

## Article

# Enhancements in Cognitive Performance and Academic Achievement in Adolescents through the Hybridization of an Instructional Model with Gamification in Physical Education

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**Abstract:** An educational physical education (PE) hybridization program based on the personal and social responsibility model and gamification strategies was used in order to explore the effect on cognitive performance and academic achievement. A 9-month group-randomized controlled trial was conducted, with 150 participants (age:  $14.63 \pm 1.38$ ) allocated into the 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 (named animals), and the mean of both verbal fluency tasks in favor of the EG. With regard to the intervention, verbal fluency (named animals), verbal fluency (named vegetables), the mean of both verbal fluency tasks, 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. Values for the last five variables (academic variables and cognitive inhibition) in addition to mathematics also increased in the CG. This study contributes to the current knowledge by suggesting that both methodologies produced improvements in the measured variables, but the use of the hybridization resulted in improvements in cognitive performance, specifically with regard to 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 with mental health, with special emphasis on cognitive functions [2–4], mental disorders/illnesses such as depression [5,6], and even suicidal 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 to promote 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 in which they found significant and positive effects of PE intervention on cognition in youth [14]. In the same vein, Ardoy et al. [15], reported

that increasing the number of hours of PE sessions may generate interesting results with regard to 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 these, 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, especially 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 in the curriculum. PE has been attributed a lower status than academic subjects [23], and sometimes is perceived as an interference [24]. However, there is no evidence to indicate that spending time 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 after school [27,28].

Active learning, technical term for a set of pedagogical practices (strategies, techniques, and methodologies), engages students in the process of learning [29]. It provides opportunities for meaningful academic activities which have a positive impact on retention, as opposed to passively listening to an expert [29–31]. In a large meta-analysis, Freeman et al. [32] compared the performance of primary- and secondary-level students who were taught using active methods. Their analyses revealed 6% higher mean scores 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 rate of traditional class students was 55% higher than that of active methodology students. In a subsequent intervention study, Hao et al. [33] also demonstrated the positive effects of active learning on academic performance. Active methodologies provide the perfect elements to promote competence development and the motivation of students, making them the protagonists of their learning and facilitating social interaction [34], while also complying with the demands of the current education system [35]. In addition, these kinds of methodologies are the most successful in improving EFs because they provide continuous challenges and also bring children joy and pride, give them a feeling of social inclusion and belonging while also helping 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 student participation, especially if the game elements used in gamification have established objectives and rewards [39]. Some of its elements, such as storytelling, the involvement of social relationships, or the action of playing, constitute a special tool in order to improve cognitive and academic performance [21,40], even when used for online learning [41]. However, only one study has investigated its cognitive consequences [42]. In gamification interventions, games have a storytelling element and a common goal [40]. On the other hand, Teaching Personal and Social Responsibility (TPSR), a model based on the transfer of autonomy to the student and generating high levels of responsibility [43], may also be appropriate in order to improve motivation and social factors [44,45]. These are important factors to improve and develop EFs [17,21]. The power of hybrid pedagogical models goes beyond the combination of educational elements [46]. These models can help educators use a multi-model approach in each program to enable innovation to fit current educational frameworks that fully reach all their students [47], maximizing their impact and enhancing the potentialities of the different pedagogical models individually [48].

Combining the two previously described methodologies is therefore proposed, as various authors [46,49,50] have suggested hybridizing pedagogical models, supported

by evidence of combined benefits in the physical/motor, cognitive, affective, and social domains which were observed only when merging different pedagogical models.

