ARTIFICIAL INTELLIGENCE IN PERSONALIZING PHYSICAL EDUCATION: A TWO-YEAR STUDY

L'INTELLIGENZA ARTIFICIALE NELLA PERSONALIZZAZIONE DELL'EDUCAZIONE FISICA: UNO STUDIO DI DUE ANNI

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ABSTRACT
The WHO recommends 60 minutes of physical activity (PA). Physical education teachers must encourage sedentary individuals to engage in PA and promote its continuity. 266 middle school students were evaluated for two years with anthropometric measurements, physical fitness. The results showed that students have different zone of proximal development, and the educational project must be personalized. Artificial intelligence can help in analyzing the student's personal data.

L'OMS raccomanda 60 minuti di attività fisica (AF). Gli insegnanti di educazione fisica devono incoraggiare i sedentari a praticare AF e promuoverne la continuità. 266 studenti delle scuole medie sono stati valutati per due anni con misurazioni antropometriche e test di fitness fisica. È emerso che gli studenti hanno diverse zone di sviluppo prossimale. Il progetto educativo deve essere personalizzato. L'intelligenza artificiale può aiutare nell'analisi dei dati personali degli studenti.

KEYWORDS
Physical education; teaching; physical activity; personalization; artificial intelligence
Educazione fisica; insegnamento; attività fisica; personalizzazione; intelligenza artificiale.

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Introduction

Physical activity (PA) is well recognized as fundamental for improving psychophysical and social health (Bouchard et al., 2012; Bull et al., 2020). Throughout all stages of life, it's clear that a certain amount and intensity of PA should be performed, even though the goals that can be achieved may vary and have different impacts on the body. Interestingly, the PA performed during the developmental years is extremely important to promote active aging for a healthy life in older age.

However, despite the WHO recommendation that people under 18 years old perform at least 60 minutes of moderate to vigorous PA (Bull et al. 2020), the number of children participating in regular PA is still low (Wu et al., 2017; Schwarzfischer et al. 2019). For this reason, the promotion of PA assumes paramount importance, mainly during the developmental years. Sports associations are very engaged in this task, but the promotion of PA should not be confined to organized activities, also because not all childrens and teenagers can engage in PA through sports associations due to their family's economic conditions. PA is so important that its most complex and elaborate form, i.e., sport, has been included in the Italian constitution (Costituzione della Repubblica Italiana, Art. 33). This highlights the attention that institutions attribute to PA and sport practice as a real tool for physical, psychological, and social wellbeing. For this reason, recently in Italy, even the teaching of physical education (PE) in primary schools has been assigned to a Sport Science teacher (Legge 234/21).

Indeed, an active lifestyle should be a matter of education rather than a technical issue. For this reason, PE teaching plays a paramount role in educating through PA and in counteracting the abandonment phenomena.

Students, as demonstrated by the research presented in this article, have different anthropometric and physical fitness measurements. The PE teacher (PET) should take these differences into account when planning a lesson to propose sustainable teaching methods. With this contribution, we want to discuss the importance of personalization in the school environment and how artificial intelligence (AI) can assist teachers in customizing lessons.

1. Role of Physical Education Teachers Today

Due to the COVID-19 pandemic, the number of children (of all ages) engaging in PA has significantly decreased. Between 2019 and 2021, the percentage of children not engaging in PA increased from 18.5% to 24.9% among 6 to 10-year-olds, from 15.7%

to 21.3% among 11 to 14-year-olds, and from 18.8% to 19.9% among 15 to 17-year-olds (Open Polis, 2024). Despite data showing improvement post-pandemic, there are still many children not participating in PA or sports.

Firstly, we cannot overlook the economic constraints faced by some families. In 2022, 13.4% of Italian minors lived in families experiencing absolute poverty, unable to afford essential goods (Open Polis, 2023). Clearly, in such financial hardship, access to educational activities like sports cannot be guaranteed. This situation leads to educational poverty.

