This is a previous version of the article published in Physical Education and Sport Pedagogy. 2024, 29(2): 160-176. https://doi.org/10.1080/17408989.2022.2039611

The Effects of Gamification on the Motivation and Basic Psychological Needs of Secondary School Physical Education Students

Victor Javier Sotos-Martinez[a], Alberto Ferriz-Valero[a]*, Salvador García-Martínez[a] and Juan Tortosa-Martinez[a]

[a]*Department of General and Specifics Didactics, University of Alicante, 03690 San Vicente del Raspeig, Spain*

**Corresponding author: Facultad Educación, Calle Aeroplano, S/N, 03690, San Vicente del Raspeig, Spain. Tlf: +34 965903400 (ext-1219) alberto.ferriz@ua.es*

Brief biography of authors:

Victor Javier Sotos-Martinez: Is a PhD Student in the Faculty of Education at University of Alicante, Spain.

Alberto Ferriz-Valero: PhD, is an Assistant Professor in the Faculty of Education at University of Alicante, Spain. He currently has more than 10 years of experience as a teacher of Physical Education in education public centres (primary, secondary and high schools)

Salvador García-Martínez: Is an Assistant Professor in the Faculty of Education at University of Alicante, Spain. He currently has more than 20 years of experience as a teacher of Physical Education in education public centres (primary, secondary and high schools)

Juan Tortosa-Martínez: PhD, is a Senior lecturer in Physical Education and Sports Science at the University of Alicante's Faculty of Education. Vice Dean of Master's Degrees and Research.

The Effects of Gamification on the Motivation and Basic Psychological Needs of Secondary School Physical Education Students

Abstract

Background: Gamification is a novel active methodology used in Physical Education to motivate students. Purpose: This study analyzed the impact of this method on the motivation of Compulsory Secondary Education students in Spain during an 8-session Physical Education Didactic Unit. Methods: A total of 275 students participated, divided into a gamified group (n = 133) and a control group (n = 142). The participants filled out 2 questionnaires, one aimed at assessing Basic Psychological Needs (BPNs) (Basic Psychological Needs in Exercise Scale) and the other at measuring the motivational component (The Sport Motivation Scale). Results: An interaction effect (Time x Treatment) was found, with the gamified group improving in BPNs (autonomy ($F(1) = 57.97$, $p = <0.001$; $\eta^2_p = 0.175$); competence ($F(1) = 37.28$, $p = <0.001$; $\eta^2_p = 0.120$); relatedness ($F(1) = 51.49$, $p = <0.001$; $\eta^2_p = 0.159$), and intrinsic motivation ($F(1) = 39.65$, $p = <0.001$; $\eta^2_p = 0.127$), while decreasing in amotivation ($F(1) = 21.42$, $p = <0.001$; $\eta^2_p = 0.073$). Conclusions: These data suggest that a gamified intervention enhances the satisfaction of the basic psychological needs, increases intrinsic motivation, while decreases amotivation in secondary education students.

Keywords: Data science applications in education; Improving classroom teaching; Informal learning; Teaching/learning strategies; Secondary education

1. Introduction

Unlike in other academic subjects, Physical Education (PE) proposes most of the teaching-learning activities from a physical (motor) point of view and makes extensive use of games as a didactic resource. Most students enjoy motor learning through games or forms of play, sports, etc. (Castañer and Camerino 2011), because they encourage interaction, collaboration and motivation to learn (Monguillot et al. 2015). However, a minority of students do not always enjoy or feel motivated by the subject's contents (Ntoumanis 2001), especially in secondary education (Fernandez-Rio et al. 2020), either because the subject does not satisfy their Basic Psychological Needs (BPNs; autonomy, competence and relatedness), because their personal experiences in the discipline have not been positive (Van Der Horst et al. 2007) or because technology captures students' interest, thereby reducing motivation for physical practice in favor of electronics entertainment (Puig Gimeno, Llamas Salguero, and Portolés Ariño 2015; Castro-Sánchez et al. 2017).

As such, motivational processes must be considered, as motivation regulates the determination or desire of the students' behavior (e.g., participation during PE class). For that purpose, the macro-theory of Self-determination (SDT, Ryan and Deci 2020) is among the theoretical frameworks that best contextualize students' motivation and psychological well-being as essential success factors at school (Lamas Rojas 2008; Carrasco-Ramírez, Matamoros-Rodríguez, and Flores-Aguilar 2019). Within SDT, the Theory of BPNs (Ryan and Deci 2000) advances three fundamental psychological needs: *autonomy*, based on the desire to feel a "locus" of causality, that is, to feel that one's actions are directly related to the result; *competence* refers to believing in one's ability or capacity to perform an activity or task effectively and efficiently; and *relatedness*, i.e. a sense of belonging to the group

(Ryan and Deci 2017). Meeting these needs promotes psychological well-being (Ryan and Deci 2019). In fact, autonomy and relatedness deserve special attention in early childhood since these factors have been linked to greater cognitive abilities such as executive functioning (Bindman, Pomerantz, and Roisman 2015) or academic commitment and performance (Vasquez et al. 2015).

The BPNs theory is a precursor to other mini-theories within SDT. These other mini-theories differentiate three types of motivations that regulate human behavior: *intrinsic motivation* (IM), based on the performance of an activity giving satisfaction per se (described in detail in the cognitive evaluation theory or CET); *extrinsic motivation* (EM), based on performing the activity to gain external recognition or the means to achieve something (Organic Integration Theory, OIT); and *amotivation* (AM), that is, the lack of motivation towards the activity (Ryan and Deci 2017). OIT describes different subtypes of EM, some controlled and some more autonomous (Ryan and Deci 2019). On the controlled side, a student can be motivated due to coercion, reward contingencies or external pressures, motives classified as external regulation (ER). Another type of EM within the controlled side is introjected regulation (IntroR) (somewhat external). This term concerns EM that has been partially internalized. In this case, behaviors are regulated by the internal rewards of self-esteem for success and by avoidance of anxiety, shame, or guilt for failure. Thus, focus on approval from self and others is highly present. On the more autonomous side of extrinsic motives, we find identified (IdR) and integrated (IntR) regulations. The first term describes how students consciously accept the worth and value of the activity. The second term, the most autonomous form of EM, involves that the student not only

recognizes and identifies with the value of the activity but also finds it to be congruent with other core interests and values.

According to the above, new pedagogical models have emerged to improve the psychological well-being and motivation of PE students to be more active during and after school hours (Jaakkola, Washington, and Yli-Piipari 2012; Shen 2014). Researchers in the field of education have become increasingly interested in a new pedagogical model called gamification (Werbach 2014). This term has been defined based on several different perspectives. One of the most widely used definitions was proposed by Deterding et al. (2011) who describes it as items from games used in other environments. Gamification was later defined as trying to resemble an activity to a game (Werbach 2014) or as a process to improve the experience of an activity through play to increase the value perceived by users (Huotari and Hamari 2012). Gamification has already been widely used in other disciplines such as marketing, healthcare, human resources, training, environmental protection and well-being (Dichev and Dicheva 2017), or other curricular and academic fields such as higher education (Dicheva et al. 2015). In the domain of PE, it represents an active and innovative pedagogical approach that has grown in importance over the last five years. In university students, Pérez-López, Rivera García, and Trigueros Cervantes (2017) created a gamified implementation called '*The Prophecy of the Chosen Ones*' directed towards students enrolled in the university degree for becoming a primary education teacher, specialized in PE. The qualitative results of this study showed that the intervention led students to gain a sense of control and responsibility, replacing the usual objective of simply passing the subject with learning how to learn. Similarly, Ferriz-Valero et al. (2020) conducted a gamified intervention using the Gamified ClassCraft®, also with university

students in the PE subject. The quantitative results indicated an increase in ER, without the students' levels of IM being affected.

Regarding secondary school students, several studies have been conducted in the field of PE. Monguillot et al. (2015) designed a fitness unit called *'Play the Game'* in which the authors concluded, based on qualitative results, that applying this learning technique increased motivation and encouraged the development of healthy habits. In this line, Fernandez-Rio et al. (2020) carried out a very complete gamified intervention from which they extracted quantitative and qualitative data. The results showed that IM increased after the intervention, most notably in students who were initially less motivated. Another study conducted with primary school students (Rutberg and Lindqvist 2018) stated that participation, motivation and learning improved with a gamified learning approach. Furthermore, these authors claimed that links between students were created. Also, in primary school pupils (10-11 years), Dolera-Montoya et al. (2021) noted that ER and Am decreased after a gamified intervention but BPNs did not change. On the contrary, in another study with primary school students on gamified didactics, using exergames, the BPNs of the group that experienced gamification improved, although no changes in the motivational variables were observed (Quintas et al. 2020). Finally, in secondary students, it was observed that motivation, cooperative work and commitment increased through the use of gamified learning approaches (Quintero González, Jiménez Jiménez, and Area Moreira 2018).

