

Effectiveness of Innovative Pedagogical Approaches to Increasing Learners' Motivation for Physical Education Lessons

Svitlana Gvozdetska¹, Volodymyr Lesyk², Tetiana Khrystova³, Serhiy Samoylyk⁴, Anna Sakhnenko⁵

¹Department of Theory and Methods of Physical Culture, Educational and Scientific Institute of Physical Culture, Sumy State Pedagogical University named after A. S. Makarenko, Sumy, Ukraine

²Department of Sports Games, Faculty of Physical Education, Sports and Health Hryhorii Skovoroda, University in Pereiaslav, Pereiaslav, Ukraine

³Department of Theory and Methods of Physical Education, Faculty of Physical Education, Sports and Psychology, Bogdan Khmelnytsky Melitopol State Pedagogical University, Zaporizhzhia, Ukraine

⁴Department of Physical Therapy, Occupational Therapy, and Health Faculty of Human Health and Natural Sciences, Drohobych Ivan Franko Pedagogical University, Drohobych, Ukraine

⁵Department of Physical Education, Faculty of Food Technology, Sumy National Agrarian University, Sumy, Ukraine

Correspondence: Svitlana Gvozdetska, Sumy State Pedagogical University named after A. S. Makarenko, Romenska str. 87, Sumy, 40002, Ukraine.

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Abstract

A decline in learners' motivation for physical education in adolescence remains a persistent challenge in modern education, underlying the search for effective pedagogical solutions. The purpose of this study is to evaluate the effectiveness of a set of innovative pedagogical approaches aimed at increasing learners' autonomous motivation during physical education lessons. The study relied on experimental design to assess the proposed approaches efficacy, along with psychometric testing to measure motivational and psychological indicators, pedagogical observation to monitor behavioral engagement and implementation fidelity as well as statistical analysis. ANOVA with repeated measurements was utilized to evaluate changes over time and bootstrap mediation analysis was applied to examine the mechanism of influence through satisfying basic psychological needs. The results demonstrated a significant increase in autonomous motivation in the experimental group ($\Delta = +0.63$ vs. $+0.14$; $p < 0.001$; $d = 0.89$), as well as elevated satisfaction of basic psychological needs (η^2 up to 0.164) and a higher participation index ($+1.50$ vs. $+0.40$; $p < 0.001$). Mediation analysis supported the interpretation that satisfaction of basic psychological needs may partly explain the association between the intervention and increases in autonomous motivation ($ab = 0.24$; 95% CI $[0.13; 0.36]$). It is concluded that integrating innovative pedagogical approaches into the structure of physical education lessons produces a comprehensive impact on both motivational and behavioral indicators in learners. The scientific novelty of the study is due to empirical validation of the mediation mechanism linking the pedagogical environment to learners' motivation. It is expedient that future research perspectives delve into examining the intervention's long-term effects as well as the role of learners' individual characteristics.

Keywords: autonomy support, motivational climate, learning engagement, satisfaction of needs, cooperative learning, self-determination, pedagogical design, learning dynamics

1. Introduction

Learners' motivation for physical activity within school curriculum remains one of the central challenges of modern physical education. Scholarly studies consistently indicate a gradual decline in interest towards physical education classes with increasing age, which is associated both with the educational environment and with the prevalence of externally controlled instructional formats (Vasconcellos et al., 2020; Ntoumanis et al., 2021). In fact, the psychological and pedagogical features of student adaptation also tend to explain these trends, which influence engagement and learning activity (Ishchenko et al., 2024). At the same time, self-efficacy appears to be an important determinant of physical activity engagement, directly linked to learners' motivation and behavioral involvement (Raievska et al., 2024).

In this context, self-determination theory plays a key role, maintaining that motivation develops through satisfying basic

psychological needs, such as autonomy, competence and relatedness (Ryan & Deci, 2020). Empirical evidence illustrates that an autonomy-supportive educational environment contributes to cultivating a more stable intrinsic motivation for physical activity (Cheon et al., 2020). Moreover, recent studies emphasize the importance of innovative pedagogical approaches as a means of personalizing instruction and enhancing learner motivation (Makarenko et al., 2024).

At the same time, the existing body of literature has several important limitations that complicate a comprehensive understanding of motivation for physical education. First, most studies focus on isolated pedagogical approaches, which prevents evaluation of their combined effect as an integrated system of pedagogical influence (Erdvik et al., 2019). Second, there is a lack of systematic analysis of the psychological mechanisms causing the change. In particular, the mediating role of basic psychological need satisfaction between pedagogical interventions and motivational outcomes empirically remains insufficiently explored. Third, quite a few studies focus exclusively on either motivational or behavioral indicators, while their simultaneous examination in a unified research framework is scarce. Consequently, there is a clear gap in the literature for studies that integrate a comprehensive pedagogical model, analyze its mechanisms of influence and assess both motivational and behavioral outcomes.

In the present study, innovative pedagogical approaches are conceptualized as the integration of autonomy-supportive teaching, gamification, cooperative learning and task differentiation into a coherent system for delivering the educational process. Within this framework, innovation is understood not as the use of individual new methods, but as their specific intentional integration into a structured pedagogical model aimed at satisfying the learners' basic psychological needs. Unlike traditional approaches, where such elements are applied in isolation, the proposed model ensures their coordinated realization across a unified lesson design, creating a synergy of motivational and behavioral outcomes. Thus, the innovative character of the approach lies in its systemic nature, coherence and functional integration rather than in the novelty of its individual components. In view of the above, it is relevant to conduct comprehensive research aimed at evaluating the effectiveness of integrating innovative pedagogical approaches in physical education and identifying the mechanisms through which they impact learners' motivation.

