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Title:

Psychological effects of gamified didactics with exergames in Physical Education at primary schools: results from a natural experiment

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Abstract

The physical effects of exergaming have been proven, but less is known about the psychological effects in elementary schools that make exergames an effective educational tool. The application of gamification to education is still an emerging practice that has been barely studied. The aim of this study was to analyse the effects of a gamified exergaming intervention in Physical Education classes in primary schools on psychological variables like motivation, flow, basic psychological needs and academic performance. A natural experiment with a non-randomised controlled design was run. The participants were recruited from four schools (n=417), and received traditional didactic intervention or a gamified exergaming intervention. Both lasted 1 month. The results showed better positive gamified exergaming effects on basic psychological needs, academic performance and some flow dimensions. The *Mechanics-Dynamics-Aesthetics* gamification model and the *Just Dance Now* exergame may be resources capable of producing positive psychological effects on school-based Physical Education.

Keywords

Elementary education, improving classroom teaching, interactive learning environments, teaching/learning strategies

1. Introduction

Researchers have been investigating the benefits of game and game-based approaches in education from the 1980s (Borges, Durelli, Reis, & Isotani, 2014). Exergames are digital motor games that aim to stimulate the player's motor skills, which are popular on the global market and have gained increasing attention by academic research (Lin, 2015; Quintas, 2019a). Exergames, understood as a type of games, are applied to Physical Education (PE) and can simultaneously provide the benefits of motor games and video games (Gee, 2003; González & Navarro, 2015). Although much has been proven about the physical benefits of exergaming, less is known about the psychological benefits in elementary schools that make exergames an effective educational tool (Li & Lwin, 2016). Some studies affirm the need to explore the psychological effects of interventions based on exergames and PE (Lau, Wang, & Maddison, 2016).

Gamification refers to the use of game-based elements in non-game contexts for the purpose of motivating actions (Deterding, Dixon, Khaled, & Nacke, 2011; Kapp, 2012). While gamification is advancing in business or marketing, its application to education is still an emerging practice (Dicheva, Dichev, Agre, & Angelova, 2015). However, recent studies indicate the limitations of empirical research into gamified education, such as its dominant application to colleges, and lack of comparative groups or the validity of measures (Dichev & Dicheva, 2017; Hamari & Koivisto, 2014; Hanus & Fox, 2015). This is why a natural experiment based on gamification principles (Hunicke, LeBlanc, & Zubek, 2004) and a recent exergame that is compatible with the school PE curriculum have been designed and applied to several primary schools.

The use of exergames in PE has been normally done according to a technical rationality, where teachers only apply didactic material mechanically (Gómez-Gonzalvo, Molina, & Devis-Devis, 2018). The inclusion of a new technology in class does not mean an essential change in didactics. Indeed it is necessary to transform the dynamics of the whole classroom (Freinet, 1993). Exergames should be focused as a means for students to experience contextualised learning by facilitating experiences that require analysing what has happened in the game to examine curricular contents in-depth (Gómez-Gonzalvo et al., 2018). This contextualised learning can be created by the gamification strategy (Gonzalez, Jimenez, & Moreira, 2018). For this reason, the exergame, as a technological resource, has been joined with gamification as a new didactic strategy in usual PE classes.

As far as we are aware, no research has used a natural experimental method with a control and an experimental intervention applied by the same teacher to examine the psychological effects of a gamified exergaming educational intervention on children. The aim of this study was to analyse the effects of a gamified exergaming intervention in PE classes in primary schools by a natural experiment in psychological variables that are relevant to PE like motivation, dispositional flow state and basic psychological needs (Huhtiniemi, Sääkslahti, & Jaakkola, 2017).

2. Theoretical Framework

2.1. Motivation, exergaming gamification and PE

The Self-Determination Theory (SDT) is a macrotheory of human motivation and personality that has been widely analysed in PE, and has already been successfully applied to games and gamification contexts (Sailer, Hense, Mayr, & Mandl, 2017). The Cognitive Evaluation Theory (CET), which is a subtheory of the SDT, concerns intrinsic motivation based on the satisfaction of behaving "for its own sake". It specifically addresses the effects of social contexts (external events in general, such as rewards) on intrinsic motivation. There is a second subtheory, the Theory of Organismic Integration (OIT), which establishes that motivation is a continuum. From more to less self-determinations we find intrinsic motivation, extrinsic motivation and amotivation. If intrinsic motivation refers to participating in activity just for the pleasure and satisfaction one feels from doing it, extrinsic motivation refers to being committed to the activity as a means to achieve something, but not as an end in itself. For extrinsic motivation, there are different ways by which behaviour is regulated: external regulation, introjected regulation and identified regulation (Ryan & Deci, 2017). External regulation implies behaviour regulated by external incentives, such as rewards or punishment. Introjected regulation is characterised by establishing rules for action that are associated with expectations of self-approval, and with avoiding feelings of guilt and anxiety. Identified regulation implies performing an activity voluntarily because individuals consider it important and beneficial, even though if they do not enjoy it. This implies identifying the subject with the importance of the activity itself. Nevertheless, the decision to participate stems from an external benefit, and not from the pleasure that is inherent to the activity. Amotivation refers to lack of intentionality and the relative absence of motivation (Ryan & Deci, 2017).

