

The Effect of Personal Challenge-Based Gamification on Physical Fitness Among Elementary School Students: A Quasi-Experimental Study

Nak Mas Ashim Hanif *, Januar Abdilah Santoso

Department of Physical Education, Faculty of Teacher Education and Educational Sciences, Muhammadiyah University of East Kalimantan, Indonesia.

* Correspondence: ashimhanif01@gmail.com

Abstract

Declining physical fitness among elementary school children has become a global concern, particularly in Southeast Asia, driven by sedentary lifestyles, urbanization, and low engagement in conventional physical education. This quasi-experimental study aimed to investigate the potential effects of an 8-week personal challenge-based gamification intervention on physical fitness and intrinsic motivation among elementary students. Thirty students (16 boys, 14 girls; mean age 10.3 ± 0.8 years) from SD Negeri 016 Sungai Kunjang participated in a one-group pretest-posttest design. The intervention was integrated into regular physical education classes (two 45-minute sessions per week). Physical fitness was measured using the FITNESSGRAM battery, while intrinsic motivation was assessed with the Indonesian-adapted Intrinsic Motivation Inventory (IMI). Gamification engagement was monitored via structured observation. Significant improvements were observed in all fitness components: cardiovascular endurance (29.5%, $d = 1.18$), muscular strength (34.8%, $d = 1.24$), muscular endurance (30.3%, $d = 1.06$), and flexibility (21.3%, $d = 0.88$). Overall intrinsic motivation increased by 35.0% ($d = 1.91$), with high engagement rates (94.2% participation). This study provides preliminary evidence that personal challenge-based gamification may be associated with improved physical fitness and intrinsic motivation. The low-cost approach shows potential for enhancing student engagement in physical education, although the lack of a control group requires cautious interpretation and further rigorous research.

Keyword: Gamification; personal challenge; physical fitness; intrinsic motivation; elementary students; quasi-experimental

Received: July 2, 2025 | Revised: March 17, March 20, April 8, 2026

Accepted: May 18, 2026 | Published: June 8, 2026



Jurnal Porkes is licensed under a [Creative Commons Attribution-Share Alike 4.0 International License](https://creativecommons.org/licenses/by-sa/4.0/).

Introduction

Childhood physical fitness is a crucial factor influencing long-term health outcomes and academic success (Donnelly et al., 2016; Santoso et al., 2022). Global trends reveal a concerning decline in physical activity levels among youngsters, with only about 23% of school-aged children meeting the World Health Organization's recommendation of 60 minutes of daily moderate-to-vigorous physical activity (Guthold et al., 2020). This decline is particularly alarming in Southeast Asian countries, including Indonesia, where rapid urbanization, increased screen time, and limited access to quality physical education have contributed to widespread sedentary behaviors among youth (Chong et al., 2024; Mahendra et al., 2026).

Conventional physical education methods often fail to engage contemporary students who are accustomed to interactive digital experiences (Arufe-Giráldez et al., 2022; Fernandez-Rio et al., 2020). The mismatch between traditional teaching approaches and students' preferences has prompted educators to explore innovative strategies that incorporate gamification to boost motivation and engagement (Sharma et al., 2024; Camacho-Sánchez et al., 2023). Gamification the integration of game design elements such as points, badges, levels, and challenges into non-gaming contexts has emerged as a promising approach to address these issues (Deterding et al., 2011; updated perspectives in Dartini et al., 2026; Onea, 2025).

Personal challenge-based gamification represents an advancement over traditional gamification by incorporating individualized goals and adaptive difficulty levels tailored to each student's abilities and progress (Nicholson, 2015; Anunpattana et al., 2021). This approach aligns with Self-Determination Theory, emphasizing the roles of autonomy, competence, and relatedness in fostering intrinsic motivation (Ryan & Deci, 2017, 2024). By allowing students to select personal challenges and monitor their own development, the method promotes ownership of the learning process and sustained engagement (Hanus & Fox, 2015; Sailer et al., 2017).