Faced with these challenges, PE hours cannot be underestimated, as they "represent a valuable tool in promoting sports among children" (Open Polis, 2024), providing the opportunity for PA, albeit in limited amounts, and instilling the values inherent in sports.

PE, both in primary and secondary school, yields benefits not just from an educational standpoint: it promotes health and, in a preventive context (e.g., obesity), encourages the adoption of active lifestyles (Colella, 2011; Sibilio, 2015).

Therefore, PETs must develop suitable and sustainable teaching methods (Borgogni, 2016; Peluso Cassese, 2016), so that students enjoy the activities without excessive frustration from setbacks and feel rewarded by their achievements. If successful, PE classes can inspire students to develop a passion for PA outside of school.

In essence, the mission of PETs is to encourage those who do not engage in sufficient PA in daily life to do so, while also motivating those who already engage regularly to continue. To achieve this, PETs must offer personalized instruction tailored as closely as possible to the unique characteristics of each individual young person (Cudicio & Sangalli, 2023).

2. Sustainable Education

Every human being is unique, singular, and unrepeatable (Bertagna, 2018); each carries their own specificities that distinguish them from all others.

However, at the school level, there is a tendency to propose standardized teaching methods, the same for everyone, which do not consider the individual peculiarities of each student. This easily leads to the identification of "absolute" categories to which students are assigned indisputably (meaning with little possibility of change): thus, creating the group of the "good" and the group of the "not good".

However, "everyone, without exception, in the most unfortunate scenario, receives at least one talent" (Bertagna, 2020, p. 3), thus we also possess abilities (not just

limitations) likely different from those possessed by others, which therefore make us unique.

Therefore, we can no longer think of dividing students into "good" and "not good," but rather we can consider each student as someone who is "good at." "We must not forget, moreover, that the talented excellences of every young person, without exception, are always similar and different from each other, never unequivocal and uniform for everyone. There is not just one way to be 'good'" (Bertagna, 2020, p. 6).

Therefore, one of the teacher's tasks should be to guide the student in the search for their unique, singular talent, which could also be outside the school context.

Similarly, regarding physical fitness, every person, and in our case, every student, not only has a different body composition but also varies in muscular fitness, cardiorespiratory fitness, flexibility, and motor skills. These considerations should prompt PETs to question the actual effectiveness of a uniform and identical educational program for every student. Specifically, what could be most affected by this situation is the sustainability of the teaching approach.

When can education be considered sustainable? It is sustainable when it aims "at the individual level to allow each person to continue practicing the activity, and at the group level to allow all participants to continue the activity" (Borgogni, 2016, p. 121). This means that a teacher has done a good job not if their students achieve astounding performances, but if they continue to engage in PA in the future, thus adopting a healthy lifestyle in line with the guidelines suggested by the WHO.

For this to happen, it is crucial that the student "is not subjected to practices that are harmful psychologically or anatomically, that education is inclusive and guiding, not demoralizing but raising awareness of skills and limitations" (Borgogni, 2016, p. 121).

Expanding, differentiating, and diversifying are excellent strategies that PETs should follow when planning their lessons. Expanding involves considering numerous diverse motor experiences; differentiating involves offering sports different from the well-known ones; diversifying involves modifying the structure, rules, and uses of classic sports (Borgogni, 2016).

Furthermore, to ensure that education is truly sustainable, certain precautions can be taken.

Firstly, considering that emotions strongly impact learning processes, what the teacher presents should be motivating to engage students more effectively.

Next, instead of adopting a horizontal teaching approach where everyone, regardless of their initial level, does the same thing, an oblique teaching method can be employed. In this approach, each student feels they are doing something

like what everyone else is doing but is exercising at their own level. This means that if the goal is to practice jumping, each student should be able to do so starting from their own level; therefore, the teacher should propose differentiated exercises based on students' abilities. In this way, while engaging in the same activity (through differentiated exercises), the student will have more opportunities to "experience the success of their actions" (Borgogni et al., 2002, p. 38).

