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Article

Enhancements on cognitive performance and academic achievement in adolescents through the hybridization of an instructional model with gamification in Physical Education

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Abstract: This study examined the effect of an educational hybrid physical education (PE) intervention on cognitive performance and academic achievement in adolescents. A 9-month group-randomized controlled trial was conducted in 150 participants (age: 14.63 ± 1.38) allocated into control group (CG, n = 37) and experimental group (EG, n = 113). Inhibition, verbal fluency, planning and academic achievement were assessed. Significant differences were observed in the post-test for cognitive inhibition, verbal fluency in animals, and the average from verbal fluency in favour of the EG. With regard to the intervention, verbal fluency in animals, verbal fluency in vegetables, the average of verbal fluency, cognitive inhibition, language, the average of all subjects, the average of all subjects except PE, and the average from the core subjects) increased significantly in the EG. The last five variables (the academic ones and cognitive inhibition) also increased in the CG, in addition to mathematics. This study contributes to the knowledge by suggesting that both methodologies produced improvements in the measured variables, but the use of a hybrid program based on TPSR and gamification strategies produce improvements in cognitive performance, specifically through the cognitive inhibition and verbal fluency.

Keywords: model-based learning; mental health; physical activity; cognitive functions; active learning.

1. Introduction

Mental health is an integral and essential component of health, defined by World Health Organization (WHO) as "*a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity*" [1]. Poor mental health is associated with rapid social change, stressful work conditions, gender discrimination, social exclusion, unhealthy lifestyle and physical ill-health [1]. Consequently, there are numerous studies that positively link physical activity (PA) and physical fitness (PF) with mental health, with special emphasis on cognitive functions [2-4], mental disorders/illnesses such as depression [5,6] and even suicide tendencies [7,8]. Explaining how and under what conditions mental health changes occur may facilitate the intervention at school [9]. Schools are the most influential places in order to promote an unique thinking focused on health [10,11]. In addition to the positive and innumerable benefits that Physical Education (PE) through PA has generally on physical health (e.g. cardiorespiratory fitness or body composition) [12,13], PE pursues other objectives such as cognitive-emotional performance and academic achievements. Sibley and Etnier completed a meta-analysis founding significant and positive effects of PE intervention on cognition in youth [14]. In the same vein, Ardoy

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et al. [15], reported that increasing the amount of hours of PE sessions may interesting results on cognition.

The cognitive training of children is, in large part, a task entrusted to the educational system [16]. High cognitive performance refers to the achievement of optimal and affective functioning of executive functions (EFs) which are essential for mental and physical health [17] and crucial for children´s adaptive behavior [2,18]. Many of them such as inhibition, working memory or cognitive flexibility, are predictive of success throughout the school years from preschool through university [19-21].

Within the school context, the academic performance of pupils is typically rated through the assessment of their knowledge and scholastic aptitude in various subjects, being the most prominent Mathematics and Literacy [22]. To enhance academic performance, instructional time for core academic subjects is prolonged and protected, often at the expense of time spent in PE and other subjects of the curriculum. PE has been attributed a lower status than academic subjects [23] and sometimes it is perceived as interference [24]. However, no evidence indicating that increased time spent in practicing PA in the school setting has an adverse effect on academic performance [25]. In fact, PE sessions also may have a positive effect on academic achievement at school [2,14,24-26], and afterschool [27,28].

Active learning, technical term for a set of pedagogical practices (strategies, techniques and methodologies), engages students in the process of learning [29] providing opportunities for meaningful academic activities which has a positive impact on retention, opposed to passively listening to an expert [29-31]. Freeman et al. [32] compared in a large meta-analysis, the performance of primary and secondary level students who were taught by the active methods. Their analyses revealed mean score 6% higher in students from active learning courses in comparison to those from passive learning courses in disciplines such as science, engineering and mathematics. In addition, the failure of traditional class students was 55% higher than that of active methodology students. In a subsequent intervention study, conducted by Hao et al. [33] also demonstrated positive effects of active learning on academic performance. Definitely, the use of active methodologies are the perfect elements to promote the competence development and motivation of students, making them the protagonists of their learning and facilitating social interaction [34] also complying with the demands of the current education system [35]. In addition, this kind of methodologies are the most successfully improve EFs because are continually challenging them and also bring children joy and pride, give them a feeling of social inclusion and belonging, and help their bodies to be strong, fit and healthy [21].

