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Effects of Varied Practice Approach in Physical Education Teaching on Inhibitory Control and Reaction Time in Preadolescents

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Abstract: This study aimed to investigate the effects of nonlinear and linear varied practice compared to a constant linear practice on inhibitory control and reaction time, which are capacities that involve cognition in preadolescents. Eighty-three participants in the 8th grade participated in the study. They were assigned to two experimental groups (varied practice), taught using nonlinear pedagogy (NLP) and linear pedagogy (VLP), respectively, or one control group (constant practice), taught using linear pedagogy (CLP). All participants were tested for inhibitory control (congruent and incongruent conditions) and simple reaction time. Overall, varied practice (both linear and nonlinear) induced larger improvements than constant practice under both congruent (p = 0.026) and incongruent (p = 0.013) conditions of inhibitory control. Additionally, VLP provided greater improvements in inhibitory control (for the incongruent condition) than NLP and CLP. Although NLP and VLP may be preferable to CLP approaches for enhancing executive functions in preadolescents, VLP seems to be the most effective approach aimed to improve cognition within PE classes.

Keywords: school; linear didactics; nonlinear didactics; teaching styles; executive functions

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1. Introduction

The World Health Organization recommends a specific daily dose of physical activity, from moderate to vigorous intensity, related to age and gender for health benefits [1]. Moreover, aerobic exercise is also considered as a "useful drug" to reduce age-related cognitive decline [2], as well as a preventative measure for cardiovascular and metabolic diseases [3].

In preadolescents, aerobic exercise affects both prefrontal executive control and hippocampal function [4] and has major effects on executive functions [5] involved in attention and concentration [6]. The prefrontal cortex, which is associated with executive functions, continues to undergo substantial changes during adolescence, as does the myelination of axons. This caused an increase in white matter and a decrease in grey matter, which led to a synaptic reorganization in 13–14 years old children [7].

As scientific literature has confirmed, the development of executive functions is also related to varied physical activity and to an adequate dose of exercise [8,9]. In this way, the literature has evidenced the necessity to consider both quantitative aspects (related to health) and qualitative aspects (related to motor control) of movement, as the same brain areas (e.g., prefrontal cortex) used to control the cognitive processes are activated during physical activity [10,11]. Although the brain reaches 95% of its development by the age of

6 [12], the prefrontal cortex takes about 20 years to achieve its ultimate growth [13]. As a consequence, inhibitory control can be particularly critical for preadolescents. This is due to the immature limbic system and prefrontal cortex and to a predominance of glutamatergic neurotransmission compared to gamma-aminobutyric acid neurotransmission, which remains under construction. This lack of inhibitory control might be responsible for immature and impulsive behavior and neurobehavioral excitement [14]. With an immature capacity to exert adequate cognitive control, preadolescents have difficulty managing executive functions, especially inhibition, which is connected to perceptual-motor executive skills [15,16].

In a specific motor context, executive functions, such as inhibitory control, are required with a simple reaction time, which is the capacity to respond quickly to a stimulus. It embodies the relationship between perception and motor action [17]. According to Vickers et al. [18], the average reaction time considerably decreases with practice in rapid hand reaction movements, due to a greater efficiency of nervous system information processing. Therefore, the higher the attention to the task and the inhibitory control, the quicker the response [19–21].

Reaction time depends on cognition and presents sensitive periods within preadolescence (from 7 to 12–13 years old) [22]. An immature stage of the brain with excess synapses, possibly due to a burst of proliferation, may decrease the performance and the frontal activation [23]. Two research lines can explain the pedagogies related to creating a transfer between motor activity and cognition. The first line refers to physical activity and cognitive commitment [24]. Integrating motor activity and cognitive tasks could improve cognitive development through interdisciplinary learning. Therefore, the child learns through motor activity, which is the means. Furthermore, voluntary control of the cognitive and motor behaviors based on transfer and interaction between the motor activity practiced in the gym and other intellectual activities could also improve, as executive functions played a key role. The second line is related to embodied cognition, which is founded on sensory-motor interaction with the environment, as brain development occurs due to the execution of the action and not to the cognition itself. This way, motor activity is the end; promoting the action, cognition develops [25,26].

Two different methodologies have been based on these two research lines in a pedagogical context. Linear and nonlinear pedagogy approaches are means for didactics which can facilitate the transfer between motor activity and cognition. In particular, repetition and variation represent the two variables of linear and nonlinear pedagogies, which favor the development of cognitive processes. The linear pedagogy is based on the cognitive ("central") theory [27,28], and it is based on deliberate practice, founded on understanding and imitation of executive models. It traditionally supports learning by constant practice based on structuring, understanding, and repeating skills until they are acquired, focusing on a specific model of movement (education to the movement).

The nonlinear approach is based on the ecological-dynamic theory (peripheral). It stimulates the learner to find more personal solutions due to the continuous exploration of different and creative motor behaviors and the flexible usage of attention to solve environmental problems [29,30]. The nonlinear approach allows better creative thinking outcomes than the linear approach [31–33]. However, at the beginning of an educational process, linear pedagogy allows the learners to learn and structure the motor skills (giving models to understand, reproduce, and memorize), favoring the initial acquisition of the automatisms through repetition. It also allows more quick, economical, and non-dispersive use of attentive resources and cognitive efforts than does nonlinear learning [34]. Furthermore, the educator's motivation in the linear pedagogy is essential and facilitates the acquisition of new skills and the use of selective attention [35].

Nevertheless, while linear and nonlinear approaches supposedly contrast each other, they are also comparable. To some extent, they are similar when the linear pedagogy approach is based on variation. In linear pedagogy, variations can relate to the coordinative difficulties defined by the characteristics of the task and the executive contrasts, which allow for the exploration of all the specific feelings of the body and movement, through a kinesthetic differentiation, to learn a model of motor skill [36,37]. In nonlinear pedagogy, variations can relate to the functional difficulties occurring. The choice about a challenging task depends on the individual's skill level, on his/her perception of the situation, and on his/her personal strategies aimed to solve environmental problems. The discovery is indirectly guided by the teacher [36].

Contextual interference is another common aspect of the two approaches. It is a robust learning phenomenon that is the interaction between many combined motor abilities and situations based on varied or randomized practices that create motor disturbance situations through new, unknown, or different stimuli. These stimuli force the focus of attention on the main task to better perceive the sensations derived from it and obey a constant adaptation and alert. Therefore, they induce a decrease in the sensibility threshold and an increase in adaptation capacity, which leads to better use of the body in general and specifically, to the range of movement referred to in the model [38]. Interference and practice variation stimulate a continuous redefinition of motor programs and a kinesthetic perception of actions [39–41].

Nonetheless, other hallmarks, such as the learners' active involvement by reflection (obtained through reciprocal observations and self-check, during varied linear applications) and guided discovery (as in the application of nonlinear styles) can be retrieved in both pedagogical approaches as further action to advance cognitive functions [27,28,42].

Motor abilities can be acquired by focusing on the movement form (external appearance of actions) or content (inner motor processes stimulated through reflection based on questions, variation, and contextual interference). Reflective practices could be focused on the different modalities in which a motor task can be solved (nonlinear approach) or on the perception of kinesthetic sensations compared to executive results (varied linear approach) [43].

In a linear pedagogy approach, the attention is characterized by a monotasking experience focused on the main goal of learning. In a nonlinear approach, the research on perceptive learning showed that an embedded learning frequently changes operational conditions and induces the learner to continuous adaptation of the attention by multitasking experiences, promoting a "learning to learn" [44].

Even if the scientific literature showed that physical exercise in a dynamic and changing environmental context could improve attention skills and cognition more than in a static and predictable context [45], to the best of our knowledge, no study investigated the effects of a different varied and constant practice on executive functions and clinical reaction time.

The present study investigated the effects on inhibitory control and reaction time of a varied practice characterized by two different educational approaches (nonlinear and linear pedagogy) compared to a constant practice characterized by the prescriptive linear pedagogy approach. We hypothesized that variations would lead to inhibitory control and reaction time effects superior to those obtained through constant practice. Furthermore, variations in a linear approach should produce comparable cognitive benefits to a nonlinear approach. Linear approach variations are aimed at fostering better kinesthetic perception and movement-specific awareness, while nonlinear approach usually applies random practice under the dynamic system's ecological theory, which is aimed to favor an embodied cognition and a better general body awareness.

We can synthesize our research questions as follows: does a reflective approach based on movement content lead to different cognitive transfer effects than an approach based on the movement form? Does a varied linear approach based on a reflective practice determine the same cognitive transfer effects as a nonlinear approach?

