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ORIGINAL

GAMIFICATION AND COOPERATIVE LEARNING: EFFECTS OF A HYBRIDIZATION IN PHYSICAL EDUCATION

GAMIFICACIÓN Y APRENDIZAJE COOPERATIVO: EFECTOS DE UNA HIBRIDACIÓN EN EDUCACIÓN FÍSICA

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ABSTRACT

The present study aimed to assess the impact of a Physical Education (PE) teaching unit on PE satisfaction classes, basic psychological needs satisfaction, motivation, school social climate and cognitive performance. A quasi-experimental design with a control group was used for a total sample of 120 students of Secondary Education (M = 13,48; SD = 1,36) to whom a questionnaire was administered to analyse the study variables. The teaching unit based on the hybridization of gamification and Cooperative Learning (GF + CL) was applied for 8 sessions. The programme showed improvements in the psychological mediators index, executive function of planning, the PE students satisfaction and

the school social climate, which would make it suitable for the improvement in the performance of PE teachers in educational centres.

KEYWORDS*:* ludification, cooperative learning, enjoyment, executive function, physical education.

RESUMEN

El presente estudio tuvo como objetivo evaluar el impacto de una unidad didáctica de Educación Física (EF) sobre la satisfacción en las clases de EF, la satisfacción de las necesidades psicológicas básicas, la motivación, el clima social escolar y el rendimiento cognitivo. Se utilizó un diseño cuasi-experimental con grupo control para una muestra total de 120 estudiantes de Educación Secundaria (*M* = 13,48; *DT* = 1,36) a los que se les administró un cuestionario para analizar las variables de estudio. Se aplicó la unidad didáctica basada en la hibridación de la gamificación y el aprendizaje cooperativo (GF + CL) durante 8 sesiones. El programa mostró mejoras en el índice de mediadores psicológicos, la función ejecutiva de la planificación, la satisfacción de los alumnos de educación física y el clima social escolar, lo que podría ser adecuado para mejorar el rendimiento de los profesores de educación física en los centros educativos.

PALABRAS CLAVE*:* ludificación, desafíos físico-cooperativos, disfrute, funciones ejecutivas, educación física.

INTRODUCTION

Education is undergoing changes at the organisational, methodological, technological and content levels, the purpose of which is the search for new learning ecologies (Coll, 2013). In this situation, model-based teaching reduces the role of the teacher in favour of meeting the needs of students (Casey, 2016). In this sense, pedagogical models try to focus on students and their characteristics, focusing on the classroom context and its development (Aggerholm et al., 2018). A good classroom climate is linked to satisfactory socio-affective interactions, given by the attitudes of teachers, students and their relationships that contribute to an adequate classroom climate within the teaching-learning process (Manzano-Sánchez and Valero-Valenzuela, 2019a). In addition, this appropriate climate can help reduce the achievement gap between students and schools with different socioeconomic status (Berkowitz et al., 2017), contributing to a reduction in violence (Polo et al., 2013), and is related to higher levels of self-determined motivation (Fan & Williams, 2018).

Along these lines, gamification (GF) is understood as "the use of mechanisms, aesthetics and ideas to engage people, incite action, promote learning and solve problems" (Kapp, 2012), encouraging students to have a greater psychological predisposition towards learning. Deterding et al. (2011) understand gamification as the use of game elements in contexts outside the game itself to make it more fun, engaging and motivational. Werbach (2012) proposes that a number of

fundamentals should be used to implement gamification: (a) dynamics: these are the concepts and the structure implicit in the game itself, (b) mechanics: these are the processes that enable the development of the game and (c) components: these are the specific implementations of the dynamics and mechanics: avatars, badges, points, levels, etc. The connection of these three elements generates a gamified activity (Spiliopoulos et al., 2019).

In addition to this emerging methodology, nowadays in physical education (PE), different Pedagogical Models (PM) are being implemented based on a broad theoretical foundation such as sport education, teaching games for understanding and cooperative learning (CL) (Pérez-Pueyo et al., 2021). Specifically, CL uses five fundamental aspects, such as positive interdependence, individual responsibility, face-to-face interaction, group processing and social skills (Johnson et al., 2013), to achieve a comprehensive and competent development of students in various domains such as social, affective, motor and cognitive (Bores-García et al., 2020). The tasks in this pedagogical model are structured so that each group member contributes proportionally to the work, and the final product depends more on group collaboration than on individual work (Johnson & Johnson, 2003).

In recent years, the practice based on PM has evolved towards a new trend that focuses on the hybridisation or combination of two or more teaching methodologies (Pérez-Pueyo et al., 2021), which has yielded better results in different domains, as well as more individualised learning adapted to any context, than the application of one model in isolation (Hortigüela-Alcalá et al., 2021) or a conventional teaching methodology (González-Víllora et al., 2019). In relation to this study, GF and CL have been hybridised in different educational stages and educational areas (Candel, 2018; Dólera-Montoya et al., 2021; Herrera, 2020; Lamoneda-Prieto et al., 2020; Moscato and Domínguez de la Rosa, 2018; Quintero-González et al., 2018), showing positive results such as greater student involvement in class, satisfaction with learning experiences and higher academic performance (Rafii, 2022).

