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Title:

Effects of gamified didactic with exergames on psychological variables associated with promoting physical exercise: results of a natural experiment run in primary schools

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Abstract

Background

Exergames are a new sociotechnological phenomenon consisting of digital motor games that aim to stimulate players' motor skills. Exergames have been well studied in their physical-motor component, but knowing more about their possible psychological effects in the school context is interesting to promote the physical exercise practice. Gamification refers to the use of game-based elements in nongame contexts whose aim is to motivate action by making activities more game-like. Gamification seems an innovative strategy to promote physical exercise habits at schools whose real effects are still poorly unknown. Physical education has significant direct and indirect influences on students' physical exercise. Exergames and gamification are associated with psychological benefits related to physically active behavior (such us enjoyment, satisfaction, positive attitude, motivation, perceived motor competence).

Purpose

The aim of this study was to analyze the effects of a gamified exergaming school intervention on psychological variables associated with physical exercise (PEx) promotion. It has been hypothesized that the gamified exergaming school intervention will produce more achievement motivation (H_1), more enjoyment (H_2), a more positive attitude toward exergames (H_3), greater exergame intention (H_4) and greater PEx intention (H_5) in students than nongamified and nonexergaming intervention with time.

Participants and setting

A natural experiment with a nonrandomized controlled design. The participants were 417 primary students (53.2% girls, n=222; 46.8% boys, n=195) recruited from two public and two nonpublic schools (control group, n=191; experimental group, n=226). Their mean age 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). The control treatment (traditional didactic intervention) was designed based on usual didactic dance teaching in Spain. Another similar experimental treatment was designed to the control treatment, but with a gamified climate and an exergame (gamified exergaming intervention). The *Just Dance Now* exergame was used because it is compatible with school facilities and is based on accessible materials. The Mechanics-Dynamics-Aesthetics framework was applied to achieve mastery-oriented motivational climates and an inclusive gamified atmosphere for all student-player types; this framework allows to introduce specific elements of mechanics (points, emblems, competition), dynamics (reinforcement, self-development, feeling of progress) and aesthetics (fun, avatars). To gamify each class, the *ClassDojo* application was used, due to allows to evaluate or measure with a scientific purpose, it is suitable for daily teaching, it has a high esthetic component and is related to primary education, and

Data collection

The students completed the Achievement Motivation in Physical Education Test (AMPET); the Sport Satisfaction Instrument (SSI); the "Attitudes Toward Exergames" scale; the "Exergame intention" scale; the "Exercise Intention" scale.

Statistical analyses

To test the research hypotheses, the two study groups were compared using factorial ANOVAs 2 (time; pre-treatment condition vs. post-treatment condition) x 2 (treatment; traditional didactic intervention vs. gamified exergaming intervention).

Findings

As the analysis threshold was set at ≤ 0.0125 with Bonferroni adjustment, the results showed better positive gamified exergaming effects on enjoyment (H_2) and attitude toward exergames (H_3). No interaction effects were found on achievement motivation (H_1), exergame intention (H_4) or PEx intention (H_5).

Conclusions

This is the first study to examine an intervention that combines Mechanics-Dynamics-Aesthetics (MDA) gamification framework as a didactic method and exergame as an educational resource, adopted as a strategy to promote the variables associated with encouraging PEx in primary schools. A gamified exergaming educational intervention, might have some positive effects on enjoyment and attitude toward exergames, but not on achievement motivation, exergame intention or direct intention to perform PEx. The ability of gamification and exergame as an exercise promotion strategy is still unclear and future research should be conducted.

Keywords

Gamification; exergame; physical exercise; promotion; primary school

Introduction

Physical exercise promotion in physical education

Physical education (PE) has significant direct and indirect effects on students' physical exercise (PEx), especially through school intervention programs in compulsory education (Martins, Marques, Peralta, Palmeira, & Costa, 2017). The systematic review by Errisuriz, Golaszewski, Born, y Bartholomew (2018) stated the need to incorporate the measurement of psychological variables (not only physical-physiological variables) into experimental studies of school interventions to assess the effect on PEx. Specifically, several exergame-based interventions have been implemented as a psychological strategy, that is, as a strategy to change attitudes, habits and behaviors associated with PEx (Li & Lwin, 2016; Lwin et al., 2016; Nguyen et al., 2016; Robertson, Jepson, Macvean, & Gray, 2016; Watson, Adams, Azevedo, & Haighton, 2016).

