Video Games vs. Diabetes

Using video games as an aid to self-care

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Abstract
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Video Games vs. Diabetes: Using video games as an aid to self-care
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Glymetrix, Inc., is a company which makes and hosts internet browser-based games designed for players who have diabetes mellitus. In an attempt to analyze these games, research on healthcare, video game design, and behavior change was compiled to create a list of design principles for video games aimed at helping players improve their long-term self-care habits, with specific attention to diabetes patients. Other games designed for players with diabetes are also examined, to refine the design principles based on previous attempts and the studies which accompanied them. These principles are applied to the two games made by Glymetrix in order to highlight their specific strengths and points for possible improvement. Additionally, players’ play habits are analyzed to find any patterns which could be informative for Glymetrix and possibly aid in encouraging players to play more.
# Table of Contents

Abstract .................................................................................................................................................. ii

Table of Contents .................................................................................................................................. iii

List of Figures ........................................................................................................................................ iv

List of Tables ......................................................................................................................................... v

1 Introduction ........................................................................................................................................ 1

2 Background Research ....................................................................................................................... 2
  2.1 Self-care ......................................................................................................................................... 2
  2.2 Behavior Change ........................................................................................................................... 3
  2.3 Game Design .................................................................................................................................. 4
  2.4 Serious Games ............................................................................................................................... 5

3 Design Principles ................................................................................................................................. 7
  3.1 Relevance ....................................................................................................................................... 7
  3.2 Goals ................................................................................................................................................. 7
  3.3 Feedback .......................................................................................................................................... 7
  3.4 Immersion ....................................................................................................................................... 7
  3.5 Individualization ............................................................................................................................. 8
  3.6 Simulation ....................................................................................................................................... 8
  3.7 Winnability ..................................................................................................................................... 8
  3.8 Socialization .................................................................................................................................. 8
  3.9 Standards ....................................................................................................................................... 9

4 Previous Games .................................................................................................................................... 10

5 Glymetrix Games ............................................................................................................................... 12
  5.1 Applying the Design Principles ................................................................................................... 12
    5.1.1 Relevance .................................................................................................................................. 12
    5.1.2 Goals ......................................................................................................................................... 12
    5.1.3 Feedback .................................................................................................................................. 13
    5.1.4 Immersion .................................................................................................................................. 13
    5.1.5 Individualization ......................................................................................................................... 13
    5.1.6 Simulation .................................................................................................................................. 13
    5.1.7 Winnability .................................................................................................................................. 13
    5.1.8 Socialization ................................................................................................................................. 14
    5.1.9 Standards .................................................................................................................................. 14
  5.2 Analyzing the Player Data ............................................................................................................. 14
    5.2.1 Initial Constraints ....................................................................................................................... 14
    5.2.2 Methods .................................................................................................................................... 15
    5.2.3 Analysis ..................................................................................................................................... 16
  5.3 Glymetrix Games: Conclusions ................................................................................................... 21

6 Conclusions .......................................................................................................................................... 22

7 References .......................................................................................................................................... 23
List of Figures

Figure 1: Player/Session data structures .................................................................................................... 15
Figure 3: All games played in 2010 (through March 6) ........................................................................... 18
Figure 4: Solitaire games played in 2010 (through March 6) ..................................................................... 19
Figure 5: Quiz games played in 2010 (through March 6) ......................................................................... 19
Figure 6: Solitaire game scores .................................................................................................................. 20
Figure 7: Quiz game scores ......................................................................................................................... 20
List of Tables
Table 1: Number of games played in 2010 (through March 6) ................................................................. 16
Table 2: Number of games played during January 8-14, 2010 ................................................................ 16
1 Introduction

In the past decade, video games have risen sharply in popularity to become one of the top forms of entertainment in the world. In the United States, video games have surpassed both music and movies to become the third-highest grossing entertainment industry (behind books and DVDs) (“Video Game Sales Wiki: Video game industry.”), and so it is no surprise that they have begun to attract attention as a medium not only for entertainment, but for spreading political, educational, or other “serious” objectives. These so called “serious games” have become so prevalent in recent years that they have spawned conferences and graduate degree programs, and it has become common to classify them into various categories, such as “advergames” (games designed/sponsored by a company to advertise a commercial brand or product), “edutainment” (games designed to deliver educational material), or “exergames” (games designed to get players to exercise and improve their physical health).

The United States has seen a sharp rise in epidemics generally caused by the modern American lifestyle, chiefly obesity and diabetes (“CDC.gov.”). Subsequently, various health-related interests have begun to examine video games as a means by which to improve the general health and lifestyle of Americans via nutritional education, health awareness, and exercise; “exergames” – games whose main mechanic involves some form of physical activity or exercise – have become increasingly common since the success of Nintendo’s *Wii Fit*, which has sold over 22 million copies worldwide (Nintendo Co. 6). The general goal of this work is to examine the possible efficacy of video games as a tool to improve the health and lifestyle of players with diabetes by educating them about their conditioning and motivating them to make positive choices in their self-care.

While significant amounts of research have been done on the science of behavior change, and the number of studies examining the effectiveness of individual uses of new media and technology in the fields of education and healthcare is growing, little research has attempted to bridge the two fields and construct a set of game design principles rooted in both theoretical cognitive science and the empirical results of previous health-based video games. This paper examines existing literature and research in several areas – chiefly, cognitive science and behavior change, traditional game design and player motivation, and the success of and reaction to “serious” games such as edutainment and health-based games – and delineates a general framework for the creation of games with the goal of improving their players’ personal healthcare. We then look at two games designed and produced by Glymetrix, Inc., in an effort to evaluate their efficacy as tools to improve the self-care practices of players with diabetes, and as a measure of the accuracy of the new design principles.