As illustrated, the scientific literature on the subject is scarce and the research that has been conducted is inconclusive as it fails to empirically support the effectiveness of gamification regarding PE students' BPNs and motivation. However, many of the studies in

which a gamified intervention was conducted did not include a control group to compare the changes produced (Martín-Moya et al. 2018; Castañeda-Vázquez et al. 2019). Control groups allow lending additional support to the fact that the changes produced are due to the practice executed in the study and not to some other external factor. In addition, some studies present methodological limitations, such as lack of probabilistic sampling (Castañeda-Vázquez et al. 2019; Ferriz-Valero et al. 2019). Innovative educational interventions should have a scientific basis, determining whether students learn more and better (Quintas et al. 2020). Therefore, new studies focusing on the effects of this methodology on the different aspects influencing students' teaching-learning processes are needed, as in the case of motivation (Carrasco-Ramírez, Matamoros-Rodríguez, and Flores-Aguilar 2019).

For this reason, the objective of the present work was to analyze the impact of a gamified intervention in secondary school PE classes compared to a non-gamified intervention, on students' psychological variables, i.e. motivation and BPNs.

Based on the literature in the field, the following hypotheses are formulated:

H1. A gamified implementation in PE classes will significantly increase BPNs (autonomy, competence and relatedness) compared to the non-gamified group (According to the results of Martín-Moya et al. 2018; Quintas et al. 2020; Quintero González, Jiménez Jiménez, and Area Moreira 2018; Rutberg and Lindqvist 2018).

H2. A gamified implementation in PE classes will significantly increase IM compared to the non-gamified group (According to the results of Quintero González, Jiménez Jiménez, and Area Moreira 2018; Rutberg and Lindqvist 2018; Fernandez-Rio et al. 2020).

H3. A gamified implementation in PE classes will significantly increase EM (integrated, identified, introjected and external regulation) compared to the non-gamified group. (According to the results of Ferriz-Valero et al. 2020).

H4. A gamified implementation in PE classes will significantly decrease Am compared to the non-gamified group (According to the results of Dolera-Montoya 2021).

2. Methodology

Participants

Two secondary schools participated in the study from April to May 2019. The criteria for selecting schools were as follows: available materials and facilities; schools in different cities; the school's predisposition and that of the PE specialists; allowing teaching the same curricular elements in all participating schools; as well as giving access to the principal investigator who performed the gamified intervention.

The final sample was composed of 275 participants (148 boys: 53.8%, and 127 girls: 46.2%). The average age of the participants was 13.84 years (SD = 1.18). In addition, 30.55% of the sample belonged to Year 8 (12-13 years; n= 84), 23.64% belonged to Year 9 (13-14 years; n = 65), 36.36% belonged to Year 10 (year 10, 14-15 years; n = 100), and 9.45% belonged to Year 11 (15-16 years; n = 26) in compulsory secondary education. A total of 22 students were excluded from the study because they met one or more of the following exclusion criteria: (a) did not attend PE classes regularly, i.e. <80% of all sessions (n = 13); (b) did not complete the questionnaires (n = 6), and; (c) did not sign the informed consent (n = 3).

All participants and legal guardians were informed of the study's benefits and potential risks. Both, participants and their legal guardians voluntarily signed the informed consent in accordance with the principles of the Helsinki Declaration (1975). They unanimously approved the publication of the data. Based on the above, the study was approved by the ethics committee of the University of XXXXXX (XX-2020-09-02). This research was funded by the University of XXXXXX, grant number "XXXX".

Design of the study

The research was conducted during the 2018/19 academic year, in the context of the PE subject, included within the Spanish Secondary Education curriculum. The study was based on a natural experimental design, including an experimental group (EG) and a control group (CG), as well as pre- and post-intervention measures. To test the postulated hypotheses, four groups were assigned to the CG and four others were assigned to the EG following a cluster-randomized sampling, maintaining one EG and one CG by educational level.

The CG was used as the non-gamified reference (Campbell and Stanley 2012). In this way, we controlled for the possible effects attributable to the school itself, by giving the same content, with the same methodology and by the same teacher (main researcher) in each pair of levels. Designs previously used in similar studies were considered (Fernandez-Rio et al. 2020; Quintas et al. 2020).

Intervention programme

According to Hastie and Casey (2014), a rigorous intervention should detail: (a) a rich description of the unit's curricular elements; (b) a detailed validation of the intervention

model; and (c), a detailed description of the programme's context. We thus detail these sections below as accurately as possible.

The intervention programme was conducted by a teacher (principal investigator) who was not familiar with the students, though he was accompanied by the teacher in charge of the group. Only one teacher conducted the intervention and remained in charge at all times, limiting any possible bias deriving from the intervention of various professionals. The principal investigator was specifically trained in the implementation of gamified pedagogical approaches, using communication technologies. The intervention programme was conducted during 8 classes in 5 weeks, lasting 55 minutes each. Each course worked on different teaching content, according to the mission statement and curricular plan. Both the EG and the CG followed the same contents within the same course during 8 sessions in total (the **supplementary document on standard lessons).**

Unlike the CG, all EG sessions were conducted using the ClassCraft gamified ICTtool ® (https://www.classcraft.com). This tool includes an educational gamified and collaborative learning proposal.

All participants had their personal and non-transferable accounts, which allowed them to access and create their custom avatars. Students could choose one of three characters: Mage, Warrior or Healer who have different powers which can help the player's team or clan by encouraging interactions and teamwork within the same clan (**Figure 1**).

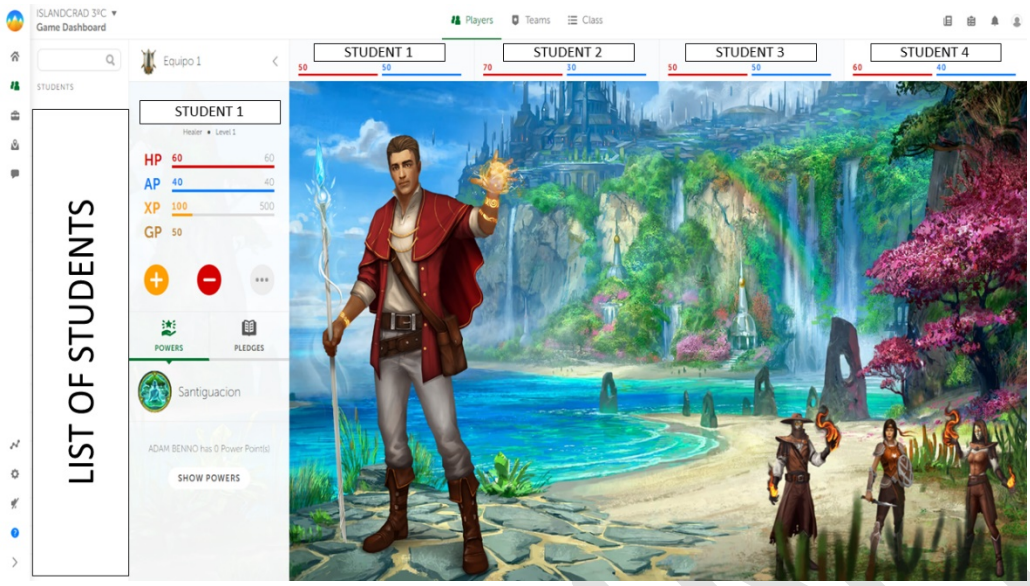

Figure 1. Teacher's view of the Classcraft interface showing the different types of points.

The gamification tool allows evaluating certain behaviors and redirecting them, considering the ultimate goal of achieving the subject's objectives (**Table 1**). These behaviors determine a student's progress, as they allow earning different kinds of points: XP (Experience Points), HP (Health Points), PP (Power Points), AP (Action Points), and GP (Golden Pieces). In this way, the points are used as a reinforcement or punishing tool to increase or decrease given behaviors (Skinner 1988).

Table 1. Equivalences between behaviours and points in ClassCraft®.

	(+) EXPERIENCE POINTS		*(-) HEALTH POINTS*	
BEHAVIOURS	*+50 XP*	*Clears the space used*	*-25 HP*	*Inappropriate language in front of peers or teacher*
	+150 XP	*Finds information about the topic for next class*	*-20 HP*	*Fails to perform the tasks or activities*
	+100 XP	*Actively participates in the group's work*	*-10 HP*	*Fails to bring the session's material*
	+75 XP	*Meets the session's objectives*	*-15 HP*	*Non-justified absences*
	+30 XP	*Asks questions of interest*	*-40 HP*	*Intimidation*

To implement the gamified classes with ClassCraft, the following equivalences were established between points and rewards (powers) or punishments (sentences, **Table 2**). In the latter, students could choose between carrying out the proposed event or accepting the punishment, damaging the character.

