iFitQuest: A School Based Study of a Mobile Location-Aware Exergame for Adolescents

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ABSTRACT
Exergames, games that encourage and facilitate physical exercise, are growing in popularity thanks to progressions in ubiquitous technologies. While initial findings have confirmed the potential of such games, little research has been done on systems which target the needs of adolescent children. In this paper we introduce iFitQuest, a mobile location-aware exergame designed with adolescent children in mind. In an attempt to understand how exergames can be used to target adolescent children, and whether they can be effective for this demographic, we outline the results of a school based field study conducted within a P.E. class. Through a detailed analysis of our results, we conclude that iFitQuest appeals to twelve to fifteen year olds and causes them to exercise at moderate to vigorous levels. However, in order to develop effective systems that can dynamically adapt to the adolescent users, further research into different categories of users' behavior is required.

Author Keywords
Exergames; location-aware games; serious games for health

ACM Classification Keywords
K.8 [**Personal Computing**]: General - *games*

General Terms
Design, Human Factors

INTRODUCTION
The World Health Organisation recently announced that the world was witnessing an obesity epidemic [35]. Overweight and obesity issues are particularly concerning with regards to children. First of all, "obesity in childhood, particularly in adolescence, is a key predictor for obesity in adulthood" [4, p.239], which in turn increases their chances of developing chronic conditions such as type 2 diabetes and abnormalities in the heart [12]. Further to the physical health concerns, obesity can be linked to psychological issues [27,34], as well poorer academic performance [5,17] and absenteeism from school [31].

Thus, the motivation for addressing weight issues is clear. However, while the problem is not a straightforward one, due to a complex interaction of many socio-economic factors [28], adopting a sedentary lifestyle and failing to participate in physical activity have been strongly linked to obesity [16]. With adolescents regularly experiencing what is known as the "adolescent slump", a dramatic downturn in physical activity around the age of 12 [29], adolescent children remain a prime target for physical activity interventions.

Recently, thanks to progressions in ubiquitous technologies, a new genre of gaming has emerged with the potential to address the problem. *Exergames* are video games which also incorporate an exercise, in an attempt to facilitate physical activity and positive behavioral change within a fun and enjoyable environment. Killi and Merilampi state "Exergames involve physical activity as a means of interacting with the game and have evolved to facilitate the physical health of the players" [11, p.103].

While exergaming remains a relatively young genre, there has already been evidence to suggest its potential to facilitate physical activity [19,22,26]. However, very few exergames have explicitly targeted adolescents, with their unique demands and needs. As young people are a prime demographic for traditional video games [7], and their parents are happy to support them in using exergames [37] we must build upon prior work on exergames to understand how to build effective exergame interventions for this age group.

In this paper we report on the attitudes and behavior of adolescent users of a location-aware exergame called *iFitQuest*. iFitQuest contains a prototype suite of mini-games designed to encourage physical activity in an enjoyable and motivating context. An important perspective underlying our work is the notion of inclusion; it is important that exergames can appeal to players of different demographics (both genders and novice to expert gamers) as well as those with different initial finesses and attitudes towards exercise. We consider throughout how different demographics react to the game, in an attempt to understand how best to design exergames for a diverse audience.

In developing our system we draw from, and build upon the existing body of literature on exergame physical activity interventions. We discuss the success of exergames, as well as the gaps in current understanding which motivate our work. A user-centered design approach is then explained along with the design of our location-aware exergame,

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iFitQuest. The results of a school based field study are then discussed along with the conclusions we have drawn from our work.

RELATED WORK

Exergames

Exergames are a relatively new concept afforded by progressions in ubiquitous technologies. Exergames aim to take the enjoyable and motivating nature of traditional video games, and combine this with the beneficial nature of physical activity. While the genre remains in its infancy, there already exists tentative research highlighting its potential. Dance Dance Revolution, while not initially developed as an exergame, has been found to increase aerobic fitness [19] as well as promote teamwork, creativity, cooperation and fair-play [36]. Another commercial example, WiiFit has been found to be more enjoyable than traditional exercise [9], as well as increasing lower limb strength and balance [22], making it a positive modification to traditional video game play.

