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Game-based learning to enhance motivation and fundamental motor skills in elementary physical education: a quasi-experimental study

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ABSTRACT

Background: Game-based learning (GBL) is widely used in physical education to enhance student motivation and fundamental motor skills (FMS). However, evidence from elementary school contexts, particularly using quasi-experimental designs with intact classes, remains limited. **Objectives**: This study examined the effects of a 12-week game-based learning intervention on motivation and fundamental motor skills among elementary school students. **Methods**: A quasi-experimental one-group pretest–posttest design was employed involving 34 elementary school students selected through purposive sampling. The 12-week intervention consisted of weekly 105-minute sessions of dexterity-based game learning. Motivation was measured using a validated questionnaire, while fundamental motor skills were assessed through an age-appropriate motor skills test. Data were analyzed using descriptive statistics, normality and homogeneity tests, and paired-sample t-tests, with Cohen's d calculated to estimate effect size. **Finding/Results**: The experimental group demonstrated significant increases in motivation and FMS from the pre-test to the post-test ($p < 0.05$). Although the effect size was small to medium, the observed increases reflect short-term positive changes following the intervention. **Conclusion**: The 12-week GBL intervention effectively enhanced motivation and FMS among elementary school students. While the findings support the use of GBL in physical education, the absence of a control group and potential class-level confounders limit causal interpretation. Future studies should employ randomized or controlled designs and include broader measures of engagement and motor competence.

Keywords: Game-based learning; motivation; fundamental motor skills; physical education; elementary school

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INTRODUCTION

Fundamental motor skills (FMS) and motivational engagement are two important aspects of physical education (PE) learning in primary schools, as early movement experiences contribute significantly to long-term physical activity participation (de Bruijn et al., 2022; Wu et al., 2024). However, the conventional learning approach that is still widely applied tends to be repetitive and teacher-centered, so it can less arouse

students' interest in being actively involved (Hu, 2024), Especially in Indonesia, PE practices tend to rely on direct instruction and provide less variety in activities. Low engagement decreases students' intrinsic motivation, which is the foundation for mastering complex movements at the next level (Liu, 2024; Singh et al., 2022). To address these challenges, game-based PE models present a pedagogical alternative combining fun with meaningful learning (Camacho-Sánchez et al., 2023). Through games, students can experience a more interesting, fun, and challenging learning context, while stimulating aspects of affective and psychomotor (Adipat et al., 2021; Gil-Madrona et al., 2020).

The game-based learning (GBL) approach offers a pedagogical alternative that aligns with children's developmental needs. Various studies report that game-based learning can increase engagement, create a fun atmosphere, and support students' cognitive, socio-emotional, and motor development (Duncan, 2020; Purwanto et al., 2024; Rosmaria & Fadhilah, 2024). Based on self-determination theory, game activities facilitate the fulfillment of psychological needs, including competence, autonomy, and relatedness, which directly contribute to increased learning motivation (Howard et al., 2021; Pereira et al., 2021).

Although several international studies demonstrate the benefits of GBL, most examine only one variable, such as motivation or learning outcomes, in isolation (Jääskä et al., 2022; Karakoç et al., 2022). In Indonesia, GBL research has focused more on motivational aspects, while empirical studies on its impact on FMS are still limited (Putri et al., 2025; Wibawa et al., 2025). Studies using long-term interventions are also rare, despite the need for a longer duration to comprehensively observe motor development. Furthermore, most studies use artificial groups, rather than intact classes, and thus are less reflective of real-life learning situations in schools.

Although PE has great potential in shaping active and healthy behavior from an early age, many primary school students show low levels of learning motivation in participating in learning activities (Sigalingging et al., 2023). Low motivation is often associated with monotonous learning experiences irrelevant to children's interests and developmental needs (Baten et al., 2020). In addition, basic motor skills that should be developed progressively in the elementary school age phase have also not shown optimal results, especially in learning environments that do not provide an adequate variety of activities (Zhang et al., 2024).

The urgency of this research is further heightened given the low level of fundamental motor skills in Indonesian children, which is associated with an increased risk of obesity, low physical fitness, and a sedentary lifestyle (Han et al., 2018; Hardianti et al., 2023; Irawan et al., 2025; Mardiansyah et al., 2024). Meanwhile, the Independent Curriculum requires active, varied, and game-based learning that is tailored to meet the needs of each student. Therefore, empirical evidence is needed to demonstrate how GBL can improve motivation and FMS in the elementary school context.