One perspective to unravel the motivational processes underlying the use of GF and CL in educational contexts is self-determination theory (SDT) (Deci & Ryan, 2000), which analyses the origin of motivation and its consequences at the cognitive, behavioural and affective levels (Vallerand, 1997). In this sense, SDT establishes that an individual's motivational states follow a self-determination continuum composed of three levels (Moreno-Murcia et al., 2010): (1) *situational level*, referring to motivation corresponding to the "here and now", (2) *contextual level*, the object of the present study and referring to orientation towards a particular context such as, for example, PE or school attendance, and (3) *global level*, referring to the adoption of specific behaviour or attitudes towards a particular aspect of life. In addition, this continuum is made up of different types of motivational regulations (Ryan & Deci, 2017), including, greater to lesser degrees of self-determination: intrinsic motivation (voluntary participation in a given activity for pleasure and enjoyment), extrinsic motivation (performance of a task incentivised by external contingencies) and amotivation (absence or lack of participation in an activity).

Evidence from educational research on cooperative games shows that activities that support the basic psychological needs of competence, autonomy and social relatedness are evaluated as more enjoyable, motivational and engaging (Ryan & Deci, 2009; Peng et al., 2012). In relation to SDT, Sailer et al. (2017) justify that the elements of play used in GF fit from a self-determination perspective because of the wide range of motivational mechanisms it promotes and because it can be encompassed within other perspectives.

Within this macro-theory of motivation, Vallerand's (1997) hierarchical model of intrinsic and extrinsic motivation indicates that motivation is determined by social factors at the situational, contextual and global levels (Moreno-Murcia et al., 2010), whose impact is mediated by basic psychological needs. The satisfaction of these three needs is essential for health and well-being (Deci & Ryan, 2000; Deci & Ryan, 2012), as well as for greater adherence to physical activity (PA) (Garn & Wallhead, 2014) and to the production of positive cognitive, affective and social consequences (Merino-Barrero et al., 2019). Among these consequences, a positive school social climate can reduce problems such as bullying, absenteeism, school failure, while improving academic performance and motivation (Borkar, 2016). For this reason, it is important to use new methodologies in PE and in other subjects because it can be useful to achieve a better school social climate and higher motivation (Valero-Valenzuela et al., 2020).

In this line of argument, both GF and CL have demonstrated their effectiveness in promoting a more self-determined motivation among students (Fernández-Argüelles & González, 2018; Fernández-Río et al., 2020; Fernández-Río et al, 2017; Vázquez Ramos, 2020), the satisfaction of their basic psychological needs (Van Roy & Zaman, 2019; Navarro Patón et al., 2018) and an improvement in cognitive domain (Melero-Cañas et al., 2021; Nopembri et al., 2019), fundamental for achieving meaningful student learning. Given the relationship between motivation and cognitive performance (Nieto-Márquez et al., 2021), the suggestion is that the application of innovative methodologies aimed at improving intrinsic motivation can also produce greater cognitive activation of students in tasks and, consequently, greater cognitive performance. The latter term refers to the optimal functioning of multiple cognitive domains such as perception, attention, memory, language, learning, problem solving, decision-making, visual construction and executive functions (Fisher et al., 2019; Koekkoek et al., 2014).

In this sense, executive functions are defined as a set of higher-order cognitive, affective and motivational processes that allow cognitive and behavioural regulation to achieve a given goal (López et al., 2017; Rincón-Campos et al., 2019), controlling thought and making sense of sensory stimuli and motor actions (Manzano-Sánchez & Jiménez-Parra, 2021). In this way, executive functions are considered a construct of cognitive skills that involve components such as the organisation and planning of a task, inhibitory control to any stimulus, working memory, cognitive flexibility, verbal fluency, maintenance of attention or the regulation of one's own emotional state (García et al., 2016; Nieto-Márquez et al., 2021), fundamental for adapting to the environment and adopting an adequate social performance (Martín-Martínez et al., 2015). The development of these

functions directly influences academic and cognitive performance (García et al., 2016; López et al., 2017; Roebers, 2017).