Table 2. Equivalent sentences and effect in ClassCraft®.

SENTENCES	*- 50 Ap*	*You've separated from your group, and no, you can't go back, you manage to survive on plants and stagnant water, but to make them drinkable you need to use AP*
	-1 XP level	*After playing against Rafael Nadal and losing, you don't get to play against someone else and you stay at home for a while eating ice cream and without training*
	-1 XP level	*Show me... you know that in F1, in motoGP and in athletic sports, the faster the better, right? Well, you've gone too fast here, and that slip made you fall, you can't remember anything after last week.*
	- 50 Ap	*Why did you dive to get that ball? You're going to need to be cured, but the healer needs AP to do that.*

**** Sentences apply when students run out of HP points.***

The CG held the same sessions corresponding to the didactic units of work mentioned above, maintaining the same activities, content, competencies, evaluation criteria and objectives to be achieved as the EG. The only difference was the implementation of the ClassCraft® tool in the EG.

A major advantage of ClassCraft® as a gamified tool is the possibility of implementing the model based on Points-Badges-Leaderboards (PBL) as the model based on Mechanics-Dynamics-Aesthetics (MDA). PBL is included when providing rewards to the student avatar. These rewards are transformed into game-specific advantages which will be meaningless if the challenge isn't big enough (Chou 2016). MDA is implicitly exposed in ClassCraft® as students are grouped into clans and the components of the intervention can

be divided into a) mechanical ones, that describe available processes and actions of the game; b) dynamics, that describe the dynamics of actions between themselves; c) aesthetics, which describe the emotional responses triggered in students (Shi et al. 2014; Buttfield-Addison, Manning, and Nugent 2016) (Table 3).

Table 3. Gamified didactic design from an MDA model.

Mechanics	Dynamics	Aesthetics	
System of earning and losing points	Value of points	Pleasure	Socialisation
Characters and Avatars	Perception of the plot	Satisfaction	Wonder
Classifications	Cooperation	Fun	Support
Teams	Competence	Empathy	Commitment
Powers	Self-expression	Interest	Freedom
Behaviours	Perceived difficulty	Excitement	Group spirit
Standards	Responsibilities acquired according to the character	Narrative	
Levels of difficulty	Progress		
Events and Notifications			
Narrative			

Measuring instruments

Participants filled out two questionnaires before and after the intervention.

Basic Psychological Needs (BPNs). The Spanish version of the Basic Psychological Needs in Exercise Scale (BPNES) (Vlachopoulos and Michailidou 2006), adapted to the context of PE (Moreno Murcia et al. 2008) was used. The questionnaire contains 12 items, grouped into three factors (four items per factor) which measure: *autonomy* (e.g., "The exercises I perform are according to my interests."), *competence* (e.g., "I feel that I have made a great step forward concerning the final goal that I have proposed.") and *relatedness*

(e.g., “I feel very comfortable when I exercise with the other classmates.”). The version used was preceded by the following introductory sentence: “In my PE classes…”. Two samples of 370 and 364 Spanish high-school students, aged between 14 and 16 years, were used in the original validation. The results of the CFA indicated acceptable adjustment of the data (χ^2/df = 3.29; RMSEA = 0.07; CFI = 0.94; IFI = 0.094; TLI = 0.92; SRMR = 0.07) (Moreno Murcia et al. 2008). In our study, Cronbach's alpha values were 0.85 for autonomy satisfaction, 0.88 for perceived competence and 0.83 for relatedness.

Motivation regulations. The Spanish version of the Sport Motivation Scale (SMS-II-PE) (Pelletier et al. 1995) was used, translated, adapted to the Spanish context and validated with a sample of high school students by Granero-Gallegos et al. (2018). This questionnaire includes 18 items grouped six into factors (three items per factor) which measure: IM (e.g., “For the pleasure I feel while I perform physical and sports activity”), IntR (e.g., “Because the practice of a physical-sports activity is a fundamental part of my life”), IdR (e.g., “Because physical-sports activities are a way to develop myself”), IntroR (e.g., “Because I'd feel bad if I didn't participate and try my classes”), ER (e.g., “Because I get rewards from the people around me when I do”) and Am (e.g., “I used to participate and strive for classes, but now I wonder if I should continue to do so”). The scale used was preceded by the following introductory sentence: “I participate and I work in the PE classes…”. A sample of 1055 Spanish high school students, aged between 12 and 17 years, was used in the original validation. The results of the CFA indicated adequate adjustment of the data (χ^2 = 481.57, $p < 0.001$; χ^2/df = 4.01; RMSEA = 0.054 (IC90% = 0.049, 0.059); CFI = 0.94; TLI = 0.95; SRMR = 0.047) (Granero-Gallegos et al. 2018). In our study, the Cronbach's

alpha values were 0.79 for IM, 0.74 for IntR, 0.80 for IdR, 0.77 for IntroR, 0.81 for ER and 0.69 for Am.

Statistical Analysis

According to Faul et al. (2007), the statistical power of the sample size was calculated using the free software G*Power (Ver. 3.1.9.6, University of Dusseldorf, Germany). The sample size, 125 participants per group, with an estimated medium effect size (0.5), and a significance of 95%, resulted in a power of 0.97.

The SPSS 24.0 statistics software was used to carry out all the analyzes. Each factor's descriptive statistics (mean and standard deviation) were calculated. Shapiro-Wilk's normality test was performed, obtaining non-normal distributions in all cases ($p < 0.05$).

To analyze baseline differences between the experimental and the CG, a Mann-Whitney U test was carried out with the entire groups and then segmented by sex and grade. The Wilcoxon test was used to verify the intragroup effect of the intervention (pre-post). The effect size was also calculated using Microsoft Excel software (Dominguez-Lara 2018). This magnitude was regarded as small when values ranged between 0.1-0.3, medium between 0.3-0.5, and large if greater than 0.5 (Cohen 1988; Coolican 2009).

In order to verify the hypothesis, a repeated-measures analysis of variance (ANOVA 2x2) mixed model was used when pre-post differences were identified, to give robustness to the analysis (Andrade et al. 2019; Quintas et al. 2020). The dependent variables were six domains in motivation and three in BPNs. Time (pre- and post-intervention) was the within-subject factor, whereas the group (control vs. experimental) was the between-subject factor. Levene test was used to check for homoscedasticity, the Mauchly test for sphericity,

and the Box´s test for the equivalence of covariance matrices. All the assumptions were correctly met in the data set, except for data normality. The effect size of the ANOVA was calculated by the partial eta-squared (η^2_p). A 95% confidence interval was calculated for the differences and the significance value was set at $p < 0.05$. Finally, in terms of internal consistency, reliability was calculated with Cronbach's alpha.

3. Results

Baseline Differences

Baseline characteristics of both groups (CG and EG), also segmented by sex, are presented in Table 4 including baseline differences. At pre-test, both groups presented similar starting values regarding the research variables. No significant differences were found among treatment groups based on sex. Instead, the U Mann-Whitney test showed only significant differences among treatment groups in Year 9, for the IM variable (Z = -2.705; $p = 0.007$; highest in CG) and IdR (Z = -2.137; $p = 0.033$).

Basic Psychological Needs (BPNs)

Table 5 and Table 6 shows the results obtained after applying the U Mann-Whiney and the Wilcoxon test in the BPNs.

In tables 5 and 6, the results indicated that, after the intervention, the EG presented significant increases in all variables: autonomy (Z = -8.601; $p < 0.001$; ES = 0.746), competence (Z = -6.930; $p < 0.001$; ES = 0.601) and relatedness (Z = -8.097; $p < 0.001$; ES = 0.702), while the CG showed a significant increase only in autonomy (Z = -2.640; $p = 0.008$; ES = 0.222) (**Figure 2**). When these variables were analyzed according to sex, the same behavior for females and males was observed. When these variables were analyzed according to the school grade, the same change was observed in all variables except for the

variable 'Competence' in Year 11 students, which showed no differences after the intervention programme. Therefore, sex and school grade did not have a great influence on the overall results.

Table 4. Comparing components between EG and CG at baseline using Mann-Whitney test according to sex (Av±SD).

