

Understanding Exergame Users' Physical Activity, Motivation and Behavior Over Time

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ABSTRACT

Effective exergames should increase the proportion of time users regularly spend in moderate to vigorous physical activity. There are currently few studies of exergame systems which evaluate the impact on physical activity over time. Those which do show increases in light intensity exercise which although valuable, do not increase the proportion of moderate to vigorous activity required for optimal health benefits. Furthermore, longitudinal studies to date have encountered a plateau effect in physical activity as the novelty of the game wears off. This paper suggests how exergame designs based on deeper understandings of player motivations could address these problems.

We report on longitudinal patterns of users' physical activity, motivations and behaviour when using exergames, based on case studies from a seven week long school based field trial. These new insights, interpreted through Bandura's theory of self efficacy, are of value to designers in the HCI community who wish to motivate users with a range of attitudes towards exercise to undertake regular moderate to vigorous physical activity.

Author Keywords

Exergames; motivation; self-efficacy; behavior change; classroom intervention;

ACM Classification Keywords

K.8 [Personal Computing]: General – games.

General Terms

Human Factors; Design; Measurement.

INTRODUCTION

A key goal of recent guidelines issued by the Chief Medical Officers in the UK is to increase the amount of regular physical activity performed by children, in order to reduce the risks of various chronic conditions such as coronary heart disease, stroke, and type 2 diabetes developing in later

life. Health benefits can result not only from increasing physical activity, but also by reducing sedentary behaviour. Physical inactivity is the fourth leading risk factor for global mortality [15]. An approach to addressing this problem is to encourage children to exercise using exergames, computer games which are designed to promote physical activity. As most children enjoy playing computer games, and elect to spend a considerable amount of free time doing so [19], researchers have started to investigate whether the motivational effects of traditional computer games can be harnessed to promote physical activity. A recent study of the game playing habits of US teenagers found that 97% play computer games, and 52% of them play them 3-5 times a week or more. Half of respondents played video games for one hour or more on the previous day [19]. According to the UK physical activity guidelines, people in this age group should spend at least 60 minutes each day in *moderate to vigorous* physical exercise, and should minimise the amount of time they spend sitting. Converting some of the time regularly spent in playing sedentary games to more active game play would protect young people against the risk factors associated with physical inactivity.

Although there are great potential health benefits for exergames, the field of research is relatively immature [14]. In a systematic review of commercial active video game studies, Biddiss and Irwin [9] concluded that such games can enable light to moderate physical activity, but that the evidence for long term efficacy is so far inconclusive.

In this paper, we examine data from a seven week long study of the exercise game iFitQuest, to understand more deeply how users' physical activity, motivation and behavior changes over time. The concept of self-efficacy is very useful for interpreting such data, and is explained in the next section. We aim to assist exergame designers in developing games which can avoid the plateau effect found in exergame evaluations to date, and also encourage users to increase their proportions of moderate to vigorous physical activity.

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RELATED WORK

Exergames

Although the last five years has seen the development of a number of new research based exergames (see [1, 10] for a concise summary), very few longitudinal studies have been conducted; most have focused on single use sessions. An exception is the American Horsepower Challenge (AHPC) study of a pedometer based video game aimed at primary school children [17]. AHPC encourages children to become more physically active by accumulating points for a school team based on the number of steps they take. In a year-long longitudinal study over sixty schools, the researchers found a significant increase in Physical Activity (PA) among participants when using the game in comparison to their pre-game activity. There was a small effect size ($d = 0.37$), corresponding to just under 10 minutes more walking per day when using the game. Although this study is promising, there appeared to be a plateau effect: step counts decreased back to pre-game levels by the third trial of the game. This raises the question of whether the game would be likely to have any long-term impact on physical activity levels. In addition, the game focused on moderate intensity walking, without taking into account the physical guidelines [15] that also specify a need for engaging in higher intensity PA.

The exergame Fish'n'Steps was also evaluated over an extended time period [20]. They focused on individualized goal setting of daily step counts, also incorporating social influences. In a six week trial with 19 adult users, there was a mean increase of 1,200 steps and 14 of the 19 participants became more regularly active. As with the AHPC study, the authors observed that the novelty of the game subsided after only two weeks, again identifying problems with maintaining interest and motivation over sustained periods.

Self-Efficacy and Motivation

When running any physical activity intervention, it is important to consider the notion of motivation. "A person who feels no impetus or inspiration to act is thus characterized as unmotivated, whereas someone who is energized or activated towards an end is considered motivated" [28, p.54]. Intrinsic motivation is associated with the desire to master a task and the satisfaction that comes with that, whereas extrinsic motivation refers to completing tasks solely as an ego boost, be it beating peers in a competition, or receiving praise from a parent, teacher or colleague [25]. Physical activity interventions naturally target those with a low motivation to exercise. Exergames aim to promote and facilitate physical activity through game-play; in order to sustain such activity longitudinally designers must consider how to positively influence participants' motivation.

Bandura's work on *Self-Efficacy* plays an important role in aiding our understanding of motivation. Bandura writes, "Self-Efficacy is concerned with judgments of how well one can execute courses of action required to deal with

prospective situations" [4, p.122]. In other words, a person's self-efficacy is their level of belief that they can perform adequately at a given task. A person's self-efficacy is domain specific, and not a constant variable [6]. A person's self-efficacy for a task is based upon 1) past performances on said task; 2) vicarious information; 3) persuasive information (such as social influence); and 4) arousal information based upon physiological cues [5].