The purpose of the study is to determine the effectiveness of a set of innovative pedagogical approaches (namely, autonomy-supportive teaching style, gamification, cooperative learning, task differentiation) in increasing learners' autonomous motivation in physical education lessons, as well as in identifying the psychological mechanisms underlying their influence.

In accordance with the purpose of the study, the following hypotheses were formulated:

H1: The integration of innovative pedagogical approaches (autonomy-supportive teaching style, gamification, cooperative learning and task differentiation) will contribute to increasing the level of learners' autonomous motivation for physical education lessons compared to the traditional instructional model.

H2: The use of innovative pedagogical approaches will result in increased satisfaction of learners' basic psychological needs (autonomy, competence and relatedness).

H3: The satisfaction of basic psychological needs acts as a mediating mechanism in the relationship between innovative pedagogical approaches and the learners' autonomous motivation.

1. To assess the impact of a set of innovative pedagogical approaches implemented within the NEED-SMART PE program on the level of learners' autonomous motivation.
2. To determine changes in satisfying learners' psychological needs (autonomy, competence and relatedness) in the context of implementing innovative pedagogical approaches.
3. To examine the role of satisfying basic psychological need as a mediator in the relationship between innovative pedagogical approaches and autonomous motivation.
4. To evaluate the impact of innovative pedagogical approaches on behavioral indicators of learner engagement (participation index, attendance).

Contemporary scholarly literature demonstrates a clear consensus that learners' motivation for physical education is determined not by the declared value of physical activity itself, but by the quality of the experience gained during lessons. This primarily is done through satisfying basic psychological needs for autonomy, competence and relatedness. A meta-analysis by Vasconcellos et al. (2020) argues a strong association between autonomous motivation and adaptive outcomes (e.g., engagement and positive emotions), whereas amotivation is linked to avoidance behaviors and negative experiences. At the same time, the authors emphasize that the key factor is the pedagogical design of the lesson rather than the specific content of physical activity.

This position is further supported by applied studies. Leyton-Román et al. (2020) demonstrate that autonomy support is positively associated with intentions to engage in physical activity outside of school. Koka et al. (2020) highlight the

negative effects of controlling teaching styles, which are associated with need frustration and decreased motivation. Thus, there is general consensus in contemporary literature regarding the importance of teaching style. However, most findings are correlational, which limits cause-and-effect relationship interpretation.

Intervention-based studies partially address this limitation but also uncover some inconsistencies. For instance, Erdvik et al. (2019) found that combined teacher training formats (online and face-to-face) produce more stable effects than isolated approaches. Cheon et al. (2022) noted improvements not only in student motivation but also in classroom social climate. At the same time, Leisterer and Paschold (2022) underline that outcomes largely depend on learners' subjective perception of teaching style, which complicates generalization.

A separate line of research focuses on the scalability of pedagogical interventions. In this light, Paap et al. (2025) demonstrate the potential of online teacher training with fidelity monitoring. However, even in such studies, the long-term sustainability of effects lacks clarity.

Among structured pedagogical approaches, cooperative learning consistently demonstrates a positive but moderate effect (Fernández-Espínola et al., 2020; $d \approx 0.38$), although high heterogeneity and variability in methodological quality are pointed out. Likewise, the Sport Education Model is typically associated with increased motivation (Tendinha et al., 2021), but its effectiveness depends largely on context and duration. Hybrid models (Gil-Arias et al., 2021; Zhang et al., 2024) show promising results, yet the mechanisms underlying their effectiveness and the quality of implementation remain insufficiently explored.

Despite its popularity, gamification features considerable methodological variability. A review by Arufe-Giráldez et al. (2022) identifies an overall positive trend in motivation, but a lack of standardization limits the possibility of reliable meta-analytic conclusions. Next, Sotos-Martínez et al. (2023) found that gamification benefits only a subset of students, while Sal-de-Rellán et al. (2025) put to question the stability of its effects due to potential novelty influences. In this regard, hybrid approaches (Valero-Valenzuela et al., 2020), appear more theoretically grounded as they combine game elements with pedagogical structure.

A similar ambiguity is observed in digital approaches. Flipped learning shows generally positive outcomes (Botella et al., 2021; Wu et al., 2025), although Ferriz-Valero et al. (2022) substantiate a limited evidence base. Also, augmented reality technologies (Liang et al., 2023) boost motivation, but the underlying mechanisms remain insufficiently elaborated.

Given the above, existing research agrees on the conclusion that learners' motivation grows under conditions that support basic psychological needs. However, several systemic limitations are traced in the literature: the predominance of short-term interventions, reliance on self-reported measures, low standardization of instruments, limited monitoring of implementation fidelity and insufficient analysis of underlying mechanisms.

These limitations highlight the need to transition beyond the study of isolated methods toward scrutinizing the incorporation of innovative pedagogical approaches as a coherent system of educational influence. In this light, particular importance is attached to the empirical verification of the mediating role of basic psychological need satisfaction in shaping motivation towards physical education.

2. Methods and Materials

Research Procedure

The study was conducted using a quasi-experimental pre-test/post-test design with experimental (EG) and control (CG) groups over an 8-week period. This design enabled to assess the effectiveness of innovative pedagogical approaches in enhancing students' motivation within authentic educational settings. The research procedure comprised three successive stages:

1) *Initial stage (pre-test)*. At the beginning of the study, baseline measurements were conducted to assess learners' motivational, perceptual and behavioral indicators, including levels of autonomous motivation, satisfaction of basic psychological needs (autonomy, competence and relatedness) as well as behavioral engagement in physical education classes.