Exergames in physical education

Exergames are digital motor games that aim to stimulate players' motor skills, which are popular on the global market, to which academic research has paid increasing attention (Lin, 2015; Quintas, 2019). Exergames, understood as a type of games, are applied to PE and can simultaneously provide the benefits of motor games and video games (Gee, 2003; González & Navarro, 2015), such as the benefit of "active learning" (the environment invites players to act), that of "psychological moratorium" (learners dare to take risks when the real consequences of their actions have a mild or little impact), that of "Situated meaning" (where the meanings of signs are always situated from and in personal experience), and enactive learning (motor learning by doing). Less is known about exergames' ability to promote PEx in primary schools (Li & Lwin, 2016). Studies defend the need to explore the psychological effects of interventions based on both exergames and PE (Lee, Kim, Park, & Peng, 2017b) because it is still unknown how it affects school performance (Bonde et al., 2014), motivation in the class (Bronner, Pinsker, & Adam Noah, 2015), and if it can really promote habits outside the classroom for activities not based on exergame (Garn, Baker, Beasley, & Solmon, 2012; Lwin & Malik, 2012; Nguyen et al., 2016) as this could allow its possible virtues to be known in education and healthy terms.

Physical activity has been conceived as any intentional body movement (Devís, 2001). PEx is planned, structured and repetitive physical activity (Caspersen, Powerl, & Christenson, 1985). Some scientific studies propose incorporating exergames into PE classes to increase children's physical activity (Chacón, Castro, Zurita, Espejo, & Martínez, 2016; Lwin & Malik, 2012) and to promote PEx practice outside classrooms (Li & Lwin, 2016) because practicing PEx is associated with health, and also with physical and psychological well-being (Wu et al., 2017). Exergames imply more physical activity (Lau, Wang, & Maddison, 2016) and, generally, more health benefits (Staiano & Calvert, 2011). Primary education years 6 and 7 coincide with students' ages being between 10 and 12 years old; psychologically, this is a key age range because it is a critical period as regards establishing or losing habits in adolescece and adulthood. This age group is thought critical for its impact on psychological and behavioral risk factors (Azevedo, Burges Watson, Haighton, & Adams, 2014), especially toward girls' physical activity (Harrington et al., 2018). Children and young people spent a lot of time on digital games and sports (Campos, 2015; Chacón et al., 2016; Chacón et al., 2015; Chacón et al., 2017), and this digital leisure can be associated with a sedentary lifestyle (Chacón et al., 2015). There are reports indicating that 86% of Spanish children aged from 10 to 14 years spend at least 1 hour in front of a screen during their leisure time (INE, 2017). It seems to make sense to combine a phenomenon like exergame linked with digital leisure time to the physical activity time recommended by the World Health Organization. This institution has advised, based on the latest global review studies (Chaput *et al*, 2020), that the optimal level of physical activity in children from 10 to 12 years of age to present health benefits is approximately 60 minutes a day (even a little more), being moderate-vigorous physical activity. A recent review concludes that exergames can be useful for promoting PEx and health in the adult population that does not normally perform traditional PEx, provided that recommendations about the duration and intensity of exergame-associated exercise are met (Street, Lacey, & Langdon, 2017). However, the effect of promoting PEx by exergaming has been demonstrated only in the short term (Williams & Ayres, 2020) and there is some ambiguity as to the degree to which videogames (nonexergaming) is, or is not, significantly associated with obesity in children and if, in turn, there is any evidence for increased exergaming use reducing screen and video game times (Kracht, Joseph, & Staiano, 2020). This may imply that the use of exergaming can be indirectly favorable for children's health, since it can psychologically promote PEx practice.

Gamification as a new psychological strategy

As Dichev and Dicheva (2017) established, besides exergames being a technological resource, it is necessary to study gamification as a new didactic method in usual PE classes. Following these same authors, gamification refers to the use of game-based elements in nongame contexts in order to motivate action by making activities more game-like. The analytical study of a technological tool in education gains didactic sense if it is associated with a formative intervention framework (Rivoltella, 2017, p. 62). Therefore, introducing exergames as a tool is not enough to produce an essential change, and gamification can be added as an educational strategy to change the dynamics of lessons.

It has been suggested that exergames should be incorporated into PE classes to enhance students' motivation (Campelo, Donaldson, Sheehan, & Katz, 2015). Several motivation-related psychological exergaming benefits have already been proven in PE classes, such as favoring change in physically active behavior (Lwin & Malik, 2012) or increasing situational interest (Sun, 2013). Moreover, gamification has been associated with motivation toward learning in educational contexts (Dichev & Dicheva, 2017). Dichev y Dicheva (2017) showed that educational gamification expectations for motivation are inflated with empirical research into the limited effectiveness of gamification. According to the Self-Determination Theory, intrinsic motivation refers to participating in activity only for the pleasure and satisfaction that one gets from doing so, whereas extrinsic motivation refers to being committed to the activity as a means to achieve something, but not as an end *per se* (Ryan & Deci, 2017). Hanus y Fox (2015) found reduced intrinsic motivation because additional rewards (badges and coins) can be interpreted as controlling. However, it has been argued that in a noncontrolling setting, well thought out gamification implementation can improve motivation by creating a mastery-focused climate (Gu & Solmon, 2016; Peng, Lin, Pfeiffer, & Winn, 2012). Therefore, gamification can act as a double-edged sword for motivation, depending on its design (Hanus & Fox, 2015).