The teacher can also propose exercises that are not simple, but in accordance with the educational progression that starts from easy and progresses to difficult, can suggest to each student an exercise that is slightly above their competence level, as "every new learning is difficult" and "falls into that area unknown to the learner" (Borgogni et al., 2002, p. 40).

It is important to consider that each student has an "actual development level" (Vygotsky, 1980, p. 125), which is determined by the set of completed learning experiences, or their current abilities. However, each student also possesses a "potential development level," which represents the set of abilities not yet possessed but that, with the guidance of an adult, in this case the teacher, can be acquired. The gap between the abilities possessed (actual level) and those not yet possessed but potentially attainable (potential level) was termed by Vygotsky as the "zone of proximal development" (ZPD). It "defines those functions that are not yet mature but are in the process of maturation, functions that will mature tomorrow but are currently in an embryonic state" (Vygotsky, 1980, p. 128).

It is necessary to identify the student's ZPD because if exercises below this level are proposed, the student will not learn anything new and may become bored; at the same time, if exercises far above the ZPD are proposed, the student will feel incapable and thus experience frustration. However, as we have already mentioned, to ensure that education is sustainable, it is crucial that students do not experience frustration because this could discourage them from practicing and would be counterproductive.

The task is complicated because the teacher must contend with the fact that each student has their own personal ZPD and unique potential development level, which are likely different from those of others.

Therefore, given the differences among students, it does not make sense to propose a uniform teaching method for all students. In fact, to make education sustainable, it is necessary for it to be personalized, which does not mean "teaching everyone the same predetermined things [...] but rather would be called to accompany each student in realizing that, in their different and unique ways, each has to deal with the same things" (Bertagna, 2020, p. 7).

In essence, when a PET designs their lessons, they must do so for "situations," meaning they must consider their students and the available space, and in advance, anticipate the response that students might give in that context to a particular exercise (Borgogni et al., 2002).
But what is “difficult” for each student? What is their ZPD? What is their potential development level? Moreover, can the teacher with their skills determine the ZPD for each student? Can they anticipate the student's response to the exercises they propose? Do they have enough time to do this?
Identifying the ZPD the potential development level of each student is an action that, although time-consuming, is feasible. It is also true that all of this would require a significant amount of time, which practically the PET, having many students, does not have available.
In this case, AI can come to their aid**.** Before delving into this statement, let us present the results of a study showing the differences in physical fitness among students of the same age.

3. Empirical evaluation

139 male students and 127 female students, from 7 schools in the municipality of Brescia, participated in this biennial follow-up study. The students were assessed in the first year (FY), age 11.7±0.42 and the second year (SY) age 12.9±0.42.
The assessment included anthropometric and physical fitness measurements.
Anthropometric measurement encompass height measured with a stadiometer 214TM (SECA, Hamburg, Germany), weight with an electronic scale 872TM (SECA, Hamburg, Germany) and body composition such as fat mass (FM) with a bioimpedentiometer BMI (HEXA MF AKERN, Firenze, Italy). Weight and height were then used to calculate the body mass index (BMI).
Physical fitness macro-areas (Caspersen et al. 1985) were evaluated as follow: cardiopulmonary fitness with the 6-minute walk test (6MWT); muscular fitness through the standing broad jump test (SBJT); flexibility using the V-sit and reach test (VSRT), and motor competence with the shuttle run test (SRT).
Protocol
The students participate in a single day of data collection and then repeat all the measurements a year later. All the tests were performed in the school’s gym. When the participants arrived at the gym, the entire protocol was explained. Each student was then measured for height and weight, wearing only underwear. Next, the participant was asked to lay down for two minutes on a medical bed before the BIA evaluation. Two electrodes were applied on the right hand and two on the right

foot. The participants then executed the 6MWT, where they were asked to walk back and forth in a 20m corridor for 6 minutes. The VSRT was performed sitting down on the floor with the legs straight and the feet 30 cm apart. The participant was then asked to bend forward and reach with their hands. The subsequent test was the SBJT, where the student was asked to perform a long jump from a line and land standing up on their feet. Lastly, the student was asked to perform a SRT 4 X 10m, where the participant had to run as fast as possible and pick up a sponge on the floor, keeping the sponge in their hand and each time they passed the turning point line changing with one on the floor.

