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DEVELOPMENT OF MULTIPLAYER EXERTION GAMES FOR PHYSICAL EDUCATION

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ABSTRACT

The potential use of serious games in educational settings is huge, because a large and growing population is familiar and engaged with playing games. However, the popularity of games has aroused also problems. For example, obesity has recently become a big problem in many countries. The development of motion-based controllers and the concern over the high levels of obesity has facilitated the new coming of exertion game genre that involve physical activity as a means of interacting with the game. In this paper a design framework for exertion games is proposed. Based on the framework three mobile multiplayer exertion games were developed and empirically evaluated in a junior high school (n = 105). The results indicated that mobile phones and heart rate belts were experienced as appropriate exertion game controllers and simple motion detection can be used to design engaging exertion games. The results showed that motion-based games and team play motivate children a lot and games could be an effective 'weapon' in the fight against the growing problem of obesity. Furthermore, the results indicated that exertion games could have also educational value and educational content could be embedded in to exertion games. Generally, it seems that exertion games could provide meaningful and cost-effective solutions for physical education and other educational contexts. In spite of promising results more research, particularly in the area of exertion game design is needed.

KEYWORDS

Exertion game, mobile phone, physical education, heart rate, multiplayer, flow experience.

1. INTRODUCTION

The development of new educational methods is necessary to accelerate learning, develop new skills for the knowledge economy and to reach learner groups that are currently unreached by conventional techniques of learning. The potential use of serious games in educational settings is huge, because a large and growing population is familiar and engaged with playing games. However, the popularity of games has also aroused problems. For example, obesity has recently become a big problem in many countries. According to Gorgu et al. (2009) the reasons for obesity include a high calorie diet and a serious lack of physical activities in the daily lives of children. It has been argued that video games are one of the main reasons for physical inactivity (Vandewateret et al., 2004; Luepker, 1999; Parizkova & Chin, 2003; Riviere, 2004; Sothern, 2004). The exertion game genre tries to change this by encouraging players to perform physical movements during gameplay. According to Mueller, Agamanolis, Vetere and Gibbs (2009) exertion games (also referred as exergames) are an emerging form of computer games that aim to leverage the advantages of sports and exercise in order to support physical, social and mental health benefits. An exertion game is controlled with an input mechanism that requires a player to intentionally invest physical exertion (Mueller, Gibbs & Vetere, 2008). Exertion can be defined as an act of exerting, involving skeletal muscles, which results in physical fatigue, often associated with physical activity and sport. The overall hope is that the sense of enjoyment that traditional video games produce can be harnessed to engage children in greater physical activity.

Basically, exergaming is not a new phenomenon. It was introduced with the Atari 2600's footpad controller in the early 1980's and popularized with Konami's Dance Revolution product in the 1990's. However, in recent years, the development of motion-based controllers has facilitated the advent of the exertion game genre. Currently, exertion games are specifically associated with Nintendo Wii game console and recent research has used it as a test-bed in many different contexts (e.g. Graf, Pratt, Hester & Short, 2009; Graves, Stratton, Ridgers & Cable, 2007). The research has shown that exertion games can be an effective form of exercise (e.g. Papastergiou, 2009; Graf et al., 2009). On the other hand Daley (2009) has criticized the previous studies and calls for more extensive and methodologically robust research. He argues that although studies have produced some encouraging results regarding the energy expenditure of exertion games, active gaming is no substitute for real sports. For example, in the Wii Sports games, players are required to move their bodies to control their virtual characters in the game, but the movements are quite small and intensity is usually low. However, research and tryouts have been also conducted in order to make the gaming more active with the help of heart rate measuring devices. The use of heart rate measurement immediately brings more intensity to the gaming experience and makes it automatically more energy requiring. For example, Nenonen, Lindblad, Häkkinen, Laitinen, Jouhtio and Hämäläinen (2007) have used heart rate as a control method in their game called Pulse Masters Biathlon. The objective of the game was to get through the track as fast as possible. The gameplay consisted of two states: cross-country skiing and target shooting. (Nenonen et al. 2007, 853) According to Nenonen et al. (2007) players felt that heart rate was a fun and interesting way to interact with the game. They were also able to show that heart rate interaction could be used with any exercise method. Most importantly, the players also reported that this could be a reason to exercise since the game was addictive, and it felt like a good exercise (Nenonen et al. 2007, 856).

In spite of criticism, previous research indicates that exertion games can provide a means to motivate, at the very least, persons who are less active. Thus, exertion games might have some potential use in the fight against youth overweight and obesity. However, more research is needed to distinguish between exertion games that contribute to increased fitness and those that only offer novel ways of controlling games. Thus, we need systematic research, particularly in the area of game design. One of the biggest challenges is the need to make the game attractive to players and at the same time effective as an exercise. The aim of this study is to provide design principles that facilitate the development of high quality exertion games for children and youth. In fact, we propose a design framework for exertion games and consider ways to implement exertion games into schools. Furthermore, we report the results of two pilot studies in which we tested three novel exertion games that are based on the framework. Finally, the evaluation results of the used exertion games and players' opinions about exergaming are presented and discussed.