Mobile Exergaming

For many, console based exergames fail to utilize the pervasive nature afforded by modern ubiquitous devices. Building upon the notion of *pervasive games,* where "games are no longer confined to the virtual world domain of the computer but integrate the physical and social aspects of the real world" [15, p.2], mobile exergames aim to bring a new dimension to the genre, by allowing play out in the real world where new and different exercise can be performed and the experience is more socially rich.

Many mobile exergames have looked at using pedometers to increase the wearer's daily step count, with the emphasis placed on continuous low intensity exercise rather than shorter, higher intensity, dedicated sessions. The American Horsepower Challenge is one such example which focused on a school based pedometer intervention. The game encouraged inter-scholastic competition and was found to increase the daily step count of those children taking part [26]. On a similar note Fish'n'Steps [13], and NEAT-o-Games [6] have used body worn sensors to track the activity level of the user and use this as an input into a competition style game, both with relative success.

Mobile geo-location enabled devices, with their ability to track the real world location of the user, form an interesting area known as *location-aware exergaming.* By using GPS data as an input into the game, players can be encouraged to travel in the real world in order to interact with the game. One such example used GPS technology to augment traditional playground style games, putting a modern twist on successful, well established play types [18].

Limitations of Current Research

However, while these early results appear positive, exergames are not simply a ready-made solution to increasing a child's activity levels. 'Novelty effects' have been observed where by initial excitement and effort quickly dwindles [13]. In some cases, researchers have also found that exergames such as the WiiFit are not physically demanding enough to facilitate the type of exercise that may be required [10, 22].

Therefore as researchers, we must carefully consider a complicated design task. Games must be made to be both enjoyable and physically demanding; these are potentially conflicting requirements (depending on the user). Further to this, exergames must be designed such that they can adapt to the unique needs of the user, pushing them in such a way that is suitable for their own fitness, goals and motivation. By catering games to the unique needs of the user, and adapting to their own situation, we hope that we can begin to combat the novelty effects and miss-calibrated exercises previously reported.

While researchers have begun looking at how the design of exergames should be approached [1, 2], few have looked at how we can model users, and as such begin to create games which can be catered to the individual's unique needs. When considering a demographic like adolescent children, we are dealing with a diverse population with unique wants and needs. While in this section we have highlighted a few examples of exergames designed for children, there exists a gap in the understanding of how different children will react to exergames. It is naive to think that exergames can appeal to all, but by understanding how different players from different demographics experience a game, we can begin to model players and take a first step towards developing adaptive exergames, capable of catering themselves to a player's unique wants and needs.

DEVELOPMENT PROCESS

The development of exergames provides an interesting problem for researchers, full of conflicting and contrasting requirements from different stakeholders. Exergames are still games and therefore they must be fun to play. As Sinclair et al. state, exergames must be fun if we want the players to return and play the game frequently [32]. However, often in contrast to this, the game must be physically demanding and facilitate physical activity. In addition, the context in which the game will be played, and the technical feasibility must all be considered.

We chose to develop our exergame to be played within a school context. Prior research on health promotion programs has found the context of the intervention is critical to the design of the program [33]. Schools have been selected as the chosen space for many health interventions due to their ability at reaching the majority of youths, the existence of appropriate facilities, as well as having existing programs for physical activity [26]. Due to these factors, as well as the success of previous ubiquitous computing health interventions in schools [26], we chose to develop our system for this context.

We chose to approach the development process using a user-centered, prototype driven approach with teenagers

Figure 1. Overview of the Escape the Ghost (left) and Collect the Coins (right) visual interface.

and teachers as design informants [8], building upon the previously published exergames design requirements [1, 2]. In this educational context, the view of a physical education teacher on exercise demands was as important as consulting teenagers about motivating aspects of games. Our design process therefore included an expert interview with a physical education (P.E.) teacher at a local secondary school, an observation of a routine P.E. class on the sports field, a focus group with six 13 year olds on their favorite games, and a session in which the same adolescents tried and critiqued off the shelf exergames available for the Wii Fit. Through this process, the adolescents provided the inspiration for the themes, content and style of the game, and the P.E. teacher provided details on the exercise requirements and contextual constraints.

IFITQUEST

iFitQuest is a location-aware mobile exergame designed to target adolescent children. The game is made up of a number of 'mini-games' each designed to target a different type of fitness, or different game mechanic.

iFitQuest uses GPS and compass data to track the real world location of the player, using this as the primary input into the game. The player's real world physical movements are used to control their virtual character. By moving in the real world, the player can interact with Non Player Characters (NPCs), visit landmarks and collect items. Figure 1 shows two example screenshots from the game.