Recent studies have demonstrated the potential of gamification in educational settings, showing improvements in student motivation, engagement, physical activity levels, and motor skill development (Arufe-Giráldez et al., 2022; Harahap, 2025; Zhao et al., 2024). In physical education, gamified interventions have been associated with increased moderate-to-vigorous physical activity (MVPA), better fitness outcomes, and more positive attitudes toward exercise, particularly when incorporating elements such as progress tracking, rewards, and adaptive challenges (Ezeddine, 2025; Onea, 2025). However, most existing research has focused on adolescent populations in Western or East Asian contexts, with limited evidence from elementary school settings in Southeast Asia (Sousa et al., 2022; Dartini et al., 2026).

The unique developmental characteristics of elementary school students such as their natural inclination toward play, competitiveness, and shorter attention spans suggest that gamification, especially designs centered on personal challenges, could be particularly effective for this age group (Edwards et al., 2016; Rice et al., 2025). Furthermore, establishing positive exercise habits during childhood is essential for lifelong physical activity adherence (Mulyawan et al., 2025; Telama et al., 2014). Despite this promise,

scientific evidence specifically examining the effectiveness of personal challenge-based gamification on physical fitness components (cardiovascular endurance, muscular strength/endurance, and flexibility) among elementary students in the Southeast Asian context remains very limited.

Although gamification shows general promise in physical education, studies testing the impact of personalized, adaptive challenge designs on fitness outcomes in Indonesian elementary school children are scarce. This study aims to fill that gap. This study investigates the impact of an 8-week personal challenge-based gamification intervention on the physical fitness of Indonesian elementary school children. It seeks to determine whether this approach can produce significant improvements in cardiovascular endurance, muscular strength and endurance, and flexibility. The study also examines changes in intrinsic motivation as a potential mechanism underlying fitness enhancements. Understanding these effects is crucial for developing evidence-based physical education programs that effectively engage modern students and promote lifelong healthy behaviors.

Method

This study employed a quasi-experimental design with a one-group pretest-posttest approach to evaluate the impact of personal challenge-based gamification on physical fitness. This design was selected due to practical constraints in the school setting, including limited access to multiple classes for randomization and ethical considerations regarding withholding potentially beneficial interventions from students. Although the absence of a control group limits causal inferences and introduces potential threats to internal validity such as maturation (natural growth and development), testing effects (familiarity with test procedures), and history (external events during the intervention period) the study incorporated several measures to strengthen rigor: standardized protocols, high attendance rates, and consistent implementation fidelity checks.

A non-equivalent control group design was considered but not feasible given the school's scheduling and resource limitations. Findings should therefore be interpreted as preliminary evidence of potential effects rather than definitive causality (Campbell & Stanley, 2015:53). Participants The study population consisted of fourth- and fifth-grade elementary school students at SD Negeri 016 Sungai Kunjang, Samarinda, East Kalimantan, Indonesia. Using purposive sampling, 30 students (16 boys and 14 girls; mean age = 10.3 ± 0.8 years) who met the inclusion criteria were selected. Purposive sampling was employed to ensure participants had consistent physical education attendance and no health restrictions, although this method carries a risk of selection bias.

To mitigate bias, clear and transparent inclusion/exclusion criteria were applied enrollment in grades 4 or 5, ≥ 90% attendance in physical education classes, no medical conditions limiting physical activity, and parental informed consent plus child assent. Exclusion criteria included chronic health issues, recent injuries, or anticipated absences during the intervention. All selected participants completed the study with no dropouts. Instruments Physical Fitness Assessment Physical fitness components were measured using the fitnessgram test battery (Plowman & Meredith, 2013:62). Cardiovascular endurance was

assessed via the Progressive Aerobic Cardiovascular Endurance Run (PACER) test (number of laps completed).