2. DESIGN FRAMEWORK FOR EXERTION GAMES

The flow theory (Csikszentmihalyi, 1991) forms a foundation to design exertion games, because it provides a universal model for engagement (Sweetser & Wyeth, 2005; Kiili & Lainema, 2008). Flow has been applied in several different domains including sports, digital games and education. These domains are partly parallel with exertion games and provide several aspects to consider. For example, Jackson and Csikszentmihalyi (1999) have stated that sports can offer such rewarding experiences that one does it for no other reason than to be part of it. Furthermore, they argue that a sport setting is structured to enhance flow. Although, winning in sports is important, flow does not depend on final outcomes of an activity, and offers athletes something more than just a successful outcome. In fact, an optimal experience usually occurs when a person's body or mind is stretched to its limits in a voluntary effort to accomplish something difficult and worthwhile (Csikszentmihalyi, 1991). Such experiences are not necessarily pleasant when they occur, but they still produce enjoyment. This is true also in exertion games. However, exertion games should not be too intensive because they are mainly targeted to persons whose fitness level is low or to persons who are not interested in regular and heavy physical exercises.

We constructed a design framework for exertion games by combining previous research results about flow and exergaming (see figure 1). The framework can be divided into five main elements: Player, flow antecedents, gameplay, flow state and social context.

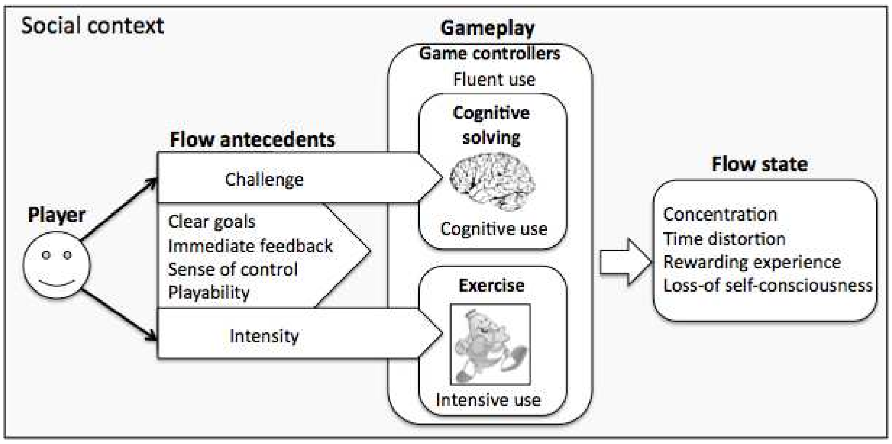

Figure 1. Design framework for exertion games

2.1 Player and Social Context

Exercising can be boring alone. For example, Paw et al (2007) found out that children seem to prefer multi-player and group game play to individual exercise. Teamwork and competition are good motivators that engage players. However, the multiplayer approach is not a magic bullet alone. Several player characteristics should be taken into account when designing exertion games in order to create enjoyable and effective experiences. For example, in what ways the game can adapt to the player? Does the game controllers work similarly for different people sizes? Could the handicapping system motivate low fitted players?

2.2 Flow Antecedents and Gameplay

Gameplay is the core of the game and its significance should not be underestimated. According to Costikyan (2002), good gameplay keeps a player motivated and engaged throughout an entire game. Game designers Rollings and Adams (2003) have defined gameplay as one or more causally linked series of challenges in a simulated environment. In fact, gameplay also includes the actions that players can take to meet the challenges. Thus, the implementation of game controllers that enable interaction with the game is crucial. Generally, the game controllers (player’s movements) should be easy to adopt and the whole user interface fluent to use.

The flow antecedents are factors that facilitate flow experience through engaging gameplay. The antecedents can be divided into two dimensions: static and dynamic. Clear goals, immediate feedback, sense of control and playability are quite static antecedents and we do not consider them in this paper. In contrast challenge and intensity are dynamic antecedents that should be adapted to players’ skill and fitness levels (Sinclair, Hingston, & Masek, 2007). In order to optimize the engagement and effectiveness of exertion games Sinclair, Hingston, and Masek (2007) have proposed a dual flow model that extends the original three-channel flow model with an effectiveness dimension that reflects an intensity-fitness balance.

Furthermore, in a recent study, Kiili and Perttula (2010) extended the dual flow model with a team flow dimension (Figure 2).

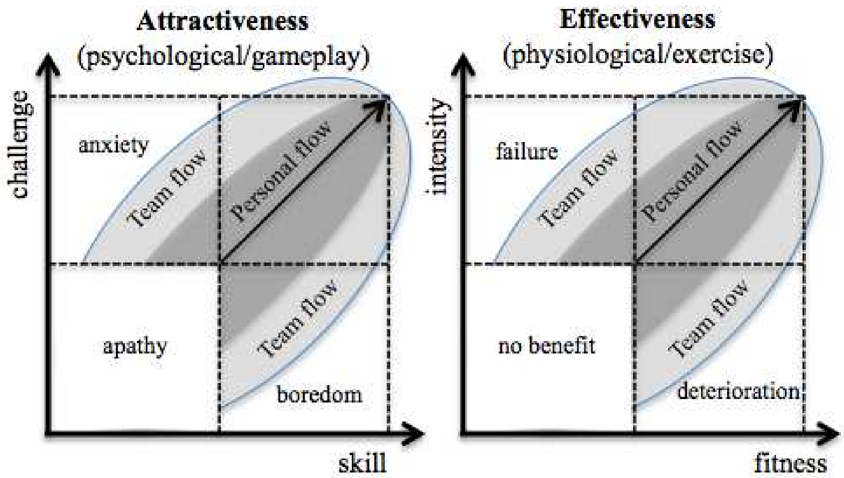

Figure 2. An extended dual flow model for exertion games (Kiili & Perttula, 2010)

According to the dual flow model the challenge-skill balance determines the attractiveness of the game. If the challenge is too low, a player tends to feel boredom and when the challenge is too high, a player tends to feel anxiety. Similarly the intensity-fitness balance determines the effectiveness of the game. If the game is too intensive, a player will fail to play the game and is unable to continue exercising. On the other hand, if the intensity is too low compared to player's fitness level, a player will enter a state of deterioration. The optimal exergaming experience can be achieved when both the attractiveness and effectiveness dimensions are in balance and a player is in the flow zone.