Why within the context of an exergame intervention, should we be concerned with the exercise self-efficacy of our participants? In their review on the role of self-efficacy within health behavior change, Strecher et al. found that "self-efficacy appears to be a consistent predictor of short and long term success" [31, p.87]. Furthermore, within the context of physical activity participation, Dziewaltowski et al. found Bandura's social cognitive theory variables (including self-efficacy) significantly predicted physical activity participation [16]. Exergame interventions with a view of sustaining behavioural change should thus not only consider the pre-intervention self-efficacy of the participants, but also set about increasing and/or maintaining the participant's self-efficacy with a view of facilitating long term behavioural change.

Further, how can we use self-efficacy *during* a physical activity intervention? Bandura states "Self-Efficacy beliefs contribute to motivation in several ways; they determine the goals people set themselves, how much effort they expend, how long they persevere in the face of difficulties, and their resilience to failures" [8, p.131]. Bandura's theories on self efficacy are a key indicator of how participants will react to self-set and assigned goals [4, 8, 22], as well as how hard they will push themselves in order to meet goals, and how they will react when faced with problems / failures.

Practitioners have begun to investigate self-efficacy within the context of exergames. In their work on promoting self-efficacy with an exergame, Song et al. investigated the way people of different self-efficacy profiles reacted to the image of their own body on screen [29]. Meanwhile, Staiano et al. found that cooperative play of *Wii Active* increased the self-efficacy of the players [30].

To summarise, self-efficacy plays a key role in not only predicting the success of a physical activity intervention, but also the behavior of those taking part during the intervention. Our work explores self-efficacy within the context of a school based exergame intervention, including how players set goals and manage difficulty levels.

THE IFITQUEST SYSTEM

iFitQuest is a location-aware exergame designed to promote physical activity within the context of school based physical activity interventions. iFitQuest (Figure 1) consists of a number of exercise based mini-games which are played out in the real world using an iPhone, and GPS technology. In essence the player controls an on-screen avatar through their movement in the real world; in order to visit a virtual



Figure 1: a) The main iFitQuest menu, showing the mini-games available to play; b) A screenshot of the Collect the Coins game.

world location, the player must move within the real world. The player can be encouraged into physical activity through various in-game tasks such as collecting objects or pursuing / evading non-player characters. iFitQuest is effectively a suite of short mini-games. Within each mini-game the player can earn up to 10 points, which are accumulated as a session total, and running intervention total. Points for each mini-game are algorithmically generated, using a mixture of player background, past player performance, and current mini-game difficulty. Thus, points are awarded in a way that encourages a level playing field between players of different abilities and fitness.

There are eight mini games which make up the iFitQuest suite, all with simple game mechanics such as collecting objects or visiting locations (*Collect the Coins* and *Visit the Fields*), outrunning or chasing animals (*Escape the Wolf*, *Return the Sheep*, and *Follow the Chicken*), or running as far as possible within a time limit (*Mystery Games 1, 2, 3*). Changes in difficulty level are simply achieved by manipulating the speed of the pursuing animals, altering the number of items to be collected or changing the amount of time available to the player to achieve a task. As recommended by a physical education teacher, the mini-games are designed to target a range of types of fitness training, including agility training, which requires swift directional changes, sprint training, speed endurance and shuttle runs.

Key to the success of our study was the ability to see emergent behavior from our participants. In order to see how different participants interpret and manipulate the exergame experience, they must be provided with a forum in which they can control their experience. In order to facilitate the emergence of a variety of behaviours, iFitQuest was designed with the following in mind.

Variety of mini-games – part of the reason behind adopting a suite of mini-games was to provide the player with a variety of games which they could play. While all games were designed to build upon specific fitness principles [23], some games could only be played at a set intensity (for example sprinting to escape the wolf) others had greater flexibility and could be played at either walking or running

pace. This allowed for not only a variety of players to cope with the games, but also allowed us to see whether players would choose to push themselves, or opt for games they felt comfortable with.

Flexibility in mini-game selection – further to the above point, we opted to give the player a lot of control over the mini-game selection. Rather than creating a game manager to monitor sessions and select which game to play, we wanted to allow players to choose their own games. A basic manager was implemented to stop players playing the same game over and over. Once a game was played three times, the player had to select another of the games in order to unlock all games for selection. The purpose of this flexibility was to evaluate whether certain people gravitated towards certain games, and if so why?

Difficulty control – each game had 10 difficulty levels. Winning a game automatically increased the difficulty level by one, while losing automatically decreased it. However, the players were also given the opportunity to manually select the difficulty of their next mini-game. We wanted to see whether the player would be happy to follow the natural progression of the game, or whether they wished to manually override the difficulty settings in order to create a more or less challenging experience.

A lack of main goal – while there was a natural micro-goal of winning at the mini-games, we did not impose any overarching goals, either by session or the overall intervention. The reason was to encourage emergent motivators and self-evaluation. Would players set themselves their own goals based on the points system, for example beating their friends' scores or setting personal points targets? Alternatively, would the players consider the points meaningless and focus on winning at the highest levels of the mini-games, or trying to set personal bests in the mystery games? This flexibility would enable us to differentiate between users with task versus ego motivations [25].