While the analysis of the games from Glymetrix does not suggest that they are effective at improving their players’ self-care habits, the games also unfortunately deviate from the set of design principles in several key areas. Therefore, the principles are then applied to the two Glymetrix games to suggest possible areas of future development and improvement. Additionally, a brief overview of emergent research in the area of social-network games is highlighted as a potential source of significant interest for Glymetrix and other developers seeking to utilize video games and other new media for healthcare purposes.
2 Background Research

The research behind this study can be divided into four general categories: health- and self-care, behavior change and psychology, general game design and entertainment, and serious-game design and education. Given the diverse, and often seemingly unrelated, natures of these four categories, this paper will present each of them separately, highlighting common points which will then be brought together at the end of this section.

2.1 Self-care

When dealing with a chronic illness, it is imperative for the patient to be able to manage his own care without constant supervision from a healthcare provider, a concept known as autonomy. However, a patient’s ability to maintain autonomous self-care is heavily influenced by his self-efficacy, the patient’s own perceived ability to perform self-care tasks. Although these two concepts are inextricably linked, they in fact each contribute to different aspects of long-term self-care, and methods for enhancing each of them are discrete (Senécal, Nouwen and White 452-457).

Increased autonomy in adults with diabetes has been shown to shift the balance of motivation from extrinsic towards intrinsic, generally without affecting overall motivation levels. Self-efficacy, on the other hand, shapes a patient’s expected outcomes of his efforts, and therefore dictates the amount of effort a patient is willing to expend on self-care activities; a patient expecting a positive result is more likely to engage in a specific behavior than a patient expecting a negative or no result. A patient’s self-efficacy also affects his perception of obstacles and aids to self-care (Bandura 143-164). Both autonomy and self-efficacy correlate with general life satisfaction and adherence to self-care activities, but autonomy correlates more closely with the former, while self-efficacy correlates more closely with the latter – and the two correlations are in fact independent of each other. Self-efficacy is subsequently the more important of the two factors when a patient is attempting to overcome a specific barrier to self-care (Senécal, Nouwen and White 452-457).

Given that every patient is unique, and that every patient has different levels of perceived autonomy and self-efficacy, it is important for self-care programs to be individually tailored for each patient. Bandura proposes a stepwise model split into three tiers of perceived self-efficacy to gradually improve patients’ perceived ability to manage their condition at home. Others have suggested increasingly individualized treatment regimens as a key to improving self-care among diabetes patients (Nauck, El-Ouaghlidi and Vardarli 587-594). In a study which examined three games designed to educate Type I (Juvenile) diabetes patients with differing levels of knowledge, testers generally agreed that they would appreciate more individualized tools “which reflect their own condition” (Aoki et al. 855-859).

However, “individual” does not mean “alone” – in fact, Bandura also claims that social support can increase the chances of long-term success, especially during the early stages of a self-change process, although he also cautions against social support which creates dependence. In one program which he examined, Bandura noted that patients whose spouses also participated generally reported higher results, while participants in physical fitness studies were encouraged by support from family members and saw longer-lasting effects. The same two studies also found that social aspects within the programs were positively received by participants, who were more likely to meet their personal fitness goals when
grouped with teammates and/or competitors with whom they could discuss their progress (Consolvo et al. 457-466; Lin et al. 261-278). Previous self-care games have already noted and taken advantage of this source of positive support to great effect; Lieberman frequently notes the importance of social interaction both among players and between players and their family and friends (Lieberman 103; Lieberman 379).

2.2 Behavior Change

One of the main goals of many health-related games (and, indeed, many non-videogame health campaigns) is to encourage and motivate people to change some form of behavior – be it diet, exercise, or addictive habits. However, inducing this sort of behavior change is not a simple task; reviews of previous research on effecting dietary changes have concluded that merely imparting knowledge of the relevant subject matter is not enough (Baranowski et al. 74). Most research on behavior change focuses instead on motivation, specifically, the differences between intrinsic and extrinsic motivation. Intrinsic or autonomous motivation is the result of an individual’s personal reasons for accomplishing some goal, i.e., they feel as though achieving that goal will have a desirable effect. Extrinsic motivation is provided by outside sources, i.e., a person works towards a goal because they feel as though someone else is expecting them to do so.

Of the two, intrinsic motivation is far more powerful: among diabetes patients increases in intrinsic motivation have been shown to lead to reductions in HbA1c levels, and it is anticipated that only intrinsic motivation is capable of generating long-term behavior changes (Williams, Freedman and Deci 1644-1651). Among students it was found that shifting the balance of educational motivation from extrinsic to intrinsic resulted in higher engagement in subject matter even in the absence of increased learning (Annetta et al. 74-85). Conversely, in a study measuring both healthy activity and attitudes towards healthy activity, it was shown that participants who expressed no initial desire to improve their own physical activity did not exhibit any positive change, while participants who did express a desire to increase their daily exercise exhibited positive behavior change. Interestingly, the group which exhibited the greatest behavior change was not the participants who professed a strong desire to exercise more, but those who expressed a medium-level desire to improve their physical health – representing a shift in their motivational factors from extrinsic to intrinsic (Lin et al. 261-278).

For patients with chronic illnesses such as diabetes, for whom long-term, at-home self-care is critical, any game aiming to change their personal behavior must do so by means of increasing their intrinsic motivation to alter their own behavior if the game is to be effective. The short-term, small gains effected by extrinsic motivational factors are eclipsed by the potential improvement of a patient who is motivated to take charge of his or her own health. It is therefore logical to examine ways in which video games can be a tool for increasing a player's intrinsic motivation to perform desirable activities.