Upper body muscular strength and endurance were evaluated with the 90-degree push-up test (repetitions with correct form). Abdominal muscular strength and endurance were measured using the curl-up test (repetitions in one minute). Flexibility was assessed with the back-saver sit-and-reach test (reach distance in cm). All tests followed standardized protocols to ensure consistency between pre- and post-intervention measurements. Intrinsic Motivation Inventory (IMI) A validated Indonesian adaptation of the Intrinsic Motivation Inventory (McAuley et al., 1989) was used to assess four dimensions of intrinsic motivation: interest/enjoyment, perceived competence, effort/importance, and value/usefulness.

The 22-item questionnaire utilized a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree). Previous validation in Indonesian elementary school populations reported good internal consistency (Cronbach's $\alpha = 0.86$). Gamification Engagement Observation Sheet Student engagement with gamification elements was monitored using a structured manual observation sheet. Trained observers recorded: challenge participation (yes/no), challenge completion (yes/no), peer interactions (frequency of encouragement/collaboration), achievement celebrations (frequency of positive responses), and effort level (1-5 scale). Although manual observation is inherently subjective, two independent observers were employed, and inter-rater reliability was established using Cohen's kappa ($\kappa = 0.82$, indicating substantial agreement).

For future studies, more objective tools such as accelerometers are recommended to complement or replace manual observations. Intervention Program The 8-week intervention (April–May 2025) integrated personal challenge-based gamification into regular physical education classes (two 45-minute sessions per week). Key elements included:

- Personal challenge system: Students selected from three difficulty levels (Bronze, Silver, Gold) on challenge cards, promoting autonomy.
- Achievement and reward system: Immediate badges, weekly “Star Performer” certificates, and visible progress charts.
- Social components: Peer support, collaborative tasks, and group celebrations.
- Narrative framework: Students acted as “Fitness Heroes” in an adventure story to enhance meaning and engagement.

Certified physical education teachers facilitated sessions with fidelity monitoring through weekly meetings and minor adjustments based on student progress. Protocols The study spanned ten weeks. Week 1 involved ethical approval, parental consent sessions, pretest fitness assessments (over two days), baseline IMI administration, and familiarization with the gamification system. Weeks 2-9 comprised the intervention phase with gamified classes. Week 10 included post-test assessments using identical procedures and post-intervention IMI. Debriefing sessions with students and teachers were conducted at the end to gather qualitative feedback.

Data Analysis Data were analyzed using SPSS version 28.0. Descriptive statistics (means and standard deviations) summarized participant characteristics and outcomes. The Shapiro-Wilk test confirmed normality ($p > 0.05$), allowing the use of parametric tests. Paired-samples t-tests were conducted to compare pre- and post-intervention scores for each

physical fitness component and IMI subscale. Effect sizes were calculated using Cohen’s *d* (small = 0.2, medium = 0.5, large = 0.8). Statistical significance was set at $p < 0.05$, with Bonferroni correction applied for multiple comparisons (adjusted $\alpha = 0.01$ for the four fitness components) to control the family-wise error rate.

Percentage change scores were also computed for practical interpretation. Subgroup analyses explored gender differences using independent-samples *t*-tests on change scores. Although paired *t*-tests with Bonferroni correction were appropriate for this study, future research with multiple correlated dependent variables may benefit from multivariate approaches such as MANOVA or linear mixed models to simultaneously analyze outcomes while better managing Type I and Type II error risks.

Result

All 30 participants successfully completed the 8-week intervention without any dropouts. The average attendance rate reached 93.3% (SD = 4.2%), with 26 students (86.7%) attending all 16 scheduled sessions. These high attendance levels indicate strong acceptability of the gamification program within the regular physical education schedule. Baseline anthropometric and demographic characteristics of the participants are summarized in table 1.

Table 1. Baseline characteristics of participants (N = 30)

Characteristic	Total (N = 30)	Boys (n = 16)	Girls (n = 14)
Age (years)	10.3 ± 0.8	10.4 ± 0.7	10.2 ± 0.9
Height (cm)	138.7 ± 6.3	140.2 ± 5.8	136.9 ± 6.5
Weight (kg)	34.2 ± 5.1	35.1 ± 4.9	33.1 ± 5.2
BMI (kg/m ²)	17.7 ± 1.8	17.8 ± 1.7	17.6 ± 1.9

Physical Fitness Outcomes Significant improvements were observed across all four physical fitness components measured by the fitnessgram battery from pre- to post-intervention (table 2). The changes were statistically significant even after applying the Bonferroni correction for multiple comparisons ($p < 0.01$).