The game is played on the iPhone, and uses Google Maps to provide the in game representation of the player, NPCs and landmarks. All virtual game items are not pre-programmed, but dynamically generated based on the current location of the user. Thus, the game can be played anywhere, at any time. Although the game was developed for in school use, due to the procedurally generated content, as well as single player gameplay, the games could be played outwith the school context. In the next two sections we describe two of the mini-games that make up the iFitQuest suite. The following two games provided the focus of our field study.

Escape the Ghost

Escape the Ghost is a simple exergame inspired by the traditional children's playground game of chase and catch. The user must try to escape capture from the ghost for a predefined period of time, moving in the real world in order to steer their virtual character away from the virtual ghost pursuing their character. This type of game mechanic was found to be effective in location-aware exergames for children [18]. Figure 1 shows a screenshot of the game.

The game difficulty can be altered in one of two ways. The time in which the player must 'survive' away from the ghost can be increased or decreased in order to alter the length of time the child is exercising. Alternatively, the speed at which the ghost will chase the child can be altered, resulting in a higher or lower intensity of exercise. Difficulty is automatically increased after a player wins a game, and is decreased after the player loses. The player may also choose to override the difficulty setting manually.

The game was designed to mirror that of sprint training, in which the athlete undertakes repetitions of high intensity bursts of speed for a short period of time. Audio and vibro-tactile cues are used to alert the player when they have been captured by the ghost or won the mini-game.

Collect the Coins

Collect the Coins was derived from the traditional Pac-Man game [20]. The user must try to collect the designated number of coins while simultaneously avoiding the patrolling ghost – which does not actively chase the player like in the Escape the Ghost game, but rather patrols around the play area. In this game there is no predefined time limit, however the aim of the player is to collect the coins in as short a time as possible. Figure 1 shows a screenshot of the game.

The game difficulty can be altered in one primary way. The number of coins the player is required to collect can be changed, in order to have them exercise for a greater or shorter length of time. As before, changes in difficulty can be triggered automatically or by the user.

The game was designed to comply with the P.E. teacher's request of 'short sharp bursts' of exercise with agility training through directional changes. The idea is that the players use the visual output on the screen to orientate themselves towards a coin, before they sprint in that direction. An audio cue and vibro-tactile output signals to the player that they have collected a coin and that they should return to the visual output in order to decide what direction to run next.

RESEARCH GOALS

In order to produce adaptable exergames, capable of targeting the specific needs of our users, we need a basic level of understanding about how different people interact with iFitQuest. Our research questions are as follows:

- *What are adolescents' opinions of the pilot games, and how much exertion do they expend in playing them?* Although previous research has indicated that exergames in general can be effective, iFitQuest requires user evaluation to establish whether the design is effective in terms of enjoyment and physical exertion.
- *How do gender and prior gaming experience affect users' attitudes towards the game?* It is known that girls and boys have different motivations and preferences for playing computer games [23]. Further, although both boys and girls enjoy games and spend a lot of time playing them, boys are more likely to devote more leisure time to gaming and are therefore usually more experienced gamers [14]. As it is also known that adolescent girls can be more at risk from obesity related illnesses than boys [24], it is particularly important to establish whether the game is sufficiently appealing to encourage them to exercise.
- *To what extent and in what way do users configure the challenge level of the game to tailor it to their fitness needs?* As any group of children will have a range of fitness levels and speed, the default settings for iFitQuest will not be calibrated correctly for all users. A simple way to achieve this is to enable users to change the difficulty level of the game (e.g. by altering the speed at which they must run to succeed in the game objectives). However, the extent to which teenaged users are willing and able to adjust challenge levels appropriately in this context is an open question which requires exploration.
- *How does winning or losing a game affect users' enjoyment of the game? Does success or failure have an impact on user alterations to difficulty levels?* Is the phrase often used by P.E. teachers "it's the taking part that counts" true in this context? Or do users play exergames motivated by a desire to win, as in competitive sports? Do users use feedback from success or failure in a game level to further personalize the difficulty setting of the game?

SCHOOL BASED FIELD STUDY

In order to begin answering these research questions we conducted a school based field study using 25 participants. Due to the exploratory nature of the work, no preconceived hypotheses had been formed.