2) *Intervention stage*. The experimental group implemented a set of innovative pedagogical approaches within the framework of the authors' NEED-SMART PE program, which included an autonomous-supportive teaching style, gamification, cooperative learning and differentiated levels of tasks (A/B/C).

During the 8-week intervention, the experimental group completed 16 structured physical education lessons delivered twice weekly. Each lesson followed a standardized format, incorporating the following: a warm-up with an element of choice (supporting autonomy), cooperative activities (enhancing social relatedness), a main component with differentiated tasks (supporting competence), a stage of reflective feedback. The proposed intervention model is systemic in nature and is rooted in the functional interaction of its components within a single pedagogical design. Each of the components plays

a distinct role in meeting the learners' basic psychological needs: an autonomous-supportive teaching style (providing choices, non-controlling feedback) is aimed at maintaining autonomy; differentiated tasks of different levels of complexity (A/B/C) provide the formation of competence through experiencing attainable success; cooperative learning and team formats contribute to the development of social belonging. Gamification elements integrate these components, enhancing engagement and maintaining intrinsic motivation without moving to external control.

The interaction of these elements within one lesson creates a comprehensive educational environment in which the satisfaction of basic psychological needs is the central mechanism for influencing the autonomous motivation and learners' behavioral activity.

Elements of gamification included the use of a system of points for effort and support, team badges for cooperation and fair play, the completion of game "missions" and "challenges", as well as progressive difficulty levels ("skill-quest"), recording individual progress. It was important to avoid individual public comparison of learners' results (open ranking), instead the emphasis was on team interaction and personal progress. Gamification was used as a means of maintaining intrinsic motivation rather than external stimulation. In the control group, physical education lessons were conducted according to the traditional model without integrating these innovative approaches.

3) *Final stage (post-test)*. Upon completion of the intervention, the same set of indicators was reassessed to determine the magnitude and direction of changes and to evaluate the effectiveness of the integrated pedagogical model.

Control of the Implementation of the Intervention (Implementation Fidelity)

Implementation fidelity was assessed during all 16 intervention lessons using a structured observation protocol. The protocol included five components: autonomy support, informational feedback, cooperative interaction, gamification elements, and absence of public comparison or controlling practices. Each component was rated on a 0–2 scale, where 0 indicated absence, 1 partial implementation, and 2 full implementation. A total fidelity score was calculated for each lesson and converted into a proportional fidelity index. Two trained independent observers conducted fidelity assessment using the same scoring rubric. Before the intervention, observers completed calibration based on sample lesson scenarios and discussed scoring discrepancies until agreement was reached. A subsample of 25% of lessons was double-rated to assess inter-rater reliability. Inter-rater reliability for the total fidelity score was high ($ICC = 0.89$). The overall fidelity index across the intervention was 0.84 ± 0.09 , indicating consistent implementation of the planned pedagogical model.

Research Methods

The study employed four methodological approaches:

- 1) Experimental method – was used to determine causal effects by comparing pre- and post-intervention changes between EG and CG.
- 2) Psychometric method – involved using standardized questionnaires to assess motivation and psychological need satisfaction.
- 3) Observation method – was used to evaluate behavioral engagement through a participation index
- 4) Methods of mathematical statistics – included analysis of variance with repeated measurements (ANOVA) to check the interaction effect (group $\times$ time), as well as mediation analysis using a bootstrap procedure (5000 resamplings) to evaluate indirect effects.

Because students were nested within physical education classes, intra-class correlation coefficients (ICCs) were calculated for the main study outcomes before the main analyses. ICC values were low for autonomous motivation ($ICC = 0.032$), basic psychological need satisfaction ($ICC = 0.028$), enjoyment ($ICC = 0.035$), participation index ($ICC = 0.041$), and attendance ($ICC = 0.018$). These values indicated minimal class-level clustering. Therefore, the main analyses were conducted at the individual level. Multilevel models were not applied because the number of clusters was limited and the estimated between-class variance was small; however, the nested structure is acknowledged as a methodological limitation.

The independent variable was participation in the innovative pedagogical intervention (EG vs. CG), while dependent variables included autonomous motivation, satisfaction of basic psychological needs, and behavioral engagement. Statistical significance was set at $\alpha = 0.05$. Autonomous motivation was defined as the primary outcome. Secondary outcomes included controlled motivation, amotivation, satisfaction of basic psychological needs, perceived autonomy support, perceived controlling teaching style, enjoyment, participation index, and attendance. Because several secondary outcomes were analyzed, the results for these indicators were interpreted as supportive and exploratory. The main inferential conclusion was based on the primary outcome and on theoretically expected changes in basic psychological need satisfaction.

Study Sample

At the initial stage, 186 students aged 10–14 were recruited for participation. This age range is early adolescence, a developmental period characterized by a decline in interest for physical activity and a transition from externally regulated to more autonomous forms of motivation. At this stage, pedagogical interventions aimed at supporting autonomy, competence and social relatedness are particularly effective in stimulating sustainable motivation for physical education. The inclusion criteria were regular attendance of physical education classes and absence of medical contraindications to participating in physical activity.

After clearing the data (excluding questionnaires with missing answers, students with absences of more than 20% of classes and statistical outliers), the final sample comprised 160 students:

- Experimental Group (n=80): 41 girls, 39 boys;
- Control Group (n=80): 40 girls, 40 boys.

The average age of the participants was 12.2 ± 1.3 years. The study was conducted in one general secondary school and included eight intact physical education classes from grades 5–8. Allocation was performed at the class level rather than at the individual level in order to reduce contamination between students within the same physical education class. Classes were assigned to the experimental or control condition before the pre-test. The experimental and control groups followed the same general physical education curriculum, but only the experimental group received the NEED-SMART PE intervention.