One of the main goals of PE classes is to provide students with the necessary motivations so they practice PE beyond the school timetable and throughout their lives (Moreno-Murcia, Gonzalez-Cutre, & Chillon-Garzon, 2009). Exergames are seen as a very promising option to maintain an active lifestyle, especially with wereables fitness technologies (Beltran-Carrillo, Beltran-Carrillo, Gonzalez-Cutre, Biddle, & Montero-Carretero, 2015). Sheehan and Katz (2010) proposed six components that exergames posits to intrinsically motivate children to engage in PE: control, challenge, curiosity, creativity, constant feedback, competition. Hansen and Sanders (2008) postulated the following characteristics of game related to motivation: fun, challenging, motivating, developmental, appropriate, individualised, contemporary. Several psychological benefits of exergaming associated with motivation have already been proven, such as favouring change towards a physically active behaviour (Lwin & Malik, 2012), especially in those who do not normally practice traditional PE (Street, Lacey, & Langdon, 2017), and are a source of situational interest motivation (Sun, 2013) by improving academic performance in subjects other than PE (Gao, Hannan, Xiang, Stodden, & Valdez, 2013), or improving motivation thanks to social interaction during exergames (Paw, Jacobs, Vaessen, Titze, & Van-Mechelen, 2008). It has been suggested that exergames should be incorporated into PE classes to enhance students' motivation (Sheehan & Katz, 2012). However, empirical support for the effectiveness of exergaming on students' motivation and in-class activity in PE is sparse (Sun, 2013).

From birth, gamification is associated with motivation and behavioural change (Kapp, 2012). There are no solid studies, as far as we know, that have found increased motivation by applying gamification to PE, although some studies from other areas have found this (Barrio, Muñoz-Organero, & Soriano, 2016; Bonde et al., 2014; Boticki, Baksa, Seow, & Looi, 2015; Hakulinen, Auvinen, & Korhonen, 2015; Shi, Cristea, Hadzidedic, & Dervishalidovic, 2014; Su & Cheng, 2013). A recent study has revealed that there are inflated expectations about educational gamification on motivation as empirical research on the effectiveness of gamification is limited (Dichev & Dicheva, 2017). Hanus and Fox (2015), along the lines of the SDT, found reduced intrinsic motivation because additional rewards (e.g. badges and coins) can be interpreted as controlling, depending on each student's profile, but this could also increase extrinsic motivation (Mekler, Brühlmann, Tuch, & Opwis, 2017). Tangible incentives given for boring tasks might increase intrinsic motivation, but giving rewards for already interesting tasks lowers intrinsic motivation (Deci, Koestner, & Ryan, 2001). Therefore, gamification can be a double-edged sword, and might produce either intrinsic motivation or external regulation (Hanus & Fox, 2015). It is necessary to check if the possibility of applying educational gamification and it not promoting external regulation; that is, less self-determined motivation. Gamification can reduce this risk of amotivation and maintain learners engaged in a learning activity if gaming features are adapted to learners (Lavoue, Monterrat, Desmarais, & George, 2019).

2.2. Dispositional Flow

Flow is an optimal state of experience, that implies being totally absorbed in the task being carried out, and creating a state of concentration that facilitates optimal performance (Csikszentmihalyi, 1990). Csikszentmihalyi (1990), and Nakamura and Csikszentmihalyi (2002) described nine dimensions that characterise the experience of flow: striking a balance between the challenge of the individual's task and skills, clearly perceived goals, unambiguous feedback, a sense of controlling the activity, autotelic, intrinsically rewarding experience, the merging of action and awareness, focusing on the task at hand, loss of self-consciousness or reduced awareness of self and time transformation. It has been suggested that flow should be seen as being divided between the collection of conditions for achieving the flow state (the first five dimensions), and the psychological outcomes that follow after the flow state has been achieved (the last four dimensions) (Hamari & Koivisto, 2014; Nakamura & Csikszentmihalyi, 2002). Flow state refers to experiencing flow in a given situation, while dispositional flow refers to the tendency of experiencing flow.

In the PE and sport context, flow is associated with a positive experience and displaying a high level of performance in a physical task (Jackson & Eklund, 2002). Both games and exercise have been regarded as some of the most probable contexts for people to experience flow in (Hamari & Koivisto, 2014). In fact some exergames incorporate all the dimensions of flow (Sheehan & Katz, 2012). In exergames, flow can be facilitated though immediate feedback to players and social interaction (Lee, Kim, Park, & Peng, 2017). Immersion has been listed as one of the eight essential elements of flow when applied specifically for games (Sweetser & Wyeth, 2005), and immersion can improve thanks to exergaming (Chen, King, & Heckler, 2014). Bronner, Pinsker, and Adam Noah (2015) found that flow experience can be positively related to physical exertion during exergame playing. Huang et al. (2018) identified the need for both exercise and achievement as novel moderators that can facilitate the flow experience. However, studies are lacking in the specific PE context.

Although no studies have been published about gamification in PE to date, in the normal PE context, perceived competition and social goals have been reported to act as predictors of the flow experience (González-Cutre, Sicilia, Moreno, & Fernández-Balboa, 2009). Computer-supported gamified services aim to motivate exercise activities by providing optimally difficult challenges and feedback (Hamari & Koivisto, 2014). Flow is often discussed as an important psychological goal to pursue through gamification efforts (Hamari & Koivisto, 2014). For the time being, social influence positively impacts not only the number of people who are willing to exercise, but also their attitudes and willingness to use gamification services (Hamari & Koivisto, 2015). Therefore, a gamified exergaming intervention is expected to improve dispositional flow.

2.3. Basic psychological needs, exergaming gamification and PE

The Basic Psychological Needs (BPN) Theory is another subtheory of the SDT that identifies three innate needs or optimal motivation and well-being (Deci & Ryan, 2000): competence, autonomy and relatedness. The competence need refers to believing in one’s ability to perform a certain task efficiently and effectively. The autonomy need (self-determination) is based on the desire to experience an internal "locus" of causality, to feel the origin of one's actions. The social relatedness need denotes a feeling of belongingness or being connected with others (Ryan & Deci, 2017). Meeting these needs in PE classes can improve affective, cognitive and behavioural outcomes (Ntoumanis & Standage, 2009). Positive relations link competence, autonomy and social relationships in motivation and intentions to be physically active in the elementary PE field (Franco & Coteron, 2017; van Aart, Hartman, Elferink-Gemser, Mombarg, & Visscher, 2017).

