

Fit for Play: Developing an Adaptive Exergame Platform to Motivate Inactive Children

Heleen Meijburg, Jef Folkerts, Nick Degens

Hanze University of Applied Sciences, Groningen, The Netherlands

h.r.c.meijburg@pl.hanze.nl

j.folkerts@pl.hanze.nl

d.m.degens@pl.hanze.nl

Abstract: Sedentary behaviour in children, four years of age and older, has increased over the last decades. These children become physically less skilled, which demotivates them for regular sports activities. They become susceptible to health risks such as obesity and have a heightened chance to develop depression and a lower self-esteem. Sports professionals acknowledge that these children in time become unable to keep up with the sports education pace, leaving them prone to social exclusion as well.

Exergames seem promising in their potential to increase the amount and quality of physical exercise in this group. Moreover, they offer strategies to motivate children to a more active and healthier lifestyle. However, some issues remain unclear regarding their applicability and individual fittingness. For one thing sports professionals have little to no experience using exergames in physical education, let alone understand which games could be appropriate to structurally activate said children. In addition, existing exergames regularly lack a suitable degree of adaptivity regarding what a child is physically capable of, which psychological needs should be addressed, and to what inactive children find appealing in terms of gameplay.

The aim of our research project is to build a first prototype of an adaptive platform for exergames to motivate inactive children to structurally engage in physical exercise more, and better. The participative design method we used in our preliminary qualitative research led to a better understanding of the barriers to move and the psychological needs children have when it comes to physical exercise. We made a first global list of requirements for the adaptive platform and an overview of necessary design directions.

Future pursuits in this project include a participative design research study amongst both children and sports professionals, and a thorough review of the literature and state of the art knowledge. We will use this knowledge to create a first prototype of an adaptive platform in collaboration with a serious game company and an organisation of sport professionals. After user testing we will use the evaluation findings as a baseline for future measurements regarding the adaptation of suggested exergames and to formalize and disseminate found design guidelines.

Key words: Exergames, Inactive Children, Physical activity, Sports Professionals, Adaptivity, Gamification, Motivation, Behavioural Change, Design Research, User-Centered Design.

Introduction

The latest figures from the Dutch Health Counsel show that 45% of children from four to twelve years of age are physically inactive. These children do not adhere (structurally) to the movement guidelines set up by the Dutch Ministry of Health and Environment (RIVM), putting these children at risk of becoming overweight or even obese at a later age (Inchley et al., 2017). Children suffering from obesity show lower general motor skill levels (D'hondt et al., 2009), have an increased risk of developing a depression (Jansen et al., 2008), show lower self-esteem, self-perception and higher body dissatisfaction (Taylor et al. 2009), and are also more prone to social exclusion (McCullough et al., 2009).

Physical education (PE) and afterschool activities, through the guided advice of a sports professional, such as a gym teacher, can help increase the physical activity levels of children, let them encounter different sports and help promote an active lifestyle. Unfortunately, while beneficial, these activities fail to reach a large part of the population and thus have difficulty to significantly change children's activity levels towards a healthy life style. This is in part due to the child itself; firstly, a child can't be forced to change their behaviour if he or she doesn't want to change and, secondly, the child spends a majority of his or her young life outside of more regulated

environments (and thus doesn't always have access to a sports professional who can regulate and enforce correct physical exercises).

Technology, particularly through the use of exergames, can play an important role in both the motivational part, i.e. making physically exerting activities intrinsically more fun, and in the scalability / connection to the guidance of sports professionals, i.e. ensuring that there is still some form of expert supervision with regards to the activities that occur outside of the regulated environment. While promising, there are few exergames that are able to change behaviour in the long term (thus crossing the divide from extrinsic to intrinsic motivation) (Mack et al., 2017) and it is difficult to distil the success factors of those that do.

In this paper we will make a first step in the description of design requirements that should guide the design of digital games, or exergames, to ensure that children become more intrinsically motivated to exercise (from a long-term perspective). As part of these requirements, we will discuss findings from theory and practice on the use of exergames and the psychological needs of children (8-10 years) to exercise more. Through these design requirements we hope to guide the designers and researchers in the design of effective exergames and furthermore take a first step in the formalization of successful design assumptions that can be used to compare and evaluate exergames in the future.