Sex	Components	EG	CG	Sig.
Total	**Intrinsic M.**	2.41 ± 0.90	2.39 ± 0.88	0.826
(n_{EG}=133;	**Integrated R.**	2.30 ± 0.80	2.44 ± 0.77	0.154
n_{CG}=142)	**Identified R.**	2.32 ± 0.89	2.43 ± 0.93	0.323
	Introjected R.	1.98 ± 0.90	1.99 ± 0.81	0.570
	External R.	1.94 ± 0.93	1.98 ± 0.95	0.626
	Amotivation	1.86 ± 0.87	1.93 ± 0.86	0.308
	Autonomy	2.89 ± 1.03	2.85 ± 1.10	0.689
	Competence	3.04 ± 1.17	3.07 ± 1.10	0.862
	Relatedness	3.16 ± 1.25	3.07 ± 1.16	0.580
Male	**Intrinsic M.**	2.42 ± 0.93	2.43 ± 0.92	0.960
(n_{EG}=70;	**Integrated R.**	2.36 ± 0.76	2.43 ± 0.80	0.594
n_{CG}=78)	**Identified R.**	2.20 ± 0.91	2.39 ± 0.99	0.236
	Introjected R.	1.96 ± 0.91	2.09 ± 0.88	0.277
	External R.	1.89 ± 0.91	1.94 ± 0.96	0.910
	Amotivation	1.85 ± 0.90	1.98 ± 0.90	0.288
	Autonomy	2.90 ± 1.00	2.91 ± 1.12	0.903
	Competence	3.00 ± 1.18	3.04 ± 1.19	0.834
	Relatedness	3.10 ± 1.22	3.09 ± 1.22	0.994
Female	**Intrinsic M.**	2.40 ± 0.88	2.35 ± 0.86	0.807
(n_{EG}=63;	**Integrated R.**	2.25 ± 0.87	2.45 ± 0.75	0.128
n_{CG}=64)	**Identified R.**	2.48 ± 0.87	2.49 ± 0.87	0.882
	Introjected R.	2.02 ± 0.90	1.89 ± 0.73	0.685
	External R.	2.00 ± 0.96	2.04 ± 0.96	0.969
	Amotivation	1.89 ± 0.84	1.89 ± 0.83	0.926
	Autonomy	2.88 ± 1.08	2.80 ± 1.10	0.679
	Competence	3.11 ± 1.17	3.12 ± 1.00	0.973
	Relatedness	3.23 ± 1.29	3.05 ± 1.11	0.420

EG= Experimental group; CG= Control group; Av= Average; SD= Standard Deviation; Sig = P-Value; Intrinsic Motivation = IM; integrated regulation = IntR; identified regulation = IdR; introjected regulation =IntroR; external regulation = ER; and amotivation = Am

Table 5. Comparing components between EG and CG at the end of study using Mann-Whitney according to sex (Av±SD).

Sex	Components	EG			CG			Sig.	ES
Total	**Intrinsic M.**	2.87	±	0.75	2.46	±	0.88	<0.001	0.358
(n_{EG}=133;	**Integrated R.**	2.32	±	0.80	2.45	±	0.74	0.183	-
n_{CG}=142)	**Identified R.**	2.37	±	0.86	2.44	±	0.89	0.579	-
	Introjected R.	1.88	±	0.87	2.02	±	0.82	0.047	-
	External R.	2.00	±	0.95	2.02	±	0.94	0.807	-
	Amotivation	1.50	±	0.59	1.94	±	0.89	<0.001	0.351
	Autonomy	3.58	±	1.00	2.98	±	1.11	<0.001	0.347
	Competence	3.60	±	1.09	3.12	±	1.14	<0.001	0.374
	Relatedness	3.75	±	1.16	3.08	±	1.14	<0.001	0.330
Male	**Intrinsic M.**	2.88	±	0.80	2.52	±	0.87	0.008	0.374
(n_{EG}=70;	**Integrated R.**	2.39	±	0.74	2.44	±	0.76	0.668	-
n_{CG}=78)	**Identified R.**	2.28	±	0.88	2.48	±	0.90	0.198	-
	Introjected R.	1.88	±	0.85	2.13	±	0.87	0.034	0.400
	External R.	2.00	±	0.90	1.99	±	0.93	0.895	-
	Amotivation	1.55	±	0.66	2.06	±	0.94	0.001	0.340
	Autonomy	3.54	±	1.00	3.07	±	1.09	0.009	0.375
	Competence	3.49	±	1.11	3.13	±	1.17	0.056	-
	Relatedness	3.61	±	1.19	3.18	±	1.15	0.020	0.389
Female	**Intrinsic M.**	2.88	±	0.71	2.39	±	0.91	0.001	0.339
(n_{EG}=63;	**Integrated R.**	2.26	±	0.87	2.46	±	0.72	0.130	-
n_{CG}=64)	**Identified R.**	2.49	±	0.84	2.41	±	0.89	0.563	-
	Introjected R.	1.89	±	0.90	1.90	±	0.75	0.507	-
	External R.	2.01	±	1.01	2.06	±	0.96	0.647	-
	Amotivation	1.44	±	0.52	1.82	±	0.83	0.006	0.364
	Autonomy	3.65	±	1.02	2.88	±	1.14	<0.001	0.316
	Competence	3.74	±	1.07	3.11	±	1.12	0.001	0.333
	Relatedness	3.90	±	1.12	2.98	±	1.13	<0.001	0.265

EG= Experimental group; CG= Control group; Av= Average; SD= Standard Deviation; Sig = P-Value; ES = Effect Size; Intrinsic Motivation = IM; integrated regulation = IntR; identified regulation = IdR; introjected regulation =IntroR; external regulation = ER; and amotivation = Am

Table 6. Comparing components between EG and CG using Wilcoxon test according to sex.

Sex	Components	EG Sig.	EG (ES)	CG Sig.	CG (ES)
Total	**Intrinsic M.**	<0.001	0.619	0.056	-
(n_{EG}=133;	**Integrated R.**	0.090	-	0.429	-
n_{CG}=142)	**Identified R.**	0.422	-	0.745	-
	Introjected R.	0.187	-	0.874	-
	External R.	0.168	-	0.352	-
	Amotivation	<0.001	0.438	0.477	-
	Autonomy	<0.001	0.746	0.008	0.222
	Competence	<0.001	0.601	0.275	-
	Relatedness	<0.001	0.702	0.532	-
Male	**Intrinsic M.**	<0.001	0.627	0.064	-
(n_{EG}=70;	**Integrated R.**	0.153	-	0.487	-
n_{CG}=78)	**Identified R.**	0.146	-	0.133	-
	Introjected R.	0.491	-	0.521	-
	External R.	0.047	0.237	0.142	-
	Amotivation	0.002	0.368	0.099	-
	Autonomy	<0.001	0.733	0.008	0.299
	Competence	<0.001	0.608	0.144	-
	Relatedness	<0.001	0.648	0.310	-
Female	**Intrinsic M.**	<0.001	0.613	0.463	-
(n_{EG}=63;	**Integrated R.**	0.366	-	0.660	-
n_{CG}=64)	**Identified R.**	0.766	-	0.247	-
	Introjected R.	0.104	-	0.978	-
	External R.	0.665	-	0.969	-
	Amotivation	<0.001	0.533	0.481	-
	Autonomy	<0.001	0.765	0.318	-
	Competence	<0.001	0.598	0.897	-
	Relatedness	<0.001	0.761	0.791	-

EG = Experimental group; CG = Control group; Sig = P-Value; ES = Effect Size

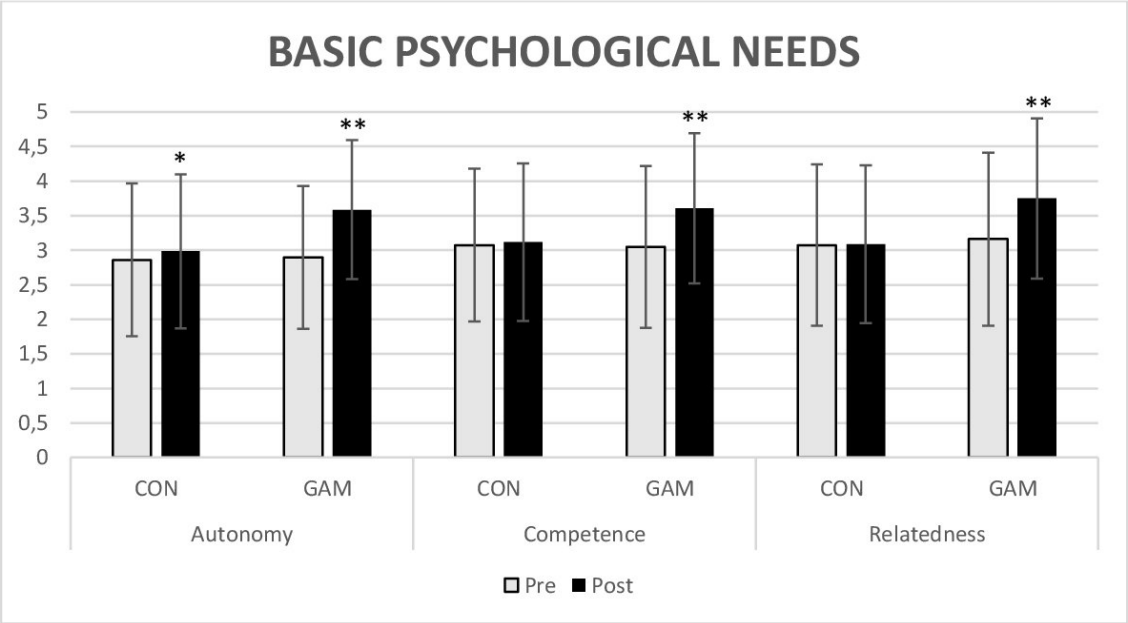

Figure 2. Descriptive data of the basic psychological needs, showing the changes produced between the pre- and post-test. *: p <.05, **: p <.001. Control group = CON, and experimental group = GAM.