No research was found that has studied the effect of exergame on BPN. Experimental studies that have examined the effects of gamification on BPN are still scarce (Dichev & Dicheva, 2017; Seaborn & Fels, 2015). Gamification is not considered effective *per se*, rather specific game design elements have specific psychological effects (Sailer et al., 2017). Peng, Lin, Pfeiffer, and Winn (2012) demonstrated that dynamically adjusting level of difficulty and badges led to increased satisfaction for the competence need, while freedom in avatar customisation led to increased satisfaction for the autonomy need. Badges, leaderboards, and performance graphs positively affect fulfilling the competence need, as well as perceived task meaningfulness, while avatars and teammates affect social relatedness experiences (Sailer et al., 2017). Mekler et al. (2017) does not coincide with these findings as they observed no effects of points, leaderboards and levels on satisfying needs, but found effects on the quantity of performance. These authors argued that these game design elements can act as extrinsic incentives. Thus current research, which is scarce, poses an ambiguous scenario as to the effects of gamification on BPN. However according to Sailer et al. (2017), the possibility of deliberately influencing psychological needs satisfaction with gamification is considered a more positive tendency than a negative one.

2.4. Hypotheses

Research in the fields of exergames (Chen et al., 2014; Lee et al., 2017; Street et al., 2017) and gamification (Barrio et al., 2016; Hamari & Koivisto, 2015; Kapp, 2012; Sailer et al., 2017) has shown that both can produce beneficial psychological effects. As the intervention of this study is based on the limitations and suggestions of other empirical studies, the following hypotheses (H) are postulated and fall in line with the results of previous studies:

H_1. The gamified exergaming educative intervention will produce less intrinsic motivation in students than the non-gamified and non-exergaming intervention with time.

H_2. The gamified exergaming educative intervention will produce more external regulation in students than the non-gamified and non-exergaming intervention with time.

H_3. The gamified exergaming educative intervention will decrease amotivation in students than the non-gamified and non-exergaming intervention with time.

H_4. The gamified exergaming educative intervention will improve dispositional flow in students than the non-gamified and non-exergaming intervention with time.

H_5. The gamified exergaming educative intervention will improve BPN in students than the non-gamified and non-exergaming intervention with time.

H_6. The rhythmic motor skill in students will be better in the gamified exergaming educative intervention compared to the non-gamified and non-exergaming intervention.

H_7. Commitment to and behaviour towards learning in students will be better in the gamified exergaming educative intervention compared to the non-gamified and non-exergaming intervention.

3. Method

3.1. Sample

The sample comprised 417 students (53.2% girls, n=222; 46.8%, n=195) from four primary schools. The mean age of the participants was 11.1 (SD=1.7), and 50.4% of the sample studied Year 6 (aged 10-11 years; n=210) and 49.6% studied Year 7 (11-12 years; n=207) in primary schools. This age group is thought to be critical about its impact on psychological and behavioural risk factors (Azevedo, Burges Watson, Haighton, & Adams, 2014), especially towards girls' physical activity (Harrington et al., 2018).

Four schools (two public schools and two non-public schools) agreed to participate in the study. The criteria to select schools were: their material adequacy (facilities, Wi-Fi connectivity), the diversity of the school's public/private, the ethnic and socioeconomic diversity of its students, schools from different cities, teaching staff's positive predisposition and accessibility for researchers. All the Year 6 and Year 7 students were invited to participate in the study via signed parental consent (n=418). One student did not participate in the study for not providing consent.

3.2. Study design

A natural experiment with a non-randomised controlled design was conducted with a pre and a post measure. This design allows maximum control without losing the naturalness of school cohorts, and is considered appropriate for studies of a similar nature (Verjans-Janssen et al., 2018). Our intention was to design a study that would overcome the limitations of previous empirical gamification and exergaming research, such as their dominant application to colleges (Dichev & Dicheva, 2017), lack of comparative groups (Hanus & Fox, 2015), or lack of measures' validity (Hamari & Koivisto, 2014). The design used in similar studies was considered (Azevedo et al., 2014; Li & Lwin, 2016; Lwin & Malik, 2012; Nguyen et al., 2016).

The control treatment (traditional didactic intervention) (Fig. 1) was designed based on the usual didactic teaching of dance in Spanish PE (Larraz, 2012). Another experimental treatment was designed very similarly to the control treatment, except for a gamified atmosphere and the presence of an exergame (gamified exergaming intervention) (Fig 2). Each treatment lasted 12 sessions (in line with each school's schedule) or 9 hours, which was applied to each school for 4 weeks during curricular PE classes. At the end of each intervention, the same academic performance evaluation test was used to make comparisons. Traditional didactic intervention and gamified exergaming intervention were applied in the same way by the same teacher. Treatments were applied to the Year 6 and Year 7 students at primary schools. In each school, both the experimental treatment and the control were applied, and it was randomly decided at what level each intervention was to be applied. At the end of the 4-week program, participants were invited to personally fill in the same virtual questionnaire that they had filled out before starting treatment using computers or tablets. Data collection took place between September 2017 and July 2018.

Fig. 1. Control group dancing salsa without exergame or gamification

Fig. 2. Experimental group dancing level 1 "Rasputin" with smartphones in hand

3.3. Ethics statement

The study received the ethical approval the Ethical Committee of Clinical Research of Aragon (Spain) on May 24. 2017 (statement number: 10/2017). All the schools invited to participate received a detailed written report of the study. In addition, a face-to-face meeting was held with the representatives of each school, who were given the opportunity to ask questions. When a school accepted to collaborate, informational letters and informed non-consent forms were sent to all parents or guardians of eligible students. All the children had access to didactic treatments, but only the participants whose parents or guardians agreed to collaborate in the study were included in the study.