Theoretical Background

Exergames

Throughout the relatively recent history of exergames (short for exertion games) several, often contrasting, definitions have been used. In search of an unambiguous definition, Oh & Yang (2010) established that "exergame" was the most frequently used term, defined as video games that require physical activity to play. Just the quantitative fact that the term exergame is mostly used was not an adequate argument for Mueller et al. (2016). Analysis of a range of definitions made them formulate a definition that relates more adequately to the character of existing exertion games: on one end of a spectrum they posit digital games that incorporate exertion and on the other end they posit sports activities that incorporate digital play (and there are examples that sit somewhere in between). From that perspective they came up with a definition that fits our approach rather well: "An exertion game is a digital game that utilizes physical exertion interactions where the physical effort is a key, if not the dominant, determinant in reaching the game's goal."

Exergames can facilitate intrinsic motivation by letting children experience more pleasure in exercise (Lamboglia et al., 2013; Bailey & McInnis, 2011). A key challenge is to select or develop exergames that not only provide enough pleasure to motivate children to move more in the first place, but that also ensure enough and adequate physical behaviour as well. In their systematic literature review Lamboglia et al. (2013) examine studies on commercially available exergames such as Wii Bowling, Tennis & Boxing, Sony Eye Toy games, dance mats, and Dance Dance Revolution. Their study confirms one of our assumptions, namely that the association of tasks with pleasure and recreation increases adherence to interventions. The authors conclude that exergaming can lead to an increased level of physical activity, energy expenditure, and cardiorespiratory function, and to a reduction of body fat and sedentary behaviour. Some reservations are in place however, as the adoption of these practices should not stand alone, but be supervised by physical educators as well whenever possible to prevent repetitive strain injury and osteomuscular disorders.

More recent research shows similar results regarding the effectivity and usefulness of exergames as described under preconditions for success. In general, the outcomes of experiments, particularly from the reviewed randomized controlled trials seem positive, but in most of the studies reservations and limitations are expressed as well. In their extensive meta-literature review, Mack et al. (2017) categorize articles in three groups: 1) serious games (improving knowledge and change behaviour in nutrition and physical activity), 2) exergames (aimed at increasing physical exercise while playing), and 3) games with a combined approach. The authors confirm our assumptions regarding a lack of long-term adherence and effects, which apparently correlates with a decreased attention span and loss of interest over time by children in longer trials using a single game. All studies reported positive effects compared to control groups in weight loss, increased activity level or enhancement of knowledge. Still, Mack et al. (2017) express their concern about the lack of psychosocial modules in the analysed games and interventions, which they consider important for changing health-related behaviour. The authors

accentuate the significance of parental guiding: parents are important role models who can influence their children's behaviour and thinking or help to solidify new behavioural patterns.

Physical Activity in Children

In this preliminary research a total of eight sport professionals were interviewed and asked to participate in a co-creation session. The sport professionals worked in different environments (villages with around a 1000 inhabitants and small cities with around 12.000 inhabitants) in the North of the Netherlands. One professional worked in a school that is situated in a lower social economic status area. They had between 3-8 years of working experience in the educational setting and had a positive attitude towards digital innovations in PE from the start of the interviews and co-creations sessions. After the co-creation study, four of the sport professionals were asked to partake in a more in-depth individual interview.

We interviewed sport professionals working in- and outside of the educational setting with children ages 4-13 years (4 in total) to better understand the barriers and psychological needs of children with regards to becoming more physically active. The professionals acknowledge that they are struggling to engage inactive children in sports activities in- and outside of the school setting. Also, they see that some children who are overweight or obese are struggling to keep up with the PE pace. Children's motivation towards PE declines even further as they progress in school, making it difficult to engage them in PE (i.e. leading to a vicious cycle in terms of amount of physical behaviour).

Recent studies confirm this decline in motivation towards PE and in turn to leisure-time physical activities (PA) in elementary and secondary education (Chanal et al, 2019). This poses an even bigger problem as other research suggests that need fulfilment and motivation in PE are predictive of time spent in leisure-time PA (McDavid, Cox & McDonough, 2014). Therefore, it can be argued that negative experiences towards physical activity in sport education leaves these children with a PE induced lack of motivation for general PA. Another cause for the decrease of exercise amongst youth is the one-sided mandatory approach to many "healthy activities" (Steenbergen et al., 2018). Being forced to move has a demotivating effect and leads to dropping out.