Achievement motivation and enjoyment

The Achievement Goal Theory (AGT) (Nicholls, 1984) has proven useful for explaining students' behavior, cognition and affect in PE and PEx outdoors (Gu & Solmon, 2016). The AGT conceives the individual as an intentional organism, directed toward a goal that rationally functions. An individual’s goals consist of striving to demonstrate competence and ability in achievement contexts, which can be mastery-oriented or performance-oriented. Thus perceived motor competence (PMC) is a fundamental motivational variable. Achievement is interpreted subjectively by the individual, as are success and failure. Environments created by educational agents (teachers, parents, etc.) in achievement contexts have been called “motivational climates” (Nicholls, 1984). The educational environment is an achievement context that can influence the orientation of an individual’s goals. According to motivational theories of achievement, Nishida (1988) built a transcultural model applied to PE, and discovered that schoolchildren who were more motivated to mastery better performed academically during PE than those who manifested motivation aimed to avoid. Nishida's achievement motivation model includes three confirmed constructs: engagement and dedication in learning, PMC, anxiety about error and stress situations (Graupera, Gutiérrez, Nishida, & Ruiz, 2004; Nishida, 1988). Positive relations appear between PMC on motivation and intentions to be physically active in the primary PE field (Franco & Coteron, 2017; Márquez, Azofeifa, & Rodríguez, 2019; Ntoumanis & Standage, 2009; van Aart, Hartman, Elferink-Gemser, Mombarg, & Visscher, 2017). Peng et al. (2012) demonstrated that the dynamic adjustment of difficulty levels and badges led to increased achievement for motivation-related dimensions. Badges, leaderboards and performance graphs also positively affect achievement motivation and perceived task meaningfulness (Sailer, Hense, Mayr, & Mandl, 2017). Conversely to these findings, Mekler, Brühlmann, Tuch, y Opwis (2017) observed how points, leaderboards and levels did not affect achievement motivation-related dimensions, but found effects on performance quantity (i.e., longer time spent on educational tasks). They argued that these game design elements can function as extrinsic incentives. However, according to Sailer et al. (2017), this is considered a more positive tendency than a negative one for the possibility of deliberately influencing achievement motivation with gamification.

Enjoyment, referred to as the level of excitement or pleasure a person derives from playing (Li & Lwin, 2016), is an essential part of any game because it is an important factor to predict future play times and play duration (Limperos & Schmierbach, 2016). Enjoyment has been a commonly cited reason for playing exergames (Lee et al., 2017b). It can be implemented by either feedback, challenge and rewards (Lyons, 2015), or mechanisms shared by exergames and gamification. Exergames can increase physical activities through enjoyment (Ho, Lwin, Song, & Yee, 2017).

Attitude toward exergames and physical exercise promotion

Exergames come over as a very promising option to achieve an active life, especially with wearable fitness technologies (Beltran-Carrillo, Beltran-Carrillo, Gonzalez-Cutre, Biddle, & Montero-Carretero, 2015). PEx through exergaming is another form of PEx. Increasing the intention to play exergames in the future (exergame intention) is a way to increase the intention to practice PEx. Attitude toward exergames predicts the exergame intention (Kari & Makkonen, 2014), which suggests that attitude toward exergaming plays an important role in individuals' future intentions to play exergames. Positive effects on exergame intention have been found in intervention studies based on exergames (Song, Peng, & Lee, 2011), and exergame intention positively correlates with attitude toward exergames (Ho et al., 2017). Exergame intention is also positively related to the future intention of doing PEx (PEx intention) (Garn et al., 2012; Li & Lwin, 2016). A study conducted with college students found that PEx intention was greater for exergaming interventions than for generic PEx (Garn et al., 2012). Lwin y Malik (2012) reported improved PEx intention with an exergaming-based intervention. Another educational intervention based on exergaming indicated participants' good attitude toward exergames, although this positive attitude did not significantly change over time (Keskinen, Hakulinen, Turunen, & al, 2014). Other studies did not find any significant results for attitudes toward exergames and their future use (Lee et al., 2017b).