3.4. Materials

The gamification system based on Points-Badges-Leaderboards (PBL) has been extenstively applied and studied. However, it only fits one player type: "achievers" (Bartle, 2003). Accordingly, the Mechanics-Dynamics-Aesthetics (MDA) framework (Hunicke et al., 2004) was used to achieve an inclusive gamified atmosphere (Shi et al., 2014) for all student-player types in the experiment. The MDA framwork was adapted to the education field. Mechanics refers to the system’s set of constituent elements, the relation linking between them, and the way in which a system can routinely function; dynamics refers to the way in which mechanics effectively works;that is, how the player-student interacts with the mechanics; aesthetics refers to both the perceptions produced by the mechanics in the player-student as it is designed (beauty) and the sensations-emotions experienced by students while playing (Quintas, 2019b). All the elements of the design are specified in Table 1. No negative points of any kind were used. Mechanic elements were designed: a system of positive points, rewards, classifications, levels of difficulty, challenges, achievements, badges, cooperative and competitive teams, virtual avatars, and the possibility of personalising avatars. Self-referential situations with an epic sense (Chou, 2014) of a cooperative group were raised to promote motivation among all the student types, even those who were not competitive. To achieve this, the *ClassDojo* application was used and an *ad hoc* virtual board (see Fig. 6) was designed.

Table 1. Gamified didactic design

time	Dynamics	Aesthetics
Dance performance point	Reinforcement Cumulability	Pleasure, Satisfaction, absortion
Creativity point		
Attention point		Social membership
Good behaviour point		
Design a choreography	Self-expression	Pleasure, Identity
Design a group choreography	Cooperation	Social membership
Leaderboard (Figure 6)	Competition	
Star badge (perfect dance)	Reinforcement Progress Collectability	Satisfaction
Green badge (for individual improvement).		Fun, Pleasure, Interest
Group Green Badge	Cooperation Collectability	Social membership, Identity
Group improvement point		
Best Dancers Badges	Competition	
Badge dancers that has improved the most		
Point helping the team	Cooperation, Collectability	
Point of dance plank	Status Competition	Identity, absortion
Custom avatar	Self-expression	Customise, Identity, Beauty,
Increasingly difficult dance levels	Progress	Fun, Satisfaction, Interest
Choosing dance Level 9 from more than 300 dances.	Self-expression	Identity, Customise
Just Dance Now and ClassDojo interface	Progress	Beauty, absortion
Music in all classes	Self-expression	Interest, Pleasure

The *Just Dance Now* exergame was used because it is compatible with the facilities of the participating schools and is based on accessible materials (screen projector, laptop, smartphone and the Internet). Its use is justified by its huge commercial success worldwide and its extensive use for youths’ leisure (Allsop, Rumbold, Debuse, & Dodd-Reynolds, 2013), and because it has been scientifically studied (Gao, Lee, Pope, & Zhang, 2016; Li & Lwin, 2016; Lin, 2015; Nyberg & Meckbach, 2017; Thin, Brown, & Meenan, 2013). Playing with a smartphone is a strategy to acquire a good psychological attitude as young people are used in it (Beltran-Carrillo et al., 2015). The experimental treatment design allowed all the students to dance several times during all the sessions.

The *Just Dance Now* exergame is a web platform that was used in the experimental group. It was necessary to pay the premium licence for 1 year. Students could dance in groups facing a large projected screen while holding a Samsung J3 smartphone in their right hand (see Fig. 2). Each smartphone performed the function of collecting each student's points while dancing as they include an accelerometer that detects movement. Twelve smartphones were obtained for this research, and the teacher always took the same smartphones to class. Students were already used to employing such a device in their daily lives. The control group learnt dance without the exergame being present and with no gamification resource (see Fig. 1).

In order to gamify learning contents, 10 exergame dances were previously selected from 300 dances. The selection criteria were motor difficulty, the dance's cultural variety, and adjusting values to Primary Education: Level 1 "Rasputin"; Level 2 "Crazy Christmas"; Level 3 "Boogie Wonderland"; Level 4 "Aquarius"; Level 5 "Let's groove"; Level 6 "#thatPOWER"; Level 7 "Hungarian Dance no. 5"; Level 8 "I will survive"; Level 9 a dance chosen by the group of students; Level 10 "Jambo Mambo". All the dances are available on the official exergame website (https://justdancenow.com/).
To make the intervention sessions gamified, the *ClassDojo* virtual platform was used. Six badges were associated with six types of points that were usually given by the teacher to students in class: creativity, good behaviour, paying attention, helping the team, motor self-improvement, group improvement, and motor perfection (called "5 stars"). Twelve badges were also designed for: the three best dancers at each level, the three best dancers every week, the three students who had improved the most, and the three groups with the most points in general (see Fig. 3). Each student's points accumulated in the ClassDojo application and could be consulted by students at any time, even at home. With those points, students could personalise their own avatars and obtain a higher score in the subject (see Fig. 4).

Fig. 3. Screenshot of the individual and comparative badges received by students through ClassDojo

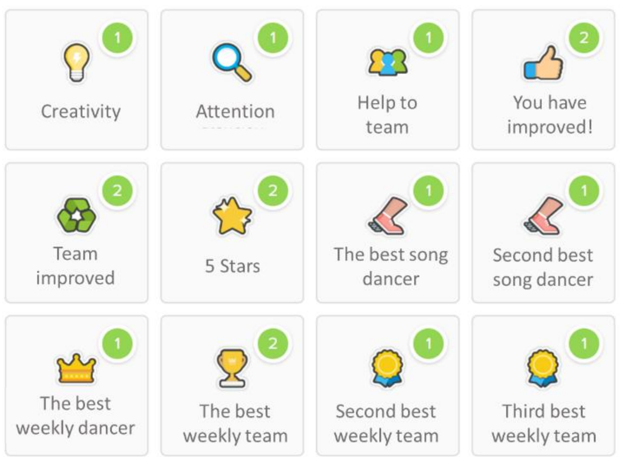


Fig. 4. Screenshot of each students' personalised avatars with the total points in the ClassDojo application

Finally, a virtual gamifier board was designed *ad hoc* using *Microsoft Excel* (see Fig. 5). Students had to enter the score of each dance indicated by the exergame into the gamifier board via a laptop that was accessible in class (see Fig. 6). The board indicated students' average results for each dance, and the totals obtained from the beginning both individually and as a group.