Additionally, it has been shown that peer and family support can produce increases in intrinsic motivation as well as actual behavior change. Both competitive and cooperative social interactions have shown increases in positive behavior and motivation change effects when examined alongside programs with the same content but no social interaction. Participants in these studies enjoyed and benefitted from friendly rivalries between teams and individuals, communication with other participants, and the
participation of spouses and other family members (Bandura 143-164; Consolvo et al. 457-466; Lin et al. 261-278).

2.3 Game Design
One of the unique advantages of video games as an educational medium is that, inherently, a game represents a safe space in which players can test their hypotheses and view the results of their choices without any real-life consequences – a concept referred to in game design as the “magic circle.” Within the magic circle, the rules of reality are suspended in favor of the rules of the game, and undesirable consequences can be undone or repaired simply by reloading a previously saved game state. Therefore, players feel free to take risks and explore unknown options, and are given feedback on their decisions by the game. The feedback mechanisms built into the game, such as scores or levels, give players the ability to continually reassess their progress and weigh the options available to their characters and their potential outcomes (Papastergiou 1-12).

When it comes to games designed for players with diabetes, the safety of the magic circle and the feedback provided by the game are critical for allowing players to make choices within the game which they might not feel comfortable making in real life – where those choices could impact their personal health. As a virtual character, however, players are free to choose as they please and receive the results of their actions as feedback within the context of the game. However, it is not sufficient for a game to provide an open sandbox in which players can simply choose actions and be either rewarded or punished for them; the goal of a game for health is to encourage and motivate players to make the right choices outside of the game.

A key point to understanding the role of games as an educational tool is that playing a game is a learning experience. As the player progresses, they become more accustomed to the rules of the game world, and gain knowledge of which actions result in which consequences in which situations. Games achieve this through consistent rules and a system of feedback which informs the player of the results of their choices – the more consistent the rules are, and the more obvious the feedback is, the better. As players advance through the game and learn which actions have the best results, they are enticed to repeat those actions (Salen and Zimmerman).

This subconscious means of learning the rules inherent in a system, and subsequently acting according to those rules, is simply a form of behavioral conditioning – one which can be extended outside of the game through mirroring, in which players begin to make choices based on their experience with the game even when not playing. The better a player’s ability to transfer the knowledge gained from the game to problems encountered in the real world, the more effective the game will be at teaching the player the solutions to those problems (Garris, Ahlers and Driskell 441-467). That is not to say that the onus of applying knowledge from games to situations outside of those games lies entirely on the player; it is also up to the game designers to present the relevant information in an engaging, easily comprehensible manner. A well-designed serious game is capable of not only imparting information, but of actually tricking the players into forgetting that they are engaging in a serious activity. In a study of the ability of video games to help participants confined to wheelchairs exercise more, most of the
players appreciated the game’s ability to help them forget they were exercising, and many said they were not aware of how hard they had been exercising (O’Connor et al. 267-273).

A video game environment is not just a representation of a location, but an entire virtual world, complete with a virtual history, virtual characters, and virtual motivations. The complexity of the story for any given game may vary widely, but one thing all games have in common is that they are discrete from everyday life. This fantasy element is another key aspect of the educational potential of video games, because games use their stories to encourage players to continue playing. As players become immersed in the reality presented by the video game, they become more invested in the outcome of the game: What will happen to their character and the world they inhabit? Who will have the highest score? Which side will win the conflict? Each of these questions encourages the player to see the game through to the end. Additionally, the more closely related the story and background of a serious game are to the subject matter at hand, the more engaging the games are for players, and the more a player’s interest in the subject will increase (Garris, Ahlers and Driskell 441-467).

When a game is designed to influence a player’s behavior, there are two main methods by which it can do so: it can place behavior-change elements into the gameplay, and it can place behavior-change concepts into the story. Unsurprisingly, game stories which are centered around the relevant subject matter are more effective at inducing behavior change; e.g., a game about diabetes is better at improving the self-care behavior of diabetic players than a game which is not about diabetes (Baranowski et al. 74-82.e10). When combined with gameplay which is also about the subject, the effectiveness is compounded – players are much more likely to learn better diabetes management skills by playing a game about diabetes, in which their decisions and actions match the choices available to a real person with diabetes. Fortunately, this narrowing of the game’s topic does not come at the expense of the game’s appeal: when players of a group of games designed to educate children with juvenile diabetes were asked whether they would recommend the game to friends without diabetes, 63.8% said they would – even more than those who said they would recommend the game to friends with diabetes (53.5%) (Aoki et al. 855-859).

The effectiveness of the game universe is even further enhanced by the presence of the player character. The presence of a character to whom players can easily relate is a significant benefit to the ability of the game to draw the player in, get them invested in the outcome of the game and of the character, encourage them to view the character as a kind of role model, and to mimic the character’s actions on their own (Lieberman 103). There are two general means by which to accomplish this: allowing players to create individualized avatars to whom they will closely relate, and including a player character with a strong personality within the story of the game. The balance between the two is more dependent on the nature of the individual game being designed than any difference in effectiveness.

### 2.4 Serious Games

Despite their laudable intentions, serious games are not exempt from the same standards of quality as commercial games. These expectations extend to every aspect of game design: audio, visual, narrative, and, most importantly, entertainment. Even in classrooms where video games were tested as an alternative to more traditional (and less entertaining) teaching methods, students nevertheless voiced a
desire for better production quality in the game, so much so that the group conducting the study concluded that a more sophisticated, complex game would be even more effective as an educational tool than the game which they tested (Papastergiou 1-12). The ideal serious or educational game would be one which the target audience would play voluntarily simply because it is a fun game to play (Baranowski et al. 74-82.e10).