However, the balancing of exertion games is not as straight forward as the balancing of traditional computer games. The basic balancing principle suggests that the difficulty level of a game can be gradually increased, because it is assumed that a player's skill level increases with playing time. Thus, for example, playtesting can be used to balance the challenges for a certain target audience. Such a solution does not work properly in exertion games. Although, a player's skills may increase during playing, in lengthy playing sessions the gradually increasing intensity will lead to exhaustion and failure. To overcome this problem, Sinclair, Hingston, and Masek (2007) have suggested that exertion games should adapt dynamically to a player's performance, or they should be based on simple mechanics that focus more on input devices and exercise movements than on complex gameplay. In general, the dual flow model provides a good starting point for designing exertion games, but more detailed design principles are still needed.

2.3 Flow State

According to Kiili and Lainema (2008), whenever people reflect on their flow experiences, they mention some, and often all, of the following characteristics: concentration, time distortion, rewarding experience, and loss of self-consciousness. In flow a person is totally focused on the activity and is able to forget all unpleasant things. Because flow-inducing activities require complete concentration of attention on the task at hand, there are no cognitive recourses left over for irrelevant information. Thus, self seems to disappear from awareness during flow. In other words, in flow there is no room for self-scrutiny Csikszentmihalyi (1991). This is very important in exertion games, because some of the players may have low self-esteem and they are afraid to exercise publicly. According to Csikszentmihalyi (1991) during the flow experience the sense of time tends to bear little relation to the passage of time as measured by the absolute convention of a clock; Usually time seems to pass really fast. Time distortion facilitates the physical gains. Rewarding experience refers to an activity that is done, not with the expectation of some future benefit, but simply because the doing itself is interesting and fun. Thus, experienced flow works as a hook that engages players and get them to play games again and again.

3. MOBILE EXERTION GAME PLATFORM

Following is a short description of the exertion game platform that is used in the research reported in this paper.

Mobile game controller. As game controllers we use the Nokia 60 series smart phones tat have a built-in 3-axis accelerometer sensor. To exploit this feature we have a custom made Mobile Python application. The mobile client sends every properly done player movement to the game server via a network socket by the WLAN connection. To determine this movement we store the accelerator sensor readings x, y and z to separate vectors. The mobile software observes approximately 35 times per second the accelerometer readings for stream sensor data. We use these vectors to compose the normed difference between old and new accelerator data. And the result presents our magnitude vector. We do not have an absolute position of the certain phone in a virtual space or an estimate of the tilt angle of the device relative to the gravitational field. In this case we are only interested in to detect the magnitude of the movement. When this value exceeds the certain margin, the mobile client software recognizes this as a squat or a jump movement. It also waits the value of the magnitude vector to fall below this margin before new movements are sent to the server. This prevents multiple sending procedures occurring during the one movement.

Although our solution detects movements, it cannot distinguish a jump from a squat, for example. In spite of that, our games are designed for certain movements. However, before starting to play players can decide what kinds of movements they will use in the game. Such an approach makes it possible to use same client-software in a variety of games and for exercising purposes.

Server side solution. Our exertion games are running in classic client-server architecture (figure 3), but the server is only a simple socket server, which echoes all received messages to all clients. The game engine is one of the clients. This way it is possible to use the same server without modifications for different games. As a drawback this solution causes unnecessary traffic between clients, which are used as controllers and game session is vulnerable to disturbance. In future versions socket server will distinguish game engines from controllers and address messages to right clients.

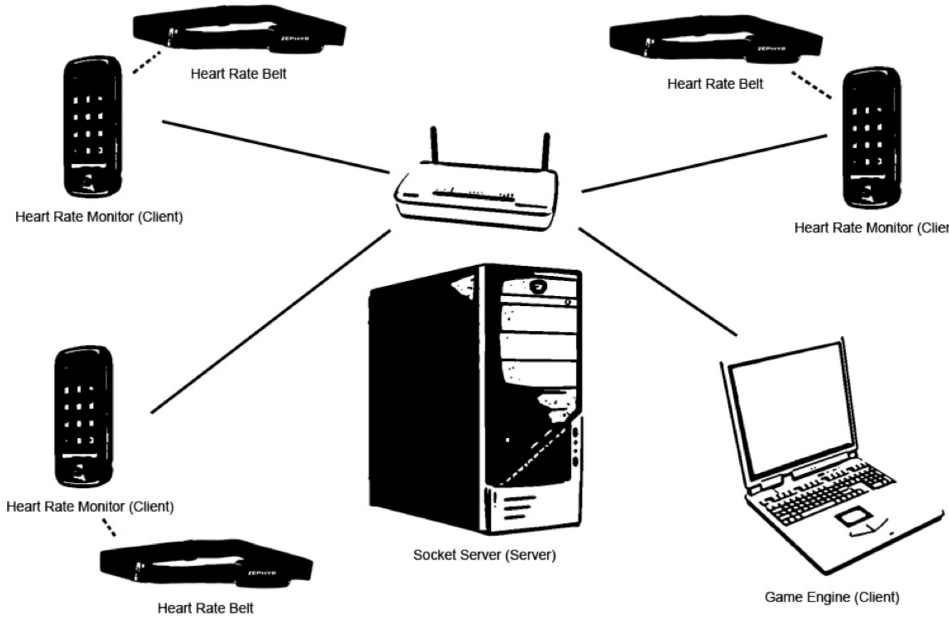

Figure 3. Mobile client-server architecture

4. STUDY 1 – ACCELERATION BASED GAMES

4.1 Method

Participants. The pilot testing was conducted in fall 2009 at the school of Kasavuori in Finland. The participants were 7th-9th graders (n = 45). The gender distribution was almost even. The school of Kasavuori provided appropriate settings for the study because it is profiled to be one of the most advanced Finnish schools in usage of new media.