2. Materials and Methods

Eighty-three students from two Italian secondary schools (8th grade) participated in the study (age 13.2 ± 0.3 years, height 1.60 ± 0.08 m, weight 48.4 ± 8.6 kg, body mass index 18.7 ± 2.2 m/kg^2). The number of participants satisfies the sample size previously calculated by the G*power software (N = 66). Due to practical reasons (intervention study performed during the curricular PE lessons), a quasi-experimental design was applied to establish cause-and-effect relationships between independent (teaching approach) and dependent (inhibitory control and reaction time) variables. Two public schools belonging to the same local area were involved in the study to prevent threats to research reliability, perhaps originating from differences in the participants' socioeconomic and cultural features. A control group was established among classes of one of the schools whose teachers previously declared to teach their students by a constant linear pedagogy (CLP) approach (one class designated). The experimental groups were designated in the other school to prevent the CLP teacher from any direct or indirect influence on his teaching approach by possibly watching the PE lessons led according to the experimental procedure. Therefore, two school classes acted as experimental groups and were taught with varied nonlinear pedagogy (NLP) and varied linear pedagogy (VLP), respectively, by two PE teachers with expertise in nonlinear and linear approaches collaborating with our research team (Table 1).

Table 1. Participant demographics.

	NLP (N = 27; 9 f, 18 m)	VLP (N = 28; 10 f, 18 m)	CLP (N = 28; 11 f, 17 m)
Age (yrs)	13.0 ± 0.0	13.0 ± 0.2	13.0 ± 0.2
Body mass (kg)	50.5 ± 8.6	49.4 ± 9.2	45.4 ± 7.3
Stature (cm)	161.3 ± 7.6	160.3 ± 10.0	159.9 ± 7.1
BMI (kg/m^2)	19.3 ± 2.4	19.1 ± 2.2	17.7 ± 1.8

NLP: nonlinear pedagogy; VLP: varied linear pedagogy; CLP: constant linear pedagogy; f: females; m: males; BMI: body mass index.

After being well informed about the study's potential risks and benefits, the participants and their parents or guardians provided written consent. They were allowed to withdraw from the study at any moment. The study was carried out under the Helsinki Declaration of 1975 and was approved by the Ethics Committee of the Università degli Studi di Milano.

2.1. Procedure

Before starting the training period, the participants were familiarized with the testing procedures, and inhibitory control and simple reaction time were assessed. In the subsequent 12 weeks, the participants attended the regular PE classes (1 h, twice a week), learning team sports basics and acro-sports as topics. Two PE specialist teachers with expertise in nonlinear and linear approaches taught NLP and VLP, while the PE school teacher using constant linear pedagogy taught CLP. Figure 1 and Table 2 depict the rationale of the study, participants' grouping, and the pedagogies' features. In addition, all interventions and examples of the teaching approaches are provided in the "training" section and Appendix A.

Table 2. Main features of the pedagogies used by the teachers.

	NLP	VLP	CLP
Theory	Ecological	Cognitive	Cognitive
Procedure	Mainly focused on the movement's content	Mainly focused on the movement's content	Mainly focused on the movement's form
Pedagogical approach	nonlinear	linear	linear
Teaching styles	Productive: guided discovery	Reproductive: self-check, reciprocal style	Reproductive: prescriptive
Task	multitask	monotask	monotask
Attention	Distributed to several elements	Focused on sensory perception and on a specific element at once	No specific requirements, limited to the necessary model's observation
Teacher's leading	Indirect (learner-centered)	Direct/Indirect (teacher/learner-centered)	Direct (teacher-centered)
Activities	random	blocks	blocks
Practice	Non-constant	Non-constant	constant

NLP: nonlinear pedagogy; VLP: varied linear pedagogy; CLP: constant linear pedagogy.

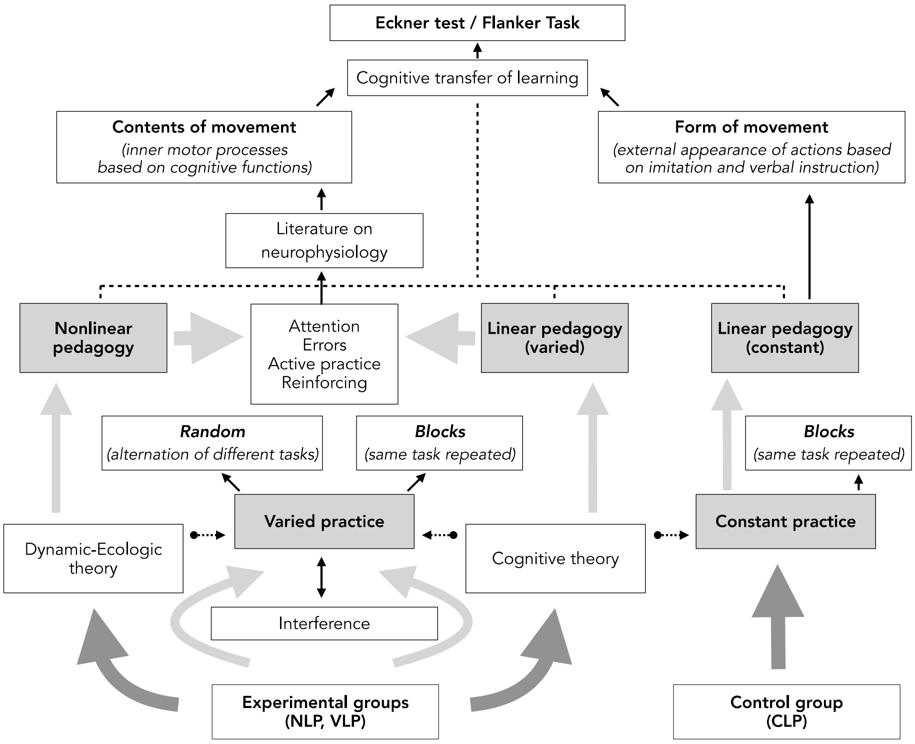

Figure 1. Study's rationale and procedure. NLP: nonlinear pedagogy; VLP: varied linear pedagogy; CLP: constant linear pedagogy.

To check that the teaching approaches corresponded to the expected ones, a random selection of PE lessons for each group was observed. PE lessons were video recorded and subsequently analyzed using the instrument for identifying the teaching styles (IFITS) [46]. The testing procedures were repeated at the end of the experimental period.

2.2. Testing Procedure

2.2.1. Inhibitory Control

A modified version of the flanker's task was used to measure the participants' selective attention and inhibition control [47]. First, participants had to detect the direction of the central arrow among the five that appeared on a computer screen as quickly and accurately as possible. Within two seconds, they had to press the A key on the keyboard when the target arrow was pointed to the left, and the L key when it was pointed to the right. They had to ignore the flanking arrows on each side, pointing towards the same or the opposite direction of the target one, and representing a congruent (left: < < < < < or right: > > > > >) or incongruent (left: > > < > > or right: < < > < <) condition.

One hundred trials were presented (50 right and 50 left target arrows) with the same probability of congruent and incongruent conditions. For both congruent and incongruent conditions, the mean response time of the correct responses and response accuracy were considered for the analysis. The survey and experiments were implemented and presented online using the PsyToolkit platform [48,49].

2.2.2. Simple Reaction Time

Clinical reaction time was measured according to the methods of Eckner et al. [50] to assess the simple reaction time. Participants had to catch an apparatus composed of a wooden graduated stick (0 to 100 cm) having a weighted disk at its extremity as quickly as possible, as the examiner released it at random intervals. The participants sat with their dominant forearm on the table's edge. The examiner suspended the apparatus so that the weighted disk was aligned with the top of the participant's open hand. The distance the apparatus fell (in centimeters) was recorded in eight consecutive trials. The mean distance was afterwards converted to time, in milliseconds, using the formula $d = 1/2\ gt^2$. Then, the average of times was considered as clinical reaction time [50].

2.2.3. Video Analysis of the PE Lessons

For each experimental group, three PE lessons were randomly video recorded at the beginning, half, and end of the training period for a posteriori examination to verify the actual teaching approach adopted by a teacher during the classes. Specifically, the total time of activity, action time, resting time, reflection time, and duration of teaching styles were assessed three times and analyzed by three PE experts using the instrument for identifying the teaching styles (IFITS) [46]. The IFITS is a validated interval recording tool [51–53] that analyses what teaching style the teacher uses during the lesson and how long the teacher uses it [42]. Every 20 s, a rater identifies which teaching style the teacher uses and reports it on the IFITS coding sheet. The rater reports the total time (min) of each teaching style and calculates the percentage of each of them for the total activity time. A more detailed description of the instrument is provided by Curtner-Smith [46]. Intra- and inter-rater reliability were assessed using the intraclass correlation coefficient (ICC). The experts had been previously instructed and trained for six hours in collecting data and operating using coding instruments. The outcomes of the video analysis are provided in Table 3.

Table 3. Analysis of the teaching styles used by the teachers during the PE lessons and details of the students' activity.