The goal of a well-designed educational game is not simply to dispense knowledge, but to increase the player's interest in the subject matter. While the former is the desired end result, the latter is the far more effective strategy for achieving it. In studies which examined the potential of edutainment software, it was found that it was possible for a game to increase a player's interest in a subject without changing their general level of knowledge about the subject (Annetta et al. 74-85), and that this increased interest led to knowledge gains even outside the context of the game (Beale et al. 263-270). Studies also found that relatively short durations of overall gameplay led to lasting interest in the material and a positive shift in the balance of intrinsic vs. extrinsic motivation (Tüzün et al. 68-77).

A good serious game is designed not only to inform players about a topic, but also to encourage them to discuss the topic outside the context of the game. The social aspect of these games is not limited simply to multiplayer gameplay, but can extend to online forums and community websites. The games become starting points for further education, connecting players with similar interests or situations, enabling them to play together, and also linking them to information outside the context of the game. In the case of a diabetes game, this could include group or team play, support and discussion circles, and access to healthcare providers and information. The game does not even need to focus solely on diabetes patients, but can be extended to appeal to their families and friends, allowing them to participate in the community and helping to inform them. The end result is a game which brings people together, and encourages them to discuss diabetes and learn about it in a fun environment (Lieberman 103).

Since a serious game by nature deals with a specific topic, generally with a goal of informing players, it is imperative that the domain information be accurate. Serious games require a multidisciplinary, collaborative effort between game designers and domain experts such as behavioral scientists and healthcare providers in order to create the best educational and entertaining experience possible for the player. Although some game design teams have reported communication difficulties with domain experts when attempting to bridge the gap between fun and learning, they also appreciated the benefit of the experts’ input (Baranowski et al. 74-82.e10).
3 Design Principles
Based on the specific agreements among the various fields of research, and the connections which can be inferred from them, it is possible to construct a set of guidelines to aid in the design of games to improve players’ healthcare. These guidelines are applied to games designed to improve players’ diabetes self-care behaviors, but the general principles remain universal.

3.1 Relevance
Any game designed with an educational or motivational goal in mind should be inextricably linked to the relevant subject. For games aimed at improving a player’s diabetes self-care, this means that they should be about diabetes. Whether that means the game’s story is about diabetes, the player’s character has diabetes, or the game mechanic is built on diabetes-related choices and actions, a game with a purpose should be clear about that purpose – and as long as the game is fun, players will enjoy it and learn from it. This relevance combines with story and character elements to create an immersive experience which deeply engages the players; they will learn about diabetes as they play the game, and they will play the game because they want to.

3.2 Goals
Self-improvement and gameplay are both driven best by short-term, readily attainable goals. Short-term goals help break a long-term objective down into pieces which the player can feel are achievable, and as the player reaches each milestone, he gains increased confidence in his ability to reach the next goal, and eventually the long-term final objective. These goals can be built into the game (e.g., reach the next level) or can be set by the player (e.g., score a million points). For a game designed to help people manage a chronic condition such as diabetes, it may be better to not give the game a long-term objective, but design it along the same lines as an MMORPG, which has no ultimate victory but encourages people to continue playing by setting personal (usually character-based) goals.

3.3 Feedback
Goals alone are not enough to make players actually enjoy a game; the game must reward them for their successes. Similarly, a game must punish players for their failures – gently, and with a nudge towards the correct solution, but nevertheless a form of punishment. For games with any kind of educational goal, this is doubly true; the player must be told when he has chosen the right action or picked the wrong answer if he is going to learn from his decisions. When combined with short-term goals, this creates a very elegant yet powerful teaching mechanism: the player works towards each goal, and is are either rewarded when he achieves it, or is given a clue as to what he did wrong when he fails. In a game about diabetes, this means rewarding the player for making healthy diet choices and for exercising, or penalizing him for not checking their blood glucose and for not exercising – all within the context of the game, but readily applicable to the player’s personal life.

3.4 Immersion
The ability of video games to immerse players in a fictional, alternate reality is one of the main reasons they are of interest to educators. Games achieve this in a myriad of ways: rich stories, engaging characters, and exciting gameplay all lend to an immersive game. But beyond the general game design
goals, this becomes even more imperative for educational games, which seek to have the player retain information or behaviors after he has stopped playing. In order to achieve this desired mirroring effect, these kinds of games must be able to guarantee the player’s investment in the outcome of the game. If the player cares about the progress of his character towards a goal, he will apply the skills and knowledge he gains from the game towards his own goals.

3.5 Individualization
In order for a health-related game to have an impact, the player must feel as though the choices he makes in-game reflect the choices available to him in the real world. The game should be designed to empower the player, to make him feel more competent and confident in his ability to manage his own diabetes care, so that the knowledge and skills gained from the game can be put to use. However, each of the millions of Americans with diabetes has a unique personal situation, and the more closely the game can represent a player’s individual circumstances, the more likely the player will be to absorb information and behaviors from the game. Creating the range of customizability necessary may be a significant undertaking, but the benefit gained by the player being able to more closely relate to the decisions he makes in the game is critical.

3.6 Simulation
The principles of Relevance, Immersion, and Individualization combine in the aspect of Simulation: presenting players with a variety of situations and allowing them to explore the options available to them. In the context of health and self-care, this allows players to make choices they might not be comfortable making in real life, and gives the game an opportunity to inform them about those decisions. This level of simulation is unique to video games and should therefore be taken advantage of, providing players with a detailed and accurate virtual world in which they can take chances and learn in ways unavailable in their daily lives.

3.7 Winnability
It sounds obvious to say that a game must be winnable – after all, what is the point of a game the player cannot win? But winnability is about more than the ability of the player to end the game; it carries with it a strong implication for goal-based motivation. When a game can be won, that means the player’s long-term goal can be accomplished successfully. When that in-game goal is tied to a real-life goal, the player begins to feel as though his own, true goal can also be accomplished successfully. This is a major factor in games designed for players with permanent or chronic illnesses – the ability to win a game about diabetes will lead to the feeling that players can win at diabetes, and each step taken towards in-game and real-life goals increases a player’s confidence in his own ability to manage his diabetes.