We focused on the following research questions: 1) How much physical activity do players undertake and how does this change over the seven week study? 2) what range of motivations for playing do users exhibit? 3) how do users choose between games and select difficulty levels and how does this relate the self efficacy?

Although iFitQuest was designed based on the results of our previous study [24], it builds upon the foundations outlined for exergames design [11, 12], for example, the concepts of free play (placing control in the hands of the player) and fair play (providing an even playing field for all players). Thus, while iFitQuest builds on the foundations of earlier exergame research, it has been designed without specific goals and minimal constraints. The flexibility of the platform, while not providing for an optimal exergame experience, will encourage the type of emergent behavior

required to answer our research questions and evaluate the role self-efficacy plays within exergames.

A STUDY EXPLORING MOTIVATION AND BEHAVIOUR WHILE USING EXERGAMES

In our previous work [24] a pilot study highlighted the potential for iFitQuest to facilitate physical activity, fit seamlessly into a school environment, as well as identifying the need for a further study on the way in which the background of a participant may influence their exergames experience. In this paper we focus on the data from a follow up longitudinal study. We explore the different emergent behaviours we saw throughout the use of our game in order to understand the ways in which a participant's background could influence their exergames experience. We begin to understand these behaviours through a psychological analysis in order to provide design guidance to future exergames practitioners.

The participating class was a Primary 7 class at a local primary education school in Scotland. In total, the study involved 12 students aged 11-12 (8 female and 4 male). Each child had access to an iPhone with the iFitQuest exergame installed. The teacher involved with the study volunteered her class due to an existing interest in physical activity and technology. The participants represented her whole class, although the children were given the opportunity to opt out of the evaluation if they did not enjoy playing the game. The teacher believed that all the participants required additional physical activity time, and due to a mixture of behaviours and attitudes, she believed the use of novel technology would prove beneficial over traditional Physical Education (P.E.) approaches. In order to facilitate the use of the game, the school provided a learning assistant to assist during the occasions when the game was to be played.

The teacher agreed to allow the class to use the game for 20 to 30 minute sessions, between once and three times per week on a flexible basis. The iPhones were made available for a period of 7 weeks, allowing for a longitudinal evaluation. Over the course of the seven weeks, iFitQuest was used on 12 distinct occasions.

Several different data collection methods were employed to permit analysis that would allow us to understand our participants' exergames experience, as well as the general success of iFitQuest within a primary education context.

A log file was created for each participant during each session, detailing the mini-games they had decided to play and how they had changed the difficulty levels of the games. For each mini-game played, the log also contained details about the participant's distance travelled and average speed (for exercise intensity) as well as the current level of difficulty and whether the participant succeeded in winning the game or not.

Each participant completed an exercise self-efficacy questionnaire (adapted from [26]) in order to measure each participant's pre- and post-intervention exercise self-efficacy.

Each participant completed a post-intervention experience questionnaire. The questionnaire asked for details on the exergames experience, such as whether they had enjoyed playing the game. It also contained questions to establish the motivation levels of the participants and what about the game had motivated them to exercise. Finally, the questionnaire asked for a self-reflection of in-game habits, asking participants to explain why they had made certain decisions (such as increase of decrease difficulty) and how they had selected which mini-game to play during each session.

Observations were also made throughout the study. At 9 of the 12 sessions a researcher was present to make observational notes of the children's behaviour while using the game. This included details of participant attitudes, conversations between participants, as well as conversations between participants and researcher / teaching assistant.

The students were individually interviewed post-study. The semi-structured interview was designed to clarify and expand upon questionnaire answers as well establish in greater depth how participants felt about iFitQuest, and its use within a school based physical activity intervention.

As a one-off during the final session of the intervention, physical activity data was gathered using ActiGraph tri-axial accelerometers, which are more accurate than data gathered on the iPhone, but which were only available for one session.

Methodologically, we adopted a case study approach for our analysis. The merits of such an approach come from our desire to retain holistic characteristics of real-life events, and individual behaviours. As we were looking for emergent behavioural patterns, rather than imposing controlling constraints, as well as using psychological theories for an explanatory analysis, case studies was the logical choice. Case studies should be used when a 'how or why' question is being asked about a) a contemporary set of events and b) over which the investigator has little or no control (i.e. not imposing laboratory controls). By considering each user as a single case, and evaluating consistencies over multiple cases, we can conduct analytical generalizations, and begin developing theories generalizable across the exergame domain [33]. Case studies were created using a mixed methods approach on our various data sources, following a *fully mixed concurrent dominant status design* [18].

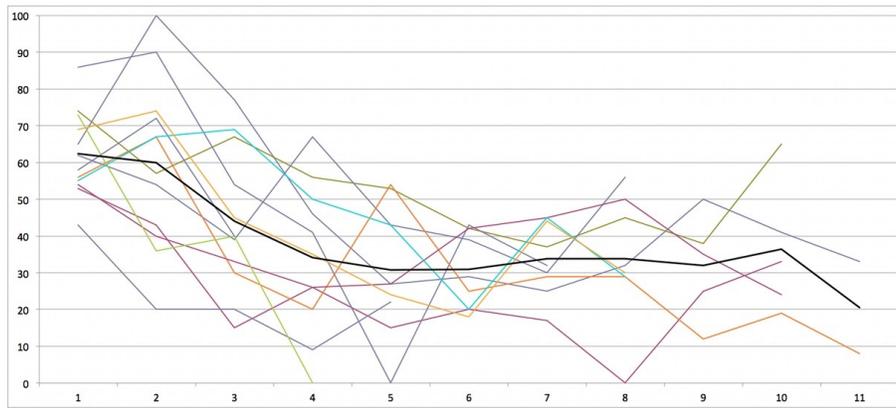


Figure 2. Graph showing the % of time participants spent performing moderate or vigorous physical activity by session. The black line indicates the average for each session.