	NLP min (%)	VLP min (%)	CLP min (%)	Intra-Rater Reliability (ICC)	Inter-Rater Reliability (ICC)
Teaching Styles					
Convergent guided discovery	16.3 ± 0.9 (30.5 ± 0.1)			0.99	0.84
Divergent guided discovery	33.3 ± 0.7 (62.4 ± 0.1)			0.99	0.80
Reciprocal		38.8 ± 2.5 (70.3 ± 0.2)		1.00	1.00
Individual-based choice	3.8 ± 0.1 (7.1 ± 0.2)	5.0 ± 0.3 (9.1 ± 0.1)	15.3 ± 0.7 (27.8 ± 0.3)	1.00	0.99
Self-check		11.3 ± 0.6 (20.6 ± 0.3)		0.99	0.87
Command			39.8 ± 2.4 (72.2 ± 0.3)	0.99	0.72
Activity					
Total time of activity	53.4 ± 2.8 (100)	55.2 ± 3.4 (100)	55.1 ± 3.2 (100)	0.99	0.81
Rest time	3.9 ± 0.3 (7.3 ± 0.1)	4.1 ± 0.3 (7.5 ± 0.1)	4.0 ± 0.2 (7.3 ± 0.1)	0.99	0.69
Time in action	36.5 ± 2.0 (68.3 ± 0.2) *	38.9 ± 2.6 (70.3 ± 0.4) *	46.5 ± 2.8 (84.4 ± 0.3)	0.99	0.99
Reflection time	13.0 ± 0.6 (24.4 ± 0.1) *	12.3 ± 0.9 (22.2 ± 0.3) *	4.6 ± 0.4 (8.3 ± 0.2)	0.99	1.00

NLP: nonlinear pedagogy; VLP: varied linear pedagogy; CLP: constant linear pedagogy. For each teaching style and activity, the duration is shown as mean ± SD, with the corresponding percentage with respect to the total in brackets. Intra-and inter-rater reliability were calculated to assess the accuracy of the IFITS evaluation by video analysis. * $p < 0.05$ vs. CLP by post-hoc analysis with Bonferroni's correction after one-way ANOVA was performed between NLP, VLP, and CLP.

2.3. Training

Experimental and control groups participated in their regular PE classes as follows.

2.3.1. Nonlinear Pedagogy

The NLP group was taught using a nonlinear approach following the "divergent and convergent guided discovery style" by Mosston and Ashworth [42] based on the dynamic ecological theory of motor learning [54]. Several features composing the specific topic of each lesson were simultaneously selected and experienced based on practice variations and randomization. Pre-requirements and not specific motor models for acro-sport and team sports skills rotated every ten to fifteen minutes. The attention to the skills was indirect, multitasked, distributed, targeted, and adapted. Changes to the environment, task, and organism constraints were made rather than to the technical execution of a defined movement model [54]. Therefore, the students were indirectly encouraged to use a varied practice, including reasoning and knowledge of their self-adaptation ability, to address the managed affordances (Table 2).

2.3.2. Varied Linear Pedagogy

The VLP group was taught differently using a reproductive teaching approach, corresponding to the "self-check" and "reciprocal" styles of the spectrum of the teaching styles by Mosston and Ashworth [42]. It was based on cognitive theory principles with varied practice. Team sports basics and acro-sports were subdivided into tasks experienced in varied block practice (using a monotasking approach). After being instructed by the teacher through detailed instructions and direct demonstrations, the students were asked to reproduce and practice each task in pairs, switching the roles of executor and observer every ten minutes. The teacher controlled and provided support, suggestions, examples, analyses of errors, and stimuli to self-correct the performance through contrasting practice (requiring right and wrong actions). Again, attention was focused on the task-specific technical execution.

Therefore, the varied practice of VLP was mainly based on observation, comprehension, reproduction of reference models, and perception of one's own body through contrasting situations that stimulate the kinesthetic sense (Table 2).

2.3.3. Constant Linear Pedagogy (Control Group)

The CLP group, acting as a control for the frequent use of the constant linear pedagogy in schools, underwent standard PE lessons promoting team and acro-sports. CLP was taught by the ordinary PE class teachers, who previously declared to follow a consistent linear pedagogy approach with their students. No requirements were made regarding his/her teaching approach, and no guidelines were given to him/her about how to address the learners' attention. However, the lessons were video recorded and subsequently inspected to ensure, as the analysis confirmed, that the adopted teaching styles did not resemble VLP or NLP approaches (Table 3).

2.4. Statistical Analysis

Data are shown as mean ± standard deviations. A Shapiro–Wilk test checked the normal distribution. A one-way analysis of variance (ANOVA) was utilized to check the potential differences between practice/teaching approaches at the baseline (pre). No significant differences were observed between varied and constant practice (using the Student's unpaired *t*-test) and between the three teaching approaches (using the analysis of variance—ANOVA) in the baseline (pre). To test whether the inhibitory control and simple reaction time were influenced by the practice/pedagogy used by the teachers during the PE period, we used two-factor ANOVA (i.e., time, practice/pedagogy) with repeated measurements of one factor (time) (two-way ANOVA RM). In case of significant interaction, Bonferroni's correction was used post-hoc for pairwise comparisons. To better interpret and discuss the results, effect sizes (ESs, as Cohen's *d* values) were calculated for the magnitude of the over-time changes (pre-post). The corresponding ES thresholds for *trivial*, *small*, *moderate*, and *large* effects were classified as <0.2, 0.2 to 0.5, 0.5 to 0.8, and >0.8, respectively. A further analysis was carried out to test potential differences subsequent to teaching practice and pedagogy. Therefore, we decided to proceed with the analysis by considering the changes after intervention with respect to before (delta, post-pre) as more directly representing the outcomes of the interventions. The Student's unpaired *t* test was used to compare the deltas of varied and constant practice approaches. The one-way ANOVA, or the corresponding non-parametric test (Kruskal–Wallis), was used to compare the deltas of NLP, VLP, and CLP. In case of significance, a Tukey's post hoc analysis (or Dunn's multiple comparisons test, in case of non-parametric data) was used for pairwise comparisons. The level of significance was set at an α level < 0.05. Statistical analysis was performed using GraphPad Prism version 7.00 for Windows (GraphPad Software, San Diego, CA, USA).

3. Results

Figure 2 shows mean ± SD of the response time of the congruent and incongruent condition of the flanker task before and after the 12 weeks of intervention (panels A and

C), with delta values (panels B and D), for varied and constant practice. The two-way ANOVA RM revealed a significant interaction (time × practice) for the congruent ($p = 0.026$; $F_{(2, 80)} = 5.08$) and incongruent condition ($p = 0.013$; $F_{(2, 80)} = 6.36$) of the flanker task. The main effect of time and group were not significant for both congruent ($p = 0.50$; $F_{(2, 80)} = 0.44$; $p = 0.99$; $F_{(2, 80)} < 1$) and incongruent condition ($p = 0.49$; $F_{(2, 80)} = 0.47$; $p = 0.60$; $F_{(2, 80)} = 0.26$). Post hoc analysis showed that varied practice improved in both congruent ($p = 0.027$, $d = 0.42$, *small*) and incongruent conditions ($p = 0.014$, $d = 0.37$, *small*). On the contrary, constant practice did not improve from pre to post in congruent ($p = 0.55$, $d = 0.17$, *trivial*) and incongruent conditions ($p = 0.45$, $d = 0.17$, *trivial*). Comparing the effects of varied and constant practice on inhibitory control, varied practice induced larger improvements (pre-post variations, deltas) than constant practice, in both congruent ($p = 0.026$) and incongruent ($p = 0.013$) conditions. Table 4 shows mean ± SD of the response accuracy of the congruent and incongruent conditions of the flanker task before and after the 12 weeks of intervention, together with delta values, *p*-values and Cohen's *d* values derived from the pairwise comparisons. For clinical reaction time (Figure 3), no significant interaction (time x practice) was revealed by the two-way ANOVA RM ($p = 0.55$; $F_{(2, 80)} = 0.34$), highlighting that the type of practice did not differently influence the clinical reaction time. Similarly, the main effect of time ($p = 0.09$; $F_{(2, 80)} = 2.78$) and group ($p = 0.169$; $F_{(2, 80)} = 1.92$) were not significant. Varied and constant practice did not improve from pre to post in the clinical reaction time ($p = 0.11$, $d = 0.21$, *small*; $p > 0.99$, $d = 0.13$, *trivial*, respectively). No significant difference was found in pre-post variations (deltas) of the clinical reaction time between varied and constant practice ($p = 0.53$).