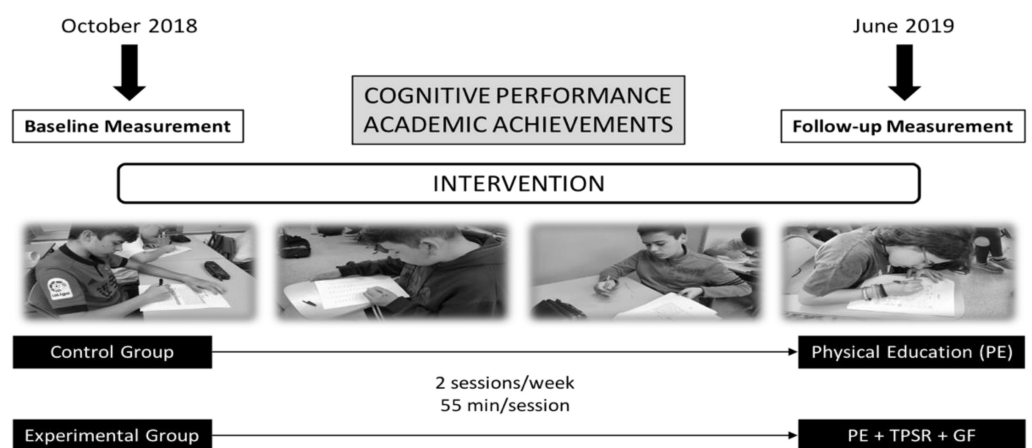
Consequently, the aim of the present study was to check whether the hybrid intervention can improve the cognitive performance and academic achievement in adolescents.

## 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) in the region of Murcia, in the southeast of Spain. The intervention program lasted for 9 months (Figure 1) in 2 secondary schools, with participants assigned to the 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 1 of the 2 secondary schools selected. The exclusion criteria included participants with any partial or chronic injury or diseases that would prevent them from performing any of the physical and cognitive tests, or who were considered to have problems requiring special attention, so that the included 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:  $14.63 \pm 1.38$  years; 77.73% of the total) finally forming part of the intervention (90 boys and 74 girls) with allocation 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). Overall, 14 of the participants did not complete the intervention; 3 were from the CG (2 boys and 1 girl) and 11 from the EG (6 boys and 5 girls). This was due to student absences from more than 20 percent of PE classes ( $n = 6$ ), including the post-test days ( $n = 8$ ).

Each group (CG and EG) received 2 PE periods of 55 min every week. While the EG took part in a PE classes based expressly on the hybridization of the TPSR and gamification strategies (taking into account game-based learning), the CG used traditional learning methods characterized by non-integration and lack of transfer of learning outside of school. Moreover, the teacher of CG had no experience in active methodologies such as those mentioned above.

### 2.2. Procedure

#### 2.2.1. TPSR Pedagogical Model

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 appro-

appropriate intervention. The teacher used general strategies to implement TPSR (i.e., presenting an example of respect, setting expectations, or providing opportunities) and specific ones (i.e., redefining success, use of personal work plan, or group responsibility) [43]. Additionally, every session followed Hellison's format [43], but was modified to keep 4 of its 5 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-related goals of the session, depending on the responsibility model level; (3) Activity plan: this represented the greatest part of the practical lesson, where responsibility strategies were included in the different tasks; and (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 Tools

Analyzing some interventions in which gamified elements and tools were used, there are no specific notions on how to carry them out efficiently. However, gamification is an important key in order to predict academic achievements, and influences the effort and time a student spends engaged in learning [52]. The intervention used an adaptation of Werbach's categories [53]: dynamics, mechanics, and components (Figure 2). Some of the gamified elements that were implemented in the intervention were as follows—(a) A powerful narrative was used that focused on the integral health of adolescents, which is increasingly limited; (b) Challenges: different activities related to competency and generally carried out outside the school context were undertaken, each with the aim of improving healthy lifestyle habits; (c) A positive emotional classroom climate was generated, assuming the opinions of other classmates and learning of their conclusions (reward items such as points or badges are important); (d) Direct and immediate feedback: individual feedback on the motor actions of students was provided through a social platform or daily in PE classes; (e) Badges: points were acquired for each achievement in the successive challenges; and (f) Final status: depending on the mythologies overcome, students could reach one of the 3 statuses (squires, Egyptian "melli", and bearers of Seneb).