IFITQUEST IN THE CLASSROOM

Overall, iFitQuest was well received in the classroom. On average, our 12 participants quantified their enjoyment of the study as 6.83, $SD = 2.1$ (on a scale of 1 to 10, with 10 representing maximal enjoyment). Of our 12 participants, 8 wanted to play the game as part of another physical activity intervention, while 4 stated that they would not. Of the reasons given for participating again: Jane stated that she “thought it [iFitQuest] was fun and exiting”, while Linda stated she enjoyed the fact “you got lots of exercise and it was fun”. Of those that would not like use the game again, Tom stated it was because he did not like the game, while James stated “it was boring”.

In the rest of this section, we explore the players’ use and experience of iFitQuest. A summary of the profile of each participant can be found in Table 1. Note that data from two of the participants who did not complete the project (due to ill health and school disciplinary procedures) is not included.

Changes in physical activity over time

Research question 1 asks how much physical activity is undertaken by participants and how this changes over time. Through our one-off activity level study using the tri-axial accelerometers, we were able to evaluate the level of exercise our participants got whilst playing iFitQuest. On average participants spent 13.9% of their time sedentary ($SD = 4.09\%$), 56.8% performing light intensity exercise ($SD = 15.28\%$), 9.2% moderate intensity exercise ($SD = 3.29\%$) and, 20.1% exercising at a vigorous intensity ($SD = 15.85\%$). Similar to the AHPC and Fish’n’Steps, iFitQuest facilitates predominantly light intensity exercise due to participants’ preference for the Collect the Coin walking game. In contrast to these previous games, data from some participants indicates iFitQuest also clearly has the *potential* to facilitate moderate and vigorous exercise in those who favoured mini-games such as Escape the Wolf or the Mystery Games. It is positive to note that our participants were motivated to remain active, spending only small proportions of their time sedentary, in this respect it represents successful exergame intervention. However, the

accelerometer data represents only a snap shot of physical activity at the end of the project. To what extent did the levels of activity change as the intervention progressed?

Previous exergames studies [20, 27] have found the presence of a novelty effect, whereby, once the novelty of the game wears off, so do does its effectiveness at facilitating physical activity. The novelty effect could manifest itself as declines in attitudes to the game, or as decreases in physical activity intensity as estimated by speed. Evidence relating to changes in attitudes comes from the feedback provided by the participants during the post-intervention questionnaires and interviews. Two thirds of our participants stated that they would like to participate in another intervention using iFitQuest, a positive indicator given the generally low desire to exercise shown by many adolescents [13]. Through our observations, and our questionnaire data, it is clear that some people were beginning to get bored with the game. This is also represented by the 4 participants who stated post-intervention that they would not wish to continue playing the game.

In terms of physical activity intensity, we can consider changes in the percentage of time users spent playing games at a moderate or vigorous intensity, i.e. when the participant plays a mini-game, do they do so at a light intensity (walking) or a moderate / vigorous intensity (jogging or sprinting)? Figure 2 shows this graphically for each participant and each session, with the thicker black line showing the average for each session. As we can see from the graph, with time, participants generally spent a smaller percentage of their time exercising at a moderate / vigorous intensity. In contrast to the AHPC which was evaluated in a similar school context, participants’ physical activity did not revert to pre-study levels. iFitQuest successfully facilitated prolonged low intensity exercise which in itself has associated health benefits [15]. However, it would be more beneficial if iFitQuest could maintain or even increase the proportion of moderate to vigorous exercise over time. Examination of players’ motivations, habits and approaches to game-play in the following

sections suggests some techniques which could be used to achieve this in the future.

Approaches to playing the game

Participants could choose to play a sample of games, focus on their favourite games, or indeed choose to play no games at all. Through an analysis of the iFitQuest log-files, we can paint a picture of how, both in a single session, and over the course of the intervention, players selected which games to play.

For many of our participants, the initial sessions represented a time to try a selection of mini-games. However, as the intervention wore on, participants started to alter their mini-game selection habits. Jane started by playing the whole spectrum of games, before settling into playing predominantly Collect the Coins by session 6. She moved from spending 25-30% of her time on the game, to on average 75%. A similar trend was seen with Mark, Karen, Lisa, and Marie. With the Collect the Coin game representing the least intense of all mini-games, this change in selection habit represents a move from more to less intense physical activity. Mark stated that he chose to predominantly play the Collect the Coin game as “I got much more points and it was easy”. Mark, driven by the desire to earn points, found a loophole where by he could earn maximal points, for minimal effort. Other participants were more interested in minimizing the intensity of exercise they needed to do, Marie stating that she “didn’t want to run”. However, not all participants showed a desire to play the Collect the Coin game. Linda chose to focus on playing the games she knew she was bad at, as she wanted to see herself improve; she stated, “I wanted to always test how good I am”. Amy also showed interesting gameplay habits, during each session she would start with intense games, before moving to the less intense games as she began to tire. This forethought allowed her to play a selection of games in each session, earning maximal points while also getting good levels of exercise. Susan chose what game to play based solely on enjoyment, without a consideration for potential points earned, or potential fitness improvements.