Videogame Play Background	Frequency	Exergame play background	Frequency
Never	1	Never	8
Once or twice per week	9	Once or twice per week	16
Most days	9	Most days	1
Every day	6	Every day	0

Table 1. Overview of the evaluation participants gaming background.

Method

Participants

We recruited 25 participants from a local high school. All participants had volunteered based on an invitation from one of their subject teachers. The participant's age ranged between 12 and 15, with the average age 12.9 and modal age 13. Of the 25 participants, 15 were male while 10 were female. As this was an open invitation, we did not preselect participants in terms of exercise or video game background. Table 1 provides an overview of our participants' gaming and exergaming preferences.

Our participants were asked to numerically self report their fitness and enjoyment of exercise with values between 1 and 10. They were on the fitter end of the spectrum (*avg.*=7.84, *SD*=1.197) and enjoyed exercise (*avg.*=8.66, *SD*=1.434).

Data Gathering

All participants completed a pre-test background questionnaire, and a post-test evaluation questionnaire. The post-test questionnaire asked the participants to numerically rate their enjoyment and exertion between 1 and 5, as well as open ended questions in order to establish the reasoning behind their ratings. As well as the questionnaires, in-game log-files were collected during play, allowing us to analyse how enjoyment/exertion changed over time, how successful the players were in the game, as well as how far, and at what speed the participants were travelling for an assessment of their activity levels. In-game ratings were collected at the completion of each level of a mini-game, users were asked to numerically rate their exertion and enjoyment between 1 and 10. Finally, an expert P.E. teacher observed the session in order to comment on the level and type of exercise being done by the participants as well as levels of effort and enjoyment in comparison to a 'traditional' P.E. lesson. Following the session, an experienced researcher interviewed the P.E. teacher in order to document her opinion.

Procedure

The evaluation consisted of two separate 3-hour sessions, with 17 participants taking part in the first session, and 8 in the second. Each session was organized as follows:

- Initial briefing by P.E. teacher and researcher.
- Time to complete pre-test background questionnaire.
- Non game warm-up conducted by the P.E. teacher.
- Short in-situ demonstration of the game.
- Free time to play the game within a designated area.
- Time to complete post-test evaluation questionnaire.
- Short informal focus groups to clarify questionnaire answers and de-brief participants.

During the free play of the game, the participants were given 30 minutes to play each of the two mini-games, 15 minutes per game. They were asked to play each game as many times as they could / wanted in that time. After each play of a mini-game, they were given an in-game rating screen where they were asked to rate their current level of enjoyment and exertion. They could also increase or decrease the difficulty level of the game, as they desired for their next playthrough. This formed the basis of the log-file analysis previously described.

RESULTS

In this section we report upon the results from our preliminary evaluation. It should be noted that log-file analysis could only be completed for 20 of the 25 participants, due to a failure in the logging system on certain devices.

General

Overall, our participants reacted positively to the experience, rating the game favorably for both enjoyment and exertion. The P.E. teacher reported that her class worked "as hard, if not more so" than her average P.E. lessons in terms of physical exertion, and that their enjoyment was greater than normal. Using the post-session questionnaire, participants were asked to rate their overall enjoyment, and overall level of exertion out of 5. Our participants gave the game an average score of 4.12 for enjoyment (SD=0.44) and 3.76 for exertion (SD=0.52). Further to this 21 of our 25 participants (84%) said they would want to play the game again. Thus, at a high level, we appear to have met our goals of developing an enjoyable and physically demanding game.

Escape the Ghost Vs. Collect the Coins

As we begin to decipher how different game mechanics appeal to different players, the first item for consideration is the way players reacted to our two mini-games. As specified in the previous section, both games were designed with different exercise types in mind, containing different game mechanisms. Escape the Ghost focuses on very simple, playground style gameplay, while Collect the Coins contains a more advanced and slow paced game in which the player must focus more carefully on their movements and balance collecting items with avoiding capture.

You got more exercise	7
It was more fun	7
You had to run more	4
It was more exciting	3
Collecting the coins was too challenging	2
It was an easier concept	2
More involving	1

Table 2. The reasons given by the children when discussing their preference of the Escape the Ghost game.

Of our 25 participants, 22 preferred the 'Escape the Ghost' game (88%). In Table 2 we present the reasons given by the participants when asked why they stated this preference. Participants were allowed to give multiple responses.