Figure 5. Gamifier board (only with the blue team)

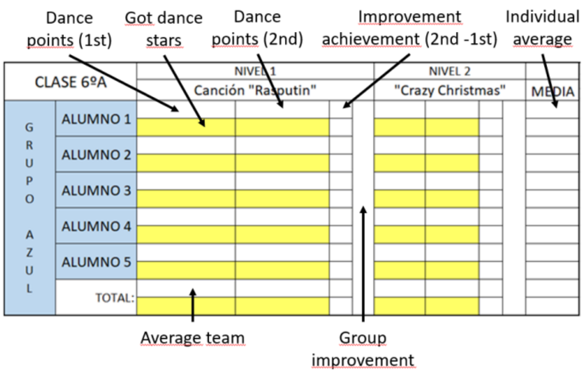


Figure 6. Example of a student inputting his dance points into the gamifier board

3.5. Measures

3.5.1. Motivation

Students completed the Perceived Locus of Causality Scale (Goudas, Biddle, & Fox, 1994), which has been validated and adapted tothe Spanish population (Moreno-Murcia et al., 2009), and comprises 20 items. Items were measured on a 5-point Likert scale, which ranged from 1 (completely disagree) to 5 (completely agree; Cronbach's α was applied to our sample=.83). This scale is the most widely used one in the Spanish context to measure motivation from the SDT (Franco & Coteron, 2017), and it measures intrinsic motivation (α=.83), identified regulation (α=.81), introjected regulation (α=.71), external regulation (α=.74) and amotivation (α=.81) (see Table 2). Extrinsic motivation (α=.78) was the result of adding the scores of identified regulation, introjected regulation and external regulation (Ryan & Deci, 2017).

3.5.2. Dispositional Flow

The participants completed the Dispositional Flow Scale-2 (Jackson & Eklund, 2002), which has validated and adapted to both the Spanish population and the PE context (González-Cutre et al., 2009), which contains 36 items. Four items were for all the nine flow dimensions (Csikszentmihalyi, 1990). Items were measured on a 5-point Likert scale from 1 (completely disagree) to 5 (completely agree; Cronbach's α=.95). This scale has been widely applied to study various physical activities, education and digital gaming (Hamari & Koivisto, 2014). This scale measures the next dimensions: a balance between the challenge of a task and the individual's skills, merging action and awareness, clearly perceived goals, unambiguous feedback, focusing on the task at hand, sense of controlling the activity, loss of self-consciousness or less awareness of self, time transformation and autotelic intrinsically rewarding experience (see Table 2).

3.5.3. Basic psychological needs

The participants filled in the Basic Psychological Needs in Exercise Scale (Vlachopoulos & Michailidou, 2006), which contains 12 items, 4 items for each dimension (Autonomy, Competence and Social Relateness) (see Table 2). This scale has been validated and adapted to the Spanish population and PE (Moreno, González-Cutre, Chillón, & Parra, 2008). Items were measured on a 5-point Likert scale ranging from 1 (completely disagree) to 5 (completely agree; Cronbach's α=.90).

3.5.4. Rhythmic motor skill

All the students in both treatments had to do a final exam that consisted in creating and representing group choreography in groups of 5-7 people. All performances were filmed. Subsequently, the rhythmic motor skill of each student was analysed on a scale from 1 (the student performed the choreography in an entirely arrhythmic way) to 5 (the student interpreted the choreography in a totally rhythmic way) (see Table 2).

3.5.5. Commitment to and behaviour towards learning

The teacher evaluated each student's behaviour throughout the treatment on a scale from 1 (the student was not committed to learn new dance skills, or did not strive in situations that posed some kind of difficulty) to 5 (the student was fully committed to learn new dance skills, and strived to continuously progress) (see Table 2).

Table 2. Descriptive data on the variables of interest.