The uniqueness of this research lies in using games as the primary medium to achieve holistic learning goals, not just for entertainment or time fillers, but as a structured and measurable pedagogical tool. In line with the findings of previous studies, it is evident that game-based PE learning in elementary schools has a positive impact on fundamental movement skills, mental well-being, physical fitness, and regular physical activity levels (Miller et al., 2016; Satria et al., 2024). Not only that, from an affective perspective, namely cognitive and decision-making, the study's results explain that game-based learning can train decision-making and tactical understanding in playing, which is integrated through practical experiences (Abad Robles et al., 2020; Barba-Martín et al., 2020).

This study aims to investigate the impact of a 12-week game-based learning intervention on the motivation and fundamental motor skills of elementary school students. To answer this objective, the following research question was formulated: Can the implementation of game-based learning increase motivation to learn physical education and improve motor skills? Based on this question, this study hypothesizes that a 12-week game-based learning intervention will lead to increased learning motivation and improved fundamental motor skills.

METHOD

Research Design

This study employed a quasi-experimental one-group pretest–posttest design, which allowed the examination of changes in motivation and fundamental motor skills (FMS) following the intervention. Although this design does not allow strong causal inference due to the absence of a control group, random assignment was not feasible because of administrative restrictions and the school's fixed class structure. As with most single-group designs, potential threats to internal validity such as maturation, testing effects, and Hawthorne effects are acknowledged and considered in the interpretation of findings

Participants

The initial population consisted of 68 elementary school students aged 7-9 years. Participants were selected using purposive sampling based on predefined inclusion criteria: being 7-9 years old, physically healthy according to school medical records, attending PE classes regularly, and having parental/guardian written consent. Exclusion criteria included medical limitations restricting physical activity, absence during the pretest, or incomplete research instruments. Based on these criteria, 44 students were initially eligible. A further screening during the pretest phase resulted in the exclusion of ten students (six due to incomplete pretest data and four due to parental withdrawal). The final sample consisted of 34 students who completed the entire 12-week intervention and both pretest and posttest assessments. The sample displayed a balanced age distribution (7-9 years) and a proportional representation of boys and girls, reflecting the natural composition of the participating classes.

Instruments

Fundamental motor skills (FMS) were assessed using a structured motor skills test specifically developed for elementary school children aged 7-9, as proposed by (Wibowo et al., 2024). The instrument measures three core components—locomotor, manipulative, and balance skills—and was adapted from the conceptual framework of the Test of Gross Motor Development, Second Edition (Valentini et al., 2018). The test includes tasks such as galloping, sliding, jumping, one-leg standing, ball bouncing, catching, throwing, kicking, and striking. All assessments were administered by trained examiners following the standardized procedures provided in the instrument manual.

Content validity demonstrated acceptable indices, with CVR values exceeding the recommended threshold (> 0.763), while reliability coefficients for all items met acceptable standards (Cronbach's $\alpha > 0.60$). Learning motivation was assessed using a 10-item validated questionnaire that has demonstrated satisfactory psychometric properties (item validity $r > 0.30$; Cronbach's $\alpha = 0.84$).

Intervention Procedures

The intervention followed a 12-week agility-based game learning program delivered once weekly for 105 minutes, aligned with the school's physical education schedule.

Participants completed pretests on learning motivation and FMS prior to the intervention and a posttest following the 12th session. Detailed weekly activities are presented in **Table 1**.