Discussion

It is interesting to note that our participants rated both the exercise aspects, and the fun aspects as the two most prevalent reasons for preference of the Escape the Ghost game. As these are the two most valuable considerations for an exergame, and often thought of as being in contrast to one another within traditional exercise, this represents a large success for this particular mini-game. As exercise and running were both mentioned as primary reasons of preference, it would be interesting to see how children with a lower preference for exercise reacted to such a game.

The simple and familiar mechanics associated with the favoured game raise the important consideration of simplicity. It is easy to over complicate a game, and by expecting the child to do too much, the important purpose of the game can be lost. These findings mirror those reported by Misund et al. who discuss the merits of simple, traditional playground game mechanics [18].

Log-File Analysis

In order to better understand the way in which the participants behaved during the session, and the way in which the play experience changed over time, a log-file analysis of the in-game recordings is required. This paper focuses on an analysis of the Escape the Ghost game, as the gaming sessions were longer for this game than for the Collect the Coins game and gave richer data.

There were a total 106 game levels played across participants. Participants played on average 5.3 levels within a session.

Enjoyment

Using the in-game reporting of our participants and the resultant log-files, we were able to analyse how the players' experience changed over the course of the session. By looking at the way in which the participants rated the first level of the mini-game and comparing that with their rating of the last level of the mini-game, we can begin to garner an understanding of how our players experienced the game.

The average numerical rating after playing one level was 7.89 (*SD*=2.33), and the average rating after the last level was 8.59 (*SD*=2.24). Of the 20 participants, 7 increased their rating between first and last levels, 2 decreased it, and 11 made no change.

These results highlights the following: a) the in-game ratings confirm the post-test scores, highlighting the high level of enjoyment of our participants; b) the players' enjoyment generally increased or stayed the same over the course of the session; and c) generally, the players' initial opinion of the game was accurate.

Discussion
Further to the general enjoyment scores, it was very positive to note the findings of our log-file analysis. Prior research has confirmed the importance of exergames having a 'pick up and play' mentality [32] as well as the importance of avoiding novelty effects [13] Although our results come from a single session, it is none the less positive to note that the participants very quickly reacted positively to the game, and this was maintained or improved upon over the course of the session. This confirms our intuition to use simple, easy to master game mechanics, which can then be built upon in order to provide a sustained experience.

Exertion
Log-file analysis indicates that the average distance travelled while playing Escape the Ghost was 349 metres (*SD*=117, range = 153-567). The average speed for a level was 5.98 (*SD*=1.17) mph. According to [21] this equates to "vigorous" aerobic activity. The entire group had a speed representing "moderate to vigorous" activity. Similar to the enjoyment discussion above, we can assess using the in game log-files the way in which a participant's level of exertion changes whilst playing our game.

Participants altered their exertion rating between their first and last level as follows: 12 increased their exertion rating, 2 decreased it, and 6 made no change. On average, the initial level of exertion having completed one game was 6.06 (*SD*=3.03), this increased to an average exertion level of 7.85 (*SD*=2.81) following the last game. Note that the P.E. teacher explained that the users had previously been taught to use self-reported exertion levels in this way for other P.E. activities. This form of self-reporting has been found to be consistent with data from heart rate monitors [30]. With the average exertion level increasing, and the majority of our participants (90%) maintaining or increasing their exertion levels, this can be viewed as a success for the system.

In Figure 2 we present a state transition diagram showing the odds after each game that a participant will alter their exertion level in comparison to the previous game. After 3 games, the player's exertion level is variable, with a 0.55 chance that it will change. However, after the 4th game this drops to a 0.33 chance of changing, and after the 5th game it drops again to a 0.29 change of changing. This shows that after an initial variable period, the level of exertion of our participants settled down to a stable level.

Discussion
It is pleasing to observe that our participants generally increased their level of exertion whilst playing the game, a rudimentary requirement of exergames. It was also interesting to observe that our participants experienced changes to their exertion during the initial games, which then settled down by the 4th or 5th level.

This is a favourable observation as it is important to work up to the desired exertion level so as to avoid injury from overworking, and then maintain this level in order to feel the physical benefits. The pick up and play aspects of our game meant that the participants could quickly begin working, while the ability to customize difficulty settings meant that the participants could begin to challenge themselves and work at an appropriately high level.