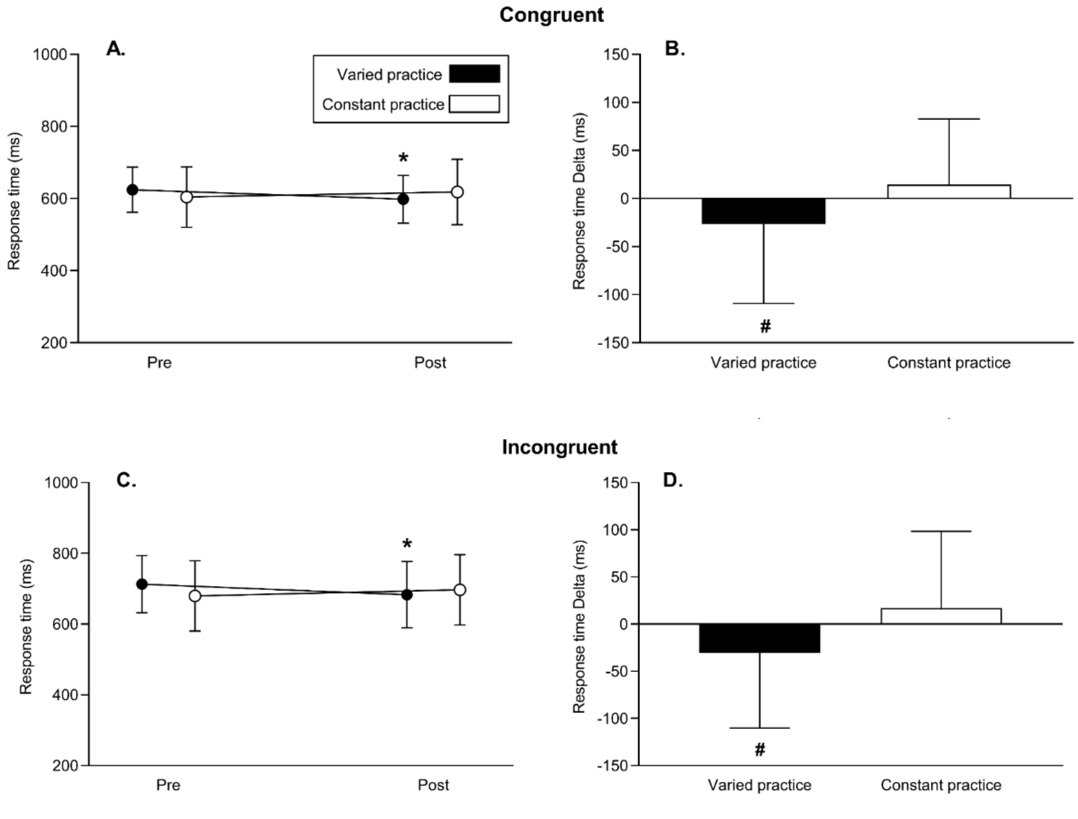

Figure 2. Inhibitory control evaluated by the flanker task, measured before and after 12 weeks of PE classes in varied and constant practice. Panels (**A**,**B**) show the response time absolute values and pre-post variations (delta, post-pre) in the congruent condition, respectively. Panels (**C**,**D**) show the response time absolute values and pre-post variations (delta, post-pre) in the incongruent condition, respectively. * $p < 0.05$ vs. Pre; # $p < 0.05$ vs. constant practice.

Table 4. Response accuracy (% of correct responses) in the congruent and incongruent condition of the flanker task in varied and constant practice.

	Time × Practice Interaction	Practice	Pre	Post	*p*-Value	Cohen's *d* ES	Delta (Post-Pre)
Congruent	$p = 0.012$; $F = 6.44$	Varied practice	87.7 ± 9.4	91.6 ± 9.1	0.146	0.41 *(small)*	3.8 ± 12.7 #
		Constant practice	91.4 ± 13.7	85.9 ± 15.0	0.138	0.40 *(small)*	−5.4 ± 20.5
Incongruent	$p < 0.001$; $F = 14.93$	Varied practice	85.9 ± 10.8	92.4 ± 7.8	0.035 *	0.60 *(medium)*	6.4 ± 13.6 ###
		Constant practice	90.5 ± 15.4	81.6 ± 16.8	0.039 *	0.57 *(medium)*	−8.9 ± 24.8

F-values with *p*-values of the time x practice interaction derived using the two-way ANOVA RM. Values are mean ± SD. *p*-values (by Bonferroni's correction) and Cohen's *d* ES refer to the pre-post comparison. * $p < 0.05$; # $p < 0.05$, ### $p < 0.001$ vs. constant practice.

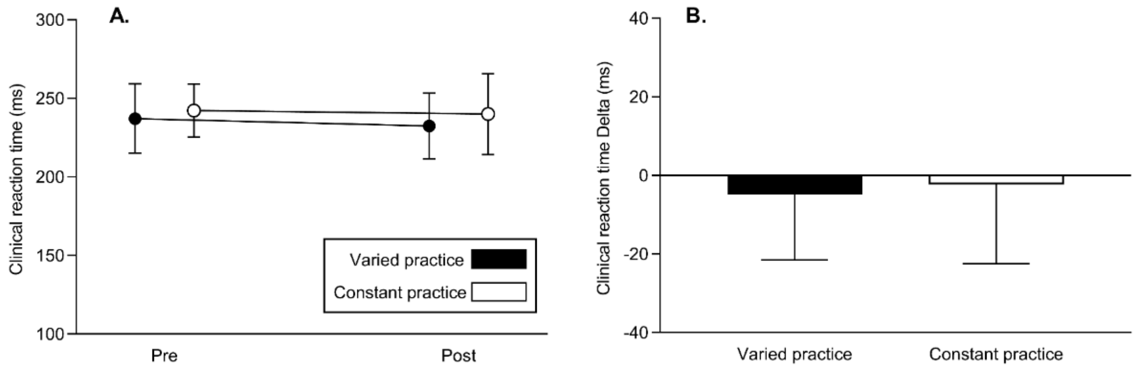

Figure 3. Simple reaction time evaluated using the clinical reaction time (Panel (**A**)) and pre-post variations (Panel (**B**); delta, post-pre) measured before and after 12 weeks of PE classes in varied and constant practice.

Figure 4A,C shows mean ± SD of the response time of the congruent and incongruent condition of the Flanker task before and after the 12 weeks of intervention, for each teaching approach. The two-way ANOVA RM revealed a significant interaction (time × practice) for the response time of the incongruent condition ($p = 0.018$; $F_{(2, 80)} = 4.19$) of the flanker task, whereas for the congruent condition, the interaction was not significant ($p = 0.066$; $F_{(2, 80)} = 2.80$). The main effects of time and group were not significant for both the congruent ($p = 0.14$; $F_{(2, 80)} = 2.20$; $p > 0.99$; $F_{(2, 80)} < 1$) and incongruent condition ($p = 0.07$; $F_{(2, 80)} = 3.32$; $p = 0.18$; $F_{(2, 80)} = 1.71$). When looking at the pairwise comparisons, teaching approach neither affected the response times of the congruent condition of the flanker task (NLP: $p = 0.07$, $d = 0.32$, *small*; VLP: $p = 0.67$, $d = 0.50$, *moderate*; CLP: $p > 0.99$, $d = 0.17$, *trivial).* Conversely, for the incongruent condition, only VLP improved from pre to post (NLP: $p = 0.11$, $d = 0.28$, *small*; VLP: $p = 0.007$, $d = 0.69$, *moderate*; CLP: $p = 0.22$, $d = 0.22$, *small).* Comparing the pre-post variations (deltas) in the response time for the flanker task between each teaching approach Figure 4B,D, no significant difference was found for the congruent condition ($p = 0.066$, $F_{(2, 80)} = 2.80$), whereas a significant difference was found for the incongruent condition for the flanker task ($p = 0.042$, $F_{(2, 80)} = 3.28$). Specifically, VLP differed significantly from CLP, confirming the positive effects of this teaching method ($p = 0.044$), whereas no significant differences were found between NLP and VLP ($p = 0.86$) or CLP ($p = 0.14$). Table 5 shows mean ± SD of the response accuracy of the congruent and incongruent condition for the flanker task before and after the 12 weeks of intervention, with delta values for each teaching approach, together with *p*-values and Cohen's *d* values, derived from the pairwise comparisons. The clinical reaction time for each teaching approach is presented in Figure 5. No significant interaction (time x practice) was revealed by the two-way ANOVA RM ($p = 0.79$; $F_{(2, 80)} = 0.23$), showing that the type of teaching approach did not differently influence the clinical reaction time. Similarly, the main effect of time ($p = 0.054$; $F_{(2, 80)} = 3.81$) and group ($p = 0.084$; $F_{(2, 80)} = 2.55$) were not significant.

Clinical reaction time did not improve from pre to post in NLP (p = 0.27, d = 0.21, *small*), VLP (p = 0.10, d = 0.22, *small*), and CLP (p = 0.51, d = 0.13, *trivial*). No significant difference was found in the pre-post variations (deltas) of the clinical reaction time between the three teaching approaches (p = 0.26; $F_{(2, 80)}$ = 1.77).