Table 1. Intervention Program

Week	Skills	Learning objectives	Game-Based Activities	Intensity and sessions	SDT
1	BAL, LOC, MAN	Basic movement adaptation	two-footed jump, throw-catch in pairs	10' warm-up, 80' core GBL, 15' cool-down; light–moderate intensity	Basic challenges → competence, partner → connectedness
2	LOC, MAN	Basic coordination	Zig-zag, target throwing	10' warm-up, 80' core GBL, 15' cool-down; moderate intensity	Path choice → autonomy, accuracy → competence
3	BAL, LOC	Body control	Ladder balance game	10' warm-up, 80' core GBL, 15' cool-down; light–moderate intensity	Peer support → relatedness
4	BAL, LOC, MAN	Movement transition	Agility, passing in pairs	10' warm-up, 80' core GBL, 15' cool-down; moderate intensity	progressive challenges → competencies
5	LOC, MAN	Accuracy and speed	rolling and catching game	10' warm-up, 80' core GBL, 15' cool-down; moderate intensity	Self-assessment → autonomy
6	BAL, LOC, MAN	Agility and spatial orientation	dribble & pass challenge	10' warm-up, 80' core GBL, 15' cool-down;moderate-high intensity	Team collaboration → relatedness
7	BAL, LOC, MAN	Advanced agility	Agility tag, zigzag sprint	10' warm-up, 80' core GBL, 15' cool-down; high intensity	Healthy competition → competence and relatedness
8	BAL, LOC, MAN	Increased control and speed	Shuttle run game, quick-reaction ball game	10' warm-up, 80' core GBL, 15' cool-down; high intensity	time challenge → competence
9	BAL, LOC, MAN	Completion of complex motor tasks	throw & move game	10' warm-up, 80' core GBL, 15' cool-down; moderate-high intensity	Group strategy → relatedness
10	BAL, LOC, MAN	Flexibility of playing tactics	Small-sided agility games	10' warm-up, 80' core GBL, 15' cool-down;moderate intensity	Strategy choice → autonomy
11	BAL, LOC, MAN	Integration of all skills	Skill circuit games	10' warm-up, 80' core GBL, 15' cool-down;high intensity	Different levels → competence
12	BAL, LOC, MAN	Integrative evaluation & games	Team challenge game	10' warm-up, 80' core GBL, 15' cool-down; moderate intensity	Team success → relatedness + competence

BAL = Balance skills; LOC = Locomotor skills; MAN = Manipulative skills; SDT = Self-Determination Theory

Statistical Analysis

This study employed several data analysis techniques, including descriptive statistical analysis to determine the mean, standard deviation, and score distribution for each

research variable. The Shapiro-Wilk test was used to assess data normality, and Levene's test was conducted to ensure homogeneity of variance. After the assumptions for parametric testing were fulfilled, a paired sample t-test was used to evaluate differences between pre-test and post-test scores in the experimental group. Additionally, Cohen's *d* was calculated to measure the magnitude of the intervention effect. The motivational outcome showed a large effect size (Cohen's d = 0.87, 95% CI [0.55, 1.18]), while the improvement in fundamental motor skills demonstrated a moderate-to-large effect size (Cohen's d = 0.76, 95% CI [0.43, 1.08]). All statistical analyses were performed using IBM SPSS version 25.

RESULTS AND DISCUSSION

The results section presents research findings to examine the effect of game-based physical education learning on elementary school students' motivation and FMS. The analysis is carried out in stages, starting from descriptive statistics, assumption tests (normality and homogeneity), and hypothesis testing through the test. The results obtained reflect significant changes in both variables after the intervention. The following is a description of the research results.