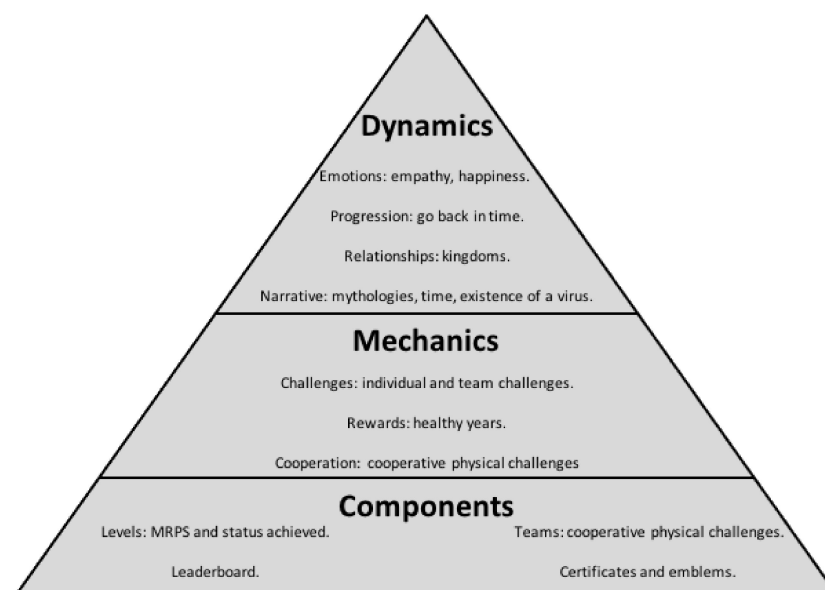


Figure 2. Element categories based on the work of Werbach and Hunter (2014).

The motivational prism of this adventure is based on the code (RAMP) of Marczewski [54]: (1) Relatedness or the need to belong to a group, working around it, and feeling that the individual goal will only be achieved by cooperating with class-

mates on a common goal; (2) Autonomy, or the opportunity to do what is thought without prohibitions; (3) Mastery, or being able to increase one's ability to control one's knowledge; and (4) Purpose, or the sense of moving in the right direction.

### 2.2.3. Direct Instruction Methodology

A methodology based on direct instruction teaching techniques was used by the CG teacher. The non-directional way of transmitting the contents, geometric and structured organizational formations of the students, and the search for results instead of learning were some of the most outstanding characteristics [55]. The teacher directed each moment of the sessions including the beginning and the end of each task, not paying attention to the progress of students.

The class structure was divided into 3 parts: Each session was divided into 3 non-connected parts. The first was an initial part (warm-up) in which the objective was to activate the organic systems with simple and analytical exercises. This part was also divided into body activation and joint mobility movements and stretching. The second or main part was focused on teaching activities. The third or final part (cool down) with passive stretching was directed entirely by the teacher [55]. A deep and extensive description of the methodology was previously published [56].

## 2.3. Instruments

### 2.3.1. Cognitive Performance

EFs were assessed through different tools. NIH Examiner battery (University of California-San Francisco, USA) [57] was the instrument to evaluate verbal fluency and planning, while Stroop Color and the Word Test [58] were used to value cognitive inhibition.

- For the verbal fluency task, examinees were instructed to name as many words (animals and vegetables) as possible in 60 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 for 3 variables: animals, vegetables, and the mean of the 2 variables.
- For the unstructured task (planning), examinees had to complete 4 pages of puzzle games. Each puzzle had a designated point value and subjects were given 6 min 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 to avoid items that were strategically poor choices.
- For the cognitive inhibition task, examinees were required to read 3 different tables as fast as possible. In the first 2 tables, subjects had to read names of colors (henceforth referred to as color words) printed in black ink and name different color patches. Conversely, in the third table, entitled the color word condition, color words were printed in a colored 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 color 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 2 specific moments: at the end of the first 3 months (October: pre-intervention) and the academic year (June: post-intervention). According to content, skills, attitude, behavior, or homework, teachers from each subject gave an average score ranging from 1 (worst) to 10 (best).

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

- Average of all subjects (8 subjects): Language, mathematics, geography/history, physics/chemistry, biology (only in the second grade of compulsory secondary education), English, PE, music, and plastic education or technology (depending on the grade).

- Average of all subjects with the exception of PE (7 subjects).
- Average of the core subjects (6 subjects): Language, mathematics, geography/history, physics/chemistry, biology (only in the second grade), and English. Although the students in the third grade had physics/chemistry and biology subjects and the students in the second grade only had physics/chemistry, the averages 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) were 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 (5 sessions per group—550 min). Each one was distributed into 11 observation periods of 5 min. The camera was installed in the classroom 2 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 behaviors, and evaluated the frequency by which teachers used the hybridized 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 by analyzing 2 different moments over 7 days, guaranteeing an agreement greater than 93%. The checklist 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) ( $TA = NTA / A + D$ ). The presence average of each element for all analyzed 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

Table 1. Cont.