3.8 Socialization
The social aspect of a game for health is the only design principle which could be legitimately described as “optional,” but it is a powerful option. Players not only enjoy multi-player or social games as part of the gameplay experience, but find the social aspects – either competitive or cooperative – to be helpful in improving motivation. The encouragement of family and friends and the challenge of friendly rivals both boost a player’s desire to win the game, and, in turn, make progress towards his own goals. The
social nature of the game could be as simple as a forum for players to chat with each other, or as complex as a whole clan and ladder system. But the ability to interact with other people who are dealing with the same problems both in and outside of the game is one which players almost universally appreciate.

3.9 Standards
As games become an increasingly common entertainment medium, exposure to them grows – which is both good and bad for designers of serious games. While this prevalence does lead to a larger potential audience, it also means that more of that audience is familiar with modern, commercial games – including AAA titles which can tax the capabilities of modern computer technology and which are built on the success of previous games. As such, players can have a very high standard for games they play, in terms of gameplay, visual and audio quality, and design and narrative, and players do not grant serious games much leeway within those standards simply because they have educational content. Playing games is a voluntary activity – one which many players invest large amounts of time and money into – and players expect a certain level of quality and fun from any game they purchase.
There have been several games designed, published, and researched with the goal of helping players manage their diabetes. Given the perceived nature of video games, these games were all aimed at children, despite juvenile diabetes representing only a very small percentage of all diabetes cases. Notable examples which this section will review include Captain Novolin, Packy & Marlon, Tamago-ya (Egg Merchant), Tantei (Detective), and Magic Tomb (Aoki et al. 855-859; Lieberman 103).

Captain Novolin was released in 1992 for the Super Nintendo Entertainment System (SNES). The game centers around the eponymous superhero, who has diabetes, when he is called upon to rescue the mayor of his town from aliens which closely resemble snack foods. The junk food aliens deplete some of Captain Novolin’s health on contact, and the player must get past them either by avoiding them or crushing them with carefully timed jumps. Throughout the game, the player is asked questions about diabetes for bonus points, and can collect various “healthy” foods to influence their blood sugar at the end of each level – in fact, the player must be careful not to pick up too many or too few of the “healthy” foods, or they can fail the level even after reaching the end if their blood sugar is not in a safe range. Captain Novolin adheres to many of the design principles above: both the character and the gameplay are about diabetes, and much of the information is applicable for children with juvenile diabetes. However, the story fails to be engaging and the game suffers from extremely frustrating gameplay – it is very difficult to dodge the enemies, and even harder to stomp on them, and losing all your lives ends the game, forcing you to restart from the beginning. So, while it does fail on the basic fun factor, Captain Novolin at least presents an example of how to integrate diabetes into the gameplay mechanic (Hawkes 7).

Packy & Marlon was released in 1995 for the SNES, and closely resembles the Super Mario series of games: up to two players can play as either Packy or Marlon, elephants attending a summer camp where they must defeat enemies in platform-based environments to eat the correct foods during the day, as instructed by their doctor. As in Captain Novolin (the two games were put out by the same publisher, Raya Systems), players are asked questions about diabetes, and are rewarded for correct answers. Players must navigate a series of levels, defeating enemies by shooting water or peanuts from their trunks and collecting the specific foods recommended by their doctor, while they search for a diabetes-related item (such as a medic alert bracelet or a glucometer). In a study of Packy & Marlon’s effectiveness at educating children about their diabetes, it was found to result in an over 75% reduction of urgent-care hospital visits compared to the control group (who played a game unrelated to diabetes) (Lieberman 26). Again, as with Captain Novolin, the game suffers from frustrating and repetitive gameplay, but is another example of how diabetes can be the foundation for the gameplay and even the player’s character (Hawkes 7).

Egg Merchant, Detective, and Magic Tomb were designed together, each intended for players with different levels of diabetes knowledge. In Egg Merchant (for players with no diabetes knowledge), the player must raise an egg with diabetes, making decisions which will determine the health of the chick once it hatches. In Detective (for players with some knowledge), the player’s character has diabetes and must manage his blood sugar to catch a criminal as quickly as possible. In Magic Tomb (for players who
lack diet-related knowledge), the player must select the appropriate foods based on the objective chosen by the game. The three-pronged approach, while obviously requiring the design and production of three separate games, is an excellent example of the success of tailoring health games for individual patients’ needs. Over half of all the testers felt the games were helpful for learning about diabetes and would recommend the game to friends – both with and without diabetes – and over 90% expressed further interest in health-related games. The development team did experience some difficulty in explaining game design to the healthcare professionals they consulted, but the success of the study speaks well for the efficacy of consulting domain experts. Additionally, although it would be prohibitive to custom-make a personalized game for each player, the decision to design each game with a narrower target audience (in this case, divided by prior knowledge) shows that a mass-produced product can still approach a level of individualization (Aoki et al. 855-859).
5 Glymetrix Games
The Glymetrix website hosts two games: a Wild West-themed version of Klondike solitaire (similar to the version commonly bundled with the Windows operating system), and a quiz game similar to the television show *Jeopardy*, in which questions of increasing difficulty are grouped into five categories. The two games differ in the amount and nature of their diabetes-related content. The solitaire game occasionally asks players a question about their diabetes, e.g., “How often do you check your blood sugar,” with possible answers being either True/False or a set of three multiple-choice options. Upon answering, the player is given a “power” that can be used in the game, e.g., finding an Ace and placing it on the foundations, or viewing a card that would normally remain hidden. In order to not appear judgmental of players and their personal decisions, it does not actually matter which of the possible answers is chosen; the player is always given the power just for answering. The quiz game has several categories of diabetes-related questions, but these categories are in the minority; most of the questions are general-knowledge and trivia questions. The quiz game does not have any “powers” like the solitaire game.