At the empirical level, Moreau et al. (2015) indicate that PA-based programmes with a high level of challenge can facilitate the improvement of cognitive skills more than a programme based on cognitive learning with conventional computer-based tasks. Thus, different studies corroborate the effectiveness of PE classes and moderate- to vigorous-intensity aerobic exercise in achieving an improvement in executive functions (Berrios-Aguayo et al., 2019; Davis et al., 2011; Zach et al., 2015). In relation to the use of active methodologies in the classroom, studies such as that of Muñoz-Parreño et al. (2021) show that the application of an Active Breaks programme through cooperative work produces improvements in the executive functions of inhibitory control, cognitive flexibility, working memory, verbal fluency and planning, all of which are measured with the NIH Examiner battery (Kramer et al., 2014). This battery has also been used in Secondary Education and in the area of Physical Education, as can be seen in the study by Melero-Cañas et al. (2021), where the application of a hybrid educational programme based on the Teaching of Personal and Social Responsibility (TPSR) and the GF yielded positive results in favour of the experimental group (EG) in the executive functions of verbal fluency, cognitive inhibition, language and planning.

For this reason, the main objective of this study was to analyse the influence of a hybrid GF + CL PE teaching unit on students' classroom satisfaction, satisfaction of basic psychological needs, self-determination index, school social climate and cognitive performance.

It is hypothesised that a teaching unit based on GF + CL will improve satisfaction in PE classes, satisfaction of basic psychological needs, motivation, school social climate and cognitive performance of secondary school students.

1. MATERIAL AND METHOD

1.1. PARTICIPANTS

A total of 120 students aged 12-17 years (*M* = 13.48, *SD* = 1.36) (59 boys, 61 girls) from a secondary school in southeastern Spain participated in this study. The school administration, together with the research team, divided the groups randomly, with the control group (CG) consisting of one teacher and 59 students from four classes of first year and one class of fourth year of secondary education (32 boys, 27 girls); while the EG consisted of one teacher and 61 students from three classes of second year and one class of the third year of secondary education (27 boys, 34 girls). The teachers had similar characteristics as both were male, aged between 30 and 40, with a degree in Sports Science and more than 5 years of teaching experience in Secondary Education. The centre was chosen for accessibility and convenience, with a commitment to keep the classrooms intact. All participants had socio-demographic and cultural characteristics corresponding to the "middle class".

1.2. INSTRUMENTS

Executive Functions. The National Institutes of Health (NIH) Examiner (Kramer et al., 2014) includes the following tests to assess executive functions in young people: (1) verbal fluency for the category 'animals': participants had to write the maximum number of animals in one minute; (2) verbal fluency for the category 'vegetables': participants had to write the maximum number of vegetables in one minute; and (3) an unstructured task (planning): participants had to complete four pages with brainteasers that have a certain number of points that add up to completion in less than six minutes. The aim was to score as many points as possible.

Academic motivation. The Échelle de Motivation en Éducation (EME), validated in the Spanish context by Núñez et al. (2005), was used. It includes 28 items distributed in seven subscales: intrinsic motivation (IM) towards knowledge, IM towards achievement, IM towards stimulating experiences, external regulation, introjected regulation, identified regulation and demotivation. The items were preceded by the statement: "I go to school because...", and students responded on a seven-point Likert-type scale, from 1 (not at all matched) to 7 (fully matched). Pre- and post-test Cronbach's Alpha values were: amotivation (0.71 and 0.64), external regulation (0.67 and 0.70), introjected regulation (0.71 and 0.76), identified regulation (0.62 and 0.67), IM towards knowledge (0.83 and 0.86), IM towards achievement (0.82 and 0.79), and IM towards stimulating experiences (0.74 and 0.76). The self-determination index (SDI), a valid and reliable measure, was calculated using the following formula: 2 x IM + identified R - (external R + introjected R) / 2 - (2 x amotivation) (Vallerand, 1997).

Basic psychological needs. The version adapted to PE and validated in Spanish (Moreno-Murcia et al., 2008; Moreno-Murcia et al., 2011) of the scale of satisfaction of basic psychological needs in exercise was used. It includes 12 items to assess autonomy, competence and relatedness to others. The introductory sentence was: "In my classes ..." and participants answered a Likert-type scale with 5 response options ranging from 1 (strongly disagree) to 5 (strongly agree). Cronbach's Alphas for the pre- and post-test were for autonomy: .74 and .81, for competence: .71 and .64, and for relatedness to others: .66 and .71. The psychological mediators index (PMI; Bartholomew et al., 2010) was calculated considering the three basic psychological needs as a single factor.

School social climate (CECSCE). It was assessed using the Spanish validated version (Trianes et al., 2006) of the California social climate and safety scale. It includes 14 items grouped into two subscales: one related to the school climate (adequate comfort, peace in the school, safety, helpfulness,...) and the other referring to the teaching climate (academic demands, fairness, accessibility with respect to treatment,...). Participants responded to a Likert-type scale with 5 response options ranging from 1 (strongly disagree) to 5 (strongly agree). Cronbach's Alpha values for the pre- and post-test were for the school: 0.79 and 0.82, and for the teacher: 0.71 and 0.66.