A quasi-experimental approach

Empirical support for the effectiveness of exergaming on students' motivation and in-class activity in PE is sparse (Sun, 2013). Several studies on the attitude towards the exergames and their future use have not found any significant results in most cases (Lee et al., 2017b), others have reported no changes after interventions (Keskinen et al., 2014; Quinn, 2013), and some even report failure to promote physical activity by exergames (Lau et al., 2016; Madsen, Yen, Wlasiuk, Newman, & Lustig, 2007). Studies are needed to advance the body of knowledge on the psychological effects of exergame, and also about the physical-physiological effects that have already been widely studied (Azevedo et al., 2014; Gao, Zhang, & Stodden, 2013; Street et al., 2017; Vernadakis, Zetou, Derri, Bebetsos, & Filippou, 2014).

Recent studies indicate the limitations of empirical research on gamified education, such as the dominant application to colleges (Dichev & Dicheva, 2017) or lack of comparison groups (Hanus & Fox, 2015). This is why a natural experiment based on gamification principles (Hunicke, LeBlanc, & Zubek, 2004), and a recent exergame compatible with the school PE curriculum, have been designed and applied at several primary schools. As far as we know, no research has used a natural experimental method with a control and experimental intervention applied by the same teacher to analyze the promotion of PEx with gamification and exergaming in schoolchildren. This natural intervention has already been studied and published previously from the psychological approach (in variables such as self-determination, flow, or basic psychological needs, academic performance) (Quintas, Bustamante, Pradas, & Castellar, 2020), and from a qualitative-hermeneutical approach (Quintas-Hijós, Peñarrubia-Lozano, & Bustamante, 2020). However, the ability of the intervention to promote physical exercise remains to be discovered and investigated.

The aim of this study was to analyze the effects of a gamified exergaming intervention on the psychological variables associated with promoting PEx. Psychological variables relevant to PE were measured (Martins et al., 2017), namely: achievement motivation, enjoyment, attitude toward exergames, exergame intention and PEx intention.

As the intervention of this study was based on the limitations and suggestions of other empirical studies, the hypotheses (H) were postulated in line with the results of previous studies (Fernandez, Méndez, Cecchini, & González, 2011; Franco & Coteron, 2017; Garn et al., 2012; Kari & Makkonen, 2014; Keskinen et al., 2014; Lee, Kim, Park, & Peng, 2017a; Li & Lwin, 2016; Lwin & Malik, 2014; Márquez et al., 2019; Mekler et al., 2017; Ntoumanis & Standage, 2009; Peng et al., 2012; Song et al., 2011; van Aart et al., 2017). Hence the gamified exergaming intervention will produce more achievement motivation (H_1), more enjoyment (H_2), a more positive attitude toward exergames (H_3), greater exergame intention (H_4) and greater PEx intention (H_5) in students than nongamified and nonexergaming intervention with time.

Material and Method

Sample

The sample comprised 417 students (53.2% girls, n=222; 46.8%, n=195) (see Table 1) from four primary schools (two public, two nonpublic). Their mean age was 11.1 (SD=1.7), and 50.4% of the sample studied primary school Year 6 (aged 10-11 years; n=210) and 49.6% studied primary school Year 7 (11-12 years; n=207) (see Table 1). The study was carried out in 22 groups-classes from the 4 schools (minimum ratio of children = 15, maximum = 25).

The criteria to select schools were: their material adequacy (facilities, Wi-Fi connectivity), public/private schools' diversity, their students' ethnic and socio-economic diversity, 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 by signed parental consent (n=418). As one student did not provide consent and was unable to participate in the study, no data about him were collected, although he went to class as normal. The study received the ethical approval of the Ethical Committee of Clinical Research of Aragón (Spain) (statement no.: 10/2017).

A chi-square analysis found no differences in distribution by sex χ^2 (1, N=417)=.018, p=.893. The independent samples t-test revealed no significant differences in attendance (t(381)=-1.065, p=0.287).

Study design

A natural experiment with a nonrandomized controlled design was conducted with a pre- and a post-measure. The study used a 2 x 2 factorial quasi-experimental design with two factors: treatment (traditional didactic treatment vs. gamified exergaming treatment) and temporal evolution (pre-treatment time vs. post-treatment time). 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).