An a priori power analysis was conducted for the primary outcome, autonomous motivation. The calculation was based on the expected group $\times$ time effect and assumed $\alpha = 0.05$, power = 0.80, two groups, two measurement points, and a medium expected effect size. A conservative minimum sample size of 128 participants was estimated. The final sample of 160 students exceeded this requirement and was considered sufficient for detecting the expected intervention effect. The sampling was conducted under typical school conditions, ensuring high environmental validity of the findings.

To control for potential teacher-related variability, the same physical education teachers worked with both the experimental and control groups. This approach minimized the influence of individual teaching styles on the outcomes. Before the intervention, teachers in the experimental group received standardized training on implementing the NEED-SMART PE program and adhering to its core components. In contrast, instruction in the control group followed the traditional curriculum without additional intervention. Thus, observed differences between groups can be attributed to the implementation of innovative pedagogical approaches rather than teacher-specific factors. Furthermore, the standardized lesson structure and systematic monitoring of implementation fidelity further reduced variability in instructional delivery.

Research Tools

The study employed a set of validated psychodiagnostic instruments to assess motivational, perceptual and affective variables:

- Autonomous motivation was measured using the *Perceived Locus of Causality Scale (PLOC)* (Goudas et al., 1994);
- Satisfaction of basic psychological needs (autonomy, competence, relatedness) was assessed using the *Basic Psychological Needs in Exercise Scale (BPNES)* (Vlachopoulos & Michailidou, 2006);
- Perceived autonomy support and controlling teaching style were evaluated using the *Learning Climate Questionnaire (LCQ)* (Williams & Deci, 1996);
- Enjoyment of physical activity was measured using the *Physical Activity Enjoyment Scale (PACES)* (Kendzierski & DeCarlo, 1991).

All instruments utilized a 5-point Likert scale to ensure responses comparability. Internal consistency was assessed in the current sample using Cronbach's alpha. Reliability coefficients were acceptable for autonomous motivation ($\alpha = 0.84$), controlled motivation ($\alpha = 0.78$), amotivation ($\alpha = 0.81$), autonomy need satisfaction ($\alpha = 0.82$), competence need satisfaction ($\alpha = 0.80$), relatedness need satisfaction ($\alpha = 0.83$), perceived autonomy support ($\alpha = 0.86$), perceived controlling teaching style ($\alpha = 0.79$), and physical activity enjoyment ($\alpha = 0.88$). These values supported the use of the scales in the subsequent analyses.

In addition to psychometric measures, behavioral engagement was assessed using the following indicators:

1. The Participation Index was used as an author-developed observational measure of students' behavioral engagement during physical education lessons. It included four observable components: active task performance, initiative, peer interaction, and response to teacher instructions. Each component was rated on a 0–2.5 scale, where 0 indicated absence of the behavior, 1.25 indicated partial or inconsistent manifestation, and 2.5 indicated stable and active manifestation during the lesson. The total score ranged from 0 to 10. Content validity was established through expert review involving four physical education teachers and two researchers in pedagogy. Experts assessed the relevance and clarity of each component using a 4-point rating scale. Item-level content validity indices ranged from 0.83 to 1.00, and the average

scale-level content validity index was 0.92. Before the main study, the protocol was piloted in one physical education class not included in the final sample. The pilot stage was used to clarify scoring descriptors and reduce ambiguity in observer interpretation. Two independent observers conducted the assessments. Before data collection, they completed standardized training and calibration using the same scoring rubric. A subsample of 25% of lessons was double-rated to assess inter-rater reliability. The inter-rater reliability for the total Participation Index was high ($ICC = 0.87$). Observers were not involved in teaching the classes and did not participate in delivering the intervention. Full blinding to group allocation was not feasible because the intervention format was visible during lessons; therefore, standardized scoring criteria and inter-rater reliability checks were used to reduce assessment bias.

2. Attendance was calculated as the percentage of lessons attended relative to the total number of lessons, providing an additional indicator of learner engagement.

3. Results

The results of the 8-week intervention conducted among students in grades 5–8 (aged 10–14) are presented in Table 1. Baseline indicators showed no statistically significant differences between the experimental (EG) and control (CG) groups across all studied variables, confirming the initial equivalence of the groups before the intervention.

The analysis was performed using the model of repeated measurements (group $\times$ time), which allowed to assess the effect of the integrated innovative pedagogical approaches while controlling for potential age-related or developmental changes in motivation. This approach ensured that the observed effects were attributed to the intervention rather than to natural fluctuations.

Table 1. Descriptive statistics ($M \pm SD$) and the effect of integrating innovative pedagogical approaches (Pre/Post)