The data obtained, then, of the FY and SY were compared using a Paired t-Test.

Results

The results showed a significant difference in performance between the first and second year basically in all the tests the participants performed. However, there is evident a difference in the results of students belonging to the same year.

The anthropometric data provided the following results: BMI showed a significant increase over time FY=19.1±3.44 SY=19.7±3.25 ($p<0.001$; Figure 1a), while there is a reduction of FM FY=19.1%±7.79% and SY=18.1%±7.81% ($p=0.03$; Figure 1b).

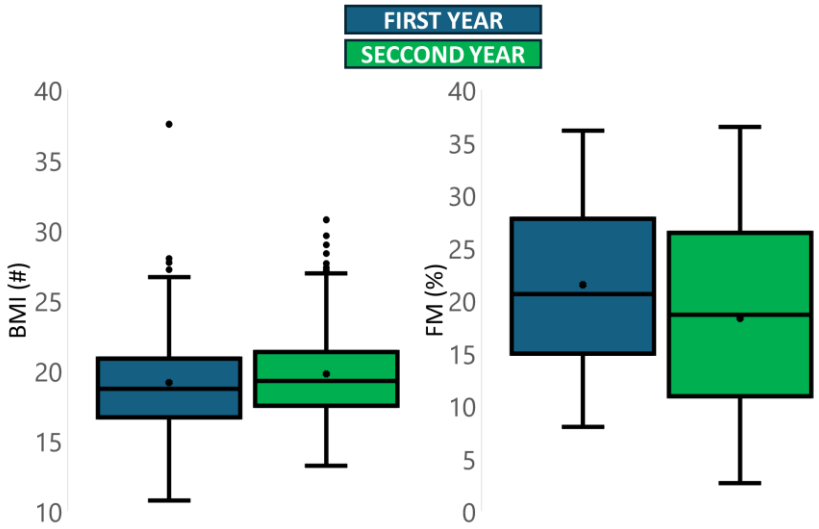

Figure 1 Boxplot of body mass index (BMI) panel A on the left and of the fat mass (FM) panel B on the right, for the students at the first year in blue and at the second year in green

The results of the 6MWT (FY=712±54.9m and SY=740±61.5m), SBJT (FY=149±21.7cm and SY=162±25.6cm) and SRT (FY=12.1±1.00s and SY=11.8±1.06s) showed all a significantly better result in the second year compared to the first ($p<0.001$; Figure 2a, 2b and 3a respectively).

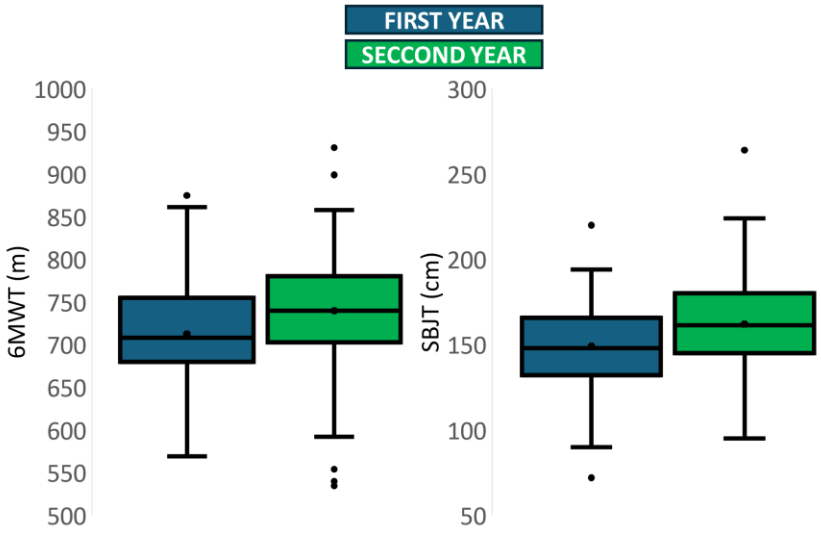

Figure 2 Boxplot of 6-minute walking test (6MWT) panel A on the left and of standing broad jump test (SBJT) panel B on the right, for the students at the first year in blue and at the second year in green.