Boys Vs. Girls
With gender a key aspect of consideration, we wanted to compare how boys and girls experienced our game. Boys and girls both enjoyed our exergames, with boys giving an average rating of 4.27 (*SD*=0.46) out of 5, and girls giving an average rating of 3.90 (*SD*=0.32). However, an

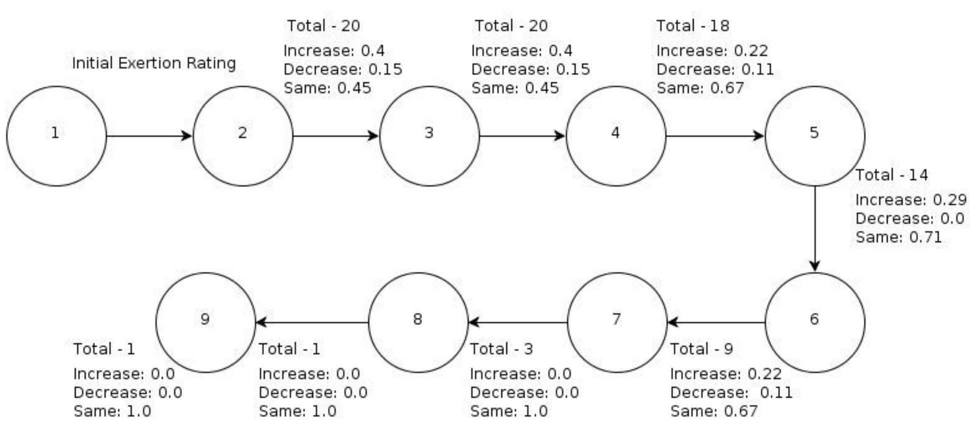

Figure 2. State diagram showing the odds of a participant altering their previous exertion score after each game.

independent sample t-test indicates that boys enjoyed the game significantly more than girls ($t(23)$=2.37, $p<0.05$). The effect size for gender was large (Cohen's d=0.94).

Discussion

By adopting a user-centred design approach and seeking the opinions of both males and females, it was disappointing to note that there was a significant difference in the experience linked to the gender of the individual. This result is not wholly unsurprising when we consider what is known about the preferences and game playing habits of both genders. A fuller analysis of more game mechanics will be done to establish whether the 'type' of game could be affecting enjoyment ratings. Character skins will also be investigated, to establish whether something as simple as using ghosts, rather than say, animals, could affect enjoyment. The issue is not however overly concerning as despite the significance findings and large effect size, girls still enjoyed the experience and indicated that they wanted to play the game again.

Gamers Vs. Non Gamers

In Table 1 we presented the frequency with which our participants played videogames. Using these four categories, we did a between groups one way ANOVA in order to establish whether there were any differences between the participants' enjoyment of our game, or the amount of exercise they got while playing the game, according to gaming experience.

Our results showed that there was no significant difference between the gaming background groups and the participants' enjoyment score (F(3,21)=0.401, $p=0.75$) or their exertion rating (F(3,21)=0.725, $p=0.55$).

Discussion

As the hope is for exergames to encourage new demographics into exercise, it is important that exergames do not solely appeal to those with an existing interest in traditional video games. Prior exergame research has highlighted the way in which game experience can influence the way in which a participant benefits from an exergame [38], however little has been reported on how a general gaming background influences the experience.

It is pleasing to report that in our game, both avid gamers and less frequent gamers displayed no distinction in their level of enjoyment and physical benefit. By mixing traditional video game mechanics with physical activity, as well as the novel interactions afforded by location-aware games, it is possible to develop a genre of gaming with equal appeal to a wide variety of gamer. This finding supports the claim that exergames will be capable of appealing to new demographics. While it is encouraging to note the regular gamers could not be distinguished from less frequent gamers, due to a lack of non-gamers in our study, further consideration must be made to this aspect during future evaluations in order to fully validate our claims.

	Increase	Decrease	No Change
Win	26	13	20
Lose	6	12	9

Table 3. The frequency with which players altered the game difficulty following a win or loss.

Success Vs. Failure

We wanted to investigate how user enjoyment was affected by the participant's success in the game. Of the 106 levels played, 68% were won by the player. By looking at each of the levels played, and the way in which a success or failure in the game affected the resultant enjoyment rating, results from a point biserial co-efficient show that there was no significant relationship ($r_{pb}=+0.17$, $t=+1.71$, $df=104$) between game outcome and enjoyment score.