Test beds: Tuck of War and Diamond Hunter. Both of these real-time mobile multiplayer games can be controlled with the mobile client software presented above. A mobile phone is kept in a pocket or alternatively on the hand during the game session. The game scene is presented by using a large public display or a video projector.

Tuck of War, ToW (see Figure 4) is designed for two teams that consist of one to five players. Players' characters are selected randomly. The goal of the game is to pull other team players one by one to the gap that is located between the teams. When the game starts players should perform squat movements as frequent as possible. One squat equals to one point to the team. The sum of the squats is the pulling power of the team. One game takes about from 30 seconds to two minutes depending on the amount of the players and fitness balance of the teams.

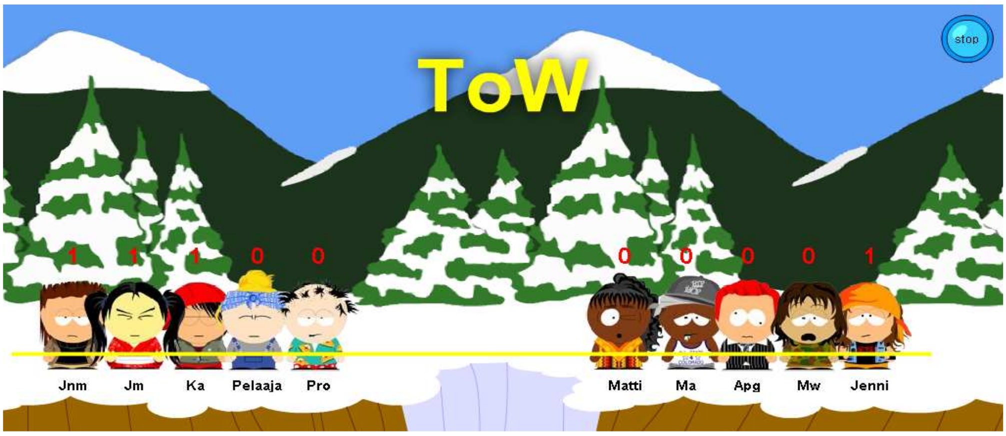

Figure 4. Tuck of War (Game characters were created with SP-Studio, www.sp-studio.de, for this prototype.)

Diamond Hunter (see Figure 5), a 2D-platform game, can be played by one to four players simultaneously. Game characters move automatically all the time and change direction as a result of collision to the wall. Players attempt to jump in a correct place and collect all the visible diamonds. They can also collect magic shoes to double their jumping power for few seconds. The best diamond collector is the winner of the game. One game takes usually from 30 seconds to two minutes depending on the amount of the players but the exercise is not intensive as in the Tuck of War game. It is noticeable that either of these current versions of presented mobile exertion games does not take into account player's physical condition.

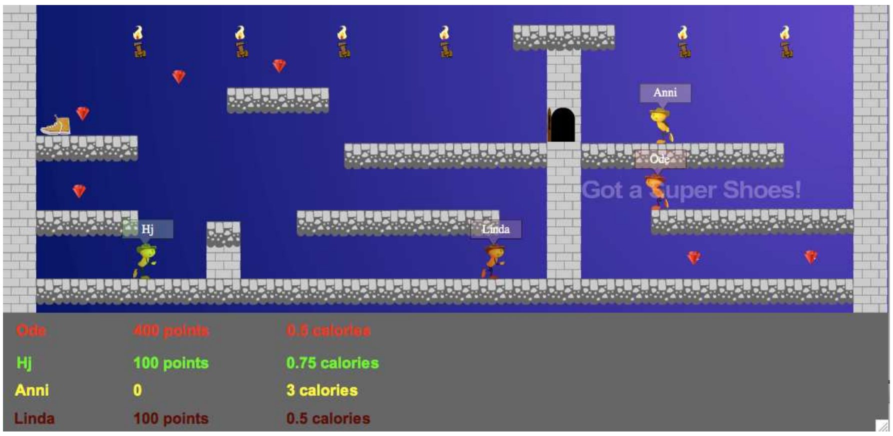

Figure 5. Diamond Hunter (Game graphics are derived from examples of ActionScript 3.0 Game Programming University book, for this prototype.)

Instruments. The evaluation of the games was mainly based on a 9-item questionnaire delivered through MoViE (Mobile Video Experience), which is a social mobile service that enables users to create video stories using their mobile phones. We used video based questionnaire in order to increase validity by avoiding interpretation problems of statements. The items of the questionnaire were from following themes derived from the proposed design framework: usability of game controllers, usefulness of exercises and the meaning of multiplayer approach. Each video question had three multiple answer possibilities; I agree, I disagree and No opinion. The questions were both spoken in the video clips and presented textually after each video. We did not include any background questions because that did not serve the main intention of this pilot study. Finally, 32 of the participants filled in the questionnaire properly.