The experimental treatment was designed (gamified exergaming intervention; Figure 1), based on usual didactic dance teaching in Spanish PE (Larraz, 2012), and added a gamified climate in class and used an exergame. Another treatment was designed, the control one (traditional didactic intervention; Figure 2), which was similar to the experimental treatment, but without either the gamified climate in class or the exergame. Before receiving any educational treatment, each student personally completed the digital questionnaires using computers or tablets during a school session. Each treatment lasted 12 sessions, or 9 h, and was applied at each school for 4 weeks during curricular PE classes. Treatments were put into practice with the primary school Year-6 and Year-7 students. At each school, both the experimental treatment and control were applied, but each student received only one treatment, the experimental or the control, depending on whether he belonged to a Year 6 or Year 7. The school year (Year 6 or Year 7) at which each intervention was implemented was randomly decided. It was decided, for ethical reasons, that all class-groups from the same school and Year receive the same treatment. At the end of the 4-week program, the participants filled out the questionnaires under the same conditions. Data collection took place between September 2017 and July 2018.

The traditional didactic treatment and the gamified exergaming treatment were applied in the same way by the same teacher-researcher at all four schools in the different cities for 10 months; that is, the same teacher taught the entire study sample to, thus, reduce any intervention bias stemming from several involved teachers. The teacher was not the usual teacher they had in each school, but only taught the classes for this study.

Materials

The gamification system based on Points-Badges-Leaderboards has been the most widely applied and well-studied. However, it only matches one type of player: "achievers" (Bartle, 2003). Therefore, the Mechanics-Dynamics-Aesthetics (MDA) framework by Hunicke et al. (2004) was used to achieve mastery-oriented motivational climates and an inclusive gamified atmosphere for all types of student-players. Mechanics refers to the system's set of constituent elements, the relation linking 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 interaction as it is designed (beauty) and the sensations-emotions felt by students while playing (Quintas, 2020). The MDA framework was adapted to the education field, and all the applied elements are specified in Table 2. 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 personalizing avatars. Self-referential situations with an epic cooperative group sense were used to promote motivation in all the student types, and even with those who were not competitive.

To facilitate the application of many MDA framework elements (Table 2), the *ClassDojo* app was used because it is one of the most widespread technological applications (Torres, 2017). This application allows to evaluate or measure with a scientific purpose, it is suitable for daily teaching, it has a high esthetic component and is related to primary education (Casanova & Serrano, 2019). Each student's points accumulated in the ClassDojo app and could be consulted by students at any time, even at home.

In the experimental group, the *Just Dance Now* exergame web platform was employed (https://justdancenow.com/). Students could dance in groups in front of a large projected screen while they held a Samsung J3 smartphone in their right hand (see Fig. 1). As smartphones had an accelerometer that detected movement, each smartphone detected every student's dance points. The control group learned to dance without using any gamifier resource or exergame (see Fig. 2). The *Just Dance Now* exergame was employed because it is compatible with school facilities and is based on accessible materials (screen projector, laptop, smartphone, the Internet). It use is also justified by its great commercial success worldwide, its marked usage in young people's leisure time (Allsop, Rumbold, Debuse, & Dodd-Reynolds, 2013) and it has been scientifically studied (Gao, Lee, Pope, & Zhang, 2016; Li & Lwin, 2016; Lin, 2015). The experimental treatment design allowed all the students to dance several times during all the sessions.

Measures

Achievement motivation. Students filled in the Achievement Motivation in Physical Education Test (AMPET) (Nishida, 1988), validated and adapted to the Spanish population (Graupera et al., 2004), which comprises 37 items. Items were measured on a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree; the Cronbach α applied to our sample=.84). This scale measured achievement motivation with three dimensions: engagement and dedication in learning (α=.88), PMC (α=.81), and anxiety before error and stress situations (α=.91) (see the Appendix).

Enjoyment. The participants completed the Sport Satisfaction Instrument (SSI), validated and adapted to PE and the Spanish population by Baena, Granero-Gallegos, Bracho-Amador, y Pérez-Quero (2012), which contains eight items. Items were measured on a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). This instrument measures two independent constructs: enjoyment (α=.81) and boredom (α=.54). To achieve acceptable reliability for "boredom" (α=.71), the second item was eliminated ("*In Physical Education classes, I often daydream instead of thinking about what I'm really doing, already warned by them*"), as pointed out by (Baena et al., 2012) (see the Appendix).

Attitude toward exergames. Students filled in the "Attitudes Toward Exergames" scale, created and validated by Ho et al. (2017) with children aged 9-12 years. It has been translated into Spanish and replaces "X-Box kinect" with a "video game in which I have to move my whole body". This instrument is composed of four items, and measures attitudes toward exergames on a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree; α=.95) (see the Appendix).

Exergame intention. Participants filled in the "Exergame intention" scale based on Li y Lwin (2016) by replacing "the game" with "a video game in which I have to move my whole body". Four questions were asked and answers were selected on a five-point scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree; α=.91) (see the Appendix).

PEx intention. Students completed the "Exercise Intention" scale created by Li y Lwin (2016). This instrument comprises four items. It measures exercise intention on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree; α=.91) (see the Appendix).