Motivation

Table 5 and Table 6 also show the results obtained after applying the U Mann-Whiney and Wilcoxon test in the motivation variables. These results indicate that after the intervention, the students in the EG increased significantly the IM (Z = -7.133; $p < 0.001$; ES = 0.619), while decreased the Am (Z = -5,054; $p < 0.001$; ES = 0.438) (**Figure 3**). No change in any of the motivational variables evaluated was found for the CG. On the one hand, when these variables were analyzed according to sex, the same behavior for females and males was observed, except for ER in males, which increased subtly after the intervention. On the other hand, when these variables were analyzed according to the school grade, the same changes were observed (IM increased and Am decreased in the EG), except for the variable Am in Year 11 students, which did not show a change after the

intervention. Therefore, sex and school grade did not have a great influence on the overall results.

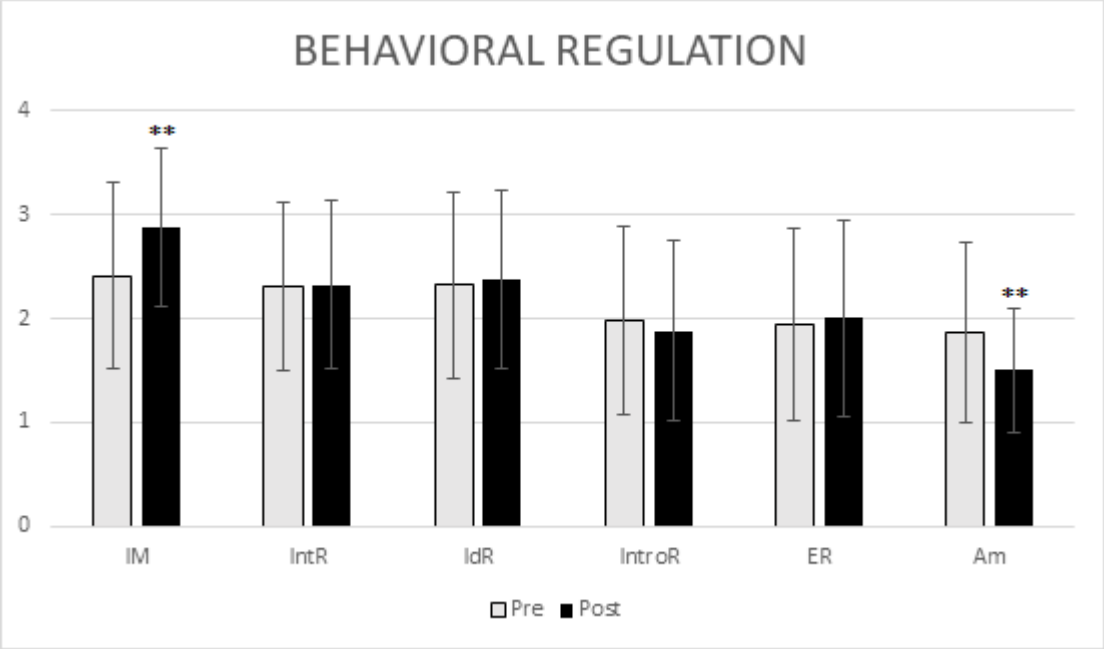

Figure 3. Descriptive data of the self-determined motivation variables in the EG, showing the change produced between the pre- and post-test. *: p <.05, **: p <.001. Intrinsic Motivation = IM; integrated regulation = IntR; identified regulation = IdR; introjected regulation =IntroR; external regulation = ER; and amotivation = Am.

Hypothesis Testing

In regards to the BPNs, an interaction effect (Time x Treatment) was found for autonomy ($F(1) = 57.97$, $p = <0.001$; $\eta^2_p = 0.175$), competence ($F(1) = 37.28$, $p = <0.001$; $\eta^2_p = 0.120$), and relatedness ($F(1) = 51.49$, $p = <0.001$; $\eta^2_p = 0.159$). That is, the gamified implementation in PE significantly increased BPNs compared to the non-gamified group. Thus, H1 was supported.

In regards to the motivation variables, an interaction effect (Time x Treatment) was found for IM. That is, the gamified group increased significantly more in this variable after

the intervention compared to the control group (F(1) = 39.65, p = <0.001; η^2_p = 0.127). Thus, H2 was supported.

An interaction effect (Time x Treatment) was also found for Am. That is, the gamified group significantly decreased Am compared to the non-gamified group (F(1) = 21.42, p = <0.001; η^2_p = 0.073), so H4 was supported. No interaction effect was found for the rest of the motivation variables and, consequently, H3 was not supported.

Discussion

The first objective of this study was to observe the impact of a gamified Didactic Unit on secondary school students' BPNs, i.e. to the variables of autonomy, competence and relatedness. The second objective was to verify the changes that the gamified intervention produced in the student´s motivation levels.

The results obtained supported Hypothesis 1 (H1) showing an improvement in all BPNs in the EG. These findings could support the idea that a gamified programme may improve BPNs levels in both secondary and primary students in PE (Quintas et al. 2020). However, these results contradict the results shown by Real Pérez, Sánchez Oliva, and Padilla Moledo (2021) in secondary students, since these authors did not find significant differences in the gamified group in BPNs, although they observed a positive trend autonomy after the intervention. Furthermore, the results obtained in this investigation are consistent with the rationale underlying SDT (Ryan and Deci 2017), according to which an improvement in BPNs is related to an increase in IM and a decrease in Am. The improvement achieved through gamification in BPNs can be attributed to the PBL and MDA systems approach. Firstly, the improvement in autonomy could be due to the PBL system, since XP, PP and GP were provided during gamification. Because of these points, students could adjust the

evolution of their avatars in ClassCraft® in any way they wanted (Xi and Hamari 2019). Secondly, the competence could be improved by aspects related to the MDA system, by using dynamics such as the value of points or the observation of their progress. Although the PBL system could also influence the change using the number of points acquired or the position in the leaderboard (Sailer et al. 2017). Finally, the improvement observed in the relatedness could be due to the implementation of the MDA system, through the narrative, cooperation and grouping into clans or teams.

The improvement in autonomy shown in the CG should also be highlighted. This improvement could be conditioned by the intervention of a new teacher (the principal investigator), who allowed the students themselves to group with whoever they wished and to choose how to conduct the activities. Moreover, the change of teacher who taught the sessions could be a novelty for the students, as they would be exposed to new experiences or at least different ones from their usual daily routine (González-Cutre et al. 2020). Consequently, it is possible to attribute the increase in autonomy suffered in the CG to the novelty provided by the change in the teaching staff (González-Cutre et al. 2016). In this line, Bagheri and Milyavskaya (2020) point out that novelty with variety is not a result of the satisfaction of the BPNs, but it is related to them, being able to affect them. Even so, the ANOVA showed that the EG improved significantly more autonomy than the CG. However, it is soon to recognize the inclusion of novelty within the BNPs theory, due to the subjective idea of this concept (cultural factors, acting reasons, greater attachment to control, etc.) (Vansteenkiste, Ryan, and Soenens 2020).

In parallel, hypothesis 2 (H2) was supported, since the IM of the EG significantly increased, while no change was visible in the CG. Only one investigation has been found in

which an increase in the IM was also observed in secondary education students after a gamified treatment (Fernandez-Rio et al. 2020). The other studies investigating the effects of gamification in PE in secondary students did not evaluate IM, which emphasizes the value of the results of the present research. Instead, studies conducted on primary school students found, after a gamified intervention, an increase in students' IM (Castañeda-Vázquez et al. 2019; Fernandez-Rio et al. 2020; Rutberg and Lindqvist 2018). These studies provided internal gamification rewards that could not be used externally, due to their unique utility within the gamified intervention (leaderboards, levels, points, etc.) and not in other contexts (extra exam points or tangible items).