5.1 Applying the Design Principles
The design principles outlined in 3 can be applied to the Glymetrix games for insight into which aspects of the games are potentially beneficial for players’ health, as well as which aspects might benefit from improvement. This section is not intended to be a full review or critique of the games, but rather an examination from the perspective of each design principle.

5.1.1 Relevance
Of the two games, solitaire is more closely linked to the topic of diabetes; each of the questions the player answers in exchange for one of the “powers” is specifically about diabetes and the player’s personal knowledge and health. While the quiz game does have some categories of questions relating to diabetes, it is not the overall focus of the game. The quiz game, especially, runs the risk of becoming too narrow in focus if all of the questions were to be about diabetes. Solitaire and the quiz game are not rich enough in story or setting that they could realistically be about diabetes any more than they currently are. While both games are not as relevant as a game about diabetes could be, each of them has struck a good balance for that type of game.

5.1.2 Goals
The goals present in the Glymetrix games are not within the games themselves, but within the site as a whole. Players can accumulate points by playing the two games, which may then be spent on an array of prizes. Each prize has a fixed, point value, giving players who are interested in obtaining a specific prize a solid, numerical goal to strive for. Because it is up to the player to decide which prizes are worth obtaining, these self-made goals are an excellent source of short-term motivation. Since some of the prizes are related to diabetes (such as medical supplies), the goals are also tied to the relevant topic. However, the goals could be more effective if they were more directly related to diabetes and the players’ personal health; as it is, there is no direct relationship between the number of points scored by a player and his health or self-care. By making the points more obviously linked to positive self-care practices, players will be more motivated to implement those practices in pursuit of their goals.
5.1.3 Feedback
Feedback is one of the areas with the most potential for improvement. While the quiz game does inform players if their answers to diabetes-related questions are right or wrong, those questions are of a more factual nature, with precise correct and incorrect responses. Solitaire, on the other hand, asks players questions about their personal health and diabetes-care practices, offering an excellent point for feedback to the players. Players are free to answer the solitaire questions however they wish; there are no right answers and they are granted the “power” no matter what they choose. While Glymetrix has stated a desire to be non-judgmental of players’ responses, the lack of feedback to players is hindering the games’ ability to guide players towards healthier choices. Without informing players of ways in which they could improve their self-care practices, players have no means of improving. Intruding into a player’s personal healthcare issues is delicate, but there is room for the games to offer beneficial feedback to players without the risk of insulting or alienating them.

5.1.4 Immersion
Due to their nature as simple games with atomic gameplay sessions, there is not much room for immersion in either solitaire or the quiz game. However, that is something which is tacitly accepted up front by the player, who understands that these games are not intended to deliver immersive experiences. While a more lengthy, story- or setting-based game about diabetes could offer greater opportunities for immersion, solitaire and the quiz game both exempt themselves from the bulk of this requirement.

5.1.5 Individualization
Individualization within the Glymetrix games is limited to players’ profiles, which is understandable given the atomic nature of the two games; there is no room for players to be given custom avatars to explore a game world, or to have persistent statistics between games of solitaire other than a total score. If greater player feedback were implemented, though, there would be room for more individualization as well. By remembering players’ previous answers to questions, the games can offer encouragement, help players stay on track, and congratulate players on significant accomplishments. All of these would give players the feeling that the game is attentive to them personally, and that their answers within the game and behavior outside of the game both matter and will result in individual information and rewards.

5.1.6 Simulation
Neither game offers much opportunity for simulation; there is no place for a player to view the potential consequences of their actions in virtual space rather than the real world. However, once again the nature of the games excuses them from this requirement, as it is understood that solitaire and trivia are not media which are designed for that kind of exploration by players.

5.1.7 Winnability
Both solitaire and quiz game are definitively winnable; when all of the cards are on the foundations in solitaire, and when all of the questions have been answered in the quiz game, the game is over. Whether or not these victories contribute to a player’s feelings of success at managing his diabetes is dependent on how strongly the player links the games to his personal health. While the overall
winnability of the games is strong, once again, increased relevance and player feedback would help that feeling of victory translate from the game world to the real world, and would give players a confidence boost that they are successfully managing their self-care.

5.1.8 Socialization
While there is no chat or communication inside the games, Glymetrix does offer a social forum for players to talk with each other outside of the games. This level of social interaction has the potential to be highly beneficial to players, especially those who are lacking in support in real life or who feel alienated by the absence of peers with similar health problems. Even without any direct connection to the games, the presence of a social space which players know is populated by people with a significant factor in common is a strong point of the Glymetrix system.

5.1.9 Standards
The ability of a game to rise up to contemporary expectations is highly subjective, but it would not be unreasonable to say that both solitaire and the quiz game are within the expected range for simple, browser-based games. While there are certainly more complex browser-based games in existence, each of them is well designed and executed. The only issue arising under the principle of standards is the somewhat generic nature of the games themselves. There does not seem to be a large incentive to choose Glymetrix’s solitaire game over the one which is commonly bundled with the Windows operating system (or any of the alternatives for other operating systems); the argument that many work administrators have removed the solitaire application from office computers is not a strong one, as any computer from which someone saw fit to remove games is probably not a computer one should be using to play games. Equally, the quiz game is limited in content: once you have seen all the questions, there is no incentive to play any further, and if the content categories are outside a player’s realm of knowledge or interest, then the game holds little appeal for them. Unfortunately, there does not appear to be much room to make the games more unique without changing their fundamental content.