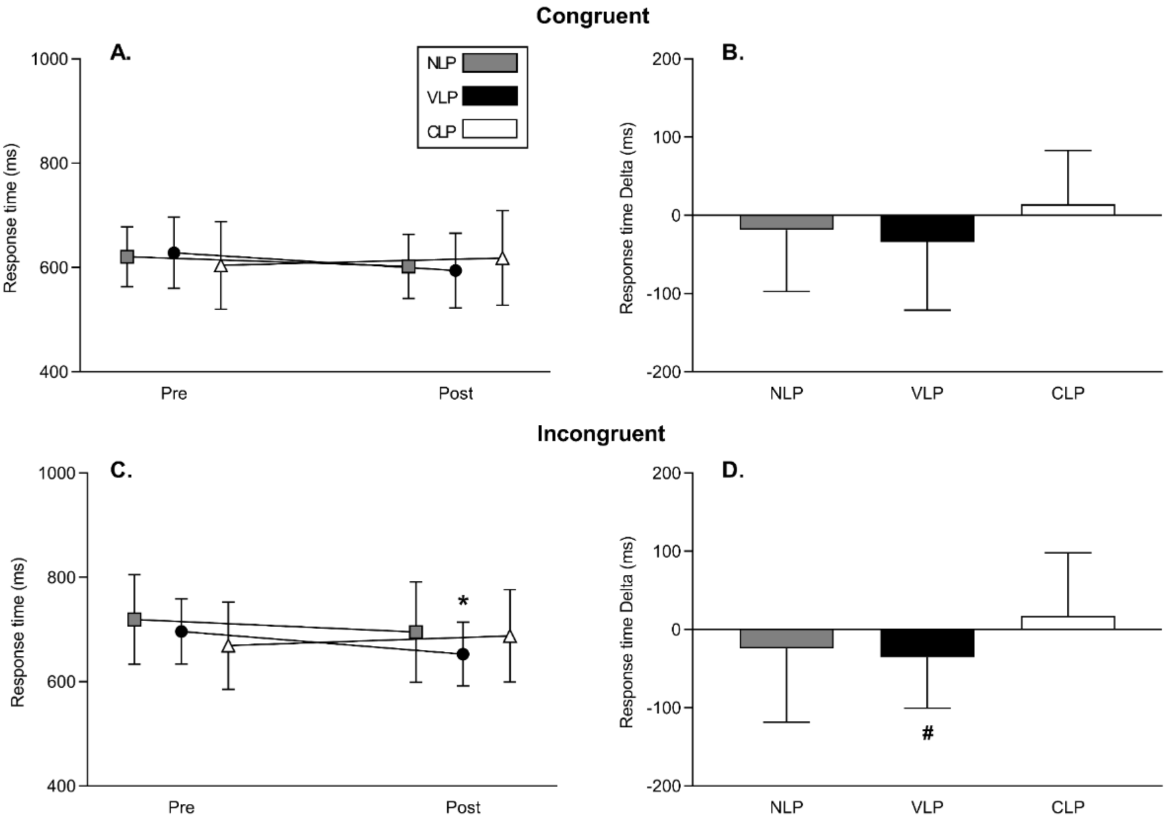

Figure 4. Inhibitory control as measured by the flanker task, measured before and after 12 weeks of PE classes using nonlinear pedagogy (NLP), varied linear pedagogy (VLP), and constant linear pedagogy (CLP). Panels (**A**,**B**) show the response time absolute values and pre-post variations (delta, post-pre) in the congruent condition, respectively. Panels (**C**,**D**) show the response time absolute values and pre-post variations (delta, post-pre) in the incongruent condition, respectively. * $p < 0.05$ vs. pre; # $p < 0.05$ vs. CLP.

Table 5. Response accuracy (% of correct responses) in the congruent and incongruent condition for the flanker task for NLP, VLP, and CLP.

	Time × Practice Interaction	Group	Pre	Post	*p*-Value	Cohen's *d* ES	Delta (Post-Pre)
Congruent	p = 0.048; F = 3.09	NLP	86.7 ± 8.8	90.4 ± 7.3	0.686	0.42 *(small)*	3.6 ± 11.5 #
		VLP	88.7 ± 10.1	92.8 ± 10.5	0.669	0.36 *(small)*	4.1 ± 14.0 #
		CLP	91.4 ± 13.7	85.9 ± 15.0	0.208	0.40 *(small)*	−5.4 ± 20.5
Incongruent	p < 0.001; F = 7.74	NLP	84.8 ± 9.3	89.7 ± 7.2	0.384	0.53 *(medium)*	4.9 ± 11.2 #
		VLP	87.1 ± 12.2	95.0 ± 7.6	0.049 *	0.66 *(medium)*	7.9 ± 15.7 ##
		CLP	90.5 ± 15.4	81.6 ± 16.8	0.018 *	0.58 *(medium)*	−8.9 ± 24.8

F-values with p-values of the time x practice interaction derived by the two-way ANOVA RM. Values are mean ± SD. NLP: nonlinear pedagogy; VLP: varied linear pedagogy; CLP: constant linear pedagogy. p-values (by Bonferroni's correction and Cohen's d ES refer to the pre-post comparisons. * $p < 0.05$; # $p < 0.05$, ## $p < 0.01$ vs. CLP.

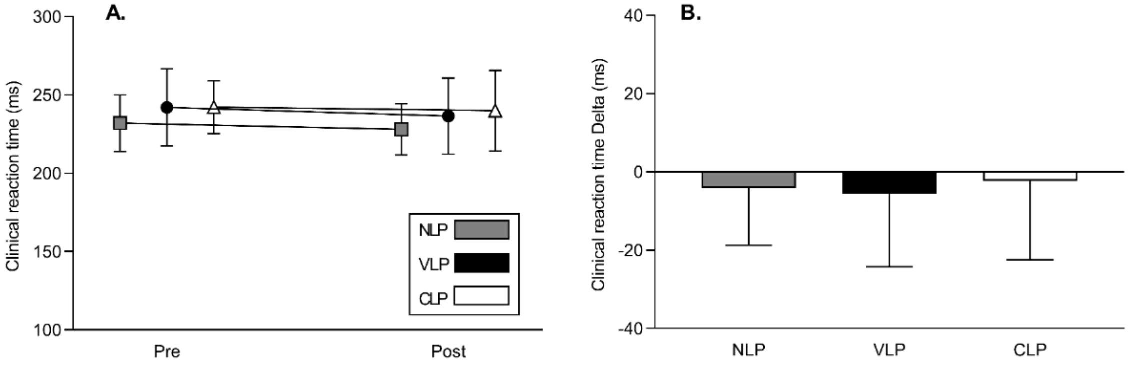

Figure 5. Simple reaction time evaluated using the clinical reaction time (Panel (**A**)) and pre-post variations (Panel (**B**); delta, post-pre) measured before and after 12 weeks of PE classes for NLP, VLP, and CLP. NLP: nonlinear pedagogy; VLP: varied linear pedagogy; CLP: constant linear pedagogy.

4. Discussion

To investigate the role of type of practice and teaching approach on cognitive improvements related to PE, we tested inhibitory control and reaction time in preadolescents before and after a 12-weeks PE period taught using different teaching approaches (e.g., the varied practice of linear and nonlinear pedagogy and constant practice of linear pedagogy). Varied and constant practices induced different outcomes in the flanker task for inhibitory control and response time.

Two notable results were reported in this study. First, 12-weeks of PE based on varied practice induced superior benefits on inhibitory control (response time and accuracy of the flanker task) compared to constant practice. Second, VLP provided greater improvements in inhibitory control (response time of the incongruent condition of the flanker task), compared to NLP and CLP, which showed no significant changes.

Together, these results showed that varied practice, characterizing both NLP and VLP, showed greater improvements in inhibitory control than CLP. Contextual interference literature showed that diversification of the proposals allows a greater motor program elaboration [55] and a better stimulation of executive functions, with a better transfer capacity related to inhibition/self-regulation [56], as shown in our study.

Furthermore, reflection time was higher in NLP and VLP than in CLP (Table 3). Reflexive approaches of NLP and VLP stimulated metacognitive processes and greater awareness, which led to a better transfer in cognition [57].

On the other hand, the time in action in VLP and NLP was lower than in CLP. We can assume that the better results in inhibitory control in VLP are due to the quality of reflection and the cognitive processes activated through a reflexive practice, not for the quantity of practice [57,58].

Thus, varied practice within a nonlinear approach encourages new arrangements and increases the ability to adapt the learning outcomes to different situations [59]. This approach relates to an incorporate cognition view [25], in which brain activation [60] and cognition depend on action, and it is founded on perception-motor interaction [26]. Linear pedagogy assumptions of VLP are different from those of NLP and consider variations to solve errors through contrasting situations stimulating the kinesthetic sense. In fact, situational difficulties raise efforts to address the requests, favoring body awareness and enhancing transfer learning [61–63]. Teachers who use this approach encourage students to overcome difficulties by focusing their attention on relevant fundamentals for success and inhibiting their intuitive, quick, and less-reasoned responses [61].