Chanal et al. (2019) used the Self Determination Theory (SDT; Deci & Ryan, 2000) to further study the developmental trajectory of motivation and its role in activity levels during PE in children aged 8-12 years. They found that a decline in autonomous motivation (a form of intrinsic motivation) is related to PE activity decline. Self-determination Theory (SDT; Deci & Ryan, 2000) states that the best strategy to foster long-term behavioural change is directed towards facilitating intrinsic motivation (engaging in an activity for its enjoyment and satisfaction). SDT states for intrinsic motivation to be stimulated three psychological needs need to be considered: competence, relatedness and autonomy. On the other hand, extrinsic motivation and corresponding behaviour is executed to reach specific goals or avoid negative outcomes. In the long-run extrinsic motivation negatively influences intrinsic motivation and should be avoided when stimulating long-term behaviour change.

In conclusion, exergame interventions directed towards promoting in-class activity and leisure-time PA should positively influence a child's level of intrinsic motivation towards sports. As children differ in their level of competency, relatedness, and autonomy, there is a specific need for interventions in PE that target these components and can be adapted to specific individual needs. Next to this the type of activity that children are particularly drawn to and have a motivating effect are activities that allow for experimentation and that are unusual (Allender, Cowburn & Foster, 2006). Other motivators outside the class setting are parental support and being in a safe environment. Young children experience barriers to move when they are forced to participate in competitive sports or must perform highly structured activities (Allender et al, 2006).

Designing a digital intervention

It is important to highlight two aspects that need to be considered in the design of a digital intervention to make children become more physically active: the exercises or games themselves, i.e. the activities that the children perform, and the meta-system, henceforth called platform, that selects appropriate exercises and ties them all together into a coherent and consistent system (i.e. the part that ensures long-term behaviour change). In this article we will focus on describing requirements for the latter.

As such, the starting point of such a digital intervention should be a *platform that takes a certain input*, such as specific characteristics, preferences or even a range of physical competence, *from a certain user*, such as a sports professional, a parent, or even the child him or herself, *and*, based on that input, *is able to recommend a range of exergames or activities*. The specific process of that selection is dependent on the context: for example, in a PE class a sports professional can help choose an appropriate game from the range, and the pupil can play that game during the class and/or in their own leisure time. The platform can then monitor and register the child's activities and progress and helps the sports professional to decide which activities to focus on during PE. Based on this concept, we present a set of requirements from theory and from practice to gain a greater understanding of how the platform should work.

Guidelines from practice

We involved eight sport professionals from the Northern regions of the Netherlands as part of a co-creation session to better understand what would be required of a digital platform to motivate children to exercise more. As sport professionals, their goal is to help every child move at its own competency level in a way that feels meaningful to them, hopefully resulting in facilitation of intrinsic motivation to physical activity within PE setting.

We asked them to come up with 30 solutions on how to deal with this challenge. These solutions were structured via the card-sorting method. The researchers subsequently translated the post-it comments with solutions and ideas from the sport professionals into full sentences, thereby clustering linked ideas. This process led to the following major outcomes: to help children move at their own competency levels and to facilitate intrinsic motivation towards physical activity, psychical education should: 1) *show children their day to day and long-term progression*, 2) *let children choose their own activities and at their own pace*, 3) help children to become mentally resilient, 4) *stimulate playing together and encourage children to help others*, 5) let children give feedback on what does and doesn't work for them, 6) feedback to the child should *make use of positive feedback techniques*, 7) cultivate a safe social environment, 8) build on children's experiences and knowledge (learning to throw by an Angry Birds game). Furthermore, information on the children their individual *progress should be shared with the sport professional in coherent and structured way*.

After this co-creation session, we held in-depth interviews with 4 (different) sport professionals. The focus was on understanding their experience with exergaming in PE and what is required from exergames to motivate inactive children to become physically active (over a longer time-span). Next to this, we tested the results from our card-sorting method by discussing the outcomes with the interviewed sport professional. A first important conclusion from the interviews is that *these sport professionals have very limited experience with exergames or use of any kind of digital means in PE (and claim that this is the case for many of their colleagues)*. Therefore, the interviewers used an example of an exergame designed for physical remedial teaching to spur the interview and gather better qualitative data (so they understood what an exergame was like).