Procedure. 1) At first, the participants played ToW and Diamond Hunter exertion games. Three observers followed the players during playing sessions and wrote down notes with respect to player-environment, player-devices, player-to-player, and player-actor interactions (Lindt et. al, 2007). 2) After the gaming sessions observers discussed briefly with players. 3) Then players filled in the video based questionnaire within 15 minutes.

4.2 Results

Overall, the players really appreciated the tested game concepts. For example, some of the players said that This was an amazingly fun game.", "This was really made in a cunning and interesting way!", and "Where can I download this?". One of the most positive aspects of the tested exertion games was that they did not represent any traditional sport games or events like track and field events, for example. This was one of the reasons why these exertion games were interpreted as being fun and suitable for a large group of pupils. Furthermore, randomly decided game characters appealed to players surprisingly a lot and lowered the threshold to start playing.

The games engaged the players in a way that they truly shared the experience of team play, which was seen in yells, screams, cheers and laughs. The pupils from 7th and 8th grade we experienced as the most enthused group of participants, which pinpoints the fact that children and youth really are the most convenient target groups for these kinds of exertion games. The players exercised with an adequate speed and reacted constantly, which indicates high player immersion and concentration. Furthermore, players got quite intensive workout during the playing session and they seemed to enjoy the physical activities.

4.2.1 Usability and Game Controller

The players seemed to understand the meaning and the use of the mobile phone as a game controller. However, there were slight problems with the use of phone's touch screen that was a new feature for most of the participants. For example, part of the participants needed assistance on how to fill in their nicknames and to get started. When the game was on, players seemed to realize the connection between their squatting or jumping and the feedback illustrated on the screen. Furthermore, mobile phones were considered, as appropriate devices for exertion games and participant would have liked to use their own phones as game controllers. The questionnaire results strengthen these observations – 70 percent of the players emphasized that the game controllers should be intuitive and easy to use. Furthermore, it came out that the motion detection has to be fast. Overall, the results clearly indicated that it is possible to design engaging exertion games with only simple motion detection.

In this research we used games that were based on simple gameplay mechanics that supported low-level motion detection. In fact, the movements that players made were simple gross motor skills and were easy to perform. Based on the observations, we argue that one does not have to know exactly what movements a player makes – the main thing is that the player is moving and is having fun. On the other hand, the study revealed that the threshold for cheating is quite low, at least for very competitive players. Players noticed very quickly that by holding the phone in one's hand instead of in a pocket, they could carry out movements more quickly and easily. Furthermore, possibilities of cheating clearly disturbed some of the players, because they tended to concentrate more on observing performances of other players than on their own. In spite of that, peer judging worked well in most of the playing groups – cheating was avoided and players could concentrate on playing.

For all practical purposes it is very hard to weed out all cheating possibilities from multiplayer exertion games. One solution is to utilize more sensors. For example, strain sensors (Merilampi, et al., in press) might be helpful in the prevention of cheating in exertion games. By adding a strain sensor on joints (knees, for example) it is possible to monitor that the player actually moves the part of the body that is meant to move. Currently, we are developing such strain sensor solutions for our exertion game platform. In spite of the possibilities that strain sensors provide, such solutions do not exclude all possibilities of cheating – for example, one can wear textiles differently than they are meant to be worn. Unfortunately, to some extent we just have to accept the fact that cheating is almost always possible.

4.2.2 Usefulness of Exertion Games

Both pupils and teachers experienced exertion games as useful applications. The majority of the participants (63%) felt that exertion games could motivate young people to move more and gain health benefits. According to the observation results, participants invariably showed signs of physical effort such as getting out of breath, sweating and symptoms of exhaustion. Like stated by one of the participant: "Hey cool! You are actually sweating!" However this did not affect the willingness to keep on playing or starting another round. Over 70 percent of the participants would like to play exertion games in schools, if such games were available. This is the most promising result for this pilot study. Furthermore, the participants also thought that the games could be integrated also to other subjects than physical education.

4.2.3 The Meaning of Social Context

The collaboration between the players worked well. The players liked to communicate and collaborate within their teams as well as compete against the opposite teams. The results revealed that teamwork motivated and engaged players a lot. This supports Jackson´s (1996) finding where interactions among teammates help individuals to attain flow. Although, neither flow nor team flow was measured directly in this study, observations and discussions with players indicated that most of the players reached a flow state during the playing sessions. In fact, in team condition teammates can support one another to overcome more challenging problems than they could overcome in a single player mode. Similarly in team condition players can divide the exercise burden among teammates. For example, in the ToW game, the team feature enabled players to vary their physical intensity once in a while without immediately losing the game. Basically, this shows that the possibilities for self-regulation are also very important in exertion games.

The competition seemed to be the striving force of playing for most of the participants. It was clear that it was desirable to win the game. For example, one player said that "Yes, let's play the game where we play together against the other group". Another player was very disappointed with their team's performance and required unyieldingly the rematch with the same teams. The meaning of social aspect was also seen also in communication during playing. Players tried to courage each other by shouting "Don't give up. We can win this!". Questionnaire results verified this aspect because almost all of the participants felt that the social side of the game was an important part of the experience itself and players undoubtedly enjoyed the game because of the presence of the other players.

5. STUDY 2 – HEART RATE BASED GAME

5.1 Method

Participants. The study was conducted in fall 2010 at the school of Kasavuori in Finland. The participants were 7th-9th graders (n = 60). Each class (16 altogether) selected four students that stand for their class in the exertion game tournament.