Satisfaction with PE. The Spanish validated version of the sport satisfaction instrument for the school context (Baena-Extremera et al., 2012) was used. It

includes eight items grouped into two dimensions: boredom and satisfaction/fun. Participants responded to a Likert-type scale consisting of 5 items ranging from 1 (strongly disagree) to 5 (strongly agree). Cronbach's alphas for the pre- and post-test were for boredom 0.56 and 0.58 and for satisfaction/fun: 0.74 and 0.63. The Alpha value was above 0.50 in all cases, considered adequate for scales of this type with few items (Hu et al., 1999) and 0.70 for the rest of the scales (Viladrich et al., 2017).

1.3. PROCEDURE

The study was approved by the Ethics Committee of the University of Murcia (2284/2019). After receiving approval, the project was presented to the school management and to the physical education teacher to request their collaboration. Finally, the project was presented to the families of the students and all those who were willing to participate signed the written informed consent.

The study followed a pre-test post-test quasi-experimental research design. Before the intervention, all questionnaires were administered. Participants were encouraged to respond truthfully at all times, indicating at all times that the responses were anonymous and would not affect their grades. At the end of the intervention, the same questionnaires were administered again following the same procedure. A member of the research team was present at all times to provide a brief explanation and report on how to complete the instruments and resolve any doubts that may arise during the process. The time required to complete the questionnaires was approximately 45 minutes, divided with a short break of five minutes between the psychosocial aspects questionnaires (30 minutes) and the cognitive performance tests (15 minutes). All the questionnaires were carried out in a class session.

INTERVENTION

An 8-session intervention program was designed and applied. Both groups followed the educational program of the educational centre, developing in all courses the contents related to basic physical abilities. On the one hand, the CG experienced a teaching approach focused on teacher decision-making, represented by a traditional teaching methodology (TTM) (Metzler, 2011). In contrast, the EG experienced a QA teaching unit, which included elements of GF. The program was implemented based on the main elements of the two structures. In the case of CL: positive interdependence (for example, common objectives among all the components of the group-class), face-to-face interaction (for example, direct contact to overcome physical-cooperative challenges), personal responsibility (for example, establishing roles and leadership within small groups), group processing (for example, posing cognitive challenges that involve reflection among group members), interpersonal skills (for example, communicative interaction among group members), equitable participation (for example, establishing small groups with different skill levels and that promote coeducation) and equal opportunities for success (for example, to reach the final challenge they must help the rest of the groups). Regarding the GF: dynamics (for example, narrative related to the search for health, progression ...), mechanics (for example, cooperative challenges, competitive challenges,

feedback, rewards ...) and components (for example, points, group ranking, achievements…). The contents addressed in both groups were based on the physical condition block, specifically, oriented towards the development of basic physical capacities (BPC) (Table 1).

Table 1. Contents and strategies used according to the research group

Session number	GF + CL (EG) strategies		Traditional teaching strategies (CG)	Examples of tasks / activities	
				EG	CG
1	***GF:*** MC, DN.	***CL:*** SC	Direct instruction, direct command and analytical strategy	BPC: individual competitive games based on endurance	BPC: endurance games
2	***GF:*** ST, MC, DN	***CL:*** SC, AU, WSG	Direct instruction, assignment of tasks and analytical strategy	BPC: strength-Based Individual Competitive Games	BPC: resistance circuit
3-4	***GF:*** ST, MC, DN	***CL:*** SC, AU, L, WSG, SGOT	Direct instruction, direct command and analytical strategy	BPC: group cohesion and trust through speed and flexibility.	BPC: speed games
5-6-7	***GF:*** ST, MEC, DN, CO, ID / C	***CL:*** L, WSG, TSG, SC, SGOT, AU, PS, CCG	Direct instruction, assignment of tasks and analytical-global strategy	BPC: Cooperative Physical Challenges Related to Cooperative Strength and Physical Challenge League	BPC:strength and Fitness Circuit
8	***GF:*** ST, MC, DN, CO, ID / C	***CL:*** L, WSG, TSG, SC, SGOT, AU, RP and CCG	Direct instruction, assignment of tasks and analytical-global strategy	BPC: Breakout-edu	BPC: flexibility circuit

Note: EG = Experimental Group; CG = Control Group; GF = Gamification; CL = Cooperative Learning; BPC = Basic Physical Capacities; ST = Setting; MC = Mechanical; DN = Dynamic; CO = Components; L = Leadership; WSG = Work in small groups; TSG = Task solved by the whole group; SC = Setting challenges; SGOT = Stable groups over time; ID / C = Identification / characterization; AU = Autonomy; PS = Problem solving; CCG = Creation and cohesion of groups.

The application of the program lasted 4 weeks (8 classes of 55 minutes each) in which the GE students had to overcome different physical, psychological and emotional challenges through cooperative physical activities. The students were divided into subgroups to solve problems posed by the teacher throughout the sessions in an autonomous way, establishing a classification system using points and a team ranking, in which badges were awarded as they successfully

achieved the goals. They challenged and cooperated appropriately, rewarding good sports behavior throughout the session.