On the other hand, the VSRT (FY=21.5±10.28cm and SY=19.7±11.89cm) showed slight decline ($p<0.001$; Figure 3b).

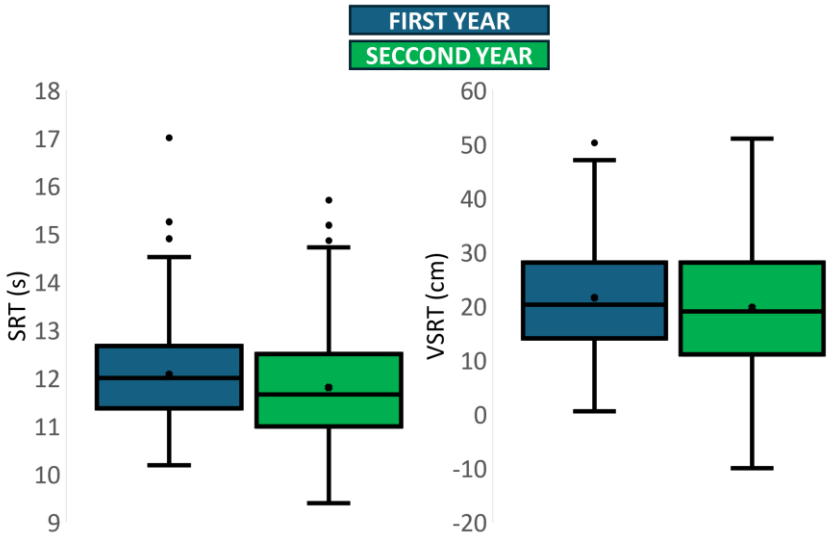

Figure 3 Boxplot of shuttle run test (SRT) panel A on the left and of V-sit and reach (VSRT) panel B on the right, for the students at the first year in blue and at the second year in green.

4. Discussion

The empirical evaluation has allowed us to uncover intriguing insights about the development of middle school students. The initial observation centers on the fact that these students' bodies are undergoing constant changes. While it may seem self-evident, the maturation process, despite following a general pattern and progression, does not occur simultaneously or at the same pace for all students. The discrepancy between chronological age and maturity age has been extensively studied, and the biological role in physical development is well-documented in literature (Beunen et al., 1981; Ries et al., 1984). The fact that the maturation process varies among individuals is underscored by the inherent differences in students' bodies. Factors such as genetics, life experiences, external and internal perturbation, motivations, and cognitive and psychological elements, to name a few, result in diverse physical forms and varying levels of physical fitness and competences.

This study revealed significant variability in the results among participants from the same year. Indeed, within a single class group, there may be individuals with obesity or underweight, high or low levels of cardiorespiratory or muscular fitness, exceptional mobility or stiffness, and excellent motor skills or poor abilities. Interestingly, regardless of their fitness levels, all students attend the same PE class throughout the year. Designing a unique class for such a diverse group, despite the strong push for personalized PE lessons, could be seen as a contradiction. The need for personalized PE classes is underscored by the varied results of our study. Students with different physical fitness levels will have different potential development levels. Consequently, their ZPD will vary in terms of scope and duration. Therefore, it is crucial to identify the most effective strategies and approaches to allow students to work within their ZPD. In this context, the role of the PET should include identifying the potential development level and subsequently adapting the work to fit within each student's ZPD. This task can be extremely time-consuming, and often PETs lack the time, tools, and capabilities to analyze these data and adjust the individual curriculum. However, an AI system could support this phase by reducing the time spent and improving the accuracy in calculating the ZPD for each student.