Moreover, in contrast with a constant practice of the CLP protocol, approaches based on variations allow the learner to self-evaluate tasks and plan outcomes [64]. The fact that a varied practice of our protocol has improved performance in the flanker task supports that pondering and reflecting, by stimulating proficiency and motor creativity, can speed up the learning process and improve executive functions, such as inhibition [65]. Therefore, frequent assessments and learning strategies based on context design and environmental changes are suggested to overcome the comfort zone (typical of constant practice), thus better promoting learning and supporting cognitive development.

The results of our study are based on the fact that qualitative, non-automatic demands activate the same regions of the brain that are used to control other cognitive aspects. The alert attentiveness created by variations and active involvement, based on the situations proposed, activate the reactivity and vigilance of the cortex [10,66]. We also tested whether a linear pedagogy induced more benefits than nonlinear pedagogy within the varied practice approach. The literature returns contrasting results, both supporting linear or nonlinear pedagogy [27,28,59]. The latter promotes motor learning through benefits from embedded attentiveness and concentration enhancement, integrating perception and action [67]. The NLP protocol (Table 2 and Appendix A) was based on the ecological dynamics theory [38]. Conversely, the monotasking approach of VLP had superior learning effects because of the prefrontal cortex activation, which reduced errors by focusing attentiveness on a single task [68]. Indeed, when looking at the pre-post comparisons, NLP showed a similar trend to VLP, albeit not significant (p = 0.11, d = 0.28, *small)*, while CLP demonstrated a clear opposite trend (see the delta comparisons in Figure 4). These considerations may support the nonlinear pedagogy approach for cognitive improvement. However, VLP improved inhibitory control compared to NLP and CLP (Figure 4), which suggests that the VLP approach seems to be the most effective method for cognitive development in response to PE.

Referring to the results, active learning, based on students' autonomy and accurately guided by the teacher (VLP), is the most efficient approach in cognitive transfer situations for 12–13 years old children. Curiosity is the key element that determined a better attentiveness and executive functions in VLP approach. Curiosity refers to what the children think is useful to learn. In the same way that an activity that is too repetitive is not attractive, neither is a practice that is too confusing [69] or little related to specific goals.

The error plays a fundamental role in VLP. In fact, the brain can compare what has been predicted through the motor program and the outcome. Mental representation can be revised by referring to the prediction error [69]. When a prediction error occurs, it engenders surprise in the performer because of a violation of his expectations [70]. This would support specific psycho-emotional and cognitive processes indispensable for a learning transfer.

It is interesting to note that clinical reaction time was the only variable not affected by the different types of practice and teaching approaches. An explanation for the lack of improvement in the clinical reaction time can be related to the fact that this test assesses simple reaction time. There is evidence showing that physical activity is related to cognitive performance requiring a high level of attentional control in a complex reaction time task (i.e., incongruent conditions with flanking information) [71] more than in a simple reaction time task (such as clinical reaction time). Moreover, according to Posner [21], rapid hand reaction movement improvements would have been expected. It is plausible that more than 12 weeks of varied intervention training are necessary to integrate elaborative processes with neuromotor actions and then to discriminate improvements in this type of reaction time.

Some limitations should be acknowledged. The NLP approach was based on prerequirements and not on specific motor models. Therefore, no motor tests were chosen for assessing acro-sports and team sport game competencies to compare the different pedagogies in which learning processes were centered. Further investigation on tasks, ages, sex, and expertise are needed to examine the effect of variability on transfer.

Practical Applications and Sustainability

Based on the results, PE teachers should provide lessons featuring learning based on reflection and varied practice. In particular, the learning should be characterized by: (a) the explanation of the usefulness and aims of the exercise; (b) the use of appropriate integrated methodology such as problem-solving, guided discovery, self-check, and reciprocal methods. These approaches can precede, be simultaneous with, or follow the practice and can be proposed before, during, or after the activity [72]. They could represent a concrete method to educate students to fit into present society.

The increasing complexity of modern society, the continuous innovations, and the consequent socio-cultural changes require quality teaching to guarantee the social utility of the learning [73,74]. The need for sustainable and quality teaching deals with the purpose highlighted by the 2030 Agenda of Sustainable Development Goals of the United Nations [75]. Among the various points covered, the document evidences the need to "*ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles*" [75].

Hence, in PE, sustainable and quality teaching should satisfy the broader need for the flexible adaptation to different contexts, promoting and developing social usefulness, and a lifetime of "good practices" pursuing long-term physical literacy [76]. In learning processes, teaching styles such as problem-solving, reciprocal, self-check, and inclusion methods could be helpful to promote engagement through active reflection and encouraging students to explore different and new solutions [77], gradually inducing them to interact with and fit into a constantly changing society.

5. Conclusions

The present study revealed that 12 weeks of PE based on varied practice improved inhibitory control more than did constant practice. The current findings also showed how a VLP better improved inhibitory control than either NLP or CLP. From a practical perspective, NLP and VLP may be preferable approaches for enhancing executive functions in preadolescents. However, VLP seems to be the most effective approach within PE classes aimed to improve cognition. Promoting PE lessons based on VLP might contribute to fostering targeted and individualized learning strategies, interdisciplinarity, metacognition (self-perception skills), and intrinsic motivation in school-age individuals.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the Università degli Studi di Milano (protocol code 2/12).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the first author.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Examples of contents and methods of activities by the pedagogies used.

NLP	VLP	CLP
No specific training on movement structure. Stimulation of functional aspects over constraints redirecting to the skills and abilities to be acquired.	Specific training addressing the movement's internal structure for learning sports basics.	Specific training addressing the movement's external structure for learning sports basics.
The teacher acts as a designer, organizes the affordances, and promotes actions by adequately setting the environmental constraints.	The teacher provides specific solutions to achieve success gradually and progressively through executive approximations, contrasts, and comparisons.	The teacher promotes segmented exercises of increasing difficulty that learners have to perform to manage the targeted skills properly.
The pedagogic fundamentals are perceiving, processing, and acting by selecting what and how to do a task.	Watching, judging, suggesting, and perceiving are the pedagogic fundamentals to master the movement, based on the internal processes of the central nervous system.	The primary educational feature is repeating the examples from the teacher many times to memorize and automatize the executions.
The teacher arranges varied environmental settings to arouse and produce adequate constraints to stimulate the functions connected to the specific targets. For example, a practice set to learn different positions and ways to manage balance relies on mats and benches. Object arrangements provide locomotory schema (climbing, passing, rolling, doing slalom, jumping) and object control (hitting, leading, throwing, catching). Eye patches or masks partially or completely limiting the vision is another example of an organismic constraint the teacher uses to force the learners' self-adaptations. Further constraints involving tasks are considered: assignments to the primary running skill are added (i.e., counting, summing, spelling a word, combining different movements, making associations as kicking with the right leg when an animal is named, or left when a plant name is called).	The teacher provides the executive model, organizes the learners in pairs, gives them individual self-evaluation sheets to detect the key points of the required techniques, the errors, and the necessary correction process. Kinesthetic information and the body's proprioception is favored by an experiential approach, based on executive contrasts and perceiving the experienced task's effectiveness. After practice, the teacher promotes group analyses and comments on each pair's work.	The teacher provides a simplified task of the target movement that the learners have to repeat until learning occurs. Then, the teacher offers frequent technical, general, and individualized feedback to guarantee the task's error solution and correct execution. Once most of the learners have had success, the next step is proposed, possessing increased difficulty. This process recurs until the target skill is properly achieved.