Taking into account that the implementation of any educational program requires specific teacher training (Lee and Choi, 2015), the teacher received training in GF + CL composed of two phases: (1) a 25-hour course on theory and practice in both strategies, where he was given an explanation concerning how to design narratives in accordance with gamification and was provided with global and specific didactic resources, as well as strategies for the development of hybridization. (2) Continuous training: the teacher progressively acquired the ability to correctly develop the methodology through suggestions over time by the research team.

FIDELITY OF IMPLEMENTATION

Following Hastie and Casey (2014), the research should provide a detailed validation of the intervention program based on models or strategies. To do this, a checklist was drawn up by two expert judges (a university professor, with more than 10 years teaching experience, and a Doctor of Physical Activity and Sports Sciences, with more than 10 years of teaching experience as a secondary school teacher) which was used in the last session, and completed once the teaching unit was finished, both by the teacher who implemented the session (self-evaluation) and by an external evaluator who was present (both teachers were evaluated with the same checklist and following the same evaluation structure), to determine to what extent each of the specific strategies of this GF + CL methodological proposal had been used throughout the sessions that made up the teaching unit. The CG teacher was evaluated with the same checklist and following the same evaluation structure. In this case, there was also an external observer who was present at the sessions, but who did not provide feedback.

The external observer evaluated the frequency with which the teachers used the strategies related to GF + CL hybridization, which ranged from 1 to 4 (from never to always). In this sense, it can be confirmed that the evaluations coincided in most cases since the evaluations did not differ by more than one point. In addition, differences were observed in the scores of all the items on the checklist between the CG and the EG, with the highest values being in the EG. There are also differences in favor of self-evaluations compared to the external evaluator, although in both cases always less than what exists depending on the methodology used.

ANALYSIS OF DATA

Initially, the validation of the instruments was carried out by analyzing the internal consistency of both the pre-test and the post-test of each of the scales, using the Cronbach's alpha test to calculate the reliability, and the results of which have already been discussed. Then, an exploratory analysis of the data was carried out through Box-Whisker diagrams and descriptive measures, in which it was detected that the results could differ between gender and age, so this was taken into account in the subsequent inferential analysis. In fact, the groups were not

homogeneous in terms of age, since the mean age in the control group was 12.9492 years with a range between 12 and 17 years, while the mean age in the EG 14 years old with a range between 13 and 17 years old.

A MANCOVA (multivariate analysis of covariance) of repeated measures was carried out on the 8 variables obtained from the different questionnaires, where the intra-subject factor was called Time (with two levels: pre-test and post-test) and as an inter-test factor. Subject, was considered the Group (with two levels: control and experimental). Additionally, two control variables were added: the inter-subject factor Gender (two levels: male and female), as well as the covariate Age, since it was found that they can have a significant effect on the measured variables. An analysis of the residuals revealed the non-fulfillment of the hypothesis of normality and homoscedasticity of some variables, so it was decided to carry out the analysis also using non-parametric tests. The results obtained with both procedures were very similar, therefore, the results of nonparametric tests were not included for brevity. The statistical package IBM SPSS 22.0 (New York: USA) was used for the analysis.

RESULTS

INFERENTIAL ANALYSIS

In the MANCOVA of repeated measures at the multivariate level, where significant differences were obtained at the level of the intra-subject factor Group ($p = 0.001$), as well as significant interactions between the factor Time and Group ($p < 0.001$). It can also be shown how the Gender factor ($p < 0.001$) and the Age covariate ($p = 0.004$) are significant (Table 2).

These results show that it was appropriate to include these two variables to control their effect. The size of the effect (partial eta squared, η_p^2) was also included, which shows that the interaction between Time and Group has a greater effect and that explains a greater part of the variation in the measurements.

Table 2. Multivariate analysis of repeated measures

Effect	Factor	F (9,108)	p-value	η_p^2
Inter-Subjects	Group	3,372	0.001 **	0.219
	Gender	4,176	0.000 **	0.258
	Age	2,880	0.004 **	0.194
Intra-Subjects	Time	1,802	0.076	0.131
	Time x Group	11,129	0.000 **	0.481
	Time x Gender	1,265	0.264	0.095
	Time x Age	1,928	0.055	0.138

Note: * p <.05; ** p <.01

Subsequently, the results are analyzed at the univariate level showing that for the intra-subject factor there are significant differences in the Time x Group interaction at the level of psychological mediators index ($p < 0.001$, $\eta_p^2 = 0.221$), social climate ($p = 0.003$, $\eta_p^2 = 0.076$), teacher climate ($p < 0.001$, $\eta_p^2 = 0.230$), boredom ($p < 0.001$, $\eta_p^2 = 0.166$), satisfaction ($p = 0.001$, $\eta_p^2 = 0.075$) and

planning (p <0.001, η_p^2 = 0.126) , showing a greater effect on the index of psychological mediators and on the teacher's climate (Table 3).