Test bed. The game played in the tournament is called Speeding (figure 6). In the game two teams compete against each other by racing top fuel cars. The objective of the game is to accelerate the car to the top speed by raising team's collective heart rate as much as possible. Car speed is directly proportional to team's collective heart rate, so they also had to maintain the top heart rate for a while. Players are allowed to decide the physical movements that they prefer to be the best and most efficient. One game takes approximately one to three minutes.

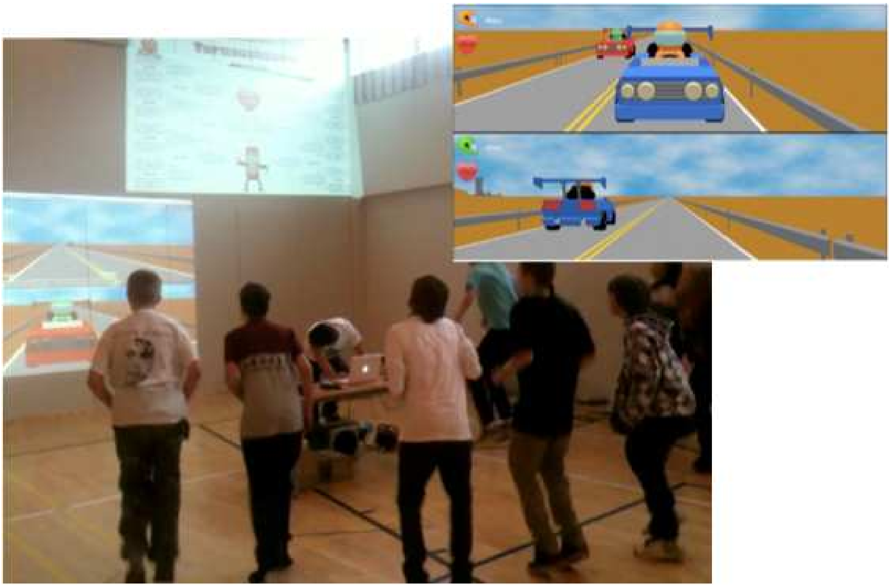

Figure 6. Students playing Speeding in the exertion game tournament

The game utilizes Panda3D game engine that allows implementing different camera angles to the game. For example, if competing teams were close to each other they were viewed by side angle. On the other hand, if the opponent is overwhelming, the game situation is presented from the first person perspective that creates a feeling of chasing.

Instruments. The evaluation of the game tournament was based on digital questionnaire including 27 items, heart rate recordings and observation. Nine of the items measured flow experience and rest focused on the usefulness of the used game controller, attitudes towards exertion games, and educational use of exertion games. The included flow dimensions were challenge-skill balance, clear goals, sense of control, immediate feedback, concentration, time distortion, rewarding (autotelic) experience, action awareness merging and loss of self-consciousness.

Procedure. 1) At first, the participants played Speeding game. The teams that reached to the final played four games during the tournament. Three observers followed the players and wrote down notes with respect to player-environment, player-devices, player-to-player, and player-actor interactions (Lindt et. al, 2007). 2) After the gaming sessions observers discussed briefly with players. 2) A day after the tournament players filled in the digital questionnaire.

5.2 Results

5.2.1 General Experiences about the Public Exertion Game Tournament

The tournament was a success and players as well as audience liked the event a lot – "Quite nice, we could have these sort of games more often.". The results indicated that a large percentage of the players would be willing to play exertion games in public spaces like schools (78 %). Players got a very insensitive workout during the tournament and 72 % reported that they gave all to win the tournament. Players used different strategies to increase their heart rate. They performed for example squats, presses, jumps and running in place. The players reported that their attention tended to focus mostly on their activity and functioning of the body as well as assessment of the opponents' physical state. Because the game involved quite heavy exercise, some of the players did not have time to draw attention to realization of the game graphics. Thus, it seems that in intensive exertion games the players do not require necessarily so-called high-tech graphical outlook. On the other hand the situation of the game needs to be clearly expressed because it is challenging to focus attention to details, when exercising. Overall, team play was experienced as fun. Only 4 % had a dissenting view of this. In addition, 64 % of the players believed that teammates made them perform better. However, opinions of the meaning of the audience varied and 25 % had no opinion of this at all.

5.2.2 Flow Experience

Table 1 shows that the flow level experienced by the players was quite high ($M = 3.70$, $SD = 1.01$), but experiences varied among players. Players' stamina did correlate with flow experience ($r = .09$, $p > .001$), which indicates that everyone could enjoy the playing. However, most of the players stated that they were in good physical shape ($M = 4.33$, $SD = .82$). The results showed that team play was appreciated a lot ($M = 4.08$, $SD = .93$) and it facilitated also the flow experience ($r = .32$, $p < .05$). Furthermore, results also revealed that flow experience was related to feeling of learning ($r = .40$, $p < .05$). Based on these findings we argue that the proposed exertion game framework and flow dimensions should be considered when designing exertion games.

Table 1. Means and standard deviations of flow dimensions and flow construct

Dimension	Mean	Standard Deviation
Challenge-skill	3.91	.84
Action-awareness	3.73	1.02
Clear goals	3.93	.92
Feedback	3.72	.99
Concentration	3.95	.96
Sense of control	3.45	.98
Loss of self-consciousness	3.67	1.23
Time distortion	3.50	1.05
Rewarding experience	3.48	1.08
Flow construct	3.70	1.01

5.2.3 Heart Rate Monitor Belts as Game Controllers

Heart rate monitoring was a new subject to players and they were eager to play games controlled with heart rate. Although heart rate monitors that were used in the experiment were not optimally designed for our purpose, players considered them as suitable game controllers (M = 3.62, SD = 1.11). In used HRM belts a separate transmitter part is attached to the belt with two poppers and it detached too easily. Users tended to improve the proper point of the heart rate belt just before a game and sometimes this caused separation between the belt and the transmitter. A fixed heart rate monitor belt would have been much more reliable solution at least for players with minor practice and knowledge about heart rate monitors. Furthermore, some of the girls experienced the use of the heart rate belt uncomfortable as one of the girls stated. “The game was neat and fun but it was a bit awkward and uncomfortable for the girls to use the heart rate monitor-belt, the big black square in the middle kept falling off constantly.”. Players commented also on other technical difficulties. “It was otherwise good, but it would have been nice, if all the heart rate monitors would have worked, everyone would have been able to take part and the teams would have been equal.”