	Control Group	Experimental Group
8. Choice and voice grant (CVG). This allows students to reflect, interact and have a voice on decisions that affect the development of the class.	0.16	0.43
9. Fostering 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). Provides the possibility of applying the values in class to other contexts in real life.	0.00	0.40
12. Set expectations (SE). This makes explicit to students what it expects of them, and the content that will be addressed.	0.33	0.93
Total Mean	0.14	0.75

### 2.5. Data Analysis

The effects of the programmed on the different variables were analyzed 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 (2 boys and 1 girl) were excluded. Consecutively, we deeply analyzed 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.

The variables obtained from the cognitive test (5 variables) and the student's grades (5 variables) were firstly analyzed by a MANOVA of repeated measurements. We differentiated between the intra-subject factor "Time" (with 2 levels: pre-test and post-test), and the inter-subject factors "Group" (with 2 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's 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 Statistical Package for the Social Sciences (IBM SPSS 24.0) was used to complete the statistical analysis, 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 centers on behalf of the minors/children participating in the study.

## 3. Results

### Inferential Analysis

The results obtained in the multivariate level at the beginning of the analysis were shown by the MANOVA test of repeated measurements. Regarding the inter-subject analysis, it can be observed that there was 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 were 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.

Attending to the objective of observing the significant differences in variables, the univariate level was analyzed attending to the variable with previously significant results. For the intra-subject factor, significant differences were found in the Time factor for language ( $F = 16.189$ ;  $p = 0.000$ ), mathematics ( $F = 7.410$ ;  $p = 0.007$ ), and 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 ( $F = 8.506$ ;  $p = 0.004$ ), and 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 ( $F = 67.346$ ;  $p < 0.001$ ), verbal fluency naming animals ( $F = 51.924$ ;  $p < 0.001$ ), verbal fluency naming vegetables, ( $F = 7.406$ ;  $p = 0.007$ ), and the mean of both verbal fluency tasks ( $F = 57.784$ ;  $p < 0.001$ ).

For the inter-subject factor, significant differences were found in the 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 ( $p = 0.032$ ).

Taking into consideration the main objective of comparing the Time and Group factors, we analyzed 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. The means and standard error estimated for the participants regarding the different variables measured in the pre-test and in the post-test are represented in Table 2, differentiated by group and including the  $p$ -values obtained by comparing these estimated averages (using the Bonferroni correction).

**Table 2.** Intervention multivariate analysis (MANOVA).

Variable	Group	Pre-Test		Post-Test		Pre–Post Comparative	
		Mean	SE	Mean	SE	$p$ -Value	Dif (SE)
Language	Experimental	6.08	0.19	6.32	0.20	0.005 **	−0.24 (0.085)
	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		
Mathematics	Experimental	5.15	0.20	5.16	0.22	0.941	−0.01 (0.124)
	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		
AAS	Experimental	5.85	0.17	6.34	0.17	0.000 **	−0.49 (0.059)
	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		
AAS-N-PE	Experimental	5.59	0.18	6.12	0.18	0.000 **	−0.53 (0.061)
	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		
ACS	Experimental	5.65	0.18	5.98	0.19	0.000 **	−0.32 (0.061)
	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 inhibition	Experimental	5.30	0.71	9.80	0.61	0.000 **	−4.49 (0.706)
	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		
VF (naming animals)	Experimental	11.08	0.30	14.23	0.29	0.000 **	−3.14 (0.245)
	Control	13.33	0.54	12.81	0.53	0.232	0.524 (0.436)
	$p$ -value + SE	0.001 **	0.634	0.023 *	0.619		



Table 2. Cont.