Gamification, understood as the selective application of game mechanics to a non-game activity that is not a fully-packaged game [36], has been used as a means of increasing motivation status in several PE interventions [37,38]. Applying educational gamification promotes students participation, especially if the game elements used in gamification have established objectives and rewards [39]. Some of its elements such as storytelling, social relationship or the action of playing, constitute a special tool in order to improve cognitive and academic performance [21,40] even using them like an online learning one [41]. However, only one intervention studied its cognitive consequences [42]. In gamification interventions, games have a storytelling and a responsibility about a common goal [40]. On the other hand, the Teaching Personal and Social Responsibility (TPSR), a model based on the transfer of autonomy to the student generating high levels of responsibility [43], may also be appropriate in order to improve motivation and social factors [44, 45], important factors to improve and develop EFs [17,21]. The power of hybridizations pedagogical models goes beyond the combination of educational elements [46]. It can help educator use multi-model approach in each program to enable innovation to fit current educational frameworks fully reach all their students [47], maximizing their impact and enhance the potentialities of the different pedagogical models alone [48].

Hybridising the two methodologies previously commented on is therefore proposed, as various authors [46,49,50] have suggested the hybridisation of pedagogical models, backed up by evidence of combined benefits in the physical/motor, cognitive, affective,

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and social domains which have been observed only when merging different pedagogical model.

Consequently, the aim of the present study was to verify whether the implementation of a program based on the hybridization of TPSR and gamification in PE classes can improve the cognitive performance and academic achievement in adolescents.

2. Materials and Methods

2.1. Study design and participants

A group-randomized controlled trial [51] was carried out from October (2018) to June (2019). The intervention program lasted for 9 months (Figure 1) in two secondary schools assigned to Control Group (CG) and Experimental Group (EG). Sociodemographic and cultural characteristics were similar. Participants aged between 13 and 15 years were enrolled in the second or third year of compulsory secondary education at the beginning of the intervention in one of the two secondary schools selected. The exclusion criteria included participants not having any partial or chronic injury or disease that would prevent them from performing any of the physical and cognitive tests, and not having been diagnosed as a student with specific needs for educational support, so that the participants could take part normally in a PE lesson.

The PE contents were exactly those established by the educational institutions in both centers. At the beginning and end of the intervention, both test sessions were carried out.

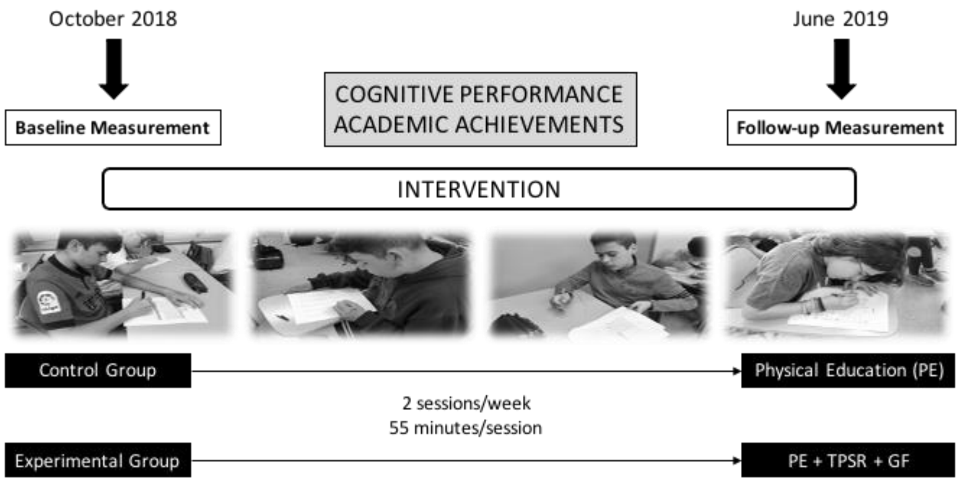

Figure 1. Variables and timeline intervention.