Regarding the inter-subject factor, the univariate analysis showed significant differences for the Group factor at the level of the index of psychological mediators (p <0.001, η_p^2 = 0.132), and satisfaction (p = 0.007, η_p^2 = 0.061);

In the Gender factor, differences were observed in ADI (p = 0.005, η_p^2 = 0.067), index of psychological mediators (p = 0.001, η_p^2 = 0.094), satisfaction (p = 0.011, η_p^2 = 0.055), verbal fluency (correct animals) (p = 0.032, η_p^2 = 0.039), verbal fluency (correct vegetables) (p = 0.036, η_p^2 = 0.037) and planning (p = 0.010, η_p^2 = 0.056); and in the covariate Age at motivation level (p = 0.007, η_p^2 = 0.061), index of psychological mediators (p = 0.001, η_p^2 = 0.094), school climate (p = 0.013, η_p^2 = 0.052), teacher climate (p = 0.002, η_p^2 = 0.081) and satisfaction (p <0.001, η_p^2 = 0.101) In general, the effect sizes were medium or low.

Table 3. Univariate analysis of repeated measures

	Time		Group		Time x Group		Gender		Age	
Variable	F (1,116)	p-value	F (1,116)	p-value	F (1,116)	p-value	F (1,116)	p-value	F (1,116)	p-value
SDI	0.641	0.425	0.008	0.929	3,080	0.580	8,329	0.005**	7,503	0.007**
PMI	0.342	0.560	17,581	0.000**	32,931	0.000**	12,014	0.001**	12,050	0.001**
School climate	0.148	0.701	1,876	0.173	9,480	0.003**	1,762	0.187	6,324	0.013*
Teaching climate	3,051	0.083	3,409	0.067	34,640	0.000**	1,881	0.173	10,127	0.002**
Boredom	2,278	0.134	1,981	0.162	23,015	0.000**	1,382	0.242	0.374	0.542
Satisfaction	0.444	0.507	7,589	0.007**	12,196	0.001**	6,710	0.011*	13,085	0.000*
VF (CA)	1,519	0.220	0.002	0.962	0.437	0.510	4,694	0.032*	1,540	0.217
VF (CV)	2,919	0.090	0.629	0.429	0.595	0.442	4,501	0.036*	1,723	0.192
Planning	0.742	0.391	2,195	0.141	16,669	0.000**	6,822	0.010**	0.079	0.779

Note: * p <.05; ** p <.01; SDI = index of self-determination; PMI = index of psychological mediators; VF (CA) = Verbal fluency (correct animals); FV (VC) = Verbal fluency (correct vegetables).

Since there are interactions between the Time and Group factors for many of the variables, it is convenient to analyze the differences between the control and EG for the pre-test and post-test separately. In the pre-test there were no significant differences between the control and EG, which indicates that the groups are homogeneous with respect to the variables of interest.

However, there were significant differences in the post-test at the level of boredom (p <0.001) in favour of the CG, and at the level of the index of psychological mediators (p <0.001), school climate (p = 0.005), teaching climate (p <0.001), satisfaction (p <0.001) and planning (p <0.001) in favour of EG, with the index of psychological mediators having a greater effect (Table 4).

Table 4. Pairwise comparisons. By rows the Pre-Post Test comparisons are presented. Comparisons between groups are presented by columns

		Pre-test		Post-Test		Pre-Post Comparison	
	Group	**Half**	**FROM**	**Half**	**DT**	***p*-value**	**Dif (DT)**
SDI	Control	6,948	0.501	7,721	0.417	0.074	-0.773 (0.429)
	Experimental	7,176	0.493	7,600	0.411	0.316	-0.425 (0.422)
	p-value + η_p^2	0.757	0.001	0.844	0.000		
PMI	Control	3,908	0.059	3,837	0.600	0.285	0.070 (0.066)
	Experimental	3,938	0.058	4,418	0.059	0.000 **	-0.480 (0.064)
	p-value + η_p^2	0.727	0.001	0.000 **	0.275		
School climate	Control	3,629	0.081	3,710	0.075	0.309	-0.080 (0.079)
	Experimental	3,587	0.080	4,022	0.074	0.000 **	-0.435 (0.077)
	p-value + η_p^2	0.725	0.001	0.005 **	0.066		
Teaching climate	Control	3,945	0.083	3,844	0.066	0.215	0.101 (0.081)
	Experimental	3,767	0.082	4,365	0.065	0.000 **	-0.598 (0.080)
	p-value + η_p^2	0.147	0.018	0.000 **	0.199		
Boredom	Control	1,392	0.105	1,659	0.090	0.019 *	-0.266 (0.112)
	Experimental	1,620	0.104	1,099	0.089	0.000 **	0.520 (0.110)
	p-value + η_p^2	0.143	0.018	0.000 **	0.133		
Satisfaction	Control	4,485	0.067	4,530	0.047	0.442	-0.045 (0.059)
	Experimental	4,535	0.066	4,880	0.046	0.000 **	-0.344 (0.058)
	p-value + η_p^2	0.604	0.002	0.000 **	0.185		
VF (AC)	Control	13,939	0.437	14,853	0.411	0.023 *	-0.914 (0.398)
	Experimental	14,105	0.430	14,634	0.404	0.179	-0.529 (0.391)
	p-value + η_p^2	0.796	0.001	0.716	0.001		
VF (VC)	Control	6,805	0.310	7,018	0.312	0.431	-0.213 (0.270)
	Experimental	6,978	0.305	7,495	0.307	0.054	-0.518 (0.266)
	p-value + η_p^2	0.704	0.001	0.298	0.009		
Planning	Control	142,075	3,173	145,744	2,051	0.178	-3,668 (2,705)
	Experimental	138,992	3,121	158,810	2,018	0.000 **	-19,818 (2,661)
	p-value + η_p^2	0.508	0.004	0.000 **	0.141		