Sport professionals were asked about limitations and benefits of exergames. *They deemed it of the utmost importance that the exergames are low on-screen time*, leaving enough time for physical activity during PE. The challenges set for the children should be attainable and *the child should feel successful as soon as possible during the activity* (as to increase their feeling of competence).

"A requirement that is of the utmost importance is that any kind of exergame is very low on screen time"

"In order to keep children motivated the challenges set for the child should be easily attainable (especially at the start)"

This is especially important for our targeted group of children; several sports professionals mentioned having failed in sports (resulting in fear of failure) to play a significant role in inactive behaviour. They deem it important to help children become mentally resilient as well. This could be done by incorporating techniques that help children to become assertive, stimulate a growth mind-set and *help children to build on their self-esteem and self-perception towards sports*.

"I especially see opportunities for inactive children using exergames to activate them through showing progression and thereby empowering these children"

Children should be able to subscribe to missions and *set goals as a group (rather than focus on competitive interactions between children, in which the weaker performing child feels left behind)*. The exergames should be in line with the developmental level and interests of the child. Next to this, hardware and software should be accessible and affordable for all children. Children should experience autonomy in using the exergame, which should be adaptable to the level of self-regulation and the skills of the individual child.

“By using these exergames children can work for themselves [self-regulation] in attaining certain skills and giving them freedom of choice in doing so [autonomy]”

The sport professionals were also asked how an exergame could support in his or her work. Advantages mentioned were: being able to help children to move better physically (with the use of video recordings, i.e. showing the children the right stance for running), being able to help with class management (so that the sports professional spends less time in organizing and explaining activities), supporting the self-regulation of children by differentiating in exercises to better fit the developmental level of the child (particularly important when the child doesn't have the support of a sport professional).

“An extra benefit of using exergames in PE could be that I have more time to coach children on a personal and individual level”

Guidelines from Theory

We consider it essential to address the relevant psychological needs that foster intrinsic motivation, being *relatedness* (playing together), *competency* (being sufficiently challenged on a skill level) and *autonomy* (for example by having freedom of choice) (Chanal et al. 2019). All these factors are also confirmed in our co-creations and interviews as being of importance and should be incorporated into platform and games alike to guide the child appropriately through the behaviour-change process.

Next to that we need to incorporate and translate the self-determination theory (SDT; Deci & Ryan, 2000) to both gameplay and game mechanics, making sure that the games answer to the need of children to engage in activities that are enjoyable in themselves. As mentioned previously SDT states that three psychological needs have to be considered to foster intrinsic motivation: competence, relatedness and autonomy. An often successfully applied model that enables us to comply to these needs “the 4 keys 2 fun” framework (Lazzaro, 2004, 2009), which addresses four distinctive entertainment traits that can be combined in several ways: 1. Easy Fun (Novelty): Curiosity from exploration, role play, and creativity; 2. Hard Fun (Challenge): Fiero, the epic win, from achieving a difficult goal; 3. People Fun (Friendship): Amusement from competition and cooperation and 4. Serious Fun (Meaning): Excitement from changing the player and their world.

The need for competence could be addressed by creating gameplay that enables easy fun and letting children experience success for example through a treasure hunt, in which children receive feedback on their activity levels and in game progression (treasures found). This could be combined with role play, in which the child steps into the shoes of a superhero, feeling more powerful than ever and thereby positively influencing children's self-perception.

The need for relatedness could then be addressed through people fun, by creating treasure hunt challenges that only can be accomplished when working together with peers, or the player is guided by a non-player character that gives hints and compliments to the child in a humorous way.

Finally the need for autonomy could be answered through serious fun, for example by confronting the player with seemingly tough ethical choices (giving the child the feel he or she is in control) during the treasure hunt (subdue the possibly friendly guard, or sneak around quietly with the risk of being captured), which in the end however all lead to success and victory, leaving the player with a sense of efficacy and autonomy.

Applying this framework properly, games are not only being tailored to the need of enjoyability, and as such of intrinsic motivation, but to the *specific motivational preferences of distinctive player types as well*, such as competitor, explorer, joker, collector, achiever, director and storyteller (Klug & Schell, 2006).