At the beginning, 211 adolescents started the program, with 164 (age: 14.63 ± 1.38 years; 77.73% of the total) who finally formed part of the intervention (90 boys and 74 girls) allocated to the CG (n = 40) and EG (n = 124). However, a total of 150 participants finished the intervention, 91.46% of the total number of students who started it, 37 in the CG and 113 in the EG. Fourteen students did not finish the study, three from the CG (two boys and one girl) and 11 from the EG (six boys and five girls), the reasons were due to school absenteeism with students missing more than 20% of PE lessons (n = 6) and discomfort during the performance of the physical or cognitive tests in the post-test (n = 8).

Each group (CG and EG) received two PE periods of 55 minutes every week. Whereas the EG took part in a PE classes based expressly on the hybridisation of TPSR and gamifications strategies, taking into account the game-based learning, the CG used traditional learning methods characterised by non-integration and lack of transfer of learning outside of school. Moreover, the teacher of CG had no experience in active methodologies like those mentioned above.

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2.2. Procedure

2.2.1. TPSR intervention program.

The goal of the implementation of TPSR program was to develop an adequate class climate not only to promote responsibility but also to construct a developmentally appropriate intervention. Teacher used general strategies to implement TPSR (i.e. being an example of respect, setting expectations or providing opportunities) and specific ones (i.e. redefining success, personal work plan or group responsibility) [43]. Additionally, every sessions followed the Hellison´s format [43], but was modified to keep four of its five parts: (1) Initial greeting: the teacher interacted with the students to create bonds with them, (2) Sensitivity talk: the teacher presented the academic and value goals of the session, depending on the responsibility model level, (3) Activity plan: this was the greatest part of the practical lesson, where responsibility strategies were included in the different tasks, (4) Group meeting and self-assessment: at the end of every session, teachers and students shared their perceptions with regard to individual and collective responsibility and behaviors, as well as the teacher's behavior, pointing their thumbs up (positive evaluation), to one side (medium) or down (negative evaluation).

2.2.2. Gamification strategies

Regarding the gamification elements in the intervention programme, the process of integrating game-design principles within varying educational experiences appears challenging and there are currently no practical guidelines for how to do so in a coherent and efficient manner. However, gamification is an important key in order to predict academic achievements, which influences the effort and time a student spends engaged in learning [52]. The intervention has used an adaptation of Werbach´s categories [53]: dynamics, mechanics, and components (Fig 2). The following elements were included as part of the gamified context: (a) Powerful narrative: the Seneb´s Enigma was designed as the common theme in order to discover a holistic concept of health, previously extinct; (b) Challenges: for each mythology, students had to participate in two different activities, generally outside the school. Each one included different difficulty levels to challenge the students individually and in groups; (c) Class climate: the focus was on performing the different tasks, helping group members, earning points, earning badges, and not on outperforming others; (d) Immediate feedback: students knew in advance how to successfully perform each activity, the number of points awarded for each task, and the level effectively achieved through a social platform; (e) Badges for achievements: students could earn points ('healthy years') to obtain several badges on each unit; (f) Final status: depending on the mythologies overcome, students could reach one of the three statuses (squires, Egyptian 'melli', and bearers of Seneb).

This part of the methodology is focused on the code to motivate (RAMP) of Marczewski [54]: Relatedness or being connected with more people in a community; Autonomy, or the sense of being able to give an opinion without censorship; Mastery, or how your skills increase until you reach absolute control; and Purpose, or the significance of each step taken.