Indicator	EG (n=80)	Pre EG Post	ΔEG	CG (n=80)	Pre CG Post	ΔCG	Interaction group $\times$ time (F(1,158); p; η^2)	d ($\Delta EG - \Delta CG$)
Autonomous motivation	3.55 $\pm$ 0.62	4.18 $\pm$ 0.58	+0.63	3.56 $\pm$ 0.60	3.70 $\pm$ 0.61	+0.14	32.5; 0.171	p<0.001; 0.89
Controlled motivation	3.10 $\pm$ 0.66	3.05 $\pm$ 0.64	-0.05	3.12 $\pm$ 0.65	3.18 $\pm$ 0.66	+0.06	3.4; 0.021	p=0.067; 0.21
Amotivation	2.30 $\pm$ 0.70	1.95 $\pm$ 0.66	-0.35	2.28 $\pm$ 0.68	2.20 $\pm$ 0.67	-0.08	11.9; 0.070	p=0.001; 0.52
Need satisfaction – Autonomy	3.40 $\pm$ 0.65	3.95 $\pm$ 0.60	+0.55	3.42 $\pm$ 0.64	3.55 $\pm$ 0.63	+0.13	23.8; 0.131	p<0.001; 0.76
Need satisfaction – Competence	3.35 $\pm$ 0.66	3.98 $\pm$ 0.59	+0.63	3.33 $\pm$ 0.67	3.48 $\pm$ 0.65	+0.15	31.0; 0.164	p<0.001; 0.87
Need satisfaction – Relatedness	3.60 $\pm$ 0.62	4.05 $\pm$ 0.58	+0.45	3.58 $\pm$ 0.63	3.68 $\pm$ 0.62	+0.10	14.1; 0.082	p<0.001; 0.64
Perceived autonomy support (teacher)	3.45 $\pm$ 0.64	3.95 $\pm$ 0.60	+0.50	3.46 $\pm$ 0.63	3.56 $\pm$ 0.62	+0.10	19.9; 0.112	p<0.001; 0.73
Perceived controlling teaching	2.85 $\pm$ 0.70	2.40 $\pm$ 0.65	-0.45	2.84 $\pm$ 0.69	2.78 $\pm$ 0.68	-0.06	16.9; 0.097	p<0.001; -0.65
Enjoyment (PACES-type)	3.60 $\pm$ 0.61	4.25 $\pm$ 0.56	+0.65	3.62 $\pm$ 0.60	3.80 $\pm$ 0.59	+0.18	24.5; 0.134	p<0.001; 0.78
Participation index (obs., 0–10)	6.10 $\pm$ 1.20	7.60 $\pm$ 1.10	+1.50	6.00 $\pm$ 1.10	6.40 $\pm$ 1.20	+0.40	33.6; 0.175	p<0.001; 0.92
Attendance (%)	88.0 $\pm$ 6.0	93.0 $\pm$ 5.0	+5.0	88.0 $\pm$ 6.0	90.0 $\pm$ 6.0	+2.0	17.8; 0.101	p<0.001; 0.67

Note: Scales 1–5: Motivation, BPNs, Autonomy support, Enjoyment

Controlling teaching: 1–5 (more = more control)

Participation index: 0–10. Attendance: %

Source: Developed by the authors

The group $\times$ time interaction showed a significant increase in autonomous motivation in the experimental group compared with the control group ($F(1,158) = 32.5$, $p < 0.001$, $\eta^2 = 0.171$; $d = 0.89$). Significant effects were also observed for autonomy, competence, and relatedness need satisfaction, with the strongest effect for competence ($\eta^2 = 0.164$; $d = 0.87$). Perceived autonomy support increased, while perceived controlling teaching decreased. Behavioral indicators also

improved: the Participation Index increased more strongly in the experimental group than in the control group (+1.50 vs. +0.40; $d = 0.92$), and attendance increased by 5% in the experimental group. These findings support H1 and H2.

To examine the indirect effects, a mediation model was tested (Table 2). The analysis was carried out on growth indicators (Post-Pre) using the bootstrap procedure (5000 resamplings), which allows assessing the stability of the indirect effect without assuming the normality of the distribution.

Table 2. Mediation model (Bootstrap 5000): BPNs as a mediator of the autonomic motivation growth

Path	β	SE	95% CI	p
a: Group $\rightarrow$ Δ BPNs	0.62	0.09	[0.44; 0.79]	<0.001
b: Δ BPNs $\rightarrow$ Δ Autonomous motivation	0.38	0.07	[0.24; 0.52]	<0.001
c (total): Group $\rightarrow$ Δ Autonomous motivation	0.46	0.08	[0.30; 0.62]	<0.001
c' (direct): Group $\rightarrow$ Δ Autonomous motivation (with a mediator)	0.22	0.08	[0.06; 0.38]	0.007
ab (indirect effect): Group $\rightarrow$ Δ BPNs $\rightarrow$ Δ Motivation	0.24	–	[0.13; 0.36]	–

Note: The model is changing: Group (0=CG, 1=EG) $\rightarrow$ Δ BPNs $\rightarrow$ Δ Autonomous motivation

Standardized coefficients (β)

Source: Developed by the authors

It is noteworthy that after the mediator's inclusion, the direct effect of innovative pedagogical approaches remaining statistically significant, fell from $\beta = 0.46$ to $\beta = 0.22$, indicating a partial mediation effect.

In terms of innovative pedagogical approaches, these demonstrated a significant beneficial effect on satisfying basic psychological needs ($\beta = 0.62$). In turn, the satisfaction of these needs largely predicted autonomous motivation ($\beta = 0.38$). Therefore, about half of the total intervention effect is explained by changes in basic psychological needs. For learners aged 10–14 years, these findings are particularly meaningful, because the observed motivational changes cannot be ascribed solely to the program novelty. Rather, they reflect systematic changes in the psychological learning environment. Accordingly, the findings are consistent with the assumption that satisfaction of basic psychological needs may be one psychological pathway linking innovative pedagogical approaches to changes in learners' autonomous motivation. At the same time, the persistence of a significant direct effect is indicative of additional influence factors, such as emotional engagement, peer interaction and the novelty of instructional format, which necessitate further examination. Overall, the mediation analysis provides empirical support for Hypothesis H3, while the quasi-experimental pre-post design requires cautious interpretation of the mediation results.

Table 3 presents the relationships between changes in variables within the EG, providing further insight into the model's internal structure.