Statistical analyses

The baseline differences between groups were compared by an independent *t*-test for the normally distributed variables and the Mann-Whitney U test for the abnormally distributed variables (see Table 3). To test the research H, the two study groups were compared using factorial ANOVAs 2 (time; pre-treatment condition vs. post-treatment condition) x 2 (treatment; traditional didactic intervention vs. gamified exergaming intervention). One-way ANOVAs were also applied to clarify the obtained effects and the interpretative process. The effect size was calculated by eta partial eta-squared (η_p^2), and the analysis threshold was set at ≤ 0.0125 with Bonferroni adjustment. This adjustment is adequate to gain validity with such a design and the statistical analysis of multiple comparisons as it is a more restrictive criterion that reduces the probability of committing type I errors; that is, a false-positive (Bland & Altman, 1995). All the statistical analyses were performed using SPSS (version 22.0, https://www.ibm.com/es-es/analytics/spss-statistics-software).

Results

The means and standard deviations of all the variables of the treatments can be found in Table 3. The H testing is shown below.

H_1 predicted that, with time, the gamified exergaming education intervention would produce more achievement motivation in students than the nongamified and nonexergaming intervention. No interaction effect (Time X Treatment) was found ($p>.0125$). However, a time effect was noted on achievement motivation ($F(1)=11.83$, $p=.001$, $\eta_p^2=.032$). Performing a more specific analysis in each group by a one-way ANOVA (Post-Pre) showed that the control group displayed less achievement motivation with time ($F(1)=12.19$, $p=.001$, $\eta_p^2=.072$). However, the experimental group did not significantly display greater or lesser achievement motivation with time ($F(1)=1.45$, $p=.229$, $\eta_p^2=.007$). Thus H_1 was not supported.

H_2 predicted that, with time, the gamified exergaming education intervention would produce more enjoyment in students than the nongamified and nonexergaming intervention. An interaction effect was found on enjoyment ($F(1)=7.56$, $p=.006$, $\eta_p^2=.02$) (see Figure 3). Thus H_2 was supported.

H_3 predicted that, with time, the gamified exergaming education intervention would produce a more positive attitude toward exergames in students than the nongamified and nonexergaming intervention. An interaction effect ($F(1)=7.08$, $p=.008$, $\eta_p^2=.018$, see Figure 4) and a treatment effect ($F(1)=24.64$, $p=.000$, $\eta_p^2=.06$) on attitude toward exergames took place. Thus H_3 was supported.

H_4 predicted that, with time, the gamified exergaming education intervention would produce more exergame intention in students than the nongamified and nonexergaming intervention. No interaction effect (Time X Treatment) was found ($p>.0125$), but a treatment effect on exergame intention was noted ($F(1)=22.94$, $p=.000$, $\eta_p^2=.056$). Performing a more specific analysis in each group by a one-way ANOVA (Post-Pre) showed that the experimental group's exergame intention significantly improved with time ($F(1)=4.8$, $p=.03$, $\eta_p^2=.023$), which was not observed with the control group. Thus H_4 was not supported.

H_5 predicted that, with time, the gamified exergaming education intervention would produce a more PEx intention in students than the nongamified and no-exergaming intervention. No interaction effect or main effects were found on PEx intention ($p>.0125$). Thus H_5 was not supported.

Discussion

The aim of this study was to analyze the effects of a gamified exergaming school intervention on the psychological variables associated with PEx promotion. The hypothesis test allowed us to affirm that a gamified exergaming educational intervention, compared to another almost identical intervention, but with neither gamification nor exergames, could have some positive effects on the variables associated with promoting PEx, like enjoyment or attitude toward exergames. That is, the experimental intervention would apparently have more benefits than the control intervention for some variables associated with promoting PEx, but not directly for exercise intention.

The results of the present study on achievement motivation suggest a differential effect of the gamified exergaming educational intervention compared to the nongamified and nonexergaming intervention. Although no interaction effect was obtained, the results revealed a lower achievement motivation level in the control group with time, which was not observed in the experimental group. This effect could be related to increased engagement and delivery in learning (Bronner et al., 2015; Sun, 2013). The experimental group's engagement might be associated with a high cognitive ability, derived from the adjusted difficulty applied of gamified design (Best, 2012), or having made more physical effort and higher usability points (Bronner et al., 2015).

The experimental group obtained more enjoyable experience than the control group, which coincides with Garn et al. (2012). The explanation for this improvement probably stems from the presence of continuous feedback, challenge and rewards (Lyons, 2015), which students did not interpret as controlling factors (Hanus & Fox, 2015), and are essential in both exergame and gamification. Enjoyment is the feature of the current gamified intervention that would most promote PEx and the future use of exergames because it is a significant predictor of both play duration and the number of times for play to occur (Limperos & Schmierbach, 2016).