Note: * p <.05; ** p <.01; SDI = index of self-determination; PMI = index of psychological mediators; FV (AC) = Verbal fluency (Correct animals); FV (VC) = Verbal fluency (correct vegetables).

On the other hand, if we compare the variables between the pre-test and the post-test for each group, for the CG there were only significant differences for the variable VF (AC) (p = 0.023). On the other hand, for the EG, the scores for the variables IMP (p <0.001), school climate (p <0.001), teaching climate (p <0.001), satisfaction (p <0.001) and planning (p <0.001) increased, while that the level of boredom (p <0.001) was reduced (Table 4).

Finally, it should be noted that this statistical technique is based on some assumptions that must be verified. This has been done, although the results of

said analysis are not shown in order not to excessively lengthen the work, finding that the hypothesis of normality and homoscedasticity are not fulfilled. Likewise, some anomalous observations have been found, but their influence is not worrisome in the model estimates. All this can invalidate the results found, so non-parametric tests have been carried out to compare the different measures between the groups as well as to compare between the pre-test and the post-test. The results obtained coincide with those found with the MANCOVA, which indicates that the fulfillment of the initial assumptions has not had consequences on the results and the conclusions do not change.

DISCUSSION

The main objective of this study was to analyze the impact of a hybrid GF + CL teaching unit on student satisfaction with PE classes, satisfaction of basic psychological needs, school social climate and cognitive performance.

Regarding the hypothesis that a teaching unit based on the hybrid methodology (GF + CL) would improve the degree of satisfaction of students in PE classes, the results have shown differences in favor of the EG in satisfaction/fun, while boredom decreased between the pre and post-test with respect to the CG. In this sense, although there are no studies that show the effects of GF + CL on the degree of satisfaction towards PE classes, the results obtained by authors such as Yildrim (2017) are in line with confirming the efficacy of gamification for promoting student satisfaction and attitude towards classes. This is important to generate adherence to PA outside the school (Moore and Fry, 2017) and increase student motivation (Granero-Gallegos et al., 2012). Similarly, Ferriz-Valero et al. (2019) also corroborate the effectiveness of cooperative methodologies so that students perceive the sessions with greater satisfaction and enjoyment. The studies that hybridize the GF and cooperative strategies in other areas and educational stages (Dolera-Montoya et al., 2021; Moscato y Domínguez de la Rosa, 2018), show that the combination of both methodologies is effective to improve the satisfaction of students toward learning experiences.

Another part of the hypothesis that was raised in this study was that the EG would improve in the SDI and in the PMI. In this case, the results have shown that there are no significant changes in motivation. These results do not agree with those of Fernández-Río et al. (2020) or Van-Roy and Zaman (2017), on GF, and with that of Fernández-Argüelles and González (2018), in relation to CL, since in their interventions they do indicate an improvement in intrinsic motivation and in self-determined motivation respectively. This may be due to the fact that they measured this variable in a more specific way in the PE subject (Fernández-Río et al., 2020), focusing on more autonomous motivation. In secondary education, there is also evidence on the effects of GF (Monguillot Hernando et al., 2015) and cooperative methodologies (Fernández-Río et al., 2017; García Martínez et al., 2020) in improving student motivation, so it can be considered that the hybridization of both methodologies can enhance the increase of that variable. Based on the theory of self-determination, Van-Roy and Zaman (2019) indicate that the elements of the game cause an increase in autonomous motivation in students when they feel supported by their basic psychological needs, although this does not occur in this study. Another possibility, according to Mekler et al.

(2017), is that the components gamify work more as extrinsic incentives that promote performance.