	Control Treatment	Experimental Treatment

	Baseline	Follow-up	Baseline	Follow-up
Intrinsic motivation	17.68 ± 2.94 (123)	16.83 ± 3.36 (123)	16.54 ± 3.46 (191)	16.30 ± 3.05 (191)
Extrinsic motivation	41.83±8.75 (124)	40.82±7.83 (124)	41.27±7.76 (191)	39.9±6.99 (191)
Identified regulation	17.27±3.37 (124)	16.59±3.37 (124)	16.80±3.20 (191)	16.28±2.81 (191)
Introjected regulation	13.06±4.2 (127)	12.53±4.36 (127)	12.73±3.67 (193)	12.68±3.68 (193)
External regulation	13.23 ± 4.12 (128)	11.48 ± 4.58 (128)	11.73 ± 4.09 (192)	10.99 ± 4.04 (192)
Amotivation	8.09 ± 4.269 (128)	9.05 ± 4.99 (128)	8.27 ± 4.38 (192)	8.71 ± 4.38 (192)
Basic psychological needs	49.7 ± 6.59 (127)	47.73 ± 9.06 (127)	47.18 ± 8.09 (190)	47.54 ± 7.35 (190)
Perceived autonomy	15.31±2,97 (126)	14.88±3.59 (126)	14.53±3.48 (190)	14.87±2.89 (190)
Perceived competence	16.56±2.66 (128)	16.02±5.58 (128)	15.68±3.27 (192)	15.82±2.94 (192)
Perceived relatedness	17.80±2.49 (128)	16.74±3.12 (128)	16.86±2.91 (190)	16.76±2.66 (190)
Dispositional Flow	138.75± 22.82 (175)	136.66±25.02 (175)	138.64±21.16 (216)	138.91±20.54 (216)
Challenge-task balance	14.96±3.16 (173)	14.95±3.14 (172)	16.86±3.12 (216)	15.16±2.88 (216)
Merging action and awareness	13.74±3.51 (170)	13.99±3.42 (170)	14.13±3.24 (213)	13.92±3.16 (213)
Clearly perceived goals	16.27±3.05 (175)	15.58±3.40 (175)	16.16±2.84 (215)	15.95±2.93 (215)
Unambiguous feedback	15.78±2.8 (172)	15.47±3.32 (172)	15.58±2.98 (215)	15.57±2.86 (215)
Focusing on the task at hand	15.59±3.17 (170)	15.62±3.13 (170)	15.81±3.17 (216)	15.59±2.82 (216)
A sense of controlling the activity	15.60±3.27 (176)	15.54±3.53 (176)	15.47±3.00 (215)	15.65±3.01 (215)
Loss of self-consciousness	14.45±3.80 (176)	14.78±3.94 (176)	14.82±3.88 (213)	15.69±2.80 (213)
Time transformation	16.37±3.28 (176)	15.5±3.8 (176)	15.87±3.50 (176)	16.6±2.88 (216)
Autotelic experience	16.92±2.8 (171)	16.15±3.47 (171)	16.28±3.23 (211)	16.65±2.84 (211)
Motor skill academic performance	-	3.78±1.30 (185)	-	4.28±1.07 (225)
Commitment to and behaviour towards learning	-	3.78±1.3 (185)	-	4.54±0.66 (206)

Mean±Standard Deviation (number of participants)

3.6. Statistical analyses

Differences at the baseline between groups were compared by using an independent *t-test* for the normally distributed variables and the Mann-Whitney U test for the abnormally distributed variables. To test the research hypotheses, the two study groups were compared using factorial ANOVAs x 2 (time; pre-treatment condition *vs.* post-treatment condition) x 2 (treatment; traditional didactic intervention *vs.* gamified exergaming intervention) (Azevedo et al., 2014; Lau et al., 2016; Vickers & Altman, 2001). The size effect was calculated by eta partial eta-squared (η_p^2). All the statistical analyses were performed using SPSS (version 22.0, https://www.ibm.com/es-es/analytics/spss-statistics-software)) and the analysis threshold was set at ≤ 0.0125 with Bonferroni adjustment (Bland & Altman, 1995).

4. Results

4.1. Sample equivalence

An independent t-test revealed significant differences between groups at the baseline in terms of: intrinsic motivation (p=.003), basic psychological needs (t(189)=3.13, p=.002), perceived autonomy (t(314)=2.06, p=.04), perceived competence (t(300)=2.76, p=.006) and perceived relatedness (t(299)=2,38, p=.018). As factorial ANOVAs 2x2 (Time x Treatment) was applied, the initial differences in these four variables were considered. A chi-square analysis found no differences in the distribution by gender (p=.893). Moreover, the independent samples *t-test* revealed no significant differences in attendance (p=0.287).

4.2. Hypothesis testing

H_1 predicted that with time, the gamified exergaming education intervention would produce less intrinsic motivation than the non-gamified and non-exergaming intervention. A treatment effect was noted on intrinsic motivation (F(1)=9.74, p=.002, η_p^2=.03, $M_{Post-Pre}$=-.545). A time effect was found on intrinsic motivation that did not survive the threshold at p≤.0125 (F(1)=4.40, p=.037, η_p^2=.014). Performing a more specific analysis in each group using simple ANOVA (Post-pre) showed that the control group displayed less intrinsic motivation with time (F(1)=4.22, p=.042, η_p^2=.033). The experimental group did not significantly display intrinsic motivation (F(1)=.54, p=.461, η_p^2=.003). No interaction effect (Time x Treatment) was found. Thus H1 was not supported.

H_2 predicted that, with time the gamified exergaming intervention would produce more external regulation in students than the non-gamified and non-exergaming intervention. An interaction effect was found on external regulation that did not survive the threshold at p≤.0125, but a tendency towards significance was noted (F(1)=4.03, p=.046, η_p^2=.013). Performing a more specific analysis in each group using simple ANOVA (Post-pre) found that external regulation significantly decreased in the experimental group with time (F(1)=6.21, p=.014, η_p^2=.032), and it increased in the control group, but not significantly (F(1)=.375, p=.541, η_p^2=.003). In any case, H2 was not supported.

H_3 predicted that with time, the gamified exergaming intervention would decrease amotivation in students than the non-gamified and non-exergaming intervention. A time effect was found on amotivation (F(1)=9.34, p=.002, η_p^2=.029, $M_{Post-Pre}$=.699). Specifically, the control group displayed increased amotivation with time (F(1)=8.32, p=.004, η_p^2=.025), but the experimental group did not (F(1)=2.76, p=.014, η_p^2=.014). No interaction or treatment effect was found. Thus H3 was not supported.