The best beneficial effects obtained in the experimental treatment on attitude toward exergames coincided with the findings of some studies with a similar study design (Garn et al., 2012), and also with studies that included a different methodological control (Campelo et al., 2015; Keskinen et al., 2014). This attitudinal improvement may be due to greater lived enjoyment (Li & Lwin, 2016). However, more positive results were expected for exergame intention (Lin, 2015) and PEx intention, despite having found a treatment effect on exergame intention. These results contrast with the study which found that playing exegames could improve participants' attitudes toward and intention to do other forms of PEx (Garn et al., 2012; Lwin & Malik, 2012; Nguyen et al., 2016). These differences may be due to the selection of sedentary or obese populations (Garn et al., 2012), not using the official PE subject hours (Lwin & Malik, 2012; Nguyen et al., 2016), or participants were older (Nguyen et al., 2016). Besides, it is possible that no mastery-oriented motivational climate was built. According to the AGT (Nicholls, 1984), this would explain lack of improvement in achievement motivation-related dimensions like PMC and, therefore, lack of PEx intention. Other studies have reported that exergames failed to promote PEx because participants considered them boring (Lau et al., 2016), but we did not find this reason. The ability of both exergame and gamification to produce PEx remains unclear, and more studies need to be done.

This study has several limitations. One-month interventions (9 h) have been carried out given the traditional way of scheduling school contents. However, longitudinal studies are necessary to ascertain the long-term psychological effects. Another study limitation is its didactic-scientific design with no single differentiating factor between the experimental and control groups because the experimental group engaged in both a gamified and (at the same time) an exergaming intervention. However, both treatments were equivalents for the other didactic elements. Future research could propose studies that specifically and separately analyze the effects of these two factors. Given our study design, the obtained results are generalizable to contexts based on gamification and exergame at school ages. However, the gender effect may have been important because, in Spain, there are cultural dance associations with girls (Azevedo et al., 2014), and some of video games with boys (Díez-Gutiérrez et al., 2004). Thus it would be very interesting to analyze gamification and exergame in a content other than dance, and to also take into account other variables related to PE, such as the actual amount of exercise performed in noneducation contexts.

To conclude, this study is the first to examine an intervention that combines MDA gamification as a didactic method and exergame as an educational resource, adopted as a strategy to promote the variables associated with encouraging PEx in primary schools. A rigorous scientific design in schools was implemented, and groups were compared, along with reliable measures such as scientific literature requests. This study evidences the possibility of joining methodological control techniques and the good naturalness of the education context. This is the only empirical study based on a natural experiment that has investigated educational gamification and exergaming with significant results. The discovered positive effects on enjoyment and attitude toward exergames make this study one of the very few that provides positive evidence for educational gamification. Improved enjoyment suggests that gamified design generates a more task-oriented motivational climate, but no conclusive results for the PEx intention variable were obtained. The ability of gamification and exergame as an exercise promotion strategy is not yet clear and future research should be conducted.

Declaration of interest statement

The authors have declared that no competing interests exist.

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Table 1. The applied MDA framework elements (extracted from Quintas, Bustamante, Pradas & Castellar (2020))

<table>
<tr><th>Mechanics</th><th>Dynamics</th><th>Aesthetics</th></tr>
<tr><td>Dance performance point</td><td rowspan="4">Reinforcement Cumulability</td><td rowspan="2">Pleasure, Satisfaction, absortion</td></tr>
<tr><td>Creativity point</td></tr>
<tr><td>Attention point</td><td rowspan="2">Social membership</td></tr>
<tr><td>Good behavior point</td></tr>
<tr><td>Design a choreography</td><td>Self-expression</td><td>Pleasure, Identity</td></tr>
<tr><td>Design a group choreography</td><td>Cooperation</td><td>Social membership</td></tr>
<tr><td>Leaderboard</td><td>Competition</td><td>Social membership, Identity</td></tr>
<tr><td>Star badge (perfect dance)</td><td rowspan="2">Reinforcement Progress Collectability</td><td>Satisfaction</td></tr>
<tr><td>Green badge (for individual improvement).</td><td>Fun, Pleasure, Interest</td></tr>
<tr><td>Group Green Badge</td><td rowspan="2">Cooperation Collectability</td><td rowspan="5">Social membership, Identity</td></tr>
<tr><td>Group improvement point</td></tr>
<tr><td>Best Dancers Badges</td><td rowspan="2">Competition</td></tr>
<tr><td>Badge dancers that have improved the most</td></tr>
<tr><td>Point helping the team</td><td>Cooperation, Collectability</td></tr>
<tr><td>Point of dance plank</td><td>Status Competition</td><td>Identity, absortion</td></tr>
<tr><td>Custom avatar</td><td>Self-expression</td><td>Customise, Identity, Beauty</td></tr>
</table>