Hypothesis 3 (H3) was not supported, since there were no significant changes in EM in any of the groups. In secondary students, only one study has assessed EM following an application of the gamified pedagogical model and no changes were observed in any extrinsic motivations (Real Pérez, Sánchez Oliva, and Padilla Moledo 2021). In university students, previous studies have found that applying a gamified intervention with digital tools (Castañeda-Vázquez et al. 2019; Ferriz-Valero et al. 2020) increased the EM, especially, the two types of controlled EM, i.e. IntroR and ER, which are powerful forms of motivation. However, they are difficult to maintain over time, producing that positive or negative reinforcements become ineffective (Ryan and Deci 2020). According to Ferriz-Valero et al. (2020), good and desirable behaviors are regulated by contingencies external to the students (awards or punishment) through the dynamics of the game itself. These authors emphasize the importance of the nature of rewards and punishment within a gamified design, according to Ryan and Deci (2020), as a change in the most EM of students can be expected if these rewards or punishments are external to the game (e.g.

points associated with better qualification of the PE subject) or intrinsic to the game itself (e.g. a badge or a level rise). The type of rewards proposed in the gamification programme would depend on many factors such as the inherent characteristics of the gamification or the participants´ grade. To follow a correct gamified development, participants must feel their participation in the gamified experience as a voluntary election and not as an imposition from the teacher to pass the subject. This is because "gamification is not a product in the way that a (serious) game is; gamification in the context of learning is a design process of adding game elements in order to change existing learning processes" (Sailer and Homner 2020 p.78). So, using external or tangible rewards could be associated with diminishing the desire to be part of a gamification experience voluntarily (Deci and Ryan 1985; Deci, Koestner, and Ryan 2001; Hanus and Fox 2015; Ryan and Deci 2019). The participant´s level of education should be probably considered as well, since a point or badge may be perceived differently by a primary student than by a higher education student. In this sense, gamification seems to have a greater predisposition towards IM improvement in primary and secondary grades (as it has been observed in the current research and others: Fernandez-Rio et al. 2020; Quintas et al. 2020) versus a greater predisposition towards a more EM in university degrees (Castañeda-Vázquez et al. 2019; Ferriz-Valero et al. 2020).

Therefore, it seems logical to think that rewards related to IM (points for getting challenges, progress bar, customized avatar or achieve skills, etc.) could achieve greater motivational improvements in primary and secondary school students instead of using rewards connected with EM, specifically, the controlled EM (IntroR and external), such as obtaining advantages in the final exam or tangible items (balls, pens, gifts, etc.). This could

justify the fact that students, in this study, did not change their EM, as the design of the awards and punishments within the gamified dynamics were all intrinsic to the Classcraft game (Table 1 and 2).

In the same line, the results described in the previous studies could also be associated with the way gamification was applied. Some authors use gamification based on the PBL model, which may also direct the motivation towards ER based on external rewards to the game itself (Ryan and Deci 2020), like the group's recognition on the leaderboard. These results could suggest that the model used may have an important influence on the less self-regulated motivation and, consequently, the relation to an ego climate (García-González et al. 2019).

Despite this fact, in the present study, secondary school students' IM significantly increased after the gamified didactic intervention, partly due to the satisfaction of the BPNs, given that these needs have been identified as an underlying mediation mechanism in previous research (Ryan and Deci 2017; Ryan and Deci 2019). A PBL system integrated into the MDA model was implemented during this intervention, whereby students earned points, personalization of avatars, skins or powers, without receiving any external rewards. Additionally, the use of the ClassCraft® tool allowed using privately exposed badges and leaderboards to reduce comparisons and competition among students (Moreno Murcia et al. 2005; Mekler et al. 2017). For these reasons, the characteristics attributable to mechanics, dynamics, and aesthetics (Table 3) supported by ClassCraft®, could have had a notable impact on students' motivational change. A greater number of studies, however, are necessary to test this latter claim.

Finally, when comparing the Am variable, the results showed a significant decrease in the gamified group unlike other results from similar studies also conducted in secondary school students (Real Pérez, Sánchez Oliva, and Padilla Moledo 2021). Instead, a study conducted in primary school students noted that the Am was also reduced after a gamified intervention, although the sample was relatively small (Dolera-Montoya et al. 2021). Therefore, an increase in IM, like the one in the present study, may lead to a reduction in Am, according to Ryan & Deci (2000). Thus, H4 was supported. The detriment of Am in the present research can be explained by the lesser importance of performance towards the ego or competition in favor of a greater focus on the task (Røset, Green, and Thurston 2020), as can be observed with an increase in competence and relatedness and a decrease in Am. In fact, as Fedesco et al. (2019) and Vasconcellos et al. (2020) exposed, Am is negatively correlated with competence and relatedness. So, by increasing competence and relatedness, less Am will be likely obtained. According to González-Cutre et al. (2016) the implementation of novelty could be associated with a decrease in Am and, consequently, it could be connected with an increase of IM in the same way (González-Cutre et al. 2016; González-Cutre et al. 2020; Ryan and Deci 2019). In this sense, the implementation of a gamified intervention likely increased the novelty of the activities.

Most of the studies that have found motivational changes in students based on gamified interventions have conducted intervention periods lasting between 4 weeks to 4 months (Fernandez-Rio et al. 2020; Ferriz-Valero et al. 2020; Quintas Hijos 2020). In the present study, the gamified intervention was conducted over a 5-week period, which seems to indicate that this duration is sufficient to achieve significant changes in motivation and BPNs.

Limitations

The innovative nature of the teaching technique in the present study, as well as the presence of the teacher (main researcher), may have constituted a conditioning factor in the results observed (González-Cutre et al. 2016). It should be pointed out that the main researcher, who delivered the intervention, was not blind to the conditions. For that reason, there is the possibility that the investigator could have used a more motivating teaching style to acquire greater improvements in the EG. Another limitation is the lack of qualitative measures, which would be useful to acquire deeper results. In addition, the limited number of articles published on this topic in secondary education students in the field of PE reduces the possibility of comparing the outcome of the present work.

Future research directions

Considering the lack of gamification-related studies in secondary students in the PE subject, future studies may investigate the effects that gamified experiences may produce in secondary school physical education students. Furthermore, those studies could make use of qualitative instruments (Robertson et al. 2016; Fernandez-Rio et al. 2020) to complement the quantitative results and it would be relevant to measure other variables of interest such as boredom, fun, stress, frustration, interest, motor practice time or academic performance. Finally, further studies are necessary to determine the optimal duration of gamified interventions in order to observe psycho-motivational improvements in secondary education students in the subject of PE.

5. Conclusion

Gamification is an innovative active methodology that seems to increase participant motivation. In the present study, a gamified intervention produced positive changes in

intrinsic motivation and amotivation. Furthermore, the intervention improved the BPNs. Therefore, our findings suggest that the use of gamification improves BPNs, enhances self-determined motivation, and reduces Am in secondary physical education students.

Acknowledgement

The authors would like to thank all the participant high schools, teachers and students for their involvement in the study. This research was funded by the University of XXXX, grant number "XXXX".

Declarations of interest: none

6. Bibliography

Andrade, Alexandro, Clara Knierim Correia, Whyllerton Mayron da Cruz, and Guilherme Guimaraes Bevilacqua. 2019. "Acute Effect of Exergames on Children's Mood States during Physical Education Classes." *Games for Health Journal* 8 (3): 250–256. doi:10.1089/g4h.2018.0083.

Bagheri, Leyla, and Marina Milyavskaya. 2020. "Novelty–Variety as a Candidate Basic Psychological Need: New Evidence across Three Studies." *Motivation and Emotion 44* (1). Springer US: 32–53. doi:10.1007/s11031-019-09807-4.

Bindman, Samantha W., Eva M. Pomerantz, and Glenn I. Roisman. 2015. "Do Children's Executive Functions Account for Associations Between Early Autonomy-Supportive Parenting and Achievement Through High School?" *Journal of Educational Psychology* 107 (3): 756–770. doi:10.1037/edu0000017.

Buttfield-Addison, Paris, Jon Manning, and Tim Nugent. 2016. “A Better Recipe for Game Jams: Using the Mechanics Dynamics Aesthetics Framework for Planning Paris.” *Proceedings of the International Conference on Game Jams, Hackathons, and Game Creation Events*, 30–33. doi:10.1145/2897167.2897183.

Campbell, Donald Thomas, and Julian C. Stanley. 2012. *Diseños Experimentales y Cuasiexperimentales En La Investigacion Social*. Argentina: Amorrortu. doi:10.1016/j.dld.2012.03.013.

