games is pointsification[5]. The shallow act of adding points to the outcome of an activity will motivate player for a short time, until they realize that the points are irrelevant.

Designing good games is difficult. Game designers can spend years designing a game and still have it fail. Testing a poorly designed game to see if it has a health benefit is similar to testing a badly written textbook to see if it helps learning. For both books and games, the quality of the artifact is vital to the quality of the effect. Unfortunately, most games developed by academics and health professional are not good games. The negative connotations of Edutainment are directly related to the number of very low-quality games that were developed by teachers rather than game designers.

The advice to academics and companies looking to develop games for health is that they need to include experienced game designers in the project from the very beginning, and allow the designer to direct the interactions. Without strong design the project is almost certain to create a bad game which will have little beneficial effect.

[5] http://www.hideandseek.net/2010/10/06/cant-play-wont-play/

4.3. Extrinsic vs Intrinsic Motivators

Games and Gamification of an activity both provide extrinsic motivators for a change in behavior. One of the hidden dangers associated with providing an extrinsic motivator is the potential to destroy intrinsic motivators. Deci et al. (1999) provide a meta-analysis showing that extrinsic motivation undermines intrinsic motivators [24]. A lack of intrinsic motivation may be acceptable in some situations such as short term rehabilitation programs, as they do not need to be permanent lifestyle changes. However, most health interventions require permanent change in the user's behavior. If the motivation for an activity is linked to a game, when the game ends what happens to the activity?

The implication for researchers working in the area of games for health is that we need to pay specific attention to the motivational aspects of the activities we are affecting, both during the experimental period and after the game has been removed. Improving healthy behaviors for a short period of time by using a computer game may have a negative overall impact on the player if, when they stop playing, they have decreased their intrinsic motivation for those activities.

All research connected to games for health needs to address the issue of motivation and provide data from participants collected well after the end of the intervention period. This requires research funding to span much longer periods and the commitment to a holistic approach to the changes created by introducing games to healthcare systems.

4.4. Games, Rhetoric and Perception

In his book Persuasive Games [25] Ian Bogost discusses the role of games as ways of conveying ideas, the rhetoric framework that alters the user's interpretation of the activity. However, the rhetoric of a game is not entirely determined by the designer. The player's experience of a game is determined by the complex interactions between the player and the set of rules, the procedures, of the game.

As the experience of the game is not strictly controlled by the designer, the player may subvert the original intention of the game. Children may enjoy the animation shown for failure more than success, and so may intentionally fail at an activity purely to watch the result. It is extremely difficult to control the experience of the user and retain the freedom of interaction which distinguishes games from films. It is the interactive nature of a game that makes it both powerful and difficult to control.

Turning an activity into a game may trivialize the activity for many people. Games are associated with lowered risk and childlike freedom. Gamifying activities that are critical to the health of an individual may diminish the seriousness of the activity. Failing to take medicine at a certain time does not merely obtain a low score in the game, it can be a fatal mistake.

Bogost has also coined the term "exploitationware" to refer to the use of games to control users to perform actions that they would not freely choose to do. This usually refers to companies using game mechanics, and the feedback mechanisms of operand conditioning to try to encourage users to spend money on products they do not need.

4.5. Gamers Will Game the System

An interesting challenge for any serious game system is the issue of the players meta-gaming the system. Meta-gaming refers to the player stepping outside the intended rules of the game and playing with the rules of the game's environment. Although this can happen with any treatment plan, because we are explicitly using game systems, the barrier to meta-gaming the plan is much lower.

Treatment plans normally have a set of instructions and rules which the patient needs to follow. If a game is included within the plan, it will have its own rules and environment. The intention is to have the player follow the rules to achieve a good score. However, just as some children will attach their pedometer to a pet dog to increase their stepping score, they will find ways to manipulate the game to win rather than to achieve the desired health outcome. For example, it is easier to get a good balance score in the game Wii fit using a sack of potatoes than to actually stand on the device.

Ensuring that there are no loopholes in the interactions of a game's rule set is difficult. When the objective is to have a positive impact on the players' health, these loopholes could not only render the game ineffective, but could cause harm by creating the illusion of success which masks an underlying problem.

There is no simple way to ensure that players are not meta-gaming. The best advice for designers of serious games is to encourage the players to accept the objective of the game. In games for health this means the player needs to understand the health benefits from playing, and how those relate to the rules of the game.

4.6. Ethics, Clinical Trials, and Approval

One of the significant barriers to working in the area of games for health is the process of applying for, and receiving ethical clearance to, conduct trials. Ethics committees for medical trials are designed to protect the patients and population. Their processes are designed around drug trials and new equipment. Both of these require very long development periods. Technology, and computer games in particular, are developed at a much faster rate than drugs or medical equipment. This creates a tension between the rapid development of a game and the need to have the content and approach audited.

Further compounding this problem of rapid development is the issue of ensuring the content is appropriate for the intended audience. Many games reveal content over the duration of play, partly to reward the player for success. Unlike a book or a movie where the whole content can be viewed, games present a significant difficulty for censoring organizations and ethics committees.

Medical ethics need to build new approval systems that allow game developers to run tests quickly and rapidly develop new games and test them with the target audience. Ethics approval needs to be given to the framework rather than a completed version of the game. Developers need to have the freedom to make changes that improve the game without having to reapply for approval for each update.

The cost of clinical trials creates another barrier to the inclusion of games in healthcare. The estimated average cost for clinical trials of new medicines was $250,000 USD in 2009 [26]. This would form a significant proportion of the development budget for most of the games for health projects. However without full clinical trials, which show the benefit of a specific game in a specific setting, it will be very difficult for games to become a standard treatment option.

5. Opportunities and the Future

Computer games will be part of the future of healthcare. They will support both personalized and participatory health. This presents a great opportunity to develop better games and provide evidence for when they are effective and when they fail.

From the personalized health perspective, games will provide a new source of information about the user, their preferences, abilities, their social networks, and even their play style. Computer games already collect large amounts of data about each player [27]. This measurement goes beyond the obvious metrics of score and completion percentage and includes such things as reaction time, actions selected, actions per second, communication with other players, and time spent in activities. This wealth of data exists, the challenge is to find ways to access and analyze it.

The European Data Protection reform[6] includes the provision for data portability. This provision requires companies who collect data about their users to provide that data to the user upon request. If this law is passed it provides the mechanism for users to voluntarily provide data from the games they are playing to a health information system. The user is in the center of these reforms, and so they must see the benefit of providing data, and have the control over how it is used.

This wealth of data and the interconnectivity between systems will require improved visualization and analysis techniques. The human mind is extremely well tuned for detecting visual patterns. Games can contribute to meet such objective both technologically and methodologically. Game Engines are already being used for visualization, but also for solving complex real world problems such as image tagging with the ESP game [28], and protein folding using Foldit [29].

Computer games will be part of personalized healthcare systems. The data they generate will be used as part of the diagnostic systems, and the games will form an integral part of most treatment plans. The first decade of the 21st century was the beginning of "dig data", the next decade will see the beginning "integrated gaming", where the data in games and social networks becomes integrated with all other forms of personal data.

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