Table 2. Changes in physical fitness components (N = 30)

Component	Pre-test M ± SD	Post-test M ± SD	Change (%)	t-value	p-value	Cohen's d
PACER (laps)	18.3 ± 5.2	23.7 ± 6.1	29.5	8.76	<0.001	1.18 (large)
Push-ups (reps)	8.6 ± 3.4	11.6 ± 3.8	34.8	9.23	<0.001	1.24 (large)
Curl-ups (reps)	15.2 ± 4.7	19.8 ± 5.2	30.3	7.89	<0.001	1.06 (large)
Flexibility (cm)	26.3 ± 4.1	31.9 ± 4.5	21.3	6.54	<0.001	0.88 (large)

The largest percentage increase was recorded in upper body muscular strength and endurance (push-ups, 34.8%), followed by abdominal muscular endurance (curl-ups, 30.3%) and cardiovascular endurance (PACER, 29.5%). Effect sizes for all components were classified as large according to Cohen’s guidelines ($d \geq 0.80$). From a practical perspective, the 29.5% improvement in the PACER test (an average increase of approximately 5.4 laps) represents a meaningful enhancement in cardiovascular endurance for 10-year-old elementary

students. At baseline, the group average (18.3 laps) was below the typical lower threshold of the Healthy Fitness Zone (HFZ) for this age group in the 20-meter PACER test.

The post-intervention average of 23.7 laps approached or entered the lower end of the HFZ range for many participants. This level of improvement can translate into better aerobic capacity, allowing students to engage in moderate-to-vigorous physical activities (such as running, playing sports, or participating in active games) for longer periods with less fatigue. In daily school life, such gains may support improved concentration during lessons, greater participation in recreational activities, and a reduced risk of health issues associated with low cardiorespiratory fitness. Muscular strength and endurance also showed notable practical benefits. The 34.8% increase in push-ups (from 8.6 to 11.6 repetitions) and 30.3% increase in curl-ups (from 15.2 to 19.8 repetitions) suggest enhanced upper body and core strength.

These improvements can facilitate better posture, support daily functional movements (e.g., carrying school bags or participating in play), and contribute to overall physical resilience. Flexibility improved by 21.3% (5.6 cm on average), which may help reduce the risk of muscle strain and support better movement quality during physical activities. Intrinsic Motivation Changes Intrinsic motivation, as measured by the Intrinsic Motivation Inventory (IMI), exhibited substantial improvements across all four subscales (table 3). The overall IMI score rose from 3.17 ± 0.69 to 4.28 ± 0.51 , reflecting a 35.0% improvement ($t = 10.45$, $p < 0.001$, $d = 1.91$, large effect).

Table 3. Changes in intrinsic motivation inventory subscales (N = 30)

Subscale	Pre-test M ± SD	Post-test M ± SD	t-value	p-value	Cohen's d
Interest/Enjoyment	3.05 ± 0.72	4.35 ± 0.54	11.23	<0.001	2.05 (large)
Perceived Competence	2.94 ± 0.68	4.16 ± 0.52	10.87	<0.001	1.98 (large)
Effort/Importance	3.48 ± 0.81	4.32 ± 0.48	8.34	<0.001	1.52 (large)
Value/Usefulness	3.21 ± 0.74	4.29 ± 0.56	9.76	<0.001	1.78 (large)

The largest gains were observed in the Interest/Enjoyment ($d = 2.05$) and Perceived Competence ($d = 1.98$) subscales. These changes suggest that students not only found the physical education sessions more enjoyable but also developed greater confidence in their physical abilities after participating in the personal challenge-based gamification program. Engagement with Gamification Elements Manual observation data revealed consistently high engagement levels with the gamification components throughout the 8-week intervention (table 4). Students demonstrated strong participation rates and a clear progression toward more challenging tasks as the program advanced.