Carrasco-Ramírez, Víctor José, Adrián Matamoros-Rodríguez, and Gonzalo Flores-Aguilar. 2019. “Analysis and Comparison of the Results Obtained after the Application of a Gamified Methodology and a Traditional One in Physical Education in ‘Bachillerato’ (Spanish Education for 16 to 18 Years Old Students).” *Education, Sport, Health and Physical Activity (ESHPA)* 3 (1): 29–45.

Castañeda-Vázquez, Carolina, Tamara Espejo-Garcés, Félix Zurita-Ortega, and Andrés B. Fernández-Revelles. 2019. “Physical Education´s Teacher Training Program through Gaming, Ict and Continuous Assessment.” *Revista Euroamericana de Ciencias Del Deporte* 8 (2): 55–64. doi:10.6018/sportk.391751.

Castañer Balcells, Marta, and Oleguer Camerino Foguet. 2011. “Un Enfoque Sistémico Para Estudiar La Motricidad Actual.” *Revista Motricidad y Persona: Serie de Estudios* 9: 9–17.

Castro-Sánchez, Manuel, Marta Linares-Manrique, Silvia Sanromán-Mata, and Antonio José Pérez Cortés. 2017. “Analysis of Sedentary Behaviors, Physical Activity and Use

of Videogames on Adolescents." *Sportis. Scientific Journal of School Sport, Physical Education and Psychomotricity 3* (2): 241–255. doi:10.17979/sportis.2017.3.2.1746.

Chou, Yu-kai. 2016. *Actionable Gamification: Beyond Points, Badges, and Leaderboards*. Taiwan: Octalysis Media. https://leanpub.com/actionable-gamification-beyond-points-badges-leaderboards/read.

Cohen, Jacob. 1988. *Statistical Power Analysis for The Behavioral Sciences*. New York: Routledge.

Coolican, Hugh. 2009. *Research Methods and Statistics in Psychology*. London: Hooder.

Deci, Edward L., and Richard M. Ryan. 1985. "The General Causality Orientations Scale: Self-Determination in Personality." *Journal of Research in Personality 19* (2): 109–134. doi:10.1016/0092-6566(85)90023-6.

Deci, Edward L., Richard Koestner, and Richard M. Ryan. 2001. "Extrinsic Rewards and Intrinsic Motivation in Education: Reconsidered Once Again." *Review of Educational Research 71* (1): 1–27. doi:10.3102/00346543071001001.

Deterding, Sebastian, Miguel Sicart, Lennart Nacke, Kenton O'Hara, and Dan Dixon. 2011. "Gamification: Using Game Design Elements in Non-Gaming Contexts Sebastian." *Extended Abstracts on Human Factors in Computing Systems*, 2425–2428.

Dichev, Christo, and Darina Dicheva. 2017. "Gamifying Education: What Is Known, What Is Believed and What Remains Uncertain: A Critical Review." *International Journal of Educational Technology in Higher Education* 14 (9): 1–36. doi:10.1186/s41239-017-0042-5.

Dicheva, Darina, Christo Dichev, Gennady Agre, and Galia Angelova. 2015. "Gamification in Education: A Systematic Mapping Study Author(S):" *Journal of Educational Technology & Society* 18 (3): 75–88.

Dolera-Montoya, Sonia, Alfonso Valero-Valenzuela, José Francisco Jiménez-Parra, and David Manzano-Sánchez. 2021. "Mejora Del Clima de Aula Mediante Un Plan de Convivencia Gamificado Con Actividad Física: Estudio de Su Eficacia En Educación Primaria." *Multidisciplinary Journal of Education* 14(28) (ISSN 1988-7701): 65–77.

Dominguez-Lara, Sergio. 2018. "Effect Size, a Quick Guide." *Educación Médica* 19 (4): 251–254.

Fernandez-Rio, Javier, Esteban de las Heras, Tristan González, Vanessa Trillo, and Jorge Palomares. 2020. "Gamification and Physical Education. Viability and Preliminary Views from Students and Teachers." *Physical Education and Sport Pedagogy* 25 (5): 509–524. doi:10.1080/17408989.2020.1743253.

Faul, Franz, Edgar Erdfelder, Albert-Georg Lang and Axel Buchner. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39*(2), doi:175-191. 10.3758/bf03193146

Fedesco, Heather N., Emily M. Bonem, Cong Wang, and Regina Henares. 2019. "Connections in the Classroom: Separating the Effects of Instructor and Peer Relatedness in the Basic Needs Satisfaction Scale." *Motivation and Emotion 43* (5). Springer US: 758–770. doi:10.1007/s11031-019-09765-x.

Ferriz-Valero, Alberto, Salvador García Martínez, Miguel García-Jaen, Ove Østerlie, and Sergio Sellés. 2019. “Gamificación: Metodologías Activas En Educación Física En Docencia Universitaria.” *Investigación e Innovación En La Enseñanza Superior*, 1116–1126.

Ferriz-Valero, Alberto, Ove Østerlie, Salvador García Martínez, and Miguel García-Jaén. 2020. “Gamification in Physical Education: Evaluation of Impact on Motivation and Academic Performance within Higher Education.” *International Journal of Environmental Research and Public Health* 17: 1–16. doi:10.3390/ijerph17124465.

García-González, Luis, Javier Sevil-Serrano, Angel Abós, Nathalie Aelterman, and Leen Haerens. 2019. “The Role of Task and Ego-Oriented Climate in Explaining Students’ Bright and Dark Motivational Experiences in Physical Education.” *Physical Education and Sport Pedagogy* 24 (4): 344–358. doi:10.1080/17408989.2019.1592145.

González-Cutre, David, Álvaro Sicilia, Ana C. Sierra, Roberto Ferriz, and Martin S. Hagger. 2016. “Understanding the Need for Novelty from the Perspective of Self-Determination Theory.” *Personality and Individual Differences* 102: 159–169. doi:10.1016/j.paid.2016.06.036.

González-Cutre, David, María Romero-Elías, Alejandro Jiménez-Loaisa, Vicente J. Beltrán-Carrillo, and Martin S. Hagger. 2020. “Testing the Need for Novelty as a Candidate Need in Basic Psychological Needs Theory.” *Motivation and Emotion 44* (2). Springer US: 295–314. doi:10.1007/s11031-019-09812-7.

Granero-Gallegos, Antonio, Manuel Gómez-López, Juan González-Hernández, Antonio Baena-Extremera, and María del Mar Ortiz-Camacho. 2018. "Spanish Adaptation and Psychometric Properties of the Sport Motivation Scale-Ii with High School Physical Education Students." *International Journal of Environmental Research and Public Health* 15 (12). doi:10.3390/ijerph15122768.

Hanus, Michael D., and Jesse Fox. 2015. "Assessing the Effects of Gamification in the Classroom: A Longitudinal Study on Intrinsic Motivation, Social Comparison, Satisfaction, Effort, and Academic Performance." *Computers and Education 80*: 152–161. doi:10.1016/j.compedu.2014.08.019.

Hastie, Peter A., and Ashley Casey. 2014. "Fidelity in Models-Based Practice Research in Sport Pedagogy: A Guide for Future Investigations." *Journal of Teaching in Physical Education* 33 (3): 422–431. doi:10.1123/jtpe.2013-0141.

Huotari, Kai, and Juho Hamari. 2012. "Defining Gamification - A Service Marketing Perspective." *Proceedings of the IADIS International Conference Interfaces and Human Computer Interaction 2012*, 17–22. doi:10.1145/2393132.2393137.

Jaakkola, Timo, Tracy Washington, and Sami Yli-Piipari. 2012. "The Association between Motivation in School Physical Education and Self-Reported Physical Activity during Finnish Junior High School: A Self-Determination Theory Approach." *European Physical Education Review 19* (1): 127–141. doi:10.1177/1356336X12465514.

Lamas Rojas, Hector. 2008. "Aprendizaje Autorregulado, Motivación y Rendimiento Académico." *Liberabit* 14 (14): 15–20.

Martín-Moya, Ricardo, Pedro Jesus Ruiz-Montero, Oscar Chiva-Bartoll, and Carlos Capella-Peris. 2018. "Achievement Motivation for Learning in Physical Education Students: Diverhealth." *Interamerican Journal of Psychology (IJP)* 52 (2): 270–280.

Mekler, Elisa D., Florian Brühlmann, Alexander N. Tuch, and Klaus Opwis. 2017. "Towards Understanding the Effects of Individual Gamification Elements on Intrinsic Motivation and Performance." *Computers in Human Behavior* 71: 525–534. doi:10.1016/j.chb.2015.08.048.

Mitchell, Robert, Lisa Schuster, and Hyun Seung Jin. 2020. "Gamification and the Impact of Extrinsic Motivation on Needs Satisfaction: Making Work Fun?" *Journal of Business Research* 106: 323–330. doi:10.1016/j.jbusres.2018.11.022.