Discussion

One interesting aspect of exergames is the way in which success and failure influence the experience. Players expect a certain amount of failure in a traditional video game; in fact very challenging aspects may provide the greatest motivation to certain players. However, this balance must be carefully managed in an exergame. It is important not to de-motivate people by setting unattainable goals. Difficulty levels must be carefully managed with regards to exercise levels as well as game aspects, it is important not to work people too hard too soon.

It is positive to note that in our game, the players experience is in no way influenced by their success in the game. By taking the focus away from simply winning and losing, and moving towards enjoyable gameplay with an active twist, players are less likely to place focus on actual success.

Difficulty Changes

Another interesting question with regards to the psychology of exercise is the way in which success in the game influences a person's behavior with regards to altering the difficulty levels.

We wanted to know whether we could see a correlation between success and failure in the game and the way in which a player altered the challenge level of the game. Did participants keep difficulty levels low to maintain success, or did they manually increase it to keep themselves exercising at a high level?

There were 86 opportunities to change the challenge setting presented across all users, and 57 changes were made (66%). There was an average of 2.85 manual changes to the challenge setting per user. Of the 57 changes, 32 increased the difficulty (56%) and 25 decreased it. In Table 3 we present the way in which players manually altered the games difficulty following a success or failure in the preceding game.

As a case study we consider the behavior of a sample of our participants. P4, who completed 6 game levels, appeared motivated by success within the game. After winning the first two games, P4 found the difficulty level they wanted to play at. Despite winning the next 3 games, P4 overrode automatic difficulty increases in order to keep the difficulty level constant. Similarly, P7 appeared motivated by in game success. Despite winning their first 3 levels, they continually lowered the difficulty such that each new level was easier than the last. On their fourth game they increased the difficulty to a high level, however a resultant loss meant that they lowered the difficulty back to the level they knew they could be successful at.

Conversely, we see examples of players willing to challenge themselves further through increases to difficulty levels. P17 won only one of their 5 games, however they chose to maintain or in two cases increase the difficulty level despite their failure on the current level. P8 increased the difficulty after success in a level, but then maintained the difficulty on a level they failed at until they could succeed, only then increasing the difficulty level. P17 is an example of someone not affected by in game success, while P8 is someone who wanted to beat the difficulty levels that had caused them problems, rather than let the system take them to an easier difficulty.

Despite the very different behaviour of the participants highlighted, each of the examples came from a player who worked within the 'vigorous' exercise category. Thus, the examples are not of players trying to 'cheat' or simply explore, rather they highlight the different ways in which players can be motivated within an exergame.

Discussion

Possibly the most interesting finding is the way in which players altered the difficulty of the game. As we speculated in the early sections, exergames must be carefully tailored to the individuals needs, not only through setting activity at the correct level, but also through setting goals which appropriately motivate the player. What we see in our findings is a wide range of behaviours, from those that seek greater challenge after a success, to those that would rather succeed consistently.

These results highlight the needs for an understanding of the user's motivation and attitude towards exercise. Where as it may seem appropriate to increase difficulty following a success in traditional video games, it is important here to consider how much challenge a participant really needs. As long as they are exercising at the appropriate level, it is not necessarily appropriate to keep increasing difficulty levels. Where as some children will be motivated by the challenge, others will be motivated by success, understanding these differences will be key to the development of a successful exergame.

LESSONS LEARNED

The results of this field study illustrate that it is possible to facilitate moderate to vigorous - yet enjoyable - exercise in adolescents using a pervasive exercise game. The user-centred design process was successful in balancing the requirements of the P.E. teacher and the adolescents, resulting in a game which motivates adolescents during out of doors physical exercise.

The results and experiences from this study lead us to the following observations.

For a game to work within the tight constraints of a school P.E. lesson, it should have a shallow learning curve.

Our observations of the P.E. class and our field study indicate that there is very little time for exercise, given the constraints of the school timetable and the time it takes to change clothing at the start and end of a lesson. For this reason, time spent using the game should be in pursuit of fitness goals rather than learning game mechanics.

Challenge may work differently for exergames.