Table 2. Descriptive Statistics of Student Motivation Pretest-Posttest

	N	Mean	Min	Max	SD
Pretest	34	32.05	23	39	3.61
Posttest	34	34.67	29	39	2.94

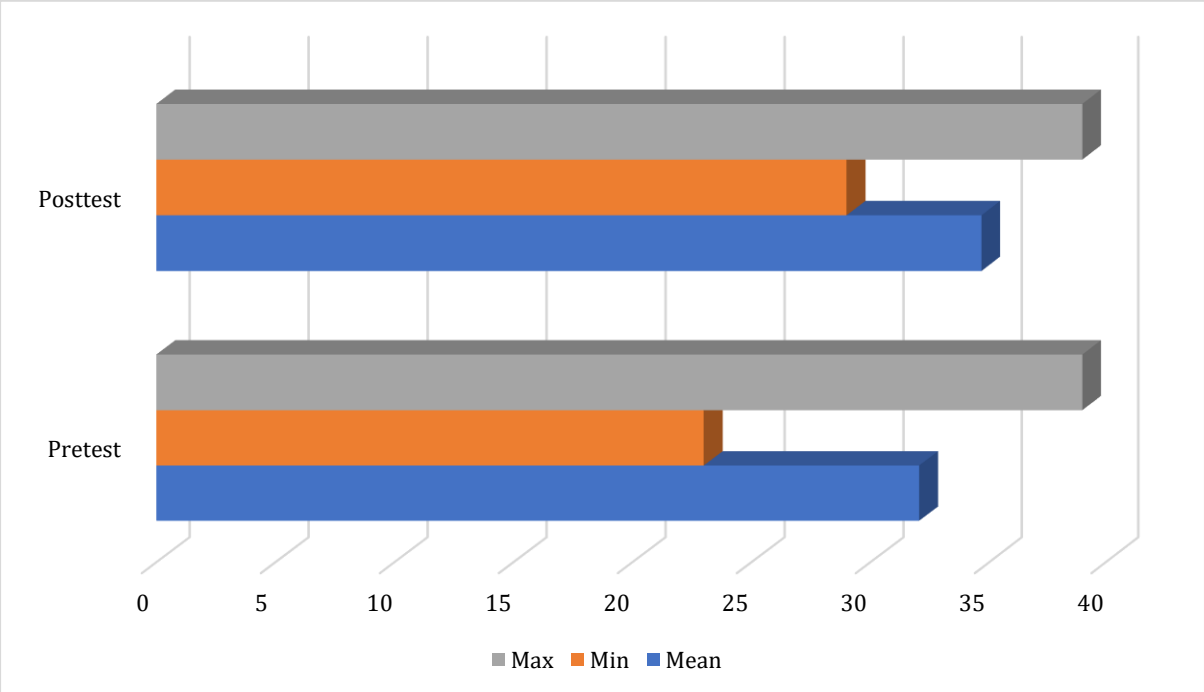

Figure 1. Pretest-Posttest Statistics Results of Student Motivation

The descriptive statistical results of students' learning motivation levels during the pre-test and post-test are explained in **Table 2**. It is explained that the average score of students' motivations before treatment was 32.05 with a SD of 3.61. After being given game-based learning treatment, the average score of students' motivations increased to 34.67.

Table 3. Descriptive Statistics of Students' FMS Pretest-Posttest

	N	Mean	Min	Max	Std. Deviation
Pretest	34	25.61	21	30	2.08
Posttest	34	27.64	22	33	3.03

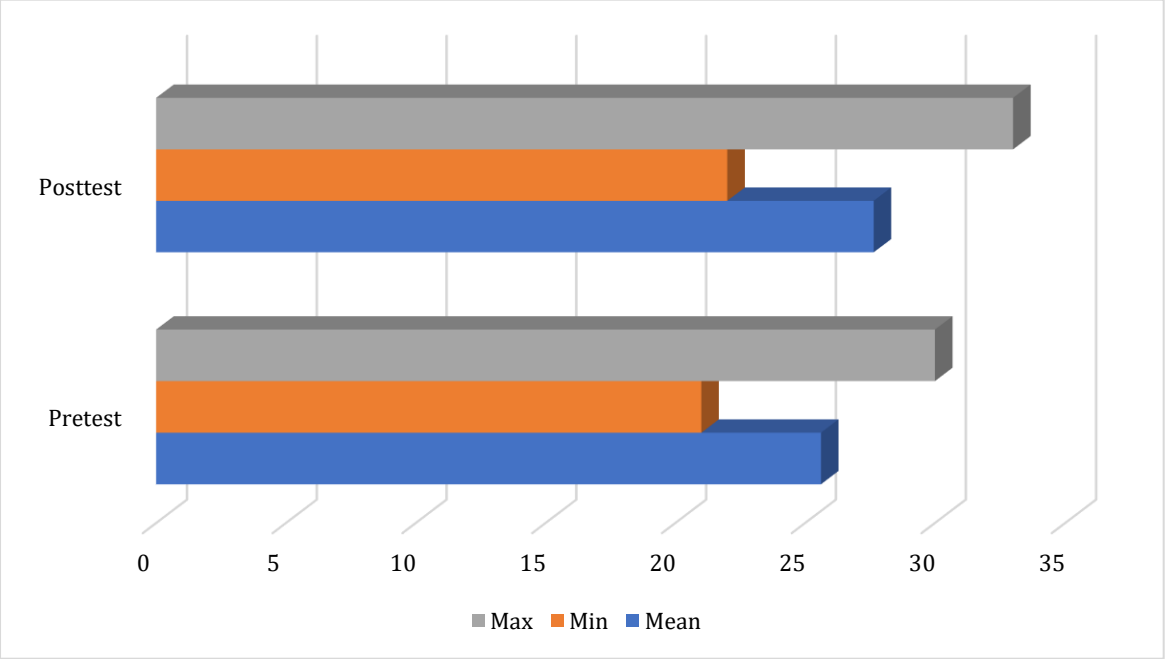

Figure 2. Statistical Results of the FMS Student Pretest-Posttest

Table 3 presents descriptive data of the pretest and posttest results of students' FMS, including balance, locomotor, and manipulative. During the pretest, the average score of students' FMS was 25.61 a SD of 2.08. After participating in the game-based learning intervention for 12 weeks, the average student FMS score increased to 27.64, with a SD of 3.03.

