Gamification and Active Games for Physical Exercise: A review of literature

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***Abstract*— Physical and active games can attract young people and children to have regular physical exercise and to promote healthy habits. We presented a review about different studies on games and gamification applied to physical exercise, specially focused on the promotion healthy habits. We found that manly studies on active games or gamified physical exercise has been focused on energy expenditure and motivation. Personalization of user experience and emerging technologies (big data, wearables, smart technologies, etc.) are presented as promising opportunities to keep the engagement in game based program and gamification of physical exercise in a long term.**

Keywords—Physical Exercise, Gamification, Active Games, Literature Review.

I. INTRODUCTION

In the school or outside of school physical exercise (PE) is considered a positive element and widely as a fun, engaging and social activity. But, many times, the PE lessons in school are the main PE that young people and children have (Pearce, 2011) [1]. Physical and active games can attract children and young people to have a regular PE and in this way, to promote healthy habits and wellbeing.

According to Cook (2013) [2], any process which satisfies the following assumptions can be transformed into a game or be gamified: a) an activity can be learned; b) user actions can be measured, c) feedbacks are timely delivered to the user. So, PE can be gamified or transformed into an active game.

In creation of active games, as in other types of games, game designers consider important to define elements called "game elements", which make any scenario a playable environment. There are many ways to classify the elements that form a game or a gamified activity. Thus, Jesse Schell (2008) [3] classifies game elements in four categories (mechanic, story, aesthetics, and technology), Zagal et al. (2005) [4] classifies these elements in four categories (interfaces, rules, entity manipulations and goals), Gabe Zichermann and Christopher Cunningham (2011) [5] classify these elements in three categories (mechanics, dynamics and aesthetics), and Jorge Simões, Rebeca Díaz Redondo and Ana Fernández Vilas (2012) [6] classify these elements in two categories (mechanics and dynamics). In this sense, Kevin Werbach (2012) [7], proposes three game elements as dynamics, mechanics and components. These three elements are organized in a pyramid structure, depending on whether the element is tactical or conceptual. The dynamics are the concept, the implicit structure of the game. Mechanical processes are those that cause the development of the game and can be of different types such as: a) on the mechanical behavior (focusing on human behavior and the human psyche), b) mechanical feedback (relative to the cycle feedback on the gameplay) and c) mechanical progression (significant accumulation of skills). The components are the specific dynamics and mechanical implementations: avatars, badges, points, collections, rankings, levels, equipment, virtual goods, etc. There are few popular components, such as points, shields and leaderboards, commonly named PBLs (Points, Badges & Leader-boards achievement). Note that the elements are not the game, the game is how these elements come together to make the player have fun.

In this paper we explore through the literature the elements of games and gamification used for PE and their effectiveness.

II. STUDIES ABOUT GAMES AND GAMIFICATION FOR PE

There are several studies on physical activity and energy expenditure through educational intervention programs. These educational programs promote the physical activity both at school and in the children's leisure time. Programs that increase and improve physical education in schools have managed not only to improve the fitness of students, but also to motivate children and adolescents to continue performing physical exercise (Sánchez López et al, 2011; Ardoy et al, 2011) [8]. It is important to realize that not all physical activity is able to positively effect a reduction in body weight (frequency, duration and intensity) (Tan et al, 2002) [9]. For example, when the energy consumed in a dancing game was measured, it was found that the cardiorespiratory response was similar to that of an aerobic dance of medium to high intensity, but, as it lasted only 8 minutes, it failed to meet the recommended daily exercise in children (60 minutes per day) (Cantallops Ramón et al, 2012) [10].