Looking in greater depth at the play habits of our participants, we saw some interesting ‘Replay Versus Avoid behavior’. High self-efficacy players such as Mark, Linda and Susan chose to regularly replay the same games, even those they were not good at. Having lost a mini-game, Mark often replayed it again at a higher difficulty setting, Linda intentionally played games she knew she was not good at, and Susan played her favourite game again and again, even though she had a low success rate. Conversely, we saw low self-efficacy players such as Jane, Lisa and Karen avoid games they were not good at. In the initial weeks, these players sampled various games, before settling to play the games they were most likely to succeed at. If we consider the contrasting self-efficacy profiles of these participants, and their contrasting behaviours, it is no surprise that those with high self-efficacy were more

willing to persevere at the games where they experienced failure. Bandura states that players with a high self-efficacy are more likely to “exert greater effort when they fail to master the challenge” [8, p.131].

Motivations

Research question 2 considers the range of motivations for play exhibited by the users. Many of the in-game selection habits were closely linked to the motivation of the participant. For example, Mark was highly motivated by points, and therefore chose the games which could maximize points but minimize effort. He used the points system towards a global leaderboard, striving to come top of the class. This is similar to Jane, who was also driven by earning more points than the rest of her class mates. Even with the same motivations, these players exhibited contrasting behaviours. Mark liked to flaunt his points total, and spent a considerable amount of time each session comparing points with his peers. Jane on the other hand, always kept her points total to herself, not even sharing her progress with her close friends. So while she was motivated to earn more points than her peers, she was less confident to broadcast her totals. We also saw other ego-based motivators: Lisa stated that the only reason she tried hard was to get praise from her teacher. We also saw Susan and Karen who were interested in points, but rather than on a global level, they wanted to compete with their peers on a head to head level. Conversely, Amy and Linda who were heavily mastery oriented, selected the games they wanted to improve at or win, Amy even showing forethought to select high intensity games first, to maximize her performance before she got tired. Of further interest is the way in which participants also set themselves specific goals while playing the game. Amy, who wanted to improve, used the Mystery Games and her personal bests, to set herself concrete goals during each session. She stated that she liked the fact there were no other distracting factors (for example items or non player characters), you just had to run, and focus on beating your score. Mark and Jane also showed interesting goal setting habits related to their desire to earn points. Mark set himself an ever increasing points target for each session, each time he successfully met his target, he increased it. He also showed a large desire to meet his target. During one session, when adverse weather caused us to stop early, Mark begged the researchers to let him play on so that he could reach his goal. On a similar level, Jane also set herself a points target for each session, however in contrast, her target was consistent and unmoving. Regardless of whether she did or did not reach her target, she maintained the same number for each session. These goal-setting behaviours, such as the strength of commitment and reactions to succeeding and failure can be linked back to the self-efficacy of the participant.

In-Game Habits

Research question 3, “how do users choose between games and select difficulty levels and how does this relate to self-

efficacy?" In general, players were willing to accept the difficulty level as recommended by the system. Over the course of the intervention, players took only 21.84% of the opportunities to override the default difficulty change.

However, those that did make changes to the difficulty, exhibited interesting behaviours. Mark was often willing to increase the difficulty level of a mini-game, even if he had previously lost at the easier difficulty. This confidence in his ability, can be linked to his high self-efficacy, and his desire for earning points. Conversely, we also saw participants decrease difficulty despite having won the preceding game, this contrasting behavior highlights a desire to play easier games, in order to maximize the opportunity for success.

Our observations suggest that different users can react to failure and success differently. While some may be driven on by failure and seek further challenge when a more obvious course of action would be a decrease in difficulty, others may seek success, and strive to win even if that means a decrease in physical exertion. In the context of an exergame, as long as in both scenarios the participant is maintaining physical activity, this sort of behavior remains beneficial.

During the study we observed some extreme behaviour which raised interesting points. During the first session, despite being both one of the fittest, and most confident, Mark displayed extreme frustration and anger towards the exergame. This was due to his inability to grasp the basic concepts of the gameplay. While Bandura's work would suggest that Mark's high self-efficacy would lead to perseverance in the face of failures, he displayed extreme behavior in the opposite direction. However, Bandura's work has also shown that when someone has a high self-efficacy, a negative outcome, and limited control over their environment, this can lead to both resentment, and protest [2, 4]. Designers must be careful therefore not to put-off a player early on in the process, when their control over the game is limited, especially when their high self-efficacy leads to high expectations towards their outcomes.

We also saw emergent cooperative play, despite no inbuilt mechanisms to support it. Players such as Linda, Susan and Laura regularly started their mini-games at the same time, in order to run together. Linda also regularly ran with friends, even when she had no mini-game active and thus was not earning points, or progressing within the game. The merits of cooperative play in exergames have been established [30], interestingly our study shows that through a flexible environment, cooperation and competition can work in tandem.