5.2 Analyzing the Player Data
One of the goals of this project was to analyze the data from the Glymetrix servers to attempt to discern any noticeable habits among their players. The analysis ran into some initial difficulties, which are discussed below, as are the eventual means decided upon to deal with the issues present in the data. Once these decisions were reached, much of the desired analysis became possible: breaking down the play sessions for both the solitaire and quiz games to determine how many times people play, and what they usually score. The constraints which had to be placed on the data unfortunately prevented the analysis from being able to determine a few items of interest, chiefly the frequency of individual player logins and the duration of their games; however, the data were able to provide a number of significant statistics of interest, which are of help in determining the play habits of Glymetrix’s users, their preferences between the two games offered (solitaire and quiz game), and their interest in the games after playing.

5.2.1 Initial Constraints
There were several anomalies within the data which necessitated limiting the portion of the overall data set which was considered. Frequently, play sessions by the same player would appear with durations of
only a few seconds, in rapid succession. It is likely that these sessions were the result of players re-dealing their cards in the solitaire game, or in clicking on the Start button multiple times. Consequently, for every game a player actually played through to completion, they may have started several dozen other sessions which would later time out. Additionally, a known server-side error in recording the ending time of play sessions resulted in sessions which were logged as lasting for several hundred hours (often without the user even scoring any points), and sessions which had no recorded end time at all. To compensate for these issues with session durations, several constraints had to be placed on which data would be considered and the analyses which could be performed; a game session was mutually defined with Glymetrix as any session activity with a length of over 10 seconds, and it was agreed that any analysis of game durations would wait until the server bug could be fixed, to enable accurate logging of session lengths. These decisions allowed for analysis of around 80% of the total data.

Thus, the final criteria and analysis of the data can be summarized as follows: a “game” is a session in which both a login and logout time were recorded, and the difference between the two was at least 10 seconds. Additionally, at Glymetrix’s suggestion, only games which took place in 2010 were considered. The data were initially sorted by player, assigning each player a list of the sessions which qualified as games under those criteria, to determine the playing habits of each player.

5.2.2 Methods

The data was extracted from the SQL database backups provided by Glymetrix and exported as a set of comma separated value (csv) files. Those files were then parsed by Python scripts designed to separate the data by player and session. Python was chosen mainly for the convenience of its built-in data types, especially its dictionaries, which function like hash tables, enabling very rapid lookup and iteration through large lists of players and/or sessions, each of which has a unique numerical id which could be used as a key. The scripts maintained a dictionary of players, each of which contained a non-empty dictionary of play sessions, which stored the session id, times, score, and whether the game was solitaire or the quiz game, as illustrated in Figure 1. Invalid play sessions, such as those with no logout time recorded or a duration under 10 seconds, were discarded during the input parsing and never added to the dictionaries. Despite the nested nature of the dictionaries, the fact that each play session had only one player meant that iterating through the entire list of players (and each sub-list of sessions) still ran in $O(n)$ time ($n =$ total number of play sessions), while sorting the keys ran in $O(n \log n)$ time with Python’s built-in list sorting.

![Figure 1: Player/Session data structures](image-url)
Depending on the desired output, the scripts were written to either print formatted text output (as in the case of tables of descriptive statistics), or to output a new set of comma separated values to be imported into Microsoft Excel for graphing.

5.2.3 Analysis
The first set of statistics analyzed was a simple set of descriptive statistics based on all games which took place in 2010. This served two main purposes: First, it illustrated the grouping of games based on their duration, in order to help solidify the restrictions on defining a “game session.” Second, it allowed a closer look at data from January 8 to 14, at Glymetrix’s request, to view the effectiveness of one of their promotional campaigns. The results are displayed in Table 1 and Table 2.

<table>
<thead>
<tr>
<th>All games</th>
<th>%</th>
<th>Solitaire</th>
<th>%</th>
<th>Quiz Game</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>11,154</td>
<td>10,154</td>
<td>736</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No logout</td>
<td>1,380</td>
<td>1,315</td>
<td>62</td>
<td>8.42</td>
<td></td>
</tr>
<tr>
<td>Zero-second</td>
<td>153</td>
<td>112</td>
<td>40</td>
<td>5.43</td>
<td></td>
</tr>
<tr>
<td>&lt; 10 seconds</td>
<td>845</td>
<td>619</td>
<td>206</td>
<td>27.99</td>
<td></td>
</tr>
<tr>
<td>&gt; 10 seconds</td>
<td>8,776</td>
<td>8,108</td>
<td>428</td>
<td>58.15</td>
<td></td>
</tr>
<tr>
<td>(After removing games under 10 seconds)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No score</td>
<td>5,713</td>
<td>5,330</td>
<td>143</td>
<td>33.41</td>
<td></td>
</tr>
<tr>
<td>Average score</td>
<td>--</td>
<td>226.60</td>
<td>--</td>
<td>320.35</td>
<td></td>
</tr>
<tr>
<td>Std. deviation</td>
<td>--</td>
<td>354.00</td>
<td>--</td>
<td>299.03</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>All games</th>
<th>%</th>
<th>Solitaire</th>
<th>%</th>
<th>Quiz Game</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>4,612</td>
<td>4,284</td>
<td>323</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No logout</td>
<td>900</td>
<td>883</td>
<td>17</td>
<td>5.26</td>
<td></td>
</tr>
<tr>
<td>Zero-second</td>
<td>64</td>
<td>56</td>
<td>8</td>
<td>2.48</td>
<td></td>
</tr>
<tr>
<td>&lt; 10 seconds</td>
<td>513</td>
<td>427</td>
<td>83</td>
<td>25.70</td>
<td></td>
</tr>
<tr>
<td>&gt; 10 seconds</td>
<td>3,153</td>
<td>2,918</td>
<td>215</td>
<td>66.56</td>
<td></td>
</tr>
<tr>
<td>(After removing games under 10 seconds)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No score</td>
<td>1,909</td>
<td>1,852</td>
<td>55</td>
<td>25.58</td>
<td></td>
</tr>
<tr>
<td>Average score</td>
<td>--</td>
<td>202.89</td>
<td>--</td>
<td>355.63</td>
<td></td>
</tr>
<tr>
<td>Std. deviation</td>
<td>--</td>
<td>280.00</td>
<td>--</td>
<td>288.13</td>
<td></td>
</tr>
</tbody>
</table>