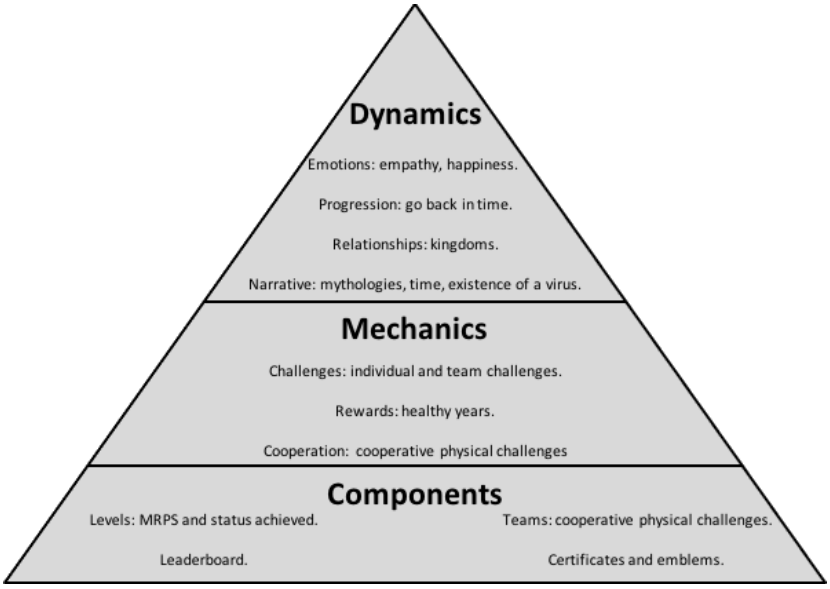

Figure 2. Elements categories based on Werbach and Hunter (2014).

2.2.3. Direct Instruction methodology

The CG teacher, non-innovative expert, used a methodology based on direct instruction whose most representative characteristics were centered on content development and teacher´s actions, without any interaction with the students and focused on the result of the tasks and not in the learning progress [55].

Each session was divided into three non-connected parts: (1) Warm-up: body temperature is increased with simple activities such as joint mobility or stretching, using methodological guidelines based on reception of contents; (2) Main part: total count of activities designed to improve the assigned technical objective; and (3) Cool down: following the stretches marked by the teacher [55].

This teacher directed and decided the selection of the contents, the strategies to control and presented tasks, the way of participation and task advances. Moreover, the beginning and the end of sports practice without the influence of students which did not have to make decisions.

A detailed and extended description of the methodologies on the study has previously been published [56].

2.3. Instruments

2.3.1. Cognitive performance

EFs were assessed through different tools. NIH Examiner [57] was the instrument to evaluate verbal fluency and planning while the Stroop Color and Word Test [58] was used to value the cognitive inhibition.

- For the *verbal fluency task*, examinees were instructed to name as many words (animals and vegetables) as possible in sixty seconds for each category. All responses were recorded by the examiner. The number of correct responses, repetitions and rule violations were totaled for each category in three variables: animals, vegetables and the average of both two variables.
- For the *unstructured task (planning)*, examinees had to complete four pages of puzzle games. Each puzzle had a designated point value and subjects are given 6 minutes to earn as many points as possible. Irrespective of actual point value, puzzles could have a high or low cost-benefit ratio. Subjects needed to plan ahead, avoid items that were strategically poor choices.
- For the *cognitive inhibition task*, examinees were required to read three different tables as fast as possible. In the first two tables, subjects had to read names of colours

(henceforth referred to as colour-words) printed in black ink and name different colour patches. Conversely, in the third table, entitled colour-word condition, colour-words were printed in a coloured ink that did not match the meaning of the word (i.e. the word 'red' was printed in green ink). In this instance, participants were required to name the colour of the ink instead of reading the word.

2.3.2. Academic achievement

Academic achievement was assessed using the students´ grades in the subjects. The grades were collected from the official school´s records at two specific moments: at the end of the first three months (October: pre-intervention) and the academic year (June: post-intervention). According to content done, skills, attitude, behavior or homework, teachers from each subject gave an average score ranged from 1 (worst) to 10 (best).

The academic variables used in this study were: grades in Mathematics and Language; the average from all subjects and with the exception of PE; and from core subjects.