References

1. World Health Organization. *WHO Guidelines on Physical Activity and Sedentary Behaviour: Web Annex: Evidence Profiles*; World Health Organization: Geneva, Switzerland, 2020; ISBN 9789240015111.
2. Prakash, R.S.; Voss, M.W.; Erickson, K.I.; Kramer, A.F. Physical activity and cognitive vitality. *Annu. Rev. Psychol.* **2015**, *66*, 769–797. [CrossRef] [PubMed]
3. Hayes, S.M.; Alosco, M.L.; Forman, D.E. The Effects of Aerobic Exercise on Cognitive and Neural Decline in Aging and Cardiovascular Disease. *Curr. Geriatr. Rep.* **2014**, *3*, 282–290. [CrossRef] [PubMed]
4. Buck, S.M.; Hillman, C.H.; Castelli, D.M. The relation of aerobic fitness to stroop task performance in preadolescent children. *Med. Sci. Sports Exerc.* **2008**, *40*, 166–172. [CrossRef] [PubMed]
5. Davis, C.L.; Tomporowski, P.D.; McDowell, J.E.; Austin, B.P.; Miller, P.H.; Yanasak, N.E.; Allison, J.D.; Naglieri, J.A. Exercise improves executive function and achievement and alters brain activation in overweight children: A randomized, controlled trial. *Health Psychol.* **2011**, *30*, 91–98. [CrossRef]
6. Diamond, A. Executive functions. *Annu. Rev. Psychol.* **2013**, *64*, 135–168. [CrossRef]
7. Theodoraki, T.E.; McGeown, S.P.; Rhodes, S.M.; MacPherson, S.E. Developmental changes in executive functions during adolescence: A study of inhibition, shifting, and working memory. *Br. J. Dev. Psychol.* **2020**, *38*, 74–89. [CrossRef]
8. Donnelly, J.E.; Hillman, C.H.; Castelli, D.; Etnier, J.L.; Lee, S.; Tomporowski, P.; Lambourne, K.; Szabo-Reed, A.N. Physical Activity, Fitness, Cognitive Function, and Academic Achievement in Children: A Systematic Review. *Med. Sci. Sports Exerc.* **2016**, *48*, 1197–1222. [CrossRef]
9. Vazou, S.; Pesce, C.; Lakes, K.; Smiley-Oyen, A. More than one road leads to Rome: A narrative review and meta-analysis of physical activity intervention effects on cognition in youth. *Int. J. Sport Exerc. Psychol.* **2019**, *17*, 153–178. [CrossRef]
10. Pesce, C. Shifting the focus from quantitative to qualitative exercise characteristics in exercise and cognition research. *J. Sport Exerc. Psychol.* **2012**, *34*, 766–786. [CrossRef]
11. Tomporowski, P.D.; McCullick, B.A.; Pesce, C. *Enhancing Children's Cognition with Physical Activity Games*; Human Kinetics: Champaign, IL, USA, 2015.
12. Spear, L.P. Neurobehavioral changes in adolescence. *Curr. Dir. Psychol. Sci.* **2000**, *9*, 111–114. [CrossRef]
13. Lenroot, R.K.; Giedd, J.N. Brain development in children and adolescents: Insights from anatomical magnetic resonance imaging. *Neurosci. Biobehav. Rev.* **2006**, *30*, 718–729. [CrossRef] [PubMed]
14. Arain, M.; Haque, M.; Johal, L.; Mathur, P.; Nel, W.; Rais, A.; Sandhu, R.; Sharma, S. Maturation of the adolescent brain. *Neuropsychiatr. Dis. Treat.* **2013**, *9*, 449–461. [CrossRef] [PubMed]
15. Smith, R.; Lane, R.D.; Alkozei, A.; Bao, J.; Smith, C.; Sanova, A.; Nettles, M.; Killgore, W.D.S. The role of medial prefrontal cortex in the working memory maintenance of one's own emotional responses. *Sci. Rep.* **2018**, *8*, 3460. [CrossRef] [PubMed]
16. Somerville, L.H.; Hare, T.; Casey, B.J. Frontostriatal maturation predicts cognitive control failure to appetitive cues in adolescents. *J. Cogn. Neurosci.* **2011**, *23*, 2123–2134. [CrossRef]
17. Mann, D.T.; Williams, A.M.; Ward, P.; Janelle, C.M. Perceptual-cognitive expertise in sport: A meta-analysis. *J. Sport Exerc. Psychol.* **2007**, *29*, 457–478. [CrossRef]
18. Vickers, J.N. Mind over muscle: The role of gaze control, spatial cognition, and the quiet eye in motor expertise. *Cogn. Process.* **2011**, *12*, 219–222. [CrossRef]
19. Ghodrati, S.; Askari Nejad, M.S.; Sharifian, M.; Nejati, V. Inhibitory control training in preschool children with typical development: An RCT study. *Early Child Dev. Care* **2019**, *191*, 2093–2102. [CrossRef]
20. Logan, G.D.; Cowan, W.B.; Davis, K.A. On the ability to inhibit simple and choice reaction time responses: A model and a method. *J. Exp. Psychol. Hum. Percept. Perform.* **1984**, *10*, 276–291. [CrossRef]
21. Posner, M.I. *Chronometric Explorations of Mind*; Lawrence Erlbaum: Oxford, UK, 1978; p. 271. ISBN 0-470-26491-8.
22. HornÌková, H.; Dolezajová, L.; KratHanová, I.; Anton, L. Differences in reaction time and agility time in 11 to 14 years old schoolboys. *J. Phys. Educ. Sport* **2019**, *19*, 1355–1360.
23. Blakemore, S.J.; Choudhury, S. Development of the adolescent brain: Implications for executive function and social cognition. *J. Child Psychol. Psychiatry* **2006**, *47*, 296–312. [CrossRef]
24. Pesce, C.; Crova, C.; Cereatti, L.; Casella, R.; Bellucci, M. Physical activity and mental performance in preadolescents: Effects of acute exercise on free-recall memory. *Ment. Health Phys. Act.* **2009**, *2*, 16–22. [CrossRef]
25. Egger, F.; Benzing, V.; Conzelmann, A.; Schmidt, M. Boost your brain, while having a break! The effects of long-term cognitively engaging physical activity breaks on children's executive functions and academic achievement. *PLoS ONE* **2019**, *14*, e0212482. [CrossRef] [PubMed]
26. Engel, A.K.; Maye, A.; Kurthen, M.; Konig, P. Where's the action? The pragmatic turn in cognitive science. *Trends Cogn. Sci.* **2013**, *17*, 202–209. [CrossRef] [PubMed]
27. Rudd, J.R.; Crotti, M.; Fitton-Davies, K.; O'Callaghan, L.; Bardid, F.; Utesch, T.; Roberts, S.; Boddy, L.M.; Cronin, C.J.; Knowles, Z.; et al. Skill Acquisition Methods Fostering Physical Literacy in Early-Physical Education (SAMPLE-PE): Rationale and Study Protocol for a Cluster Randomized Controlled Trial in 5–6-Year-Old Children From Deprived Areas of North West England. *Front. Psychol.* **2020**, *11*, 1228. [CrossRef]