Another factor to consider when planning a physical activity is motivation. Studies and intervention programs involving physical activity show that it is necessary to

encourage and motivate children with an appealing activity, in addition to encouraging them to participate in team rather than individual sports (Borràs Rotger et al, 2008) [11]. In this sense, exergames can be helpful to increase the motivation in children and adolescents. For example, as part of a study involving a group of overweight children and adolescents using the dance platform Dance Dance Revolution (DDR) as a routine physical activity (5 days/week and 30 minutes/day), telephone follow-ups were conducted that, in addition to collecting data on time use and level of motivation, reinforced their participation. However, the results indicated that the participation rate was low as the game was not motivating enough. Proposals to increase participation were made, such as encouraging cooperative play, increasing the musical variety and including a competitive component in these activities (Maddison et al, 2007) [12].

In the same vein, the effect of a weekly session of group play in motivating children 9-12 years old to play a dancing videogame in their homes was evaluated. The findings revealed that group play sessions increased the motivation and level of participation of children (Chin et al, 2008) [13]. Moreover, there is ample research on the energy expenditure of sedentary activities, traditional games and gaming assets that seeks to subvert the false beliefs that exist around videogames. This research has focused on the application of videogames to promote health based on the good results that have demonstrated the use of active videogames to maintain an active lifestyle. One study analyzed the energy expenditure (EE) required by a sedentary game and two active videogames (one involving movements of the upper body, and a dancing game). They found that the conventional game increased the basal EE 22%, while active ones increased basal EE 108% (movements of the torso) and 172% (dancing). They also noted that obese children had higher EE when playing the dancing video game than non-obese children (Lanningham-Foster et al, 2006) [14]. A later study found that the EE of an active game was significantly higher than that derived from other activities such as remaining at rest, standing, watching television seated and sitting while playing a conventional videogame (Lanningham-Foster et al, 2009) [15]. Similar results were obtained in another study that analyzed the EE in a sample of children ages 6 to 12 participating in a conventional video game and two active games for the XaviX Port console. One was a bowling simulator and other game involved fighting and avoiding obstacles. The results indicated that the EE required by active videogames was higher than resting and conventional videogames (Mellecker & McManus, 2008) [16]. Another study reported similar results when evaluating energy consumption in children playing active and non-active videogames. Its findings showed an increase over the base line of between 120% and 140% in the EE and the energy consumed when participants were playing active games, values that were similar to other types of activities such as a light walk, jogging and swimming (Maddison et al, 2007) [17]. A study at the University of Oklahoma with a group of children ages 10 to 13 measured the calories consumed at rest, while watching television and while walking. The data were then compared with the calories burned when playing videogames (Wii Sports and DDR). The results showed that children burned the same amount of calories when they walked moderately and three times more than while resting (Wetzsleon et al, 2008) [18].

Although some studies have shown positive results involving the energy costs of playing these kinds of games, said energy cost rises when these same virtual activities are executed in reality, indicating that this type of activity cannot replace actual activities and sports. Only a small number of active videogames, or "exergaming", manage to have children perform physical activity of moderate intensity (Wortley, 2015) [19]. More studies and more scientific evidence are needed to evaluate the effectiveness and sustainability of this type of active videogame and its potential interest as a clinical tool.

Therefore, there are several studies how to use interactive technologies to promote healthy habits in children (Hourkade, 2015) [20]. In this regard, gaming platforms such as Nintendo Wii, Microsoft Kinect and others, include body movement as an interactive element to promote physical activity. These technologies will continue to advance unabated in coming decades, thus making it necessary to study their metabolic efficiency and how they can be effectively applied promoting physical activity (ExergameFitness, 2014) [21]. Outdoor physical activities are also supported by technology through augmented reality, sensors, mobile devices and so on. In this area Lund et al (2005) [22] were pioneers in designing the Playware technology that uses sensors, actuators, hardware and software building blocks for playgrounds. This work led other researchers to consider how this type of playground could be designed. For example, Sturm et al. (2008) [23] focused on objectives such as social interaction, simplicity, challenge, goals, and feedback. Seitinger (2009) [24] was concerned with how these playgrounds could be used to develop spatial skill, including taking multiple perspectives, zooming in and out, estimating distances, experiencing movement, finding visual cues, advocating ubiquitous interfaces that could support aspects of spatial cognitive development. Another approach to promoting outdoor physical activity is digitally enhancement through the use of mobile devices (Magielse & Markopoulos, 2009) [25].