Table 4. Student engagement with gamification elements

Indicator	Frequency/Percentage
Challenge participation rate	94.2%
Challenge completion rate	82.4%
Choice of difficulty level	Bronze: 28.3% Silver: 45.7% Gold: 26.0%
Peer encouragement (per session)	4.2 ± 1.3 instances
Achievement celebrations	87.5% of completions
High effort ratings (4–5/5)	78.3%

Notably, the proportion of students selecting Gold-level challenges increased progressively from 15.0% in week 2 to 38.3% in week 8. This shift indicates that students developed greater self-efficacy and were willing to push their limits as they experienced success and received immediate feedback through badges and progress charts. Gender Differences and Individual Response Patterns Both boys and girls showed improvements in all fitness components and motivation subscales. Independent-samples t-tests on change scores revealed no statistically significant gender differences in the magnitude of improvement for any variable (all $p > 0.05$).

However, descriptive patterns indicated that girls tended to show slightly larger gains in flexibility (23.4% vs. 19.5% for boys), while boys exhibited marginally greater improvements in upper body strength (36.2% vs. 33.1%). At the individual level, every student (100%) improved in at least three of the four fitness components, and 83.3% ($n = 25$) demonstrated gains across all four areas. Students in the lowest baseline fitness tertile experienced the most pronounced percentage improvements, especially in cardiovascular endurance (mean improvement of 38.2% compared to 22.4% in the highest tertile). This pattern suggests that the personal challenge approach, with its adaptive difficulty levels, was particularly beneficial for students who started with lower fitness levels, potentially helping to narrow initial disparities within the group.

Discussion

Given the limitations of the one-group pretest-posttest design employed in this study, the observed improvements in physical fitness components and intrinsic motivation indicate significant potential for personal challenge-based gamification in elementary physical education. These findings align with Self-Determination Theory (SDT) and suggest that incorporating personalized challenges, adaptive difficulty levels, immediate feedback, and social elements may enhance student engagement and fitness outcomes. However, causal interpretations must be made with great caution, as the absence of a control group means that factors such as natural maturation, repeated testing effects, or external influences during the 8-week period cannot be entirely ruled out.

The large effect sizes observed across cardiovascular endurance ($d = 1.18$), muscular strength and endurance ($d = 1.06 - 1.24$), and flexibility ($d = 0.88$), along with a very large improvement in overall intrinsic motivation ($d = 1.91$), are promising. In particular, the approximately 29.5% increase in PACER performance and 30–35% gains in push-up and curl-up repetitions represent meaningful practical enhancements for 10-year-old students. Such changes may support greater participation in daily physical activities, improved aerobic capacity, and better movement quality, potentially contributing to long-term health benefits. These patterns are consistent with recent studies on gamification and game-based approaches in physical education, which have reported improvements in motivation, moderate-to-vigorous physical activity, and certain fitness parameters among school-aged children.

Nevertheless, direct comparisons with previous research must consider important design differences. Many earlier studies reporting smaller gains (typically 15–20% in fitness

measures) utilized randomized controlled trials or non-equivalent control groups, allowing stronger causal inferences. In contrast, the current study's single-group design, while practical in a real school setting, limits the ability to attribute changes solely to the intervention. Recent systematic reviews and meta-analyses on gamification in physical education have similarly noted improvements in motivation and engagement, but emphasize that effects on objective fitness outcomes are more variable and often modest when compared against control conditions.

The substantial increases in all IMI subscales, particularly Interest/Enjoyment and Perceived Competence, provide insight into possible psychological mechanisms. The personal challenge system appeared to support the basic psychological needs outlined in SDT autonomy (through choice of difficulty levels), competence (via progressive challenges and visible progress), and relatedness (through peer encouragement and group celebrations). This alignment may explain the high engagement rates (94.2% participation and 82.4% completion) and the observed shift toward more difficult (Gold) challenges over time. These results are in line with Flow Theory, as the three-tiered challenge structure likely helped maintain an optimal balance between skill level and task difficulty, reducing boredom or anxiety.