Monguillot Hernando, Meritxell, Carles González Arévalo, Carles Zurita Mon, Lluís Almirall Batet, and Montse Guitert Catasús. 2015. "Play the Game: Gamificación y Hábitos Saludables En Educación Físico." *Apunts Educación Física y Deportes* 119: 71–79. doi:10.5672/apunts.2014-0983.es.(2015/1).119.04.

Moreno Murcia, J. A., N. Alonso Villodre, C. Martinez Galindo, and E. Cervelló Gimeno. 2005. "Motivación, Disciplina, Coeducación y Estado de Flow en Educación Física: Diferencias según la Satisfacción, la Práctica Deportiva y la Frecuencia de Práctica." *Cuadernos de Psicología Del Deporte* 5 (1 & 2).

Moreno Murcia, Juan Antonio, David González-Cutre Coll, Mariana Chillón Garzón, and Nicolás Parra Rojas. 2008. "Adaptación a la Educación Física de La Escala de las

Necesidades Psicológicas Básicas en el Ejercicio." *Revista Mexicana de Psicologia* 25 (2): 295–303.

Ntoumanis, Nikos. 2001. "A Self-Determination Approach to the Understanding of Motivation in Physical Education." *British Journal of Educational Psychology* 71 (2): 225–242. doi:10.1348/000709901158497.

Nunnally, Jum C. 1978. *Psychometric theory.* Nueva York: McGraw-Hill.

Pelletier, Luc G., Kim M. Tuson, Michelle S. Fortier, Robert J. Vallerand, Nathalie M. Briére, and Marc R. Blais. 1995. "Toward a New Measure of Intrinsic Motivation, Extrinsic Motivation, and Amotivation in Sports: The Sport Motivation Scale (SMS)." *Journal of Sport and Exercise Psychology* 17 (1): 35–53. doi:10.1123/jsep.17.1.35.

Pérez-López, Isaac J., Enrique Rivera García, and C. Trigueros Cervantes. 2017. "'The Prophecy of the Chosen Ones: An Example of Gamification Applied to University Teaching." *Revista Internacional de Medicina y Ciencias de La Actividad Fisica y Del Deporte* 17 (66): 243–260. doi:10.15366/rimcafd2017.66.003.

Puig Gimeno, Belén, Fátima Llamas Salguero, and Alberto Portolés Ariño. 2015. "Relationship Between Information and Communications Technology with the Academic and Practicing Physical Activity in Primary Education." *Didáctica, Innovación y Multimedia 32*: 1–10.

Quintas, Alejandro, Juan-Carlos Bustamante, Francisco Pradas, and Carlos Castellar. 2020. "Psychological Effects of Gamified Didactics with Exergames in Physical Education

at Primary Schools: Results from a Natural Experiment." *Computers and Education* 152. doi:10.1016/j.compedu.2020.103874.

Quintas Hijos, Alejandro. 2020. *Teoría Educativa Sobre Tecnología, Juego y Recursos En Didáctica de La Educación Infantil*. Zaragoza: Prensas de la Universidad de Zaragoza.

Quintero González, Lucia Esther, Francisco Jiménez Jiménez, and Manuel Area Moreira. 2018. "Beyond the Textbook. Gamification through ITC as an Innovative Alternative in Physical Education." *Retos* 34: 343–348.

Real Pérez, Mateo, David Sánchez Oliva, and Carmen Padilla Moledo. 2021. "Africa Project «La Leyenda de Faro»: Effects of a Methodology Based on Gamification on Situational Motivation about the Content of Corporal Expression in Secondary Education." *Retos* 42: 567–574. doi:10.47197/retos.v42i0.86124.

Robertson, Judy, Ruth Jepson, Andrew Macvean, and Stuart Gray. 2016. "Understanding the Importance of Context: A Qualitative Study of a Location-Based Exergame to Enhance School Childrens Physical Activity." *Plos One 11* (8): 1–27. doi:10.1371/journal.pone.0160927.

Røset, Linda, Ken Green, and Miranda Thurston. 2020. "Norwegian Youngsters' Perceptions of Physical Education: Exploring the Implications for Mental Health." *Sport, Education and Society 25* (6). Taylor & Francis: 618–630. doi:10.1080/13573322.2019.1634043.

Rutberg, Stina, and Anna-Karin Lindqvist. 2018. “Active School Transportation Is an Investment in School Health.” *Health Behavior and Policy Review* 5 (2): 88–97. doi:10.14485/hbpr.5.2.9.

Ryan, Richard M., and Edward L. Deci. 2000. “Self-Determination Theory and the Facilitation of Intrinsic Motivation, Social Development, and Well-Being.” *American Psychologist* 55 (1): 68–78.

Ryan, Richard M., and Edward L. Deci. 2017. *Self-Determination Theory: Basic Psychological Needs in Motivation, Development, and Wellness*. New York: Guilford Press.

Ryan, Richard M., and Edward L. Deci. 2019. “Brick by Brick: The Origins, Development, and Future of Self-Determination Theory.” *Advances in Motivation Science* 6: 111–156. doi:10.1016/bs.adms.2019.01.001.

Ryan, Richard M., and Edward L. Deci. 2020. “Intrinsic and Extrinsic Motivation from a Self-Determination Theory Perspective: Definitions, Theory, Practices, and Future Directions.” *Contemporary Educational Psychology* 61. doi:10.1016/j.cedpsych.2020.101860.

Sailer, Michael, Jan Ulrich Hense, Sarah Katharina Mayr, and Heinz Mandl. 2017. “How Gamification Motivates: An Experimental Study of the Effects of Specific Game Design Elements on Psychological Need Satisfaction.” *Computers in Human Behavior* 69: 371–380. doi:10.1016/j.chb.2016.12.033.

Sailer, Michael, and Lisa Homner. 2020. “The Gamification of Learning: A Meta-Analysis.” *Educational Psychology Review* 32 (1) 77–112. doi:10.1007/s10648-019-09498-w.

Shen, Bo. 2014. “Outside-School Physical Activity Participation and Motivation in Physical Education.” *British Journal of Educational Psychology 84* (1): 40–57. doi:10.1111/bjep.12004.

Shi, Lei, Alexandra I. Cristea, Suncica Hadzidedic, and Naida Dervishalidovic. 2014. “Contextual Gamification of Social Interaction - Towards Increasing Motivation in Social e-Learning.” *Advances in Web-Based Learning – ICWL 2014*, 116–122. doi:10.1007/978-3-319-09635-3_12.

Skinner, B. F. 1988. *About Behaviorism*. New York: Random House USA Inc. doi:10.1093/analys/18.6.132.

Van Der Horst, Klazine, Marijke J. Chin A. Paw, Jos W. R. Twisk, and Willem Van Mechelen. 2007. “A Brief Review on Correlates of Physical Activity and Sedentariness in Youth.” *Medicine and Science in Sports and Exercise* 39 (8): 1241–1250. doi:10.1249/mss.0b013e318059bf35.

Vansteenkiste, Maarten, Richard M. Ryan, and Bart Soenens. 2020. Basic Psychological Need Theory: Advancements, Critical Themes, and Future Directions. *Motivation and Emotion*. Vol. 44. Springer US. doi:10.1007/s11031-019-09818-1.

Vasconcellos, Diego, Philip D. Parker, Renata Cinelli, Katherine B. Owen, Nathanial Kapsal, Jane Lee, Devan Antczak, et al. 2020. “Self-Determination Theory Applied to

Physical Education: A Systematic Review and Meta-Analysis." *Journal of Educational Psychology 112* (7): 1444–1469. doi:10.1037/edu0000420.

Vasquez, Ariana C., Erika A. Patall, Carlton J. Fong, Andrew S. Corrigan, and Lisa Pine. 2015. "Parent Autonomy Support, Academic Achievement, and Psychosocial Functioning: A Meta-Analysis of Research." *Educational Psychology Review* 28 (3): 605–644. doi:10.1007/s10648-015-9329-z.

Vlachopoulos, Symeon P., and Sotiria Michailidou. 2006. "Development and Initial Validation of a Measure of Autonomy, Competence, and Relatedness in Exercise: The Basic Psychological Needs in Exercise Scale." *Measurement in Physical Education and Exercise Science* 10 (3): 179–201. doi:10.1207/s15327841mpee1003_4.

Werbach, Kevin. 2014. "(Re)Defining Gamification: A Process Approach." *International Conference on Persuasive Technology*, 266–272. doi:10.1007/978-3-319-07127-5_23.

Xi, Nannan, and Juho Hamari. 2019. "Does Gamification Satisfy Needs? A Study on the Relationship between Gamification Features and Intrinsic Need Satisfaction." *International Journal of Information Management* 46: 210–221. doi:10.1016/j.ijinfomgt.2018.12.002.