Table 4. Data Normality Test Results

	Statistic	df	Sig.
Pretest Motivation	.978	34	.718
Posttest Motivation	.950	34	.127
Pretest FMS	.978	34	.719
Posttest FMS	.943	34	.074

Table 4 shows the results of the data normality test for the learning motivation and FMS variables, both on the pretest and posttest. The normality test was conducted with a df of 34 for each variable. The analysis results show that all significance values (Sig.) are above the significance limit of 0.05, namely .718 for the motivation pretest, .127 for the motivation posttest, .719 for the FMS pretest, and .074 for the FMS posttest.

Table 5. Homogeneity Test Results Data

Variable	Levene Statistic	Sig.
Motivation	1.462	.231
FMS	1.127	.107

Table 5 presents the results of the homogeneity of variance test for learning motivation and FMS variables using the Levene test. The results show that the significance value for the motivation variable is .231 and for motor skills is .107.

Table 6. Paired Sample Statistics

		N	Mean	SD
Motivation	Pretest	34	32.0588	3.61764
	Posttest	34	34.6765	2.94104
FMS	Pretest	34	25.6176	2.08915
	Posttest	34	27.6471	3.03397

Descriptive statistics of paired sample test results for student learning motivation and FMS variables before and after treatment are explained in **Table 6**. For the motivation variable, the average pretest score was 32.06 with an SD of 3.62, while the average posttest score increased to 34.68 with an SD of 2.94. For the FMS variable, the pretest score from 25.62 with an SD of 2.09 increased to 27.65 in the posttest, with a standard deviation of 3.03. The increase in the average scores on these two variables indicates a change after the treatment in the form of game-based learning.

Table 7. Paired Samples Test

	Mean	SD	t	df	p-value	Cohen's d	Interpretation
Motivation pretest-posttest	2.62	3.01	5.079	33	.000	0,87	Large effect
FMS pretest-posttest	2.03	2.68	4.416	33	.000	0,76	Medium to large effect

The results of the paired sample t-test presented in **Table 7** show the difference between pretest and posttest scores for both variables. The mean score for the learning motivation variable was 2.62 with an SD of 3.01. The 95% confidence interval ranged from 1.57 to 3.67. The t-value was 5.079 and the p-value was 0.000, indicating that the increase in motivation after treatment was statistically significant ($p < 0.05$).

The mean value for the FMS variable is 2.03 with a standard deviation of 2.68. The 95% confidence interval ranges from 1.09 to 2.96. The t-value is 4.416 and the p-value is 0.000, which means that the increase in students' FMS after treatment is also statistically significant ($p < 0.05$).

The increase in motivation from 32.05 to 34.67 (2.6-point increase; d = 0.87, 95% CI [0.55, 1.18]) and the improvement in FMS from 25.61 to 27.64 (2.0-point increase; d = 0.76, 95% CI [0.43, 1.08]) demonstrate apparent positive effects of the game-based learning (GBL) intervention. Based on Self-Determination Theory, engaging in activities that provide a sense of competence, autonomy, and social connectedness contributes directly to increased intrinsic motivation (Pereira et al., 2021). In this study, students were given choices in gameplay (autonomy), were progressively challenged (competence), and worked collaboratively in groups (relatedness), which collectively contributed to significant improvements in motivation.

From a motor development perspective, a 2-point increase in the FMS represents progress, consistent with the literature, which suggests that repetitive, structured active play can improve the basic motor skills of elementary school-aged children (Sun & Chen, 2024). Between 7 and 9 years of age, small yet consistent changes in movement patterns are indicators of healthy neuromotor development. Educationally, a 2-3-point increase represents 7-10% of the pretest score, which is considered an educationally meaningful change in research on the FMS and child motivation, particularly when the intervention takes place within a regular learning context. Similar studies in elementary school children have shown that a change of ≥ 5% is typically considered a relevant improvement in the context of physical education (García-Hermoso et al., 2020). While the effect sizes in the present study were moderate to large, they remained slightly lower than those reported in studies involving higher intervention frequencies (e.g., 2-3 sessions per week)

or supervised motor skill-focused programs (Olsen et al., 2024). However, considering that this intervention was implemented once per week during regular PE class time, the improvements achieved are educationally and practically meaningful.

Findings suggest that implementing game-based physical education learning has a positive impact on students' active participation in learning, basic motor skills, and their physical fitness and mental health (Anggraini et al., 2025; Yan et al., 2023). Similar to the results of other studies, which explain that game-based learning can improve cognitive abilities as well as social-emotional aspects (Gibson et al., 2017). Other findings suggest that structured, play-oriented physical activity programs can increase children's motivation and self-efficacy (Kelso et al., 2020; Patel et al., 2024; Villegas-Balderrama et al., 2023).