DISCUSSION: FUTURE OF EXERGAMING

We recognize that this study is limited in various ways. It is based on the application of one particular exergame, used within the context of one school based intervention. Future work is required to replicate these results across a number

of schools, for longer time periods and with a variety of exergames. However, the purpose of this evaluation was exploratory in nature, and the qualitative analysis revealed some interesting points for future investigation.

The role of success

Our study highlights the loose definition of success within exergames. From a player's perspective is success winning at the game? Is it improving fitness? Is it merely showing good effort and trying your best? Within our class of participants, we saw a wide variety of definitions of what success means to individual players; Mark and Jane found success in winning, and getting the most points in the class. Meanwhile Susan and Karen, while not interested in the 'big-picture' competition, found motivation through beating the points score of their friends. Players with a mastery focus such as Linda and Amy found success in beating their personal bests or winning at the mini-games, even if that meant losing a lot of mini-game along the way. Our previous work has highlighted that in exergames, success is not necessarily linked with enjoyment [24]; the current paper extends this to document the interesting ways in which people react to successes and failures. Consulting the self-efficacy literature, we see that high self-efficacy can determine the positive way in which people can react to failure, and persevere in the face of difficulties, often exerting even greater effort when they fail to master a challenge [8]. This can explain the replay / avoidance behavior we saw, as well as the way in which Linda was committed to playing the games at which she knew she was not likely to succeed, and the way Mark often actually increased the difficulty level of a game, even after a defeat. We see here the key way in which self-efficacy dictates the commitment of a player and the way in which they will or will not bounce back from failures. This is an important consideration when developing exergames, and deciding on the appropriate challenge level for its participants.

The Role of Competition

Exergame practitioners have begun to evaluate the role of competition within exergames. Lin et al. [20], Poole et al. [27] and Toscos et al. [32] have all looked at how competition, and raised social awareness can impact upon the effectiveness of an exergame intervention. Within our intervention we saw a number of individuals who were motivated by the competitive aspects, be it Mark or Jane who looked for overall competitions, or Susan and Karen who cared more about competing head to head with their friends. Due to the framing of the task, the use of a points system as well as the novelty of researcher observations, this type of ego-based motivation is not unexpected [25]. We did however see participants, such as Linda, who drew no motivation from competition, instead showing mastery traits in trying to improve her performances. Nicholls' work showed the ego-based motivators can lead to less intrinsic motivations which in turn can lead to less prolonged motivation. Competition also increases the differentiated

conception to evaluate oneself, which is a negative outcome for low performers. During the study we saw participants exhibit negative behaviours due to competition. James wanted to exercise in a separate area of the playground so as to be out of sight of his peers, while Laura argued with her friends that her absences caused her lower score, not her performance. Mark took pleasure in ridiculing the lower performers in the game, while Jane felt the need to keep her scores private to all, including her close friends.

Competition can and has been effective within exergame interventions. However, the participant's background must be considered carefully when evaluating the suitability of a competitive exergame. Not only can these ego-based approaches, in the long term, lead to undesirable motivations, they can also negatively affect the behavior of the player. Especially when considering plays of low ability or low self-efficacy, highlighting through competition their inadequacies is likely to cause undue stress and more damage than good.

Goal-Setting

The merits of goal-setting for facilitating motivation are well established [21]. Despite the lack of formal goal structure within iFitQuest, we saw various interesting examples of participants self-setting goals. Mark and Jane both utilised the points system of the game to set themselves a points target as a goal for each session. Meanwhile, some players (e.g. Linda) were motivated through improving their mini-game scores, while others (e.g. Amy) were motivated by beating their personal bests on the Mystery Games. What is particularly interesting here is the way participants reacted to fulfilling or failing to meet their goals, and the way in which participants set their goals. Although Mark and Jane, both showed similar behaviour in adopting the points system to set goals, their subsequent behaviour was contrasting. While Mark (high self-efficacy) set himself ever increasing points targets, and showed a strong commitment and desire to meet those targets; Jane (low self-efficacy) set herself a concrete and unmoving target, which could easily be met each session. While her goal was very different, Linda (high self-efficacy) specifically stuck to games she knew she needed to improve at, and did not give up playing those games until she was happy with her progress. Conversely, a number of participants (with low self-efficacy) showed avoidance behaviour for certain mini-games having failed to meet the micro-goal of the game.

This diversity in behaviour can be explained through Bandura's social cognitive theory. Bandura has shown that those with a high self-efficacy set themselves higher goal challenges, and have a greater commitment to achieve those goals [7]. Bandura writes "Those with a strong sense of efficacy set higher goals for themselves. Adopting further challenges creates new motivating discrepancies" [8]. A strong belief in one's performance efficacy is essential to mobilize and sustain the effort required to succeed [3].

Bandura goes on to state "Self-Efficacy beliefs contribute to motivation in several ways; they determine the goals people set themselves, how much effort they expend, how long they persevere in the face of difficulties, and their resilience to failures" [8].

By looking at an exergame intervention over the course of 7-weeks, it was possible to observe the interesting way in which participants not only formulated self-set goals, but also the way in which they evolved with time based on the self-efficacy of the participant, and in-game performance. Thus, future exergame practitioners should carefully consider the role of self-efficacy within their system. With self-efficacy a mediator of assigned goals [21] and influential over goal commitment and reactions to failure, viewing in-game behaviour through the lens of self-efficacy can aid in the understanding of the exergame experience.