- *Average from all subjects (eight subjects)*: Language, Mathematics, Geography/History, Physics/Chemistry, Biology (only in 2nd grade), English, PE, Music and Plastic education or Technology (depending on the grade) subjects.
- *Average from all subjects with the exception of PE (seven subjects).*
- *Average from core subjects (six subjects)*: Language, Mathematics, Geography/History, Physics/Chemistry, Biology (only in 2nd grade) and English. Although the students in 3th grade have Physics/Chemistry and Biology subjects and the students in 2nd grade only have Physics/Chemistry, the average are the same in both groups.

2.4. Fidelity of implementation

Hastie and Casey (2014) [59], indicated that researchers should provide: '(a) a rich description of the curricular elements of the teaching unit, (b) detailed validation of program implementation based on models or strategies, and (c) detailed description of the "program context" so that readers acquire an accurate and complete understanding of the research design and results obtained'. Parts (a) and (b) have already been detailed in the previous paragraphs. For a detailed validation of model implementation, the research team tried to videotape all sessions. The teachers of each group (CG and EG) were filmed and analyzed by an external observer in order to verify the fidelity of TPSR and gamification implementation in 10 isolated sessions randomly throughout the intervention (five sessions per group—550 minutes). Each one was distributed in eleven observation periods of 5 minutes. The camera was installed in the classroom two sessions prior to the beginning of the study to familiarize students with it and to avoid nonspontaneous behaviors and reactive bias.

Two experts, people trained in the application and evaluation of these types of pedagogical models, checked the reliability of both methodological behaviours and evaluated the frequency that teachers used the hybridisation learning models, choosing between 0 (absence of element) or 1 (presence of element). These experts were trained beforehand to check the quality of their record-keeping by calculating the inter-observer and intra-observer agreements. Inter-observer agreement was carried out between the new teacher and the expert teacher guaranteeing an agreement greater than 87%, while the intra-observer agreement was carried out analysing two different moments over seven days, guaranteeing an agreement greater than 93%. The check list instrument (Table 1) was informed by the tool for assessing responsibility-based education (TARE) [60] adding the categories for a gamified intervention [53]. The instrument was used to identify the gamification and responsibility elements respectively. Total agreements (TA) were calculated using the formula: number of total agreements (NTA) divided by agreements (A) plus disagreements (D) (TA = NTA/A + D). Presence average of each element for all analysed sessions was calculated.

Table 1. Fidelity implementation instrument.

	Control Group	Experimental Group
1. Mechanics (MC). Grants rewards and provides feedback on the accomplishment of the challenges.	0.33	0.80
2. Dynamics (DN). Introduces a narrative thread into the session. Generates curiosity.	0	0.63
3. Components (CO). Generates missions, realms (groups), roles/status, badges, rankings and markers.	0	0.90
4. Leadership (L). Allows students to lead or be in charge of a group.	0	0.90
5. Task in group (TIG). The activity is carried out in a group, with the participation of all team members.	0.16	0.80
6. Autonomy (AU). Empowers students to meet cooperative challenges.	0.33	0.96
7. Problem solving (PS). Works with problem situations that force the student to seek solutions through inquiry or investigation.	0.16	0.66
8. Choice and voice grant (CVG). It is allowed to reflect, interact and give them a voice on decisions that affect the development of the class.	0.16	0.43
9. Foster the group creation and cohesion (GCC). Favors the cohesion and creation of groups in the proposed activities.	0.16	1
10. Role in evaluation time (RET). Allows students to play a role in assessing learning.	0.00	0.53
11. Transfer (T). The possibility of applying the values in class to other contexts in real life.	0.00	0.40
12. Set expectations (SE). It makes explicit to students what it expects of them. Also on the content that will be addresses.	0.33	0.93
Total Mean	0.14	0.75

2.5. Data analysis

The effects of the programme on the different variables were analysed taking into account the distribution of the sample. The sample was purified through Mahalanobis´ technique solely with the variables of cognitive performance (EFs), because the variables of academic achievement were calculated by the students´ grades. For this reason, three subjects (two boys and one girl) were excluded. Consecutively, we carried out an exploratory analysis of the data, using descriptive measurements, detecting that there were significantly different results between the groups in pre-test, so this was taken into account in the inferential analysis carried out.