Consider how challenge is structured in a traditional computer game. Typically, the difficulty of the game increases as the player successfully completes tasks [25]. Even after several hours of gaming, the player will have increased competence through practice and will be performing more demanding tasks. In contrast, players of exergames cannot keep increasing their level of physical effort indefinitely due to physical exhaustion. Further, as they get more tired, they have to expend more effort to maintain their initial performance. Often the goal of an exercise session is to maintain (rather than increase) performance over a short, bounded time period. If the game mechanics are tightly coupled to the exertion level of the game, difficulty level cannot keep increasing. On the other hand, non-exertion related game mechanics (such as puzzle solving) could increase in difficulty while exertion levels were maintained at a constant level. Flow theory suggests that players would value the sense of accomplishment which comes from an upwards challenge trajectory [3]. A successful design could perhaps be one in which the exertion mechanics involved repetitions of a task interspersed with rest periods but an additional mechanic increased the cognitive challenge for the player during the rests. If not, designers will need to develop a set of game mechanics designed around satisfying the player as they keep their performance constant. An additional complication comes from the fact that physical exercise causes pleasurable chemical changes in the brain (such as endorphin release) which are likely to increase motivation in a way which even the most zealous of sofa-bound gamers are unlikely to experience.

Further work is necessary to further understand the interaction between a constellation of player attributes and player behaviour when playing the game. Although the P.E. teacher described the lack of physical fitness of her pupils in general, it transpired that the learners who took part in the field study reported themselves as already fit, and by and large had positive attitudes towards exercise. This is a shortcoming in our evaluation because we are unable to compare the experience of unfit individuals to fit individuals, or those with low opinion to exercise to those with high. We also lacked the number of participants which would have been necessary to conduct an analysis for interaction effects between gender and gaming background.

In our next study, we will deliberately attempt to work with learners who are less fit and less inclined towards exercise in order to investigate whether their attitudes to the game, and behaviour while using it are different. For example, it is likely to be the case that users who do not enjoy exercise and have poor self-efficacy in this area will enjoy the game less, and exert themselves less than the users from the current study. It is also possible that their behaviour during the games will be different; such users are arguably less likely to increase the difficulty level during the game, and their enjoyment may decrease if they lose a level. Ideally, enjoyment of the game and exertion levels should increase after winning a level if the game truly does have a motivating effect. These effects may be mediated by the gaming background of the user: it is likely that users who do not typically enjoy exercise but who are avid gamers are more inclined to enjoy the game than users who like neither exercise nor games. Following on from this study, we will conduct an eight week longitudinal intervention to establish how players' attitudes to exercise and physical fitness change once the use of the game becomes a routine part of P.E. class. Using the results of these studies, we aim to design an adaptive exergame which can generate personalised exergame programmes for individuals based on their fitness, their attitude towards exercise and their previous performance with the game.

CONCLUSIONS

What are adolescents' opinions of the pilot games, and how much exertion do they expend in playing them? Results from a school based field study with 25 users which indicate that iFitQuest is enjoyable for 12-15 year olds, and it facilitates moderate to vigorous exercise.

How do gender and prior gaming experience affect users' attitudes towards the game? Girls and boys both enjoyed the game and would like to use it again. There is a significant difference with a large effect size between genders; boys are more likely to rate the game more highly. There was no significant difference in attitudes towards the game among groups with different prior gaming experience.

To what extent and in what way do users configure the challenge level of the game to tailor it to their fitness needs? Users accepted the opportunity to change the difficulty level of the game 66% of the time. As 56% of these changes were to increase the difficulty, this suggests that the users were attempting appropriate changes rather than simply 'cheating' by making the game easier.

How does winning or losing a game affect users' enjoyment of the game? Does success or failure have an impact on user alterations to difficulty levels? The users' enjoyment ratings did not appear to be influenced by success or failure in the game, suggesting that their motivation was not affected by their performance. This result may not hold for less fit users or those with low self-efficacy as they may become demoralized after losing a game. After losing a level, the players were most likely to decrease the difficulty level, presumably trying to make the challenge more appropriate. After winning a level, players were most likely to increase the difficulty, indicating an appropriate desire to increase challenge and exertion.

The above answers to these research questions provide the first steps towards developing exergames which appropriately tailor physical activity to user characteristics, highlighting the different ways in which a particular demographic group experiences an exergame, and the way in which an accurate player model will be required to create effective adaptive exergames.

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