Collaboration and social aspects must be considered in the design of educational videogames. Padilla et al (2012) [26] propose a set of theoretical issues for educational videogames and for game-based learning. Collazos, González and Gutierrez (2014) [27] present a set of patterns for monitoring and evaluating educational videogames. Gonzalez and Navarro (2015) [28] present a structural framework based on the fundamentals of motor play to guide the design and evaluation of active videogames. Therefore, González et al (2015) [29] specifically analyze the effectiveness of commercial programs like the Wii and of an exergaming program called TANGO:H, developed by our research group. TANGO:H was designed following principles of educational, collaborative and active videogames [27, 29].

III. Related Projects for PE

There are several research projects related with gamification, education and PE, such as the following:

- PEGASO project: uses wearable technologies and games to encourage healthy lifestyles amongst

teenagers Wortley (2015) [19] shows a case study on the use of Gamification strategies and wearable lifestyle technologies for personal health management, in the framework of the European Project PEGASO. This author describes the results of two-year project exploring the potential of various lifestyle tracking and health monitoring equipment and the impact on the health parameters and well-being. The data captured and visualized by the mobile applications linked to these lifestyle technologies illustrates how gamification and enabling technologies have evolved in support of pervasive personal health management. URL: http://www.pegaso4f4.eu/

- DOREMI project: The main goal of DOREMI project is the "active ageing" based on three keys: healthy eating, active lifestyle and social interaction. The decline of cognitive ability is strongly related to lifestyle, as well as social engagement, cognitive stimulation, nutrition and physical activity. DOREMI is focused on social inclusion with the help of cognitive games and the development of a social and gamified environment. URL: http://www.doremi-fp7.eu/project

- BEACONING project (Breaking Educational Barriers with Contextualized, Pervasive and Gameful Learning): The 'anytime anywhere' learning concept is developing through pervasive, context-aware and gamified techniques and technologies, framed under the Problem-Based Learning approach. The project will create a platform as ubiquitous solution based on context aware systems, procedural content generation, pedagogy-driven gamification, learning analytics and cloud technology. URL: http://beaconing.eu/

- ProsocialLearn project (Gamification of Prosocial Learning for Increased Youth Inclusion and Academic Achievement): this project is founded on the hypothesis that children at risk of social exclusion, lacking empathy and showing high levels of aggressive or anti-social behaviors, should benefit from digital games tailored to teach prosocial skills (the ability to identify the benefits of cooperation, recognize the emotions and needs of others and express trustworthiness) that can help them achieve academically, appreciate team work and recognize the value of understanding other people's needs. The gamification of prosocial learning will be driven by a set of well-defined prosocial learning objectives that are designed for the development of specific prosocial skills, in terms of prosocial theory, gameplay and game mechanics. Moreover, ProsocialLearn will create a new ecosystem through a new market for digital games, designed to support learning and development of prosocial skills, and offering games developers scientifically proven prosocial game elements for development digital games. An application programming interface (API), ProsocialAPI, will allow developers to integrate functions into games including visual sensing, identification of prosocial signals from in-game actions, personalized adaptation of game elements, player profiles, game mechanics and expressive virtual characters, and support for data collection with protection of personal data. URL: http://prosociallearn.eu/

- LEGEND, Sport goes viral: The main goal of this project is to create an ecosystem of tools and apps to key agents of the sport sector. As Google does with its platform but with the sport as the soul, the core of LEGEND platform is Search but then it provides with dozens of tools. With this tool, public (local government, Universities or Schools) and private (sport facilities, individuals, federations, associations, etc.) managers from all around the world can send real time alerts, manage the classifications in an easy way, generate automatic calendars, publish the rules and news, define roles as referees or team managers and many more features to come. Also they have developed mobile apps for following the league but also the users can organize their friendly matches, comment on them before and after the match, check the results of their friends and to share them in other social networks. So, to motivate people to report the results, the project added an algorithm to calculate their skill level of every sport and also added gamification technics to the app so users can get badges depending on their results. Finally, users can track and check all their stats and historical results. URL: https://ec.europa.eu/easme/en/sme/5462/legend-sport-goes-viral