A MANOVA of repeated measurements was the first analysis carried out on the ten variables obtained from the different cognitive tests (five variables) and the student´s grades in the subjects (five variables), where we called the intra-subject factor 'Time' (with two levels: pre-test and post-test), and we called the inter-subject factors 'Group' (with

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two levels: control and experimental). Subsequently, the inter-subject age factor and gender were added as covariates, since we found that these factors could have a significant effect on the measured variables. Additionally, the intervention effect size was estimated using the d-Cohen [61] with Hedges correlation for small sample sizes [62]. Taking into account Cohen reference, the effect size is considered small when it is 0.2–0.5, medium when it is 0.51–0.8 and large with values greater than 0.8. The entire statistical analysis was performed with the Statistical Package for the Social Sciences (IBM SPSS 24.0), establishing the level of significance as $p < 0.05$

2.6. Ethics statement

Insofar as ethical rules are concerned, the study previously received the approval of the Ethics Committee of the University of Murcia (2871/2020). All participants were treated in accordance with ethical guidelines with respect to consent, confidentiality, and the anonymity of the participants. Moreover, an informed written consent was obtained from the parents and the headteachers of the school centres on behalf of the minors/children participating in the study.

3. Results

3.1. Inferential analysis

The MANOVA test of repeated measurements shows the results at the multivariate level as the first step in the analysis. Regarding the inter-subject analysis, it can be observed that there is a significant difference in the Gender covariate (Lambda of Wilks = 0.836; F = 2.986; $p = 0.003$) as well as the Group factor (Lambda of Wilks = 0.575; F = 11.232; $p < 0.001$). It can also be observed that there are significant differences in the intra-subject analysis in Time (Lambda of Wilks = 0.771; F = 4.512; $p < 0.001$) and between Time–Group ((Lambda of Wilks = 0.508; F = 14.716; $p < 0.001$) and Time–Age (Lambda of Wilks = 0.761; F = 4.783; $p < 0.001$) interactions.

With the objective to observing the significant differences on variables, the univariate level was analysed attending to the variable with previously significant results. For the intra-subject factor, significant differences were found in Time factor for language (F = 16.189; $p = 0.000$), mathematics (F = 7.410; $p = 0.007$), the average of all subjects (F = 6.061; $p = 0.015$) with the exception of PE (F = 4.239; $p = 0.041$); in Time and Age interactions for language (F = 19.703; $p < 0.001$), mathematics (F = 8.506; $p = 0.004$), the average of all subjects (F = 10.327; $p = 0.002$) with the exception of PE (F = 7.838; $p = 0.006$); and in Time and Group interactions for mathematics (F = 4.912; $p = 0.028$), cognitive inhibition (F = 67.346; $p < .0001$), verbal fluency in animals (F = 51.924; $p < 0.001$), verbal fluency in vegetables (F = 7.406; $p = 0.007$), and the average of verbal fluency (F = 57.784; $p < 0.001$).

For the inter-subject factor, significant differences were found in Gender factor for Language ($p = 0.005$), the average of all subjects ($p = 0.039$) and with the exception of PE ($p = 0.024$); and the average of core subjects ($p = 0.032$).

Since the main objective was to observe interactions between the Time and Group factors for many of the variables, we could separately analyse the differences between the CG and the EG for the pre-test and the post-test. Similarly, the variables in the pre- and post-tests were compared separately for each group. Thus, Table 2 reflects the means and standard error estimated for the participants regarding the different variables measured in the pre-test and in the post-test, differentiated by group. In addition, the p-values obtained by comparing these estimated averages (using the Bonferroni correction) are included.

Table 2. Intervention multivariate analysis (MANOVA).