Regarding the key motivations of young children to engage in physical activity we learn from Allender et al. (2006) that *competition and highly structured activities must be avoided*, as they are un motivating for young children to participate in. On the other hand, participation seems more enjoyable if *children are encouraged to experiment with different and unusual activities*.

Another recommendation concerns *parental support as a crucial aspect in motivating children to be physically active*, an advice that also answers adequately to the psychosocial necessities to which Mack et al. (2017) refer. Our own intent to let sports professionals guide and motivate their pupils fits this psychosocial motivational aspect as well, together with our aim to offer games that encourage social play with peers, although not in a competitive way.

As far as the adaptation and personalization of exergames are concerned, we need to consider the requirements of what Hardy et al. (2015) call the Dual Flow Model. This is their valuable attempt to combine psychological and physiological requirements to make exergames both attractive and effective. The authors assert that because of the existence of similar constructs - such as challenge, performance, load - in user/game experience research and sport sciences, we need to assess how game experience and physical activity influence each other. To achieve this we need to effectively make use of the three adaptation layers of their Dual Flow Model: 1. constitutional adaptation (*the adaptation of the game to the physical constitution of the player*); 2. user experience adaptation (*describes the adaptation of a game according to the personal preferences of a player and according to the increasing skills of a player*); 3. physiological or training adaptation (*enables the adaptation of the game to the requirements posed by sport science*). Obviously these three layers must be considered separately, but in fact are completely interdependent.

To apply dynamic adaptation to the games while they are being played, Hardy et al. (2015) make use of their StoryTecRT editing system. The technical architecture of our platform obviously must manage the three adaptation layers to address the individual needs and requirements regarding these layers. Hardy et al. (2015) however assert that a reasonable adjustment of the training load poses a challenging problem. The training load requirements from sports science – aiming at certain training effects - can easily lead to a situation where the player feels she cannot cope with the game's demands, which is likely to decrease the overall game experience and therefore motivation to play. The authors suggest to first *start with an evaluation of the game experience and acceptance and use these findings as a baseline for future measurements for the adaptation of the training load*. This order fits our approach perfectly well, since we initially aim at the fostering of intrinsic motivation as an essential component of long-term adherence.

Conclusions and future directions

To enhance the motivation to play & move and to foster long term adherence in children a digital platform (and the incorporated exergames) need to conform to a range of conditions and requirements. One must make sure that children experience more pleasure in and through exercise: the association of tasks with pleasure and recreation increases adherence to interventions. It is also essential to address the relevant psychological needs that foster intrinsic motivation, being relatedness, competency and autonomy, in the long-term.

Next to the psychological needs derived from Self Determination Theory the platform should incorporate ways in which the self-esteem and self-perception of children can be positively influenced. Other psychosocial elements the platform should address is a way in which parents can play as a role-model and to motivate and stimulate their children outside of the school setting. If these needs are properly integrated into gameplay, the platform will answer to the need of children to engage in activities that are enjoyable in themselves.

One of the entertainment models that seems fitting is the 4 keys 2 fun-framework, which not only enables us to tailor exergames to the need of enjoyability, and as such of intrinsic motivation, but to the specific entertainment needs of distinctive player types as well. Furthermore, applying this framework properly, children can be encouraged to experiment with different and unusual activities, which is a motivational factor in itself. To keep games enjoyable over a prolonged period - and thus stimulate long term adherence and motivation - adaptation and personalization of exergames are essential factors. We consider it relevant to adapt and use the three interdependent adaptation layers of the Dual Flow Model, being constitutional adaptation, user experience adaptation and physiological or training adaptation.

In future work we aim to take a next step in the formalization of the above-mentioned design guidelines. We will conduct a thorough review of the literature & state of the art and using this knowledge to create a first prototype of a digital platform in collaboration with a serious game company and an organisation of sport professionals. After ample user testing of the gameplay experience and the functionality of the experience adaptation we will use the evaluation findings as a baseline for future measurements regarding the adaptation of suggested exergames. In that very process we make sure that sports professionals guide and motivate their

pupils to answer adequately to the psychosocial motivational requirements. Finally, we believe children that who previously did not enjoy physical activities and PE that much, not only will build up more confidence in their ability to move but will gain genuine pleasure in moving and physical activities all together.

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