Table 3. Correlations between changes in EG ($n=80$) after intervention

Variables (Δ)	Δ Autonomous motivation	Δ BPNs total	Δ Autonomy support	Δ Controlling teaching	Δ Enjoyment	Δ Participation
Δ Autonomous motivation	1	0.62**	0.49**	–0.41**	0.55**	0.46**
Δ BPNs total	0.62**	1	0.53**	–0.38**	0.44**	0.40**
Δ Autonomy support	0.49**	0.53**	1	–0.52**	0.39**	0.31*
Δ Controlling teaching	–0.41**	–0.38**	–0.52**	1	–0.36**	–0.28*
Δ Enjoyment	0.55**	0.44**	0.39**	–0.36**	1	0.48**
Δ Participation	0.46**	0.40**	0.31*	–0.28*	0.48**	1

Note: Pearson r , Δ = Post – Pre

* $p < 0.05$, ** $p < 0.01$

Source: Developed by the authors

Changes in autonomous motivation (Δ AM) showed the strongest positive correlations with changes in basic psychological needs satisfaction (Δ BPNs; $r = 0.62$), enjoyment (Δ Enjoyment; $r = 0.55$) and behavioral participation (Δ Participation; $r = 0.46$). These associations indicate that improvement in motivational indicators is typically accompanied by both enhanced psychological well-being and observable behavioral engagement. Negative correlations with perceived controlling teaching style ($r = -0.41$) further confirm that reductions in controlling instructional practices are an important condition for stimulating autonomous motivation. In adolescence, this pattern is specifically relevant, when increase in

perceived autonomy support is strongly associated with decrease in perceived control ($r = -0.52$), suggesting that students are sensitive to changes in the interpersonal style of teacher–student interaction. Overall, the findings indicate that motivation, satisfaction of psychological needs, enjoyment and behavioral participation form an integrated and coherent system of mutually supportive processes.

The consistency of correlations across these constructs substantiates the internal structural validity of the intervention model. Figure 1 illustrates the fidelity of implementing the intervention protocol in 16 lessons, demonstrating a consistently high level of adhering to the designed pedagogical framework.

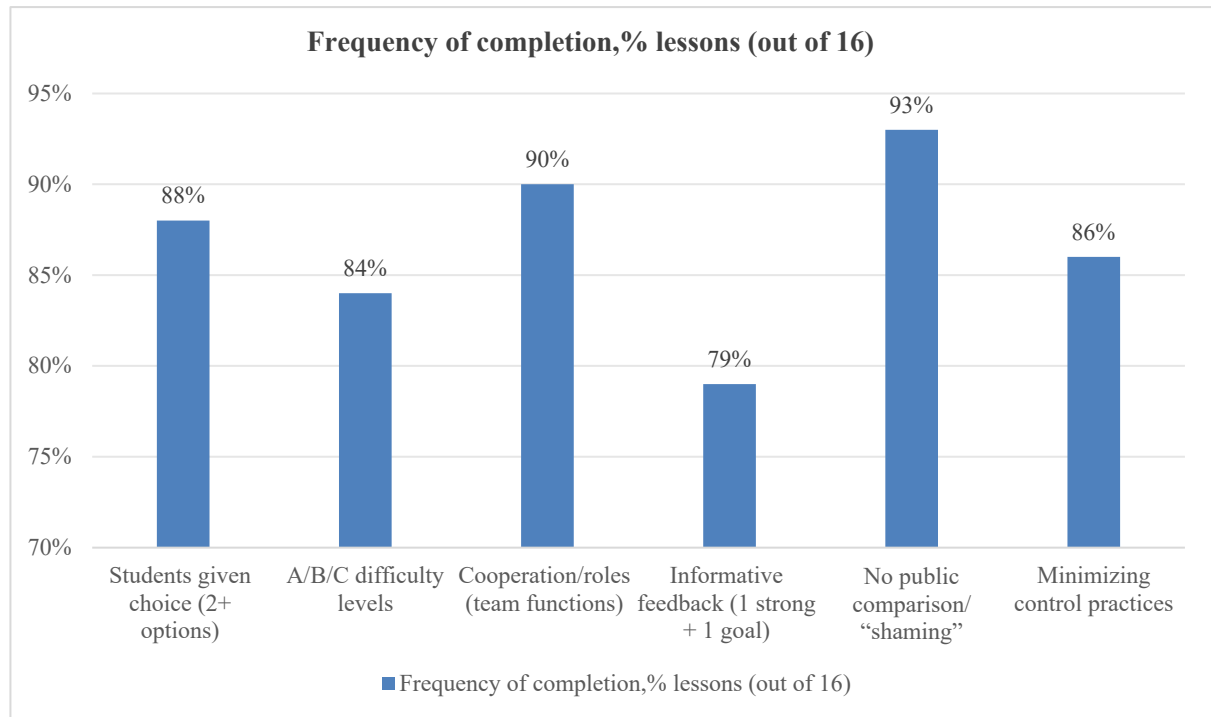


Figure 1. Implementation fidelity of the NEED-SMART PE intervention across 16 lessons in the experimental group
Source: Developed by the authors

Note. Values represent the percentage of planned intervention components implemented across 16 lessons. The overall fidelity index was 0.84 ± 0.09 .

A high overall implementation fidelity index (0.84 ± 0.09) indicates consistent and systematic delivery of the intervention components throughout the study period. This level of adherence decreases the likelihood that the observed effects are ascribed to random variation or unsystematic pedagogical practices, in such a way strengthening the internal validity of the findings.

Among the individual components, the highest adherence rates were observed for the absence of public comparison of student performance (i.e., avoidance of rankings and competitive grading; 93%) and the implementation of cooperative learning structures (90%). These elements are especially relevant for students aged 10–14 years, for whom social evaluation and peer comparison play a significant role in shaping self-perception and motivation. A comparatively lower fidelity score was recorded for providing structured informative feedback (79%), thus indicating a potential area for further improvement of the intervention protocol. Overall, the implementation of the innovative pedagogical model demonstrated a high level of adherence to the planned design. This supports the conclusion that the observed effects can be attributed to the intervention rather than external or random factors.