What distinguishes this study is its focus on early elementary school students (ages 7-9), an age group that is relatively rare in experimental interventions. Compared with previous studies, which have mostly involved adolescents or adults, the findings demonstrate a comparable and even more pronounced pattern of increases in intrinsic motivation due to the developmental characteristics of early childhood that are highly responsive to play-based learning approaches (Luo et al., 2020; Sal-de-Rellán et al., 2025). The 12-week treatment duration also contributed to the intervention's results. The relatively long exposure ensured consolidation of skills and motivation, which aligns with longitudinal findings that sustained practice is essential for stable gains in fundamental motor skills (Dapp et al., 2021; Van Capelle et al., 2017).

Despite variations in methodology and context across studies, the similarity of results reinforces the point that pedagogical approaches rooted in play and active student engagement tend to be more effective in supporting physical, cognitive, and emotional development (Goh et al., 2022; Hasan et al., 2023; Parker et al., 2022). This study adds to previous research by providing experimental evidence conducted in a real elementary school setting and demonstrating measurable impact. Such contextual evidence is important for low- and middle-income countries, where empirical studies on innovative physical education pedagogies remain scarce.

From a pedagogical point of view, these results are significant. Increased motivation reflects higher student engagement, an essential prerequisite for effective learning. On the other hand, the improvement in FMS shows that game-based learning strategies can fulfill the objectives of physical education with a fun and meaningful approach. These results reinforce the urgency of integrating a play-based approach as a supplement and a core strategy in physical learning. The findings in this study provide evidence that game-based physical education is a practical learning approach for achieving holistic physical education goals.

These findings reinforce the pedagogical value of GBL for primary education. For teachers, incorporating structured play is recommended as it allows children to experience success, enjoy social play, and stay physically active, factors essential to sustaining long-term participation in PE. Practical strategies include using small-sided games, providing differentiated challenges, and integrating reflection to enhance motor learning. Such approaches align with UNESCO's guidelines for Quality of PE that emphasize child-centered instruction and lifelong physical activity engagement. (Uhlenbrock & Meier, 2021). This study further explains that PE plays a crucial role in the growth and development of elementary school students. The relationship between basic motor skills and motivation in PE can influence students' active participation in physical activities (Ensrud-Skraastad & Haga, 2020; Menescardi et al., 2023). Therefore,

implementing game-based physical education in elementary school can contribute to students developing active lifestyle habits throughout their lives.

The limitation of this study lies in its population of elementary school students aged 7-9 years, making it less representative if applied to a larger and broader population that includes other age groups. Another limitation is that this study did not continuously test the effectiveness and impact of the program, so it cannot provide long-term results. Another limitation is related to the limited time, energy, and costs, which prevent conducting a more in-depth intervention to determine other factors that may influence it, such as family conditions, social status, and a more detailed examination of the students' environmental conditions. This study used a single-group pretest-posttest design without a control group, which limits causal interpretation. Several threats to internal validity may exist, including: (a) testing effects, where improvements may be due in part to familiarity with the assessment; (b) Hawthorne effects, as students may have demonstrated increased effort due to the presence of the researcher; and (c) teacher influence, as the same teacher provided instructional support throughout the intervention. Additionally, maturation may contribute to the natural motor development of children aged 7 to 9 years. These uncontrolled variables may have influenced the outcomes.

Future research is recommended to employ a more comprehensive and specific research design, involving long-term studies, so that causal relationships can be continuously assessed and improvements in motivational variables related to physical education learning and basic motor skills can be accurately measured. Regarding the population and sample, the scope can be expanded by involving various characteristics of the research subjects.

CONCLUSION

The present study demonstrates that a 12-week game-based physical education program significantly improved both learning motivation and fundamental motor skills among elementary school students aged 7–9. These results reinforce the principles of self-determination theory by showing that playful, autonomy-supportive, and competence-driven activities can meaningfully enhance affective and psychomotor learning outcomes. This study contributes to the limited experimental evidence in Indonesia by integrating motivation and FMS outcomes within a single game-based intervention for young learners. Practically, the findings highlight the need for PE teachers to adopt structured, developmentally appropriate game-based strategies to foster active engagement, enjoyment, and motor skill development in daily PE practice. Although the study was limited by its one-group design and relatively small sample, future research should employ randomized or longitudinal designs to examine long-term effects and explore variations across different age groups and school contexts.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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