On the other hand, the hypothesis of an improvement in the level of satisfaction of basic psychological needs is fulfilled, coinciding with the findings of Sailer et al. (2017), who showed how students expressed that they felt more autonomous, competent , and had better relatedness with their peers as a consequence of the game elements used. Along with the above, Van-Roy and Zaman (2019), indicates that the GF does not have to be directly linked to the most self-determined forms of motivation, but that the intermediate variable of basic psychological needs must be added for a better understanding of the functioning of the GF, which is in line with the present study. In relation to the cooperative methodology, the study by Fernández-Río et al. (2017) in which the CL was applied in PE, found improvements in the perception of the psychological need for relatedness. In this line, studies that used cooperative strategies in the implementation of hybrid pedagogical models in PE and in the secondary stage (Gil-Arias et al., 2017; Menéndez-Santurio y Fernández-Río, 2016), found improvements in the needs psychological autonomy, competence and relatedness, in the students of the EG.

Regarding the hypothesis that refers to the improvement of the classroom climate, the results show improvements between the pre-test and post-test and with respect to the CG for the school and teacher climate in favor of the EG. These results can be related to studies that use active methodologies such as that of Manzano-Sánchez and Valero-Valenzuela (2019b) where improvements were obtained in the school social climate in primary and secondary school after the application of a teaching unit based on the improvement of values in the classroom (Hellison, 2011). The study by Pérez-López et al. (2017), who applied the GF in the university context, shows the effectiveness of this teaching strategy to increase student motivation and satisfaction with the classroom climate and with their learning, and Ferriz-Valero et al. (2019) also demostrate the potential of CL to promote prosocial behavior and improve the atmosphere of coexistence in the classroom. Research that has investigated the effect of GF (Mora-González and Martínez-Téllez, 2015; Ardoy et al., 2017) and CL (Fernández-Río et al., 2017) on the classroom climate, show that both methodologies have a great impact on the creation of a relaxed classroom and center climate, in which prosocial behavior based on collaboration and cooperation predominate. This can be verified in the study by Dolera-Montoya et al. (2021), where the hybridization of the GF with the CL through physical-cooperative challenges yielded improvements in the social climate of the classroom in favour of the EG.

The last of the study hypotheses concerned the improvement of executive functions in young students, specifically verbal fluency and planning. The results showed significant improvements in planning, producing an increase in this variable in the EG. These results are in line with those reported by Davis et al. (2011), who also obtained improvements in planning capacity in a group of 7-11 year-old students, after the implementation of a 13-week aerobic exercise program using cooperative strategies. On the other hand verbal fluency did not show significant improvements unlike the study by Kvalø et al. (2017), although in this study the focus was on increasing PA and not with a methodology based

on CL. Regarding the studies that implemented active methodologies in the classroom, the research of Muñoz-Parreño et al. (2021) in Primary Education found improvements in the executive functions of inhibitory control, cognitive flexibility, working memory, verbal fluency and planning in the EG, after applying an educational program of active breaks through cooperative work. In the secondary education stage, the study by Melero-Cañas et al. (2021), in which a hybridized educational program in PE based on the PSRP and the GF was applied, showed significant differences in favour of the EG in the executive functions of verbal fluency, cognitive inhibition, language and planning, compared to a CG that used conventional teaching. Both studies used the NIH Examiner battery to assess students' cognitive performance.

As the main limitations of the present study, we would like to point out that the number of participants was quite low. In this sense, future studies should include larger populations and different educational centers or socioeconomic contexts. Second, the intervention time was limited, so the number of sessions of the teaching program and the implementation of both strategies should be increased. On the other hand, only the executive functions of verbal fluency and planning in paper format have been analyzed, due to the difficulties encountered in installing the NIH Examiner program on the computers in the educational center. In future studies, it would be convenient to use this program to assess other executive functions such as cognition, social behavior, working memory and congnitive flexibility and validate into Spanish, since although there is a version adapted to Spanish of the NIH Examiner the possible results of the psychometric tests in Spanish are unknown. In addition, instruments have been used that are more in line with the general educational environment than the PE subject itself, such as the "EME" motivation questionnaire, the "CECSCE" school climate questionnaire and the sports satisfaction questionnaire, so it becomes an aspect that may have conditioned the results. For future research it is advisable to select instruments that assess these variables in the PE context. Finally, no variable related to the level of PA was measured, so it is considered of great relevance that future research focuses on analyzing the consequences that both strategies cause in the time of motor engagament of PE students.

CONCLUSSIONS

It is concluded that the methodology based on the use of GF – CL strategies may be adequate to improve the degree of satisfaction of students towards PE. Likewise, the hybridization of strategies implied a decrease in boredom, a greater satisfaction of basic psychological needs and an improvement in the execuve planning function of the students in addition to a more favorable school climate.

If would be interesting for future research to measure whether this hybridized methodology generates a sufficient stimulus in the times of motor engagement and physical activity of PE students, as well as the relationship between the aerobic component and other executive functions such as mental flexibility, inhibitory control and working memory. In this way, the impact of GF + CL on cognitive performance could be analyzed more effectively. It would also be interesting for future studies to take into account other factors such as the level of obesity and physical condition of the subjects.

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