- Play the Game: gamification and healthy habits in physical education: Monguillot Hernando et al (2015) [30] have studied the impact of the gamification as learning strategy in PE subject at school. The study has been designed as a didactic unit named "Play the game" where students of three secondary schools has to achieve a healthy cardiac frequency in their physical activity through different challenges, levels, points, leaderboards and badges. Therefore, Play the game has innovative elements, such as personalization, cooperation, emotions, technologies and a combination of formal and informal contexts. The results of Play the game show the potential of gamification as an emergent learning strategy in PE because increase the motivation and promote the healthy habits in the students. URL: http://www.raco.cat/index.php/ApuntsEFD/article/viewFile/291497/379978

- VIDEM (Developing healthy habits and physical education through active educational games for hospitalized children and adolescents) funded by

the Ministry of Science and Innovation, Ref. EDU 2010-10010, had the main goal of developing healthy habits through motor games and active video games in hospital classrooms. Among the objectives of the project, there are: a) Designing a model of educational intervention through physical exercise and ICT. The exercise is the transversal educational strategy, related attitudes and communicative values for integration of minors; b) Evaluating the influence of physical activity with learning games and motor play in learning healthy habits. In addition, training interventions and effectiveness of game models and tools applied are valued. In this context, it has been made and validated an integrated educational program formed by motor games and active videogames for the development of healthy lifestyles at a primary school (González et al, 2015) [29]. URL: http://videm.es/

- SALUD-in (Platform for Interactive Virtual Rehabilitation with Physical Social Games for Health and Techniques of Natural Interaction) Ref PROID20100218, funded by the Canarian Agency for Research, Innovation and Information Society. This interactive platform, aimed at hospitalized children, allow the virtual-based rehabilitation based on physical social games for health and natural interaction techniques. It is based multiplayer games, with games designed for physical and cognitive rehabilitation, a motion capture system and biomedical data based on a low cost system (Kinect sensor and weareables devices). Further it comprises a clinical management system and remote monitoring of rehabilitation exercises and medical records of patients. URL: http://saludin.es/
- PROVITAO (Active videogames program for Outpatient Treatment of Obesity). The PROVITAO Ref OBE05 project, funded by the CajaCanarias Foundation (2014-2017), aims to support the treatment of obesity at early ages, contributing to improving the state health patients and preventing future disorders in adulthood. It has a model of educational intervention designed for education in healthy habits, with an exercise program, motor games and commercial and own active video games, created in the research group, such as TANGO: H. The whole program is "gamified", in order to motivate and to achieve the engagement of children during the intervention in schools and home (one school year). URL: http://provitao.ull.es

Some example of the last gamified platforms or active games to develop healthy habits and can be used in PE are:

- SuperBetter: This platform increases resilience - the ability to stay strong, motivated and optimistic even in the face of difficult obstacles, making more capable of getting through any tough situation. URL: https://www.superbetter.com/
- Zombies, Run!: is a new game, with app for the smart phone, that turns running into quests, collection of items, and building of fortress to protect participants from zombies. When participants run, stories are narrated, punctuated by personal music playlists, item collection, and random sprinting to avoid zombies. URL: https://zombiesrungame.com/
- Fitocracy: Participants work in teams and in a community on exercise goals, with easy documentation of workouts and instant motivation and feedback to improve. URL: https://www.fitocracy.com/
- VirZoom: this technology combines Virtual Reality (FR) and Fitness Technology. VirZOOM is a static bicycle connected to VR games. For example, the user can live different virtual experiences: power a horse in a race, a tank in battle, a fire-breathing dragon through mountains. URL: http://virzoom.com/