Summary

In this paper we have explored the extent to which iFitQuest promotes physical activity and how this changes over time; the range of motivations exhibited by iFitQuest users; and considered how users with different self-efficacy profiles choose between games, self-set goals, and selected difficulty levels.

iFitQuest successfully facilitated light intensity exercise over the seven week period. It initially encouraged moderate to vigorous intensity exercise in many participants, but this tended to plateau in the last few weeks of the study. It would be beneficial to improve the design so that the game gradually increases (rather than reduces) the proportion of time spent in moderate to vigorous intensity exercise over time. We believe that this design goal is achievable in the future through tailoring the game to individuals' motivations and self-efficacy profiles.

iFitQuest players exhibited variations of both ego-based and task-based motivators, including trying to attain the highest overall score, trying to gather more points than specific individuals, trying to fulfill self identified goals, and trying to master particular games. We observed that the goals people set themselves, the player's commitment to reach their goal, and their reaction when they either succeed or fail in meeting their goal can all be usefully interpreted through the lens of self-efficacy theory. This theory can also be used to understand the way in which people choose to play the game, how they react to winning and losing, where they gain their satisfaction, as well as how they draw their motivation. This study highlights the need to consider self-efficacy as a key component when designing an exergame intervention.

We recommend that designers of exergames should conduct longitudinal evaluations to ensure that the intensity of user exercise is appropriate and sustained. We argue that to counteract the potential plateau effect and maintain exercise intensity, consideration of self-efficacy is necessary because it has a central role in maintaining motivation

	Pre S.E.	Post S.E	Pre Fitness	Intervention Summary	Game Selection Summary
Mark	3.5	3.5	High	Enjoyed the intervention, and enthusiastically participated throughout the study. Heavily motivated by the points system, setting personal points goals each session.	Played a variety of games, focussing on those where he could earn the most points.
Lisa	2	2	Medium	Showed a mixed attitude, at times participating enthusiastically, at others using the time to talk with her peers.	Played low intensity games to minimise exercise, avoiding games she was not good at.
Linda	3.5	2.875	Low	Enjoyed the intervention and showed consistent motivation. Motivated by mini-game mastery, and enjoyed the social aspects of the game, exercising regularly with peers.	Focussed on games she wasn't good at, gaining motivation from seeing herself improve. Willing to play the whole range of available games.
James	3.5	2.75	Medium	Low motivation. Played the game in private to avoid his peers. Missed the middle portion of the intervention due to unrelated behavioural problems.	Predominantly low intensity game. Showed avoidance behaviour on failure, although this may be due to a wish to avoid high intensity exercise.
Jane	2.5	2.875	Medium	Heavily motivated individual who enjoyed the intervention. Liked to earn points, setting goals each session. Was private about her progress.	Predominantly low intensity games that she was good at and thus represented the best opportunity to earn points.
Amy	2.75	3	Low	Enjoyed the intervention, and was heavily motivated to succeed in various respects. She constantly monitored her personal bests, and her points total relative to friends.	The whole variety of games, starting each session with the most physically demanding, before moving to low intensity games as she tired.
Marie	3.375	2.25	High	Like Lisa showed a mixed attitude, sometimes participating, while at other using the intervention to socialise with peers.	Predominantly low intensity games, as she was the one participant who wished to specifically "avoid running".
Susan	3.25	3.125	Low	Benefited heavily from the intervention, commenting throughout that she felt "more fit". Was consistently motivated despite relatively low in-game success.	A selection of games Not put-off by losing games, happily replaying those with which she had minimum success.
Laura	2	2.5	Low	Started enthusiastically but became bored with the game. Liked to play with friends and earn points but got tired with the same mini-games each session.	Randomly selected games during each session. Liked to compete with friends for points but not to the extent that she tailored game selection
Karen	2.625	2.5	Medium	Like Hazel, started enthusiastically but became bored with the game. Was heavily influenced by her peer group, both positively and negatively.	Predominantly low intensity games, although she did exercise at a high intensity if challenged by her peers.

Table 1. A summary of each participants' profile.

through effective goal setting. We recommend that exergame designers should consider: how self-efficacy predicts players' responses to success or failure within their game and how this should influence challenge level; how to design for interaction between multiple players given that competition is not necessarily conducive to sustained engagement; and how to set motivational and achievable physical activity goals in response to users' self-efficacy profiles.

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REFERENCES

1. Altamimi, R., and Skinner, G. A Survey of Active Video Game Literature. *Journal of Computer and Information Technology 1*, 1 (2012), 20-35.
2. Bandura, A. *Aggression: A Social Learning Analysis*. Englewood Cliffs, N.J: Prentice-Hall (1973).
3. Bandura, A. *Social Learning Theory*. Englewood Cliffs, NJ: Prentice-Hall, (1977).
4. Bandura, A. Self-Efficacy Mechanism in Human Agency. *American Psychologist 37*, 2 (1982), 122-147.
5. Bandura, A. *Social Foundations of Thought and Action: A Social Cognitive Theory*. Englewood Cliffs, NJ: Prentice Hall. (1986).
6. Bandura, A. Perceived Self-Efficacy in the Exercise of Personal Agency. *The Psychologist: Bulletin of the British Psychological Society 10*, (1989), 411-424.