H_4 predicted than with time, the gamified exergaming intervention would improve dispositional flow in students more than the non-gamified and non-exergaming intervention. No interaction effect or main effects on dispositional flow took place. Thus H4 was not supported. However, an interaction effect on time transformation was observed (F(1)=21.96, p=.000, η_p^2=.053, $M_{exp-control}$=.069) (see Fig. 7). Specifically, the time transformation of the control group significantly reduced with time (F(1)=8,28, p=.005, η_p^2=.046), while it significantly increased in the experimental group (F(1)=12.02, p=.001, η_p^2=.053). Thus the gamified exergaming intervention improved students' time transformation compared to the non-gamified and non-exergaming intervention. An interaction effect on autotelic experience was found (F(1)=12.83, p=.000, η_p^2=.033, $M_{exp-control}$=.65), and a time effect on autotelic experience was observed that did not survive the threshold at p≤.0125 (F(1)=4,37, p=.037, η_p^2=.011). Specifically, the control group's autotelic experience significantly reduced with time (F(1)=9.16, p=.003, η_p^2=.051), but it did not significantly increase in the experimental group. Thus the gamified exergaming intervention did make autotelic experience better than the non-gamified and non-exergaming intervention did.

A time effect on the loss of self-consciousness was noted (F(1)=7.89, p=.005, η_p^2=.02, M_{Post-}

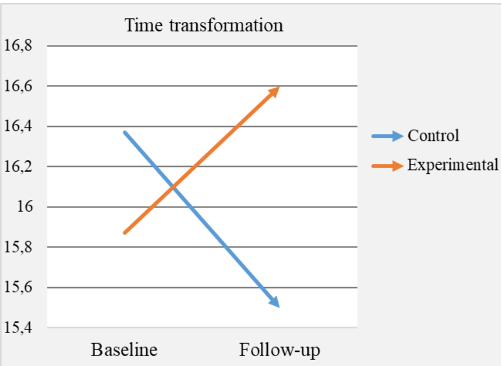
$_{Pre}$=.601), and a treatment effect on loss of self-consciousness was observed, but it did not survive the threshold at p≤.0125 (F(1)=4.57, p=.033, η_p^2=.012, $M_{Exp.-control}$=.45). A time effect on clearly perceived goals (F(1)=7.5, p=.006, η_p^2=.019, $M_{Post-Pre}$=-.445), and on the sense of controlling the activity (F(1)=7.72, p=.006, η_p^2=.019, $M_{Post-Pre}$=.057) was also found.

H_5 predicted that with time, the gamified exergaming intervention would improve the BPN in students than the non-gamified and non-exergaming intervention. An interaction effect was observed on BPN (F(1)=7.35, p=.007, η_p^2=.023, $M_{exp-control}$=1.359) (see Fig. 8). An interaction effect (F(1)=7.99, p=.005, η_p^2=.025, $M_{exp-control}$=.456) and a time effect (F(1)=11.7, p=.001, η_p^2=.036, $M_{exp-control}$=-.577) on perceived relatedness took place. All the needs as a whole improved in the experimental group compared to the control group. Thus H5 was supported.

H_6 predicted that the rhythmic motor skill in students would be better in the gamified exergaming intervention than it would in the the non-gamified and non-exergaming intervention. A significant difference appeared in rhythmic motor skill academic performance between the groups (t(406)=-7.21, p=.000, η_p^2=.032). Rhythmic motor skill academic performance was better in the gamified exergaming intervention than in the non-gamified and non-exergaming intervention. Thus H6 was supported.

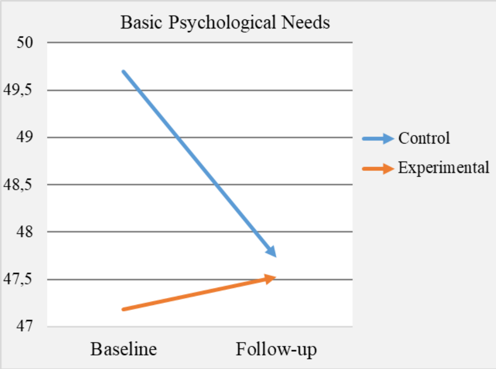
H_7 predicted that commitment to and behaviour towards learning in students would be better in the gamified exergaming intervention and would increase more than in the non-gamified and non-exergaming intervention. A significant difference between groups was found in commitment to and behaviour towards learning (t(407)=-4,2, p=.000, η_p^2=.042). Commitment to and behaviour towards learning was better in the gamified exergaming intervention increased than in the non-gamified and non-exergaming intervention. Thus, H7 was supported.

Figure 7. Interaction effect on time transformation



X-axis represents mean score on time transformation.

Figure 8. Interaction effect on BPN



X-axis represents mean score on Basic Psychological Needs.

5. Discussion

The results confirmed that a gamified exergaming educational intervention, compared to another almost identical intervention (but with neither gamification nor the exergame) can have some positive psychological effects on variables like intrinsic motivation, external regulation, amotivation, BPN, some dispositional flow dimensions and academic performance.

The association between gamification and motivation has often been of a theoretical kind and not empirical (Dichev & Dicheva, 2017). The results of the present study suggest improvement to the motivational aspect towards PE, and that intrinsic motivation, external regulation and amotivation were better in the gamified group. However, Hanus and Fox (2015) found reduced intrinsic motivation, which they attributed to the existence of badges, leaderboards and competition mechanics. Besides Lavoue et al. (2019) found reduced intrinsic motivation due to a low level of acceptance of “non-serious” elements in a serious environment, perceived as disturbance by intrinsically motivated learners. This may be due to them using only the BPL system, and no *Mechanics-Dynamics-Aesthetics* framework. As the control group displayed reduced intrinsic motivation over time, and as it did not significantly decrease in the experimental group, it was considered to be a relatively positive result. This may suggest that it is possible to build a gamified environment where points, badges or leaderboard are not interpreted as controllers by students, which was one of the dangers to be considered (Deci et al., 2001; Mekler et al., 2017). It has been argued that, in a non-controlling setting, the well-thought out implementation of gamification could improve intrinsic motivation by satisfying users' BPN (Peng et al., 2012). However in our study, all the BPN as a whole improved more in the experimental group than in the control group, which allowed us to suggest a slight improvement in intrinsic motivation. This could be explained by the support of appropriate learning contexts where the badges given by teachers make sense (Boticki et al., 2015), by the improvement that unexpected rewards are able to produce (Deci et al., 2001; Lepper, Greene, & Nisbett, 1973), or by the presence of an exergame. Exergames can improve motivation thanks to very visual avatars (Li & Lwin, 2016), situational interest as a resource (Sun, 2013) motivation, enactive experience (Li & Lwin, 2016), or psychological well-being (Azevedo et al., 2014).