IV. Trends in Gamification and Games for PE

A. *Personalization*

People have different ways of get fun. So, the research has identified different player types and motivations to play. Bartle (1996) [31] identified four player types: killer, achiever, socializer, and explorer. Regarding the motivations, Lazzaro (2004) [32] detected four motivational factors for playing games: hard fun, easy fun, altered state and people factor, and Yee (2006) [33] identified three main motivation components: achievement, social and immersion. So, the student model must represent the way people play, and the types of players. The personalization of game elements in the system (Monterrat et al, 2013) [34] should take into account the forms of adaptation proposed by Kobsa et al. (1999) [35]: to user data, to usage data and to environment data. Besides, a typology of engaged behaviors to determine if a player is engaged or not has been proposed by Bouvier et al. (2013) [36]. Some research can help to understand the influence of environment data. For example, Cheng (2011) [37] tried to find the good moments to play at work.

Therefore, in order to gamify an activity, you need to find the right way to motivate the right person at the right time [38]. So, it is important to know the different types of motivation, which can be: a) intrinsic: inherent in the person, taken for its own sake or interest (for example, status, power, access to certain skills) or to contribute to a common good and b) extrinsic: outside the person, made for reward or feedback. Furthermore, the social component is also important (to compete, to collaborate and to compare achievements). So, in the social game, the objectives can be competitive or collaborative. Thus, in team games, it should be considered a separation between the collective mechanical equipment (projects, group scores, etc.), from the mechanical equipment that only apply to the individual (motivation, positive reinforcement, etc.) (González, Toledo & Muñoz, 2015) [39].

Adaptation and personalization are concepts closely related and similar, which have a common goal: to provide a closer user experience by offering content close to the user, tailored to your interests and seeking to increase loyalty and satisfaction (González, Toledo & Muñoz, 2015) [39]. To perform this adaptation / personalization, the basic elements are: to define the user profile, to define the content and functionality that you want to adapt, and to define the interface elements that allow this adaptation / personalization. Personalization allows the adaptation of the interface automatically according to the user profile and experience with the system. For this, there are different techniques to infer the user's needs and preferences, such as rule-based filtering, simple filtering, collaborative filtering and content filtering (Uchyigit & Ma, 2008) [40]. For personalization / adaptation of a gamified system, we must think about what are the features that make the system fun and if the system can work with or without these gamified features. We must also think about how these features relate to gamified different user profiles. Moreover, we must also consider whether the system can work independently to gamification without affecting the core functionality, which in our case is learning. For example, a leaderboard can be activated for the most competitive users, while not for others like introspective or special needs users. For the adaptation / personalization experience, the gamification engine must decide when and how specific and general features will be activated, taking into account: a) the student model (consisting of the user profile or static information and user history or dynamic information, and b) contextual information.

The static part of the student model or profile contains data such as age, gender, administrative information, learning style, type of player and preferences. Identifying the type and player preferences will increase the student motivation. The dynamics of the model student or history contains information of student interaction with the learning system and the state of their learning. However, a gamified system must also incorporate the trace of student interaction with the system for activation or deactivation of the functionality of gamification to increase the degree of engagement. Moreover, contextual information is essential in a gamification engine. The students can perform the activities from school, work or in their free time, in the classroom with their peers and with the teacher, or remotely. Student can also do the activities from a tablet, a mobile device, a laptop or desktop computer. All these contextual characteristics affect the gamified experience and the gamification engine must be able to adapt the features to different contexts. For example, if the activity is carried out in the classroom with teacher assistance, the chat cannot be very useful.

Many gamification initiatives use points, badges and leaderboards as a way to motivate and incent participants to alter their behavior (Gadiyar, 2014) [41]. These gamified systems use analytics to measure and monitor users' actions and social components to increase the user motivation. Most of them fail to keep the user involved over the long term. To solve this problem, the entire gamification process should be considered from a highly personalized view (Gadiyar, 2014) [41].