7. Bandura, A. Self-Regulation of Motivation Through Anticipatory and Self-Regulatory Mechanisms. In R.A. Dienstbier (Ed.), *Perspectives on Motivation: Nebraska Symposium on Motivation* 38, (1991), 69-164.
8. Bandura, A. Perceived Self-Efficacy in Cognitive Development and Functioning. *Educational Psychologist* 28, 2 (1993), 117-148
9. Biddiss, E., and Irwin, J. Active Video Games to Promote Physical Activity in Children and Youth. *Arch Pediatr Med* 164, 7 (2010), 664-672.
10. Buttussi, F., and Chittaro, L. Smarter Phones for Healthier Lifestyles: An Adaptive Fitness Games. *Pervasive Computing* 9, 4 (2010), 51-57
11. Campbell, T., Ngo, B. and Fogarty, J. Game design principles in everyday fitness applications. In *CSCW 08*, ACM Press (2008), 249-252.
12. Consolvo, S., Everitt, K., Smith, I. and Landay, J. Design requirements for technologies that encourage physical activity. In *CHI 06*, ACM Press (2006), 457-466.
13. Currie C, Zanotti C, Morgan A, Currie D, de Looze M, Roberts C, Samdal O, Smith O, Barnekow V. Social determinants of health and well-being among young people. HBSC international report from the 2009/2010 Survey. *Health Policy for Children and Adolescents No. 6, WHO Regional Office for Europe*, Denmark. (2012).
14. Daley, A. J. Can exergaming contribute to improving physical activity levels and health outcomes in children? *Pediatrics* 124, 2 (2009), 763-71.
15. Department of Health, Physical Activity, Health Improvement and Protection. Start Active, Stay Active: A report on physical activity for health from the four home countries' Chief Medical Officers. London (2011).
16. Dzewaltowski, D.A., Noble, J.M. and Shaw, J.M. Physical Activity Participation: Social Cognitive Theory Versus the Theories of Reasoned Action and Planned Behaviour. *Journal of Sport and Exercise Psychology* 12, 4 (1990), 388-405.
17. Eiriksdottir, E., et al. Assessing Health Games in Secondary Schools. An Investigation of the American Horsepower Challenge 2009-2010. *Georgia Institute of Technology Technical Report*. Atlanta. (2011).
18. Leech, N. L., & Onwuegbuzie, A. J. A typology of mixed methods research designs. *Quality and Quantity*, 43, (2007). 265-275.
19. Lenhart, A. and Kahn, J. Teens, video games, and civics. Pew Internet and American Life Project (2008). Retrieved 23/12/11 <http://www.pewinternet.org/Reports/2008/Teens-Video-Games-and-Civics.aspx>
20. Lin, J.J., Mamykina, L., Lindtner, S., Delajoux, G. and Strub, H. B. Fish'n'steps: Encouraging physical activity with an interactive computer game. In *UbiComp'06*, ACM Press (2006), 261-278.
21. Locke, E.A. and Latham, G.P. *A Theory of Goal Setting and Task Performance*. Englewood Cliffs, NJ: Prentice Hall (1990).
22. Locke, E.A. and Latham, G.P. Building a practically useful theory of goal setting and task motivation: A 35-year odyssey. *American Psychologist* 57, 9 (2002).
23. Macvean, A. Developing Adaptive Exergames for Children. In *IDC'12*, ACM Press (2012), 339-342.
24. Macvean, A., and Robertson, J. iFitQuest: A School Based Study of a Mobile Location-Aware Exergame for Adolescents. In *MobileHCI'12*, ACM Press (2012), 359-368.
25. Nicholls, J.G. Achievement Motivation: Conceptions of Ability, Subjective Experience, Task Choice and Performance. *Psychological Review* 91, 3 (1984) 328-346.
26. Philippaerts, R., Matton, L., Wijndaele, K., De Bourdeaudhuij, I., Taks, M., Lefevre, J. Reliability and validity of a computer-assisted physical activity questionnaire for 12- to 18-year old boys and girls. *8th Annual Congress European College of Sport* (2003).
27. Poole, E., Miller, A., Xu, Y., Eriksdottir, E., Catrambon, R. and Mynatt, E. The place for ubiquitous computing in schools: Lessons learned from a school-based intervention for youth physical activity. In *UbiComp'11*, ACM Press (2011), 395-404.
28. Ryan, R.M. and Deci, E.L. Intrinsic and Extrinsic Motivations: Classic Definitions and New Directions. *Contemporary Educational Psychology* 25, (2000), 54-67.
29. Song, H., Peng, W. and Lee, K.M. Promoting Exercise Self-Efficacy With an Exergame. *Journal of Health Communications* 16, 2 (2011), 148-162.
30. Staiano, A.E., Abraham, A.A., and Calvert, S.L. Adolescent Exergame Play for Weight Loss and Psychosocial Improvement: A Controlled Physical Activity Intervention. *Obesity Journal* (2012).
31. Strecher, V.J., McEvoy, B., Becker, M.H. and Rosenstock, I.M. The Role of Self-Efficacy in Achieving Health Behaviour Change. *Health Education Quarterly* 13, 1 (1986), 73-91.
32. Toscos, T., Faber, A., An, S. and Gandhi, M. Chick Clique: Persuasive Technology to Motivate Teenage Girls to Exercise. In *CHI 2006 EA*, ACM Press (2006).
33. Yin, R. *Case Study Research: Design and Methods (4th Edition)*. Sage Publication Inc (2008).