Despite of these technical problems, only 18 % thought that the heart rate monitor was not compatible as an exertion game controller. The correlation ($r = .48$, $p < 0.01$) between the willingness to play similar games again and the suitability of the heart rate monitor as a game controller was significant. This may be partly affected the fact that the use of heart rate belt was unprecedented to most of the students, so the novelty may have influenced the results. In fact 86 % of the players would have liked to also see their own heart rate in addition to their team’s collective heart rate during the game. The expression of own heart rate would have supported the selection of exercising strategy – it would have been easier to perceive the causes and consequences.

Figure 7 visualizes heart rate data of the tournament’s final game. As we can see the initial heart rate values of both teams (Team 1: 139 bpm; Team 2: 126 bpm) were quite high. We assume that the excitement of final game affected this. Anyhow, both teams ended up to quite high values – over 190 bpm). This indicates that players exercised very intensively. The team 2 that had a lower starting rate won the match.

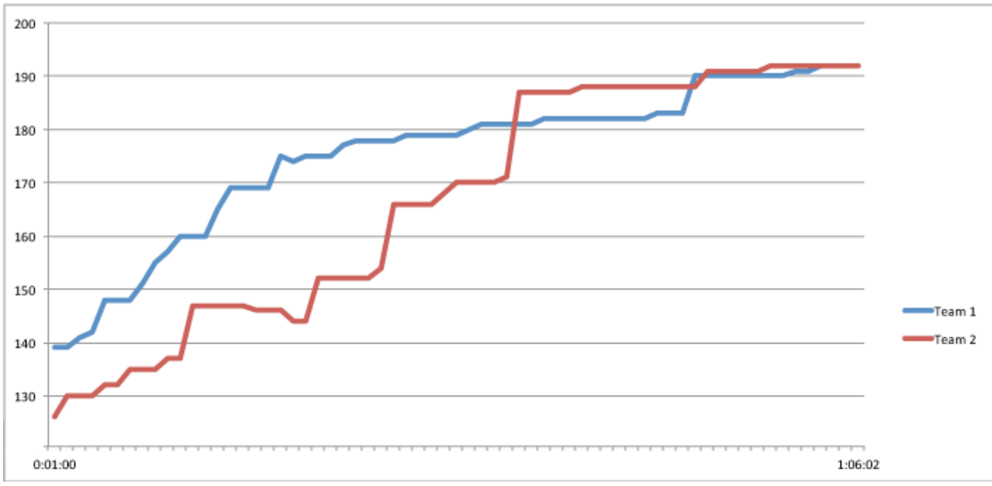

Figure 7. Both team’s collective heart rate values during the final game.

Players criticized also the way in which the heart rate data was transformed to the speed of the car. Some of the players felt that they were treated unfairly. For example, one player stated that “I think the game was useful/functional, but it should not be based on how the heart rate is rising, instead it should measure how low one can actually keep one’s heart rate during the exercise. In such case the players who are in better shape would succeed better than the players that are in poor shape and whose heart rate will rise up to 200 even before the actually exercising begins.”. In fact fairness, perplexed surprisingly many players as following comments shows. “There should have been longer pauses and resting periods in order to get the heart rate come down.” “It would have been nicer if there had been longer breaks between the games, since we had two games in a row.”. Such discussions indicate that players really thought and analyzed the gameplay, which supports also the learning of body functions.

5.2.4 Educational Value

The opinions about educational value of Speeding varied among players (M = 3.02, SD = 1.25). 42 % of players felt that they learned new things about behavior of their heart. On the other hand 37 % reported that they did not learn anything new from playing the game. The expression of each player’s own heart rate would have facilitated learning. In such case it would have been possible to play game more strategically. It seems that some of the players would have needed guidance in order to maximize the learning outcomes. As Mayer (2004) has pointed out, guided discovery learning is much more effective than pure discovery learning. Guidance, structure and focused goals cannot be ignored when trying to promote appropriate cognitive processing. Triggers, clear goals and guidance are vital at the least to learners with low metacognitive abilities and in informal context. Furthermore, players did not appreciate the idea of embedding educational content into exertion games (M = 2.82, SD = 1.242). However, it is possible that players could not imagine the way how educational content could be embedded to exertion games. Thus, research on that theme is needed.

6. GAME BALANCING ISSUES

Game balancing means the adjustment of game elements so that the game delivers a desirable experience to the player. Although balancing varies a lot between different games, common balancing principles can be distinguished. Some balancing methods that came out during this research are considered next.

Challenge-Skill Balance. In exertion games the quality of the playing experience arises from interplay between the psychological and physiological balance (extended dual flow model, Figure 2). Thus, balancing should begin by determining the desired balance between physical activities and mental activities. In any case, the aim of challenge-skill balancing is to deliver rewarding experiences to players by providing them with an appropriate amount of challenges and successful experiences. Generally, the aim is to avoid experiences of anxiety, exhaustion and boredom.