Gamification techniques should try to understand users, their personality, feelings, behaviors and actions. Big data, behavioral insights and elements of psychology can be used in gamification to provide a better end-user experience. Thus, in a gamification experience, every feedback, message or response should relate with user characteristics and situation properly. Typical gamification approaches, includes PBL, Levels, Feedback, Reward and Recognition techniques. The social gamification includes social media, communities, Web 2.0 elements, and big data analytics. Next generation of gamification systems, includes the elements for a personalized and contextual experience, such as: behavior-based frameworks, mental models, neuroscience and big data analytics.

B. Technology for Gamification and Games for PE

Technology plays a central role in the lives of today's children and young people. So, the use of new technologies, apps and devices into schools, could offering more engaging physical activities and healthier lives to students. Technology should be the core of engagement strategies in PE.

Lister et al (2014) [42] establish that apps 'represent a promising opportunity for getting people active and have received considerable attention but this has been at the expense of in-depth analysis of effectiveness'. So, if the applications not are developed properly, they will end up in a common technology cycle of hype with the users' feelings of failure and frustration on technology. To promote positive and active user experience in apps, many apps uses gamification, but they only use the most convenient game elements and did not use the full potential of gamification to create a success gaming experience. So, Lister et al (2014) [42] have conducted an analysis of 132 most popular apps in markets seems to agree with this criticism. Moreover, the authors studied if the apps tend to focus on motivational components of behavior without adequately addressing capability or behavioral triggers. The review of gamification in apps found they tended to ignore the ability of an individual to perform the behavior. But, the ability is central to achieving long-term behavioral change. So, digital rewards like badges or points when this may not produce a long-term behavioral change. We believe that apps have potential in physical education, the design of this apps needs put attention in to achieve a sustained change in behavior.

In a report called "The Class of 2035: Promoting a Brighter and More Active Future for the Youth of Tomorrow" [43] the authors said that today's children and adolescents live sedentary lives full of computers, video games and television. However, technology including wearable devices can stimulate children to get outdoors and exercise. In this sense, wearable technology could play a key role in keeping people fit and active, and some organizations, like Youth Sports Trust, highlighting the need to include wearable technology and gamification in physical education classes in schools. Mobile apps and wearable technology can be useful tools in physical education, fitness, and athletics, and gamification can increase children's engagement in physical activities. The report found that three out of four schoolchildren said they enjoy physical education classes while an additional 40 percent are looking for more physical activity opportunities. Furthermore, they said 'in

order to get children active from a young age, a more holistic approach to PE is needed, one which integrates technology and the delivery of a seamless, intuitive and digitally enhanced form of physical activity.'

Therefore, smart textiles can be introduced in the schools, as PE uniforms, and can take an important role in PE. For example, there are biosignal-monitoring underlayers produced by Athos, which read muscle effort, heart rates and breathing rates, interpret this information and push recommendations to mobile phones.

But tracked data on the activities and statistical information cannot be enough to motivate and enhance physical activity. Coaching support in physical activity can be an important key of success in PE. Moreover, school PE teachers will need skills and resources to offer a diverse set of PE activities focused on health, fitness and emotional wellbeing, and supported by technologies. Digital literacy should start at early ages and PE teachers must be put attention at this area. Primary school teachers tend to be generalists, while future technologies may require a specific knowledge or expertise to use effectively. Furthermore, a more holistic approach is needed that integrate the technology with the PE in a transparent and intuitive way.

V. Conclusions

In this paper we presented a review about different studies on games and gamification applied to physical exercise, specially focused on the promotion healthy habits. We found that manly studies on active games or gamified physical exercise has been focused on energy expenditure and motivation.

Although, we found several studies and related project about how to use interactive technologies to promote healthy habits, most of games and gamified programs fail to keep the user involved over the long term.

So, we believe that providing a more personalized experience can solve the problem of the engagement in long term. Personalization and emerging technologies (big data, wearables, smart technologies, etc.) based games and gamification for physical activity promising opportunity for getting people active.

Acknowledgments

This work has been supported partially by Fundación Caja Canarias, Project PROVITAO OBE05.

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