Variable	Group	Pre-test	Post-test	Pre–post Comparative

		Mean	SE	Mean	SE	*p*-value	Dif (SE)
	Experimental	6.08	0.19	6.32	0.20	0.005**	-0.24 (0.085)
Language	Control	5.16	0.34	5.76	0.36	0.000**	-0.59 (0.152)
	p-value + SE	0.025*	0.405	0.183	0.424		
	Experimental	5.15	0.20	5.16	0.22	0.941	-0.01 (0.124)
Mathematics	Control	4.87	0.36	5.45	0.39	0.010**	-0.55 (0.336)
	p-value + SE	0.505	0.419	0.531	0.459		
	Experimental	5.85	0.17	6.34	0.17	0.000**	-0.49 (0.059)
AAS	Control	5.87	0.30	6.37	0.31	0.000**	-0.50 (0.106)
	p-value + SE	0.957	0.357	0.942	0.364		
	Experimental	5.59	0.18	6.12	0.18	0.000**	-0.53 (0.061)
AAS-N-PE	Control	5.79	0.33	6.27	0.32	0.000**	-0.47 (0.108)
	p-value + SE	0.596	0.384	0.696	0.380		
	Experimental	5.65	0.18	5.98	0.19	0.000**	-0.32 (0.061)
ACS	Control	5.51	0.33	5.88	0.34	0.001**	-0.37 (0.109)
	p-value + SE	0.706	0.391	0.806	0.405		
Cognitive	Experimental	5.30	0.71	9.80	0.61	0.000**	-4.49 (0.706)
inhibition	Control	8.00	1.27	4.70	1.09	0.009**	3.30 (1.25)
	p-value + SE	0.000**	1.48	0.000**	1.27		
Verbal	Experimental	11.08	0.30	14.23	0.29	0.000**	-3.14 (0.245)
fluency	Control	13.33	0.54	12.81	0.53	0.232	0.524 (0.436)
(animals)	*p-value* + SE	0.001**	0.634	0.023*	0.619		
Verbal	Experimental	6.90	0.21	7.85	0.22	0.000**	-0.94 (0.177)
fluency	Control	7.21	0.38	7.16	0.39	0.873	0.05 (0.315)
(vegetables)	*p-value* + SE	0.489	0.446	0.135	0.455		
Verbal	Experimental	9.00	0.22	11.04	0.21	0.000**	-2.04 (0.148)
fluency	Control	10.27	0.39	10.00	0.38	0.276	0.27 (0.263)
(average)	*p-value* + SE	0.006**	0.461	0.020*	0.448		
	Experimental	139.57	2.25	290.81	108.20	0.166	-151.2 (108.7)
Planning	Control	141.47	4.00	176.71	192.38	0.856	-35.23 (193.2)
	p-value + SE	0.685	4.65	0.611	224.01		

Note: * $p < .05$; ** $p < .01$; SE = Standard Error; ALM = Average Language and Mathematics; AAS = Average all subjects; AAS-N-PE = Average all subjects, no PE; ACS: Average core subjects.

Most of the variables did not differ among the study groups at baseline, except for language (p = 0.025) which was marginally lower in the CG, and verbal fluency in animals (p = 0.001); the average from verbal fluency (p = 0.006) and cognitive inhibition (p < 0.001), were also lower in the EG. However, it is relevant to remark that there were significant differences in the post-test with cognitive inhibition (p < 0.001), verbal fluency in animals (p = 0.023), and the average from verbal fluency (p = 0.020) in favour of the EG. In addition, these results are extremely relevant because in the pre-test they were significantly higher in the CG. Hence, the increment was even more significant.

However, if we compare the effect of intervention observing the results between the pre-test and the post-test for each group, it can be observed that for the CG, there are significant differences in language (p < 0.001), mathematics (p = 0.010), the average from all subjects (p < 0.001), the average from all subjects except PE (p < 0.001), the average from the core subjects (p = 0.001), and cognitive inhibition (p = 0.009). Regarding the EG, the results increased significantly in language (p = 0.005), the average from all subjects (p < 0.001), the average from all subjects except PE (p < 0.001), the average from core subject (p < 0.001), cognitive inhibition (p < 0.001), verbal fluency in animals (p < 0.001), verbal fluency in vegetables (p < 0.001) and the average from verbal fluency (p < 0.001). Only mathematics and planning were not significantly increased in EG

4. Discussion

This intervention program was carried out to ascertain whether the hybridization based on TPSR and gamification could improve the cognitive performance and academic achievement in adolescents.