Variable	Group	Pre-Test		Post-Test		Pre-Post Comparative	
		Mean	SE	Mean	SE	<i>p</i> -Value	Dif (SE)
VF (naming vegetables)	Experimental	6.90	0.21	7.85	0.22	0.000 **	−0.94 (0.177)
	Control	7.21	0.38	7.16	0.39	0.873	0.05 (0.315)
	<i>p</i> -value + SE	0.489	0.446	0.135	0.455		
Verbal fluency (mean)	Experimental	9.00	0.22	11.04	0.21	0.000 **	−2.04 (0.148)
	Control	10.27	0.39	10.00	0.38	0.276	0.27 (0.263)
	<i>p</i> -value + SE	0.006 **	0.461	0.020 *	0.448		
Planning	Experimental	139.57	2.25	290.81	108.20	0.166	−151.2 (108.7)
	Control	141.47	4.00	176.71	192.38	0.856	−35.23 (193.2)
	<i>p</i> -value + SE	0.685	4.65	0.611	224.01		

Note: \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; SE: standard error; ALM: average language and mathematics; AAS: average of all subjects; AAS-N-PE: average of all subjects except PE; ACS: average of core subjects; VF: verbal fluency.

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 naming animals ( $p = 0.001$ ); the means of both verbal fluency tasks ( $p = 0.006$ ) 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 for cognitive inhibition ( $p < 0.001$ ), verbal fluency naming animals ( $p = 0.023$ ), and the mean of both verbal fluency tasks ( $p = 0.020$ ) in favor 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 by observing the results between the pre-test and the post-test for each group, it can be observed that for the CG, there were significant differences in language ( $p < 0.001$ ), mathematics ( $p = 0.010$ ), the average of all subjects ( $p < 0.001$ ), the average from all subjects except PE ( $p < 0.001$ ), the average of the core subjects ( $p = 0.001$ ), and cognitive inhibition ( $p = 0.009$ ). Additionally, the results with respect to the EG show a significant increase in language ( $p = 0.005$ ), the average of all subjects ( $p < 0.001$ ), the average of all subjects except PE ( $p < 0.001$ ), the average of core subjects ( $p < 0.001$ ), cognitive inhibition ( $p < 0.001$ ), verbal fluency naming animals ( $p < 0.001$ ), verbal fluency naming vegetables ( $p < 0.001$ ), and the mean of both verbal fluency tasks ( $p < 0.001$ ). Only mathematics and planning were not significantly increased in the EG.

#### 4. Discussion

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

In the first place, it is important to state that there are no studies based on the hybridization of pedagogical models that have evaluated academic achievement. The results observed did not show a significant contribution to 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 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 the fact that their relationship with academic achievement is unclear, and as such it is uncertain 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 by 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 hybridization of pedagogical models is an appropriate way to improve the levels of motivation, engagement, and EFs [47], it has never been used before for cognitive performance.

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

In addition, our results took the same approach as several active learning interventions enhancing EFs [30,31,42]. Benzine 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, had significantly increased values for cognitive variables such as selective attention and concentration levels compared to the CG.

#### *Strengths and Limitations*

The study sample 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, as the CG was unequal with respect to the EG. In addition, post-test dates should not coincide with those of evaluations. Furthermore, it could be convenient not to extend the post-intervention tests until dates close to the evaluations established by the educational centers, due to possible dropouts in the intervention.

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. Another plausible explanation for the absence of improvements in the academic achievement could be that while new teaching methodologies tirelessly advance towards the discovery of integrative strategies that achieve success for all students, the evaluation systems that continue to be used eminently evaluate memory. That is, they remain anchored in a past that does not allow integration for all the students, fundamentally evaluating memory and not knowledge exchanges or competition skills that are acquired while students are immersed in a process of knowledge reconstruction.

Although experienced and qualified people carried out the tests, they were different in the 2 moments of the test (pre and post). The search for personnel was complicated, which we understand may be a limitation.

The activity was carried out after school hours, which may also be a limitation affecting final academic scores.

For future studies it is recommended to include an experimental group using traditional strategies such as direct instruction with gamification, as the occasional use of gamification within direct instruction can give a refreshing air to the traditional teaching style and have a positive effect on the students.

#### **5. Conclusions**

The results obtained with the intervention suggest that the use of 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 for better academic achievement. However, academic achievement is influenced by several factors which are hardly controllable.

State authorities and education administrations should delve into the search for pedagogical approaches such as the hybridization of pedagogical models which have demonstrated an effectiveness in achieving significant learning. This is even more relevant in a pandemic era like the current one for reasons relating to happiness, disconnection, motivation, and finding different ways of presenting tasks.

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

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