5. The Role of Artificial Intelligence

Human beings, thanks to their intelligence, can learn, understand language, reason, solve problems, but they can also perceive, be introspective and self-aware, as well

as make decisions (Di Tore, 2023). AI has been created in its image and likeness, but it is still unable to comprehend and act like a human. AI can emulate some human cognitive functions, such as “reasoning, logical reasoning, image and speech recognition, and decision-making” (Di Tore, 2023, p. 470).

Since each student is unique, individual, also in terms of physical fitness levels, possesses a personal potential development level, AI can be used to personalize students' learning paths. To do this, consideration can be given to the ZPD, needs and preferences, and performance data (Di Tore, 2023; Panciroli et al., 2020).

How can it do this? To answer this question, we must consider that AI learns using the same mechanisms of learning as humans; however, it clearly cannot do everything alone, and human guidance is necessary.

Among the various learning mechanisms (supervised, reinforcement, and unsupervised), for the AI system that PETs can use for the purposes described above, supervised learning has been considered the most suitable (Panciroli et al., 2020).

Indeed, through this mechanism, the system receives pre-labeled data that serve as examples; when presented with new data, it will be able to label them based on the examples it has already received.

In essence, to determine each individual student's potential development level, AI will utilize data available in the literature, specifically anthropometric and physical fitness data at time 0 and time 1 from the entire available sample. When teachers input the anthropometric and physical fitness data of their students (that correspond to the current level), AI will compare them with the literature data and provide the potential development levels that each student should reach by time 1.

If the dataset available in the literature is limited, we can consider a self-feeding system: essentially, each teacher inputs the collected data at time 0 and time 1 for each student. We can hypothesize that over time and with the expansion of the database, the system will have enough data points to compare with new inputs at time 0 and subsequently provide the physical fitness levels that students should or could achieve by time 1.

With each student's potential development level, the teacher can propose differentiated exercises within each student's ZPD. Thanks to this, each student will train on their "challenge” level.

However, the teacher should not think that the potential development level identified at time 1, by the AI, is the absolute maximum level that can be achieved. The bodies and skills of students are constantly evolving, especially during the

period of lower secondary schools. Therefore, it is crucial for the teacher to periodically request a new evaluation from the AI based on the results achieved.
Therefore, "AI can be used to make learning more efficient, personalized, and engaging" (Di Tore, 2023, p. 475). However, it is crucial that the teacher understands the basics of AI, its risks, opportunities, and develops adequate skills to use it appropriately (Cesaretti, 2021; Di Tore, 2023); on the other hand, AI cannot completely replace the teacher, as it has several limitations. For example, besides not being able to offer the same quality of instruction, in personalization it could overlook students' personal needs or possess biases and implicit prejudices (Di Tore, 2023).
Fundamentally, the teacher remains the true main actor in curriculum planning and customization; therefore, AI should be considered as a tool that is available to teachers, not their replacement (Cesaretti, 2021).

Conclusions

When designing a lesson, the PETs must consider that students are different and have their own ZPD. Therefore, they must personalize the instruction to avoid students experiencing frustration during practice. The goal, indeed, is for students to have an active lifestyle and engage in PA regularly even outside of school.
AI can serve as a valuable tool for educators, enabling personalized instruction by tailoring to the unique ZPD for each student. However, it is important to note that AI alone is insufficient. The effectiveness of personalized teaching hinges on the teacher's ability to leverage their skills and make the learning process sustainable.
As for the PA to be proposed at school, it does not necessarily have to be a recognized sport governed by existing rules. Instead, it can be innovatively designed and calibrated to foster harmonious progress in areas of immediate development.

Author Contribution:
A.C., conceptualization; data collection; writing original draft preparation (chapters: introduction, 3-4 and conclusion), revision and editing; *corresponding author.
S.S., conceptualization; writing original draft preparation (chapters: 1-2-5), revision and editing.
L.L., conceptualization; writing original draft preparation (chapters: introduction, 1), revision and editing.
A.B., conceptualization; writing original draft preparation, revision and editing; study supervision.

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