In the first place, it is important to state that there is no study based on the hybridisation of pedagogical models that has evaluated academic achievement. In this sense, the results observed did not contribute significantly to the enhancements of any of the academic variables studied in relation to the CG. Our conclusions coincided with different systematic reviews which found a null relationship between its PA interventions and academic achievement [63,64]. In fact, Watson et al. [64] concluded by suggesting that it is not possible to draw definitive conclusions due to the level of heterogeneity in intervention components and their relationship with academic achievement not being clear as to whether improvements in academic-related outcomes were a result of the intervention or a result of the break from academic instruction [63].

However, several studies based on active learning found a link with the improvement of academic achievement [32,33]. Watkins and Mazur concluded their intervention highlighting the substantial impact on the retention of students in STEM subjects (science, technology, engineering, and mathematics) using these kind of methodologies [65]. Haak et al. [66] concluded their study by stating that active learning increased performance on exam questions that demanded higher-order cognitive skills and improved introductory biology scores.

Notwithstanding these facts, academic achievement may be explained by controlling cognitive abilities and developing EFs [67]. Despite the fact that the use of a hybridisation of pedagogical models is the appropriate way to improve the levels of motivation, engagement, and EFs [47], it has never been used before in order to seek a cognitive performance.

The results in this current study, speaking cognitively, contributed significantly to the improvements of verbal fluency in animals, verbal fluency in vegetables, the average of verbal fluency, and cognitive inhibition. These results confirm the importance of several aspect such as storytelling, social relationships, and the power of playing which Diamond [17,21] or Howard-Jones [40] highlighted to improve cognitive performance.

In addition, our results took the same approach with several active learning interventions enhancing EFs [30,31,42]. Benzing et al. [30] found positive effects on the EFs in students who used an active strategy based in activities with high cognitive demands with respect to the group with low cognitive demands and the sedentary group. Meanwhile, Flynn et al. [31] showed that children who used active learning techniques improved their EFs significantly. Ruiz-Ariza et al. [42] concluded that the EG, who used Pokemon GO, significantly increased their cognitive variables such as selective attention and concentration levels compared to the CG.

4.1. Strengths and limitations

The amount of representation in the study may be a limitation because it is not optimal enough in terms of quantity to draw definitive conclusions. In this line, the distribution of students by group may be another limitation being the CG unequal with respect to the EG. Furthermore, It could be convenient not to extend the post-intervention tests until dates close to the evaluations established by the educational centres, due to possible experimental mortality.

Academic achievement is a variable which is difficult to control since it can be influenced by numerous variables beyond the teaching methodology such as small sample sizes, cross-sectional design, failure to take account of confounders, or bias. However, the methodology of the CG was not entirely controlled. This fact may explain the improvements found regarding cognitive planning and language.

Although experimented and qualified people were used to carry out the tests, they were different in the two moments test (pre and post). It was so complicated the search for personnel for which we understand that it may be a limitation.

The activity carried out after school hours represented in the number of days per week students receive extra lessons may also be a limitation, affecting their final academic scores.

5. Conclusions

The results obtained with the intervention suggest that the use of a hybridization based on TPSR and gamification strategies generated improvements in cognitive performance but not in academic achievement. The intervention managed to improve some EFs such as cognitive inhibition and verbal fluency. The observations from these data highlight the importance of promoting and empowering cognitive processes to attain better academic achievement. However, academic achievement is influenced by several factors which are hardly controllable.

State authorities and education administrations should consider the inclusion of innovative programmes and their hybridisation as a tool to guarantee an optimal cognitive performance in adolescents. It is even more relevant in a pandemic era like the current one for several powerful reasons such as happiness, disconnection, motivation and a different way of posing the tasks.

Future studies involving larger sample sizes should confirm or contradict these preliminary findings.

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