The results of this research clearly showed that the eagerness of players dropped very rapidly if the physical endurance of players differed significantly. For example, if the opponent team was very overpowering in the Tow game or in the Speeding game, the underdog team easily gave up without trying their best. In such competitive games a handicapping system could be a useful balancing method. A handicapping system could be implemented, for example, in terms of dynamic adjustment. For example, heart rates, player profiles or the performance of players could be used to create teams and in that way facilitate the experiences of players. The challenge of game design is to implement such adaptation solutions that are harmonious and transparent to players. For example, heart rate monitoring could be used to determine a player's fitness level and the intensity of exercising during the game. For example, a player with a high heart rate could earn more points from performing a single movement than a low pulse player. On the other hand, based on heart rate monitoring, a cheering system for low pulse players could be implemented. Such a system could motivate certain players to exercise more intensively. Furthermore, personal trainer type of elements could be implemented based on heart rate data.

Playing Time. In exertion games it is very important to balance the length of the gameplay. The length of the game should be based on desired fitness aims: is the game designed to develop stamina, speed, flexibility, muscular strength etc.? For example, the ToW game is designed to develop stamina and muscular strength. In ToW the relationship of squat movements performed and pulling power of the team is adjusted so that one game last approximately 30 to 120 seconds. However, the playing time of each player varies, because the weakest players are removed from the game (fall into the gap or pit) during the match. Furthermore, the significance of a players' fitness level plays an important role in balancing. Designers should pay attention to the fact that usually when the playing time increases, the performance of players also gets weaker, at least in high intensity games.

Embedded educational content. According to previous research engagement in a physically loading work (gameplay) affects attention focus (Tenenbaum, 2001). The research has shown that when the physical workload increases, attention allocation shifts from dissociation to association (e.g. Tenenbaum, & Connolly, 2008; Hutchinson & Tenenbaum, 2007). Association can be defined as turning focus inward and toward bodily sensations, while dissociation is focusing outward and away from body sensations (Scott, Scott, Bedic, & Dowd, 1999). Thus, the integration of learning content and exertion interfaces raises new game design challenges. Generally, if educational content is embedded into the game, the intensity of exercising should be balanced so that perception of content is possible and player can voluntarily invest cognitive effort on processing of content. If intensity of exercising is too high player may miss relevant content or processing is only superficial, which does not lead to deep learning.

7. CONCLUSION

The results of the presented studies were very positive. The concepts of tested exertion games were successful although they were only low-fidelity prototypes. It seems that there is certainly space for physically activating games in schools. This is especially important because obesity and the lack of exercise seem to be big problems with youngsters. Overall, the results indicated that exertion games could motivate pupils to move more and improve their health through gaming. In fact, players got quite intensive workout during the playing sessions and they seemed to enjoy the physical activities. The results revealed that students are willing to play exertion games as a part of physical education or during lesson breaks. We did not find any difference between genders or age groups – both sexes were equally interested on playing. However, when interpreting the results, we have to take into account the novelty effect of tested games. It is possible that the games engaged students because they had never played such games before. Thus, in future we are going to conduct long-term studies in order to explore the playing experiences more deeply and reveal the real impacts of exertion games in players' health.

The results also showed that mobile phones and heart rate belts can be used as exertion game controllers and games can be played on large public screens in schools and other public places. Based on the results, we argue that the use of mobile phones as game controllers could broaden the field of exergaming tremendously and facilitate the diffusion of exertion games in general. Young people have increasingly smart phones that include built-in acceleration sensors. In other words, they already have a game controller in their pocket all the time – also in school. On the other hand, the use of mobile phones might be prohibited or restricted in certain schools that can disturb the diffusion of the mobile exertion games. The use of heart rate belts as game controllers is more challenging and requires resources from schools. Furthermore, a set of heart rate belts could be used as game controllers in physical education lessons, but in guided manner. However, it seems that mobile phones provide more sustainable solution for exertion games targeted for school contexts.

Generally, smart phones provide several advantages for exergaming. Firstly, it is rapid to create client software prototypes. Secondly, an information related to the game can be displayed on a screen of a phone, which is not possible using some other game controllers, like Wiimote or Blobo for example. As a result of this, it is real two-way communication during the game and players can receive information that is not visible to other players. Also, individualized gaming information can be displayed on the screen of a phone or voice feedback can be utilized. Thirdly, a smart phone's internal memory allows saving research data to log-files. And moreover, a player can scope out her progress and history in exertion games from the client software. Fourthly, the overwhelming feature in smart phones is a WLAN-connection, which allows the high amount of simultaneous players, fast data transfer and wide area connectivity, which is important in school settings. Especially, a large number of players turned out to be very motivating factor in tested exertion games.

Overall, exertion games seem to motivate children a lot and they would like to play exertion games in their free time as well as in schools. In the future, there could be one large public screen at a schoolyard and for example 50 students could attend simultaneously the game during the breaks. Other scenario is that the schools could have game rooms designed especially for this purpose where mobile exertion games could be played. In this case the schools could provide phones for game controllers as well. Additionally, we assume that exergaming could motivate also sedentary adults to move more and have positive impact on the whole society's healthiness – exergaming could be an effective 'weapon' in the fight against obesity that is a growing problem in western society. However, more research is needed in order to distinguish between exertion games that contribute to increased fitness and those that only offer novel ways to control games. Furthermore, the area of educational exertion games is totally unexplored field. The results of this paper indicated that exertion games could have also educational value. However, more research is needed to distinguish design principles for educational exertion games.

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