Increasingly difficult dance levels	Progress	Fun, Satisfaction, Interest
Choosing dance Level 9 from more than 300 dances.	Self-expression	Identity, Customize
Just Dance Now and ClassDojo interface	Progress	Beauty, absortion
Music in all classes	Self-expression	Interest, Pleasure

Table 2. Descriptive data in the variables of interest: mean and standard deviation (sample size)

	Control Treatment		Experimental Treatment	
	Baseline	Follow-up	Baseline	Follow-up
Attendance	-	9.61 ± .79 (191)	-	9.69 ± .69 (226)
Achievement motivation	114.76 ± 15.86 (159)	110.73 ± 14.09 (159)	115.22 ± 15.37 (199)	114.02 ± 15.8 (199)
Engagement and delivery in learning	60.52 ± 8.59 (171)	58.15 ± 9.66 (171)	60.49 ± 7.9 (205)	59.21 ± 8.28 (205)
Perceived motor competence	19.59 ± 5.81 (178)	19.2 ± 5.9 (178)	20.25 ± 6.08 (214)	20.42 ± 5.65 (214)
Anxiety in the face of error and stress situations	33.98 ± 12.23 (172)	33.67 ± 12.58 (172)	34.89 ± 12.69 (208)	35.02 ± 13.56 (208)
Satisfaction towards PE	27.74 ± 2.89 (178)	26.97 ± 3.54 (178)	27.35 ± 3.39 (218)	27.41 ± 3.34 (218)
Enjoyment in PE	22.76 ± 3.05 (166)*	22.13 ± 3.22 (166)	21.85 ± 3.71 (211)*	22.22 ± 3.18 (211)
Boredom in PE	3.1 ± 1.94 (174)	3.34 ± 1.85 (174)	3.41 ± 2.01 (215)	3.26 ± 1.78 (215)
Attitude toward exergames	22.63 ± 6.18 (177)	21.79 ± 7.10 (177)	23.55 ± 5.2 (211)	24.93 ± 4.43 (211)
Exergame intention	14.55 ± 4.87 (177)	14.36 ± 5.43 (177)	16.01 ± 4.02 (209)	16.66 ± 3.51 (209)

Physical exercise intention	15.77 ± 4.38 (177)	15.72 ± 4.53 (177)	15.38 ± 4.21 (216)	15.75 ± 3.97 (216)

* Significant differences between groups at the baseline were found (t(374)=2.613, p=.009).

Figure 1. Experimental group dancing level 1 'Rasputin' with smartphones held in hands

Figure 2. Control group dancing salsa without either an exergame or gamification

Figure 3. Interaction effect on enjoyment

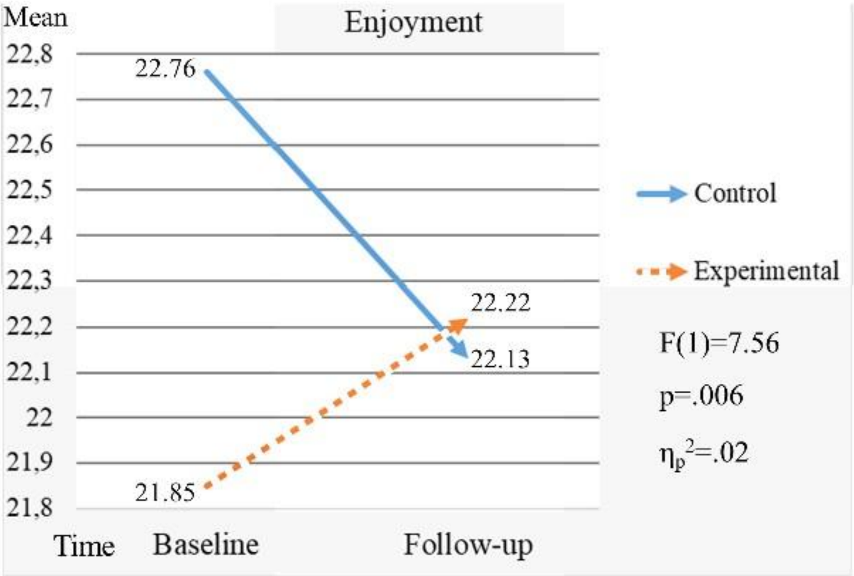

Figure 4. Interaction effect on attitude toward exergames