Table 4 illustrates the effect of integrating innovative pedagogical approaches in junior (grades 5–6) and senior (grades 7–8) subgroups.

Table 4. Subgroup analysis by age: Grades 5–6 vs 7–8 (Δ Autonomous motivation)

Subgroup	EG Δ M (Post–Pre)	CG Δ M (Post–Pre)	Δ Diff	F(1,156); p	d
Grades 5–6	+0.70	+0.16	+0.54	21.6; $p < 0.001$	0.94
Grades 7–8	+0.56	+0.12	+0.44	12.8; $p < 0.001$	0.75

The effect of the intervention was stronger among learners in grades 5–6 ($d = 0.94$) compared to those in grades 7–8 ($d =$

0.75). This pattern is consistent with developmental characteristics of early adolescence. Younger learners are generally more sensitive to environmental changes and pedagogical innovations. However, older adolescents tend to exhibit more stable and consolidated motivational patterns. Still, the effect remained statistically significant in both groups, indicating that the integration of innovative pedagogical approaches is effective across the entire 10–14-year age range. At the same time, grades 5–6 appear to represent a more sensitive developmental period for the formation of autonomous motivation.

4. Discussion

The findings of this study support and extend previous research on the effectiveness of pedagogical interventions grounded in Self-Determination Theory (SDT) in physical education. For example, Leisterer and Paschold (2022) reported that autonomy-supportive teaching significantly enhances learners' satisfaction with physical education lessons ($\eta^2 \approx 0.17, p < 0.01$). Similarly, in the present study, students in the experimental group demonstrated a substantial increase in lesson satisfaction ($\Delta = +0.65, d = 0.78$), which is consistent with these findings. Likewise, effects on enjoyment and emotional engagement were also reported by Walters et al. (2023), where a school-based wellbeing intervention for girls resulted in increased satisfaction with physical activity and more positive attitudes to activities.

A meta-analysis by Kelso et al. (2020) identified moderate effects of school-based interventions on intrinsic motivation ($g \approx 0.42$) and identified regulation ($g \approx 0.38$), but only a small effect on perceived autonomy ($g \approx 0.15$). In contrast, the present study demonstrated considerably stronger effects on autonomous motivation ($\Delta = +0.63, d = 0.89$) and satisfaction of basic psychological needs ($d \approx 0.8$). These results suggest that the integration of multiple innovative pedagogical approaches within a coherent instructional system may boost intervention effectiveness as compared with typically reported in the literature.

Similar but less pronounced effects were observed by Sevil-Serrano et al. (2022), where school-based interventions increased autonomous motivation, though effect size remained within moderate ranges. Notably, Kelso et al. (2020) also highlighted limitations in the quality of intervention studies, including risks of bias and methodological heterogeneity. Instead, the present study employed a rigorous quasi-experimental design with adequate sample size, cross-validation of measures, and controlled implementation fidelity, thereby reinforcing the reliability and validity of the findings.

The comparison in terms of the level of control and amotivation is especially interesting. In our study, controlling motivation did not change significantly ($p = 0.067, d = 0.21$), while amotivation decreased sharply ($\eta^2 \approx 0.07, d \approx 0.52$). Similarly, Khajeaflaton Mofrad (2024) demonstrated that a specially designed novelty-maintenance intervention results in a significant reduction in amotivation ($F(1.52) = 43.4, p < 0.001, \eta^2 = 0.31$) and a considerable increase in MVPA. In their study, learners' MVPA increased from 9.7% to 23.1% of lesson time. In our work, the Participation Index increased by +1.50 units ($d = 0.92$) and lesson attendance increased by +3%, which is consistent with Khajeaflaton Mofrad's findings and emphasizes the practical benefits of introducing innovative pedagogical approaches.

Carriedo et al. (2023) showed that high autonomous support increases students' MVPA up to 73.7% of lesson time and significantly increases perceptions of autonomy and competence ($p < 0.001$). In our experiment, similar trends were observed: satisfaction and the need for autonomy ($d = 0.76$) and competence ($d = 0.87$) increased significantly, which confirms the conclusions of Carriedo et al. (2023) about the key role of teacher support in shaping intrinsic motivation. Further, Leisterer and Paschold (2022) demonstrated that the combination of different forms of support (kinesthetic, procedural, cognitive) leads to a significant increase in the positive emotional perception of PE lessons. In our study, the comprehensive implementation of choice of activities, encouragement of cooperation and constructive feedback worked to a similar result. Thus, EG students showed significantly more positive feelings and higher lesson satisfaction compared to CG. Similar results were received by Gil-Arias et al. (2017), where the integration of the TGfU model and Sport Education contributed to increases in intrinsic motivation and satisfaction with participating in physical activity.

Furthermore, Tilga et al. (2021) in a similar intervention study explored that increased teacher support for basic needs leads to an increase in students' autonomous motivation ($\beta = 0.61, p < 0.001$). The said researchers also argued that changes in teacher support directly increase attitudes and intentions toward physical activity in leisure time. Similarly, our analysis yielded positive correlations between motivation, satisfaction of needs and participation levels, consistent with the trans-contextual model of motivation and the findings of the above scholars. Similar patterns were revealed by Yermakhanov (2025), where an autonomy-oriented program also contributed to increases in learners' intrinsic motivation and activity outside school hours.