Amotivation in the experimental group did not significantly increase with time, but it did in the control group. This could be interpreted as the gamification design of this intervention having been well adapted to students, thus amotivation did not increase in the well-adapted gamified group, as found by Lavoue et al. (2019). However, it cannot be stated that treatment reduced amotivation, but may have only prevented increased amotivation in relation to control. More specific studies are necessary about the effect of gamification and exergames on amotivation to confer our study interpretative power.

It is necessary to think more didactically in dynamic and aesthetic spheres (Hunicke et al., 2004; Shi et al., 2014) in class, and not only about gamification mechanics (the PBL system). In our study, the dynamics was based on the motivational tips of the SDT, and aesthetics was based on both the *Just Dance Now* exergame and the *ClassDojo* application. Other studies have coincided in finding increased motivation through gamification (Barrio et al., 2016; Behzadnia, Adachi, Deci, & Mohammadzadeh, 2018; Bonde et al., 2014; Su & Cheng, 2013), but are difficult to compare given their research design or educational context.

Although better positive results were expected in Dispositional Flow, they were only partially found. Perhaps because they were found in those flow dimensions caused at the same time in both gamification and the exergame because they belong to the fields most closely associated with flow: games and exercise (Hamari & Koivisto, 2014). In exergames, flow can be facilitated by immediate feedback and social interaction (Lee et al., 2017). However, as no differences were found on the "clear feedback" dimension, but in both "autotelic experience" and "time transformation", we consider that flow in this intervention was achieved by the *Just Dance Now* exergame and from the aesthetic part of the design (absortion, pleasure, fun and identity). These results coincide with Bronner et al. (2015), who found a positive correlation between flow and engagement, and a high level of performance in a physical task. Lin (2015) reported similar psychological effects between dance videos and the *Just Dance* exergame, in which feedback and controllers intervened. The autotelic experience acquired with the experimental treatment was the most important flow factor, which implies that students have lived a comforting, fun and intrinsically rewarding experience (Nakamura & Csikszentmihalyi, 2002).

The gamified exergaming intervention improved BPN. This is consistent with theoretical works about the power of gamification to address experiences of competence (Peng et al., 2012). Similarly, these results coincide with those of Sailer et al. (2017), who found that participants in a game treatment that used badges, leaderboards and performance graphs experienced higher levels of BPN than the participants under a control condition. Mekler et al. (2017) obtained negatively perceived competence results, perhaps as a result of the nature of the task, or because meaningful feedback or perceived challenge was lacking. Sailer et al. (2017) found improved perceived relatedness thanks to the presence of avatars and teammates, which can partially explain the effects of our gamified exergaming intervention on social relatedness, in addition to certain elements, like group badges and points for helping the team. This result could show that it is possible to apply educative gamification without improving only the competition relation, but also the cooperation relation.

Commitment to and behaviour towards learning improved. These findings agree with many studies into gamification (Chang & Wei, 2015) and exergames (Oh & Yang, 2010; Peng, Lin, & Crouse, 2011). Academic performance also improved in the rhythmic motor skill, which coincides with that found by Hanus and Fox (2015), who did not report any reduced effort in the gamified group. A recent systematic review shows that there could be an association between physical performance (energy expenditure) and positive psychological effects of playing exergames (Lee et al., 2017). One explanation for the improved academic performance between these two very similar treatments is that students who had gamification elements spent more time per exercise (Bonde et al., 2014).

6. Research limitations and future research directions

Although this study sample may suffice given the research design, future research could perhaps extend the sample by allowing significant results to be obtained in those variables in which we found none. The sample size (n=417) can be considered adequate according to similar studies (Azevedo et al., 2014; Li & Lwin, 2016; Nguyen et al., 2016).

Given the traditional way of programming school contents, 1-month interventions (9 h) were held, but longitudinal studies are necessary to know the long-term psychological effects.

This age group is thought critical given its impact on psychological and behavioural risk factors, especially for girls' physical activity (Harrington et al., 2018). Besides, the video games phenomenon is associated with males (Díez-Gutiérrez et al., 2004) and dance with females (Azevedo et al., 2014). Therefore, it is necessary to know the effects of such interventions according to gender as a future research line.

Future studies may include different gamification elements, another exergame, or distinct PE contents to be applied and compared. Other psychological variables can be studied based on the design of this study, such as satisfaction, boredom, physical self-concept or frustration.

7. Conclusion

This study is the first to examine the psychological effects of an intervention combining gamification as a didactic method and an exergame as an educational resource. It sought to cover the need of conducting a scientific study in schools, with group comparisons of groups and reliable measures, as the scientific literature requests. This study is an example of combining rigour in the didactic design of treatments and the rigour of a quasiexperimental scientific methodology. It also falls in line with a few empirical studies based on natural experiments in educational gamification and exergaming which obtained significant results by measuring the effectiveness of an intervention in a *real world* setting.

Our findings may mean that this study is one of the few that provides positive evidence for educational gamification. The *Mechanics-Dynamics-Aesthetics* gamification model and the *Just Dance Now* exergame are resources capable of producing positive psychological effects on school-based PE.

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***Highlights (for review)**

- Mechanics-Dynamics-Aesthetics framework creates an adequate gamified atmosphere.
- Just Dance Now exergame is a good educational resource.
- A gamified exergaming intervention improves Basic Psychological Needs at school.