28. Renshaw, I.; Chow, J.Y.; Davids, K.; Hammond, J. A constraints-led perspective to understanding skill acquisition and game play: A basis for integration of motor learning theory and physical education praxis? *Phys. Educ. Sport Pedagog.* **2010**, *15*, 117–137. [CrossRef]
29. Liao, C.M.; Masters, R.S. Analogy learning: A means to implicit motor learning. *J. Sports Sci.* **2001**, *19*, 307–319. [CrossRef]
30. Masters, R.S.W. Theoretical aspects of implicit learning in sport. *Int. J. Sport Psychol.* **2000**, *31*, 530–541.
31. Pesce, C.; Faigenbaum, A.D.; Goudas, M.; Tomporowski, P. Coupling our plough of thoughtful moving to the star of children's right to play. In *Physical Activity and Educational Achievement*; Meeusen, R., Schaefer, S., Tomporowski, P., Bailey, R., Eds.; Routledge: London, UK, 2017; pp. 247–274.
32. Richard, V.; Lebeau, J.-C.; Becker, F.; Boiangin, N.; Tenenbaum, G. Developing Cognitive and Motor Creativity in Children Through an Exercise Program Using Nonlinear Pedagogy Principles. *Creat. Res. J.* **2018**, *30*, 391–401. [CrossRef]
33. Santos, S.D.L.; Memmert, D.; Sampaio, J.; Leite, N. The Spawns of Creative Behavior in Team Sports: A Creativity Developmental Framework. *Front. Psychol.* **2016**, *7*, 1282. [CrossRef]
34. Tanaka, Y.M.; Sekiya, H.; Tanaka, Y. Effects of Explicit and Implicit Perceptual Training on Anticipation Skills of Novice Baseball Players. *Asian J. Exerc. Sports Sci.* **2011**, *8*, 1–15.
35. Hein, V.; Ries, F.; Pires, F.; Caune, A.; Heszterane Ekler, J.; Emeljanovas, A.; Valantiniene, I. The relationship between teaching styles and motivation to teach among physical education teachers. *J. Sports Sci. Med.* **2012**, *11*, 123–130. [PubMed]
36. Guadagnoli, M.A.; Lee, T.D. Challenge point: A framework for conceptualizing the effects of various practice conditions in motor learning. *J. Mot. Behav.* **2004**, *36*, 212–224. [CrossRef] [PubMed]
37. Davids, K. The constraints-based approach to motor learning: Implications for a non-linear pedagogy in sport and physical education. In *Motor Learning in Practice: A Constraints-Led Approach*; Davids, K., Renshaw, I., Savelsbergh, G., Eds.; Routledge: Oxfordshire, UK, 2010; pp. 3–16.
38. Calvo, P.; Gomila, A. *Handbook of Cognitive Science: An Embodied Approach*; Elsevier Science: Amsterdam, The Netherlands, 2008; ISBN 978-0-08-046616-3.
39. Hall, K.G.; Magill, R.A. Variability of Practice and Contextual Interference in Motor Skill Learning. *J. Mot. Behav.* **1995**, *27*, 299–309. [CrossRef] [PubMed]
40. Henz, D.; John, A.; Merz, C.; Schollhorn, W.I. Post-task Effects on EEG Brain Activity Differ for Various Differential Learning and Contextual Interference Protocols. *Front. Hum. Neurosci.* **2018**, *12*, 19. [CrossRef] [PubMed]
41. Wulf, G.; Lee, T.D. Contextual interference in movements of the same class: Differential effects on program and parameter learning. *J. Mot. Behav.* **1993**, *25*, 254–263. [CrossRef]
42. Mosston, M.; Ashworth, S. *Teaching Physical Education*, 1st ed.; Spectrum of Teaching Styles: Jupiter, FL, USA, 2008; Available online: https://spectrumofteachingstyles.org (accessed on 9 September 2021).
43. Myer, G.D.; Kushner, A.M.; Faigenbaum, A.D.; Kiefer, A.; Kashikar-Zuck, S.; Clark, J.F. Training the developing brain, part I: Cognitive developmental considerations for training youth. *Curr. Sports Med. Rep.* **2013**, *12*, 304–310. [CrossRef]
44. Thrun, S.; Pratt, L. *Learning to Learn*; Springer: New York, NY, USA, 1998; p. 354. ISBN 978-0-7923-8047-4.
45. Formenti, D.; Duca, M.; Trecroci, A.; Ansaldi, L.; Bonfanti, L.; Alberti, G.; Iodice, P. Perceptual vision training in non-sport-specific context: Effect on performance skills and cognition in young females. *Sci. Rep.* **2019**, *9*, 18671. [CrossRef]
46. Curtner-Smith, M.D. Instrument for Identifying Teaching Styles (IFITS). Available online: https://spectrumofteachingstyles.org/assets/files/articles/CurtnerSmith2001_IFITS.pdf (accessed on 15 November 2020).
47. Eriksen, B.A.; Eriksen, C.W. Effects of noise letters upon the identification of a target letter in a nonsearch task. *Percept. Psychophys.* **1974**, *16*, 143–149. [CrossRef]
48. Stoet, G. PsyToolkit: A software package for programming psychological experiments using Linux. *Behav. Res. Methods* **2010**, *42*, 1096–1104. [CrossRef]
49. Stoet, G. PsyToolkit: A novel web-based method for running online questionnaires and reaction-time experiments. *Teach. Psychol.* **2017**, *44*, 24–31. [CrossRef]
50. Eckner, J.T.; Whitacre, R.D.; Kirsch, N.L.; Richardson, J.K. Evaluating a clinical measure of reaction time: An observational study. *Percept. Mot. Ski.* **2009**, *108*, 717–720. [CrossRef] [PubMed]
51. Bryant, L.G.; Curtner-Smith, M. Effect of a physical education teacher's disability on high school pupils' learning and perceptions of teacher competence. *Phys. Educ. Sport Pedagog.* **2009**, *14*, 311–322. [CrossRef]
52. Bryant, L.G.; Curtner-Smith, M.D. Impact of a physical education teacher's disability on elementary pupils' perceptions of effectiveness and learning. *Adapt. Phys. Activ. Q.* **2008**, *25*, 118–131. [CrossRef] [PubMed]
53. Bryant, L.G.; Curtner-Smith, M.D. Influence of a physical education teacher's disability on middle school pupils' learning and perceptions of teacher competence. *Eur. Phys. Educ. Rev.* **2009**, *15*, 5–19. [CrossRef]
54. Button, C.; Seifert, L.; Chow, J.Y.; Araujo, D.; Davids, K. *Dynamics of Skill Acquisition: An Ecological Dynamics Approach*; Human Kinetics: Champaign, IL, USA, 2021.
55. Bortoli, L.; Robazza, C.; Durigon, V.; Carra, C. Effects of contextual interference on learning technical sports skills. *Percept. Mot. Ski.* **1992**, *75*, 555–562. [CrossRef] [PubMed]
56. Diamond, A.; Lee, K. Interventions shown to aid executive function development in children 4 to 12 years old. *Science* **2011**, *333*, 959–964. [CrossRef]

57. Bransford, J.D.; Brown, A.L.; Cocking, R.R. *How People Learn: Brain, Mind, Experience, and School*; National Academy Press: Washington, DC, USA, 2000.
58. Dietrich, A. The cognitive neuroscience of creativity. *Psychon. Bull. Rev.* **2004**, *11*, 1011–1026. [CrossRef]
59. Chow, J.Y.; Teo-Koh, S.M.; Tan, C.W.K.; Button, C.; Tan, B.S.-J.; Kapur, M.; Meerhoff, R.; Choo, C.Z.Y. *Nonlinear Pedagogy and Its Relevance for the New PE Curriculum*; Office of Education Research, National Institute of Education: Singapore, 2020.
60. Koziol, L.F.; Budding, D.E.; Chidekel, D. From movement to thought: Executive function, embodied cognition, and the cerebellum. *Cerebellum* **2012**, *11*, 505–525. [CrossRef]
61. Ávila, L.T.G.; Chiviacowsky, S.; Wulf, G.; Lewthwaite, R. Positive social-comparative feedback enhances motor learning in children. *Psychol. Sport Exerc.* **2012**, *13*, 849–853. [CrossRef]
62. Wulf, G.; McConnel, N.; Gartner, M.; Schwarz, A. Enhancing the learning of sport skills through external-focus feedback. *J. Mot. Behav.* **2002**, *34*, 171–182. [CrossRef]
63. Wormhoudt, R.; Savelsbergh, G.J.P.; Teunissen, J.W.; Davids, K. *The Athletic Skills Model: Optimizing Talent Development Through Movement Education*, 1st ed.; Routledge: London, UK, 2017.
64. Sierra-Díaz, M.J.; González-Víllora, S.; Pastor-Vicedo, J.C.; López-Sánchez, G.F. Can We Motivate Students to Practice Physical Activities and Sports Through Models-Based Practice? A Systematic Review and Meta-Analysis of Psychosocial Factors Related to Physical Education. *Front. Psychol.* **2019**, *10*, 2115. [CrossRef] [PubMed]
65. Zelazo, P.D. Executive function: Reflection, iterative reprocessing, complexity, and the developing brain. *Dev. Rev.* **2015**, *38*, 55–68. [CrossRef]
66. Tomporowski, P.D.; Pesce, C. Exercise, sports, and performance arts benefit cognition via a common process. *Psychol. Bull.* **2019**, *145*, 929–951. [CrossRef] [PubMed]
67. Gibson, J.J. *The Ecological Approach to Visual Perception*; Psychology Press: New York, NY, USA, 2014; ISBN 9781315740218.
68. Kouneiher, F.; Charron, S.; Koechlin, E. Motivation and cognitive control in the human prefrontal cortex. *Nat. Neurosci.* **2009**, *12*, 939–945. [CrossRef] [PubMed]
69. Dehaene, S. *How We Learn: The New Science of Education and the Brain*; Penguin Books Limited: New York, NY, USA, 2020; ISBN 9780241366479.
70. Rescorla, R.A.; Wagner, A.R. A theory of Pavlovian conditioning: Variations on the effectiveness of reinforcement and non-reinforcement. In *Classical Conditioning II: Current Research and Theory*; Black, A.H., Prokasy, W.F., Eds.; Appleton-Century-Crofts: New York, NY, USA, 1972; pp. 64–99.
71. Hillman, C.H.; Motl, R.W.; Pontifex, M.B.; Posthuma, D.; Stubbe, J.H.; Boomsma, D.I.; de Geus, E.J.C. Physical activity and cognitive function in a cross-section of younger and older community-dwelling individuals. *Health Psychol.* **2006**, *25*, 678–687. [CrossRef] [PubMed]
72. Rink, J. *Teaching Physical Education for Learning*; McGraw-Hill: Boston, MA, USA, 2010; p. 428.
73. Bentley, T. *What Learning Needs, towards Educational Transformation: A Challenge of Nations, Communities and Learners*; Routledge: London, UK, 1998.
74. Wright, J.; Burrows, L.; MacDonald, D. *Critical Inquiry and Problem-Solving in Physical Education*; Routledge: London, UK, 2004; ISBN 0415291631.
75. United Nations. *Transforming Our World: The 2030 Agenda for Sustainable Development*; United Nations: New York, NY, USA, 2015.
76. Whitehead, M. *Physical Literacy: Throughout the Lifecourse*; Taylor & Francis: Oxfordshire, UK, 2010; ISBN 9780203881903.
77. Lutze-Mann, L. Strategies for enhancing student understanding through active engagement (LB113). *FASEB J.* **2014**, *28* (Suppl. S1), LB113. [CrossRef]