The lack of long-term verification and combined interventions was highlighted in previous reviews (Kelso et al., 2020; Shan et al., 2026). For example, it was noted by Shan et al. (2026) that although SDT-based models (in particular, the Sport Education Model) effectively increase intrinsic motivation and satisfaction of autonomy, competence and relatedness, the data on long-term effects of such approaches is lacking. Although our study is limited to an 8-week implementation period, it already addresses an important stage of school motivation development, thus demonstrating real practical outcomes (attendance, participation), which is absent in many previous studies. Importantly, different age

groups were considered in the current study: older learners (grades 7–8) showed a slightly smaller increase in results ($d \approx 0.75$) compared to younger ones ($d \approx 0.94$), which indicates the need to adapt methods to age characteristics, which is not often discussed in the literature.

Several limitations can be noted when critically evaluating existing studies. In particular, a significant number of publications have small sample sizes, short duration of intervention and lack control groups. It is worth mentioning that Kelso et al. (2020) indicate a high risk of bias in randomized motivation studies. In addition, Leisterer and Paschold (2022) utilized only a single intervention lesson and a small number of classes, thereby limiting generalization. In contrast, we conducted an 8-week quasi-experimental intervention with a control group and not only psychological indicators were measured but also behavioral outcomes (attendance, participation), thus bridging this gap. Another limitation is the rare assessment of implementation fidelity. Our data on protocol adherence (~90%) demonstrates a high quality of implementation, which usually remains unknown or not reported in similar studies.

Thus, our study carries further the existing findings: it not only confirms the key role of autonomous support in increasing motivation but also demonstrates that integrating the novelty elements and interpersonal interaction can significantly strengthen these effects. At the same time, a longer intervention period was ensured and included quantitative behavioral outcomes (participation and attendance), addressing several methodological limitations. As our observations show, an integrated approach (combining traditional game-based and emotional-supportive methods) enables the most pronounced improvements in learners' motivation and active participation.

The results of this study are consistent with most publications regarding the positive impact of autonomous support on learners' motivation. At the same time, we also identified the effects that were not previously addressed or are seldom taken into account, such as a significant decrease in amotivation, an increase in real participation and increased attendance in lessons, as well as significant changes in maintaining novelty. The elements of novelty and involving student participation reveals the potential of the "problem of ignoring innovations" in previous studies. Our methodology bridges this gap by suggesting effective strategies that provide deeper and more sustainable changes in learners' motivation for PE lessons.

Limitations

The study has certain limitations that should be considered when interpreting the results. In particular, the current research did not address the influence of individual student characteristics, such as gender or level of physical fitness, which should be explored in future studies. Although the obtained ICC values indicated minimal clustering effects, the limited number of class-level clusters restricted the use of full multilevel modeling. Therefore, future studies should include a larger number of classes and schools and apply multilevel or cluster-robust analytical strategies. Despite this limitation, the low ICC values support the robustness of the individual-level analysis used in the present study. The mediation analysis was based on pre-post change scores in a quasi-experimental design. Therefore, the indirect effect should be interpreted as evidence consistent with the proposed theoretical pathway rather than as definitive proof of causal mediation.

Recommendations

It is expedient to incorporate the autonomy-supportive pedagogical strategies in physical education practice, including differentiated tasks, cooperative learning formats and reflective feedback. Further promising directions include adapting the program to learners' age-specific characteristics and integrating innovative pedagogical approaches into the long-term practice of physical education teaching.

5. Conclusions

The results of the study confirm the effectiveness of innovative pedagogical approaches in physical education aimed at enhancing the motivation in learners aged 10–14 years. It was established that to implement a structured program combining an autonomous-supportive teaching style, elements of gamification, cooperative learning and differentiated levels of task complexity provides a statistically significant enhancement in learners' autonomous motivation. In particular, we recorded a significant increase in autonomous motivation, a decrease in amotivation, and an increase in satisfying basic psychological needs, namely autonomy, competence and social relatedness.

The results obtained justify the assumption that motivational changes are not only quantitative but also qualitative, reflecting a transformation in the internal regulation of the learners' activity. Mediation analysis made it possible to show that satisfaction of basic psychological needs is a principal psychological mechanism of affecting innovative pedagogical approaches on motivation. This is in line with the provisions of the self-determination theory. On the other hand, the partial nature of mediation indicates the presence of additional influencing factors, in particular emotional engagement and social interaction. A notable finding is also the improvement of behavioral indicators, in particular increased student participation in the educational process and attendance, which confirms the practical significance of the observed changes. Age-related analysis established that the most salient effect was noted in younger adolescents (grades 5–6), which

suggests higher sensitivity of this age group to changes in the educational environment.

When it comes to the most effective technique, it was an integrated approach combining autonomous-supportive learning, cooperative interaction, gamification elements and task differentiation. Thus, it can be considered a promising model for conducting physical education lessons in an innovative way.

The scientific novelty of the study is due to empirical substantiation of the efficacy to integrate innovative physical education pedagogical approaches as a holistic educational intervention which impacts learners' motivation. For the first time, it has been demonstrated that the comprehensive application of an autonomous-supportive teaching style, gamification, cooperative learning and task differentiation ensures not only an increase in autonomous motivation, but also systemic changes in terms of satisfying learners' basic psychological needs and their behavioral engagement. It was demonstrated that satisfaction of basic psychological needs is a key psychological mechanism (mediator) through which the influence of innovative pedagogical approaches on learners' motivation is exercised.

The practical value of the study is seen in the possibility of implementing innovative pedagogical approaches in institutions of general secondary education to increase learners' motivation in physical education. The developed NEED-SMART PE program can be used as a tool for applying these approaches in teaching practice and in teacher training programs.

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Author contributions

All the authors participated and were involved in the conceptualization of the study, collation of data, analysis and review of the study as well as the writing, and proof reading of the manuscript. All authors read and approved the final version of the manuscript

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