From those results, it became clear that the restriction of games to those with a duration of more than 10 seconds, as well as the removal of all games with no logout time recorded and those with zero-second duration, reduced the data set significantly. Especially within the solitaire game, where a player might repeatedly refresh the page to get a more favorable deal, the number of games which qualify under the restrictions as full game sessions is only 80% of the sessions recorded in the database (8,108 out of a total 10,154).
The most obvious result these statistics reveal is the overwhelming popularity of solitaire over the quiz game. Over 90% of all play sessions recorded were for the solitaire game. Unfortunately, because the Glymetrix website currently requires separate user accounts for each game, it is not possible to tell how many players play both games, but that statistic has very little bearing on the obvious popularity of solitaire. Within the games played (both for solitaire and quiz game), the majority of play sessions qualified as full sessions under the restrictions, but the database bug which records logout times incorrectly (or not at all) unfortunately disqualifies a significant percentage of the data from proper analysis – 1,315 of 10,154 solitaire games (13%) and 62 of 736 quiz games (8.5%) have no recorded logout time.

For the solitaire game, one of the most significant statistics is the number of games in which no score is recorded. Considering that this statistic was calculated after removing sessions lasting under 10 seconds (which should account for most of the re-deals and page refreshes), this seems to indicate one of three possibilities: that the players are unusually inept at Klondike solitaire, that the players did not bother to actually play the game after starting it, or that the database is not properly recording scores, possibly for games in which points were scored but the game was never taken to a completed state. While Glymetrix has admitted the possibility of such a bug, it is not currently known whether it actually exists. Given that with standard Klondike solitaire, between 82 and 92 percent of all possible game deals are winnable, the first option is highly unlikely (Bjarnason, Tadepalli and Fern 139). This seems to indicate either that there is a significant error within the solitaire game software, or that players simply lose interest in the game very quickly. Unfortunately, those two possibilities are extremely dichotomous, making any concrete conclusion very difficult.

Figure 2-Figure 4 show the number of players who have played a specific number of games (total, solitaire, and quiz). Figure 3, specifically, seems to support the conclusion above that players lose interest in the solitaire game quickly. While there are a certain number of statistical outliers, such as one user who has played over 1200 games of solitaire, the vast majority of players have played only one or two sessions of solitaire, and zero sessions of the quiz game. Figure 2, the combined data for both games, shows an extremely steep decline in the number of players who have played a given number of games: while over 300 players have played exactly one game, that number drops by half for two games, and to only 28 players for five games.
Figure 2: All games played in 2010 (through March 6)
Figure 3: Solitaire games played in 2010 (through March 6)

Figure 4: Quiz games played in 2010 (through March 6)
The scores also indicate a general lack of interest in playing the solitaire game. Figure 5 shows that the number of games with a total score of zero is nearly 2/3 of all sessions – again, however, it remains uncertain if those scores are accurate or the result of an error within the Glymetrix software. The quiz game scores (Figure 6) are less markedly divided, but zero is still the most common score, with 23.5% of all quiz game sessions. Because of the known issues with recording session logout times, there is no way to determine if those zero scores were earned in full-length games, are the result of a server error, or are the result of players losing interest in the game after a very brief period of playing. For games which are taken to completion, the sharp peak at 300-399 in Figure 6 shows that there is a very consistent average among quiz game players, in contrast to the more evenly spread out scores for solitaire.
5.3 Glymetrix Games: Conclusions

While a game built from the ground up with the design goals in mind might be able to fulfill them all, such a game would obviously be a significant undertaking. As games which are already in existence and to some extent complete and unchangeable, solitaire and quiz game both have several strong points and some places where improvements could be made without requiring an entirely new game. By offering more discrete, specific feedback to players about their self-care choices, both games could unlock significant potential to be a positive influence on players’ health. By being upfront that the goal of the games is to educate and help players, the Glymetrix games could open players to the idea that the games could be useful, fun tools in their daily lives.

The play habits of the Glymetrix users, while they indicate an overwhelming preference for solitaire over the quiz game, do not show that players are inclined to play either game more than once or twice. In addition, the collected data seem to indicate that many players do not finish games after beginning them. It is still unclear just how much of this data is erroneous due to issues with the Glymetrix databases, but given the restrictions decided on in order to maximize the probability that the data used were correct, it seems likely that the results are at least correct as generalities, if not as specific statistics. The Glymetrix games exhibit strong potential to become popular and entertaining games among players with diabetes, which could lead to an increase in player interest in the games and loyalty to the site, and consequently to improvements in the players’ daily lives.
6 Conclusions
It should not come as a surprise that video games have enormous potential as educational tools in many fields, including healthcare. Beyond that, it seems that a properly designed game with the goal of improving its players’ self-care habits for a chronic illness such as diabetes could have a noticeable, positive effect. While the data from the Glymetrix games could not confirm or deny the validity of the design principles outlined above, they do show that there is an interest in diabetes-related games. Although more research is needed to determine whether a game designed according to the guidelines would have a more marked effect, the combination of research across various fields and investigation of similarly-focused games shows encouraging evidence to the positive.
7 References