From a practical standpoint, the intervention demonstrates that effective gamification does not necessarily require expensive digital tools. The use of simple challenge cards, paper badges, progress charts, and peer support mechanisms can be readily implemented in resource-limited schools. The 8-week duration, integrated into regular physical education classes, proved sufficient to yield observable improvements, suggesting that similar approaches could be adopted as a sustainable strategy within standard academic schedules. The comparable benefits observed for both boys and girls, as well as the relatively larger percentage gains among students with lower baseline fitness, further highlight the potential inclusivity of personal challenge-based designs.

Limitations several limitations should be acknowledged. The one-group pretest-posttest design constrains causal claims, as maturation and testing effects may have contributed to the observed changes. The relatively small sample size drawn from a single school limits generalizability to other educational contexts in Indonesia or Southeast Asia. Additionally, reliance on manual observation for engagement data, although supported by acceptable inter-rater reliability, remains subjective; future studies could incorporate more objective measures such as accelerometers. The short 8-week intervention and lack of follow-up assessment also prevent conclusions about the sustainability of fitness and motivation gains over time.

Finally, the study did not isolate the relative contributions of individual gamification elements (e.g., personal challenges versus social features or narrative framing), making it difficult to determine which components were most influential. Future directions future research should employ stronger designs, such as randomized controlled trials or quasi-experimental studies with non-equivalent control groups, to better establish the effectiveness of personal challenge-based gamification relative to traditional physical education. Longitudinal studies with extended follow-up periods are needed to examine whether improvements in fitness and intrinsic motivation translate into sustained physical activity habits.

Investigations in diverse Indonesian and Southeast Asian school settings, with larger and more heterogeneous samples, would enhance generalizability. Furthermore, component analysis studies that systematically vary specific gamification elements could help optimize intervention design for maximum impact and efficiency. Exploring technology-enhanced versions (e.g., mobile applications or wearables) alongside low-tech manual approaches would also provide valuable comparative insights. In summary, this quasi-experimental study provides preliminary evidence that personal challenge-based gamification holds promise for enhancing physical fitness and intrinsic motivation among elementary school students.

While the findings are encouraging, they should be interpreted cautiously given the methodological constraints. With further rigorous investigation, gamification strategies incorporating personalized challenges have the potential to become a valuable component of evidence-based physical education programs aimed at promoting lifelong healthy behaviors in children.

Conclusion

This quasi-experimental study, utilizing a one-group pretest-posttest design, provides preliminary evidence that an 8-week personal challenge-based gamification intervention may be associated with improvements in physical fitness components and intrinsic motivation among elementary school students. The observed large effect sizes in cardiovascular endurance, muscular strength and endurance, and flexibility, along with substantial gains in intrinsic motivation, suggest that incorporating personalized challenges, adaptive difficulty levels, immediate feedback, and social elements has the potential to enhance student engagement and fitness outcomes in physical education settings.

The findings indicate that students not only showed measurable gains in key fitness parameters such as a nearly 30% increase in cardiovascular endurance and over 30% improvement in muscular strength and endurance but also reported higher levels of enjoyment, perceived competence, and value toward physical activity. These changes were accompanied by consistently high engagement rates and a progressive willingness to undertake more challenging tasks, highlighting the possible motivational benefits of the personal challenge approach for fourth- and fifth-grade students. Practically, the results suggest that simple, low-cost gamification strategies can be effectively integrated into regular physical education classes without requiring advanced technology.

This approach appears particularly promising for creating a more inclusive learning environment, as students across varying baseline fitness levels, including those with lower initial fitness, demonstrated notable improvements. Such strategies may help address common barriers to participation in physical education and support the development of more positive attitudes toward lifelong physical activity. However, due to the methodological limitations of the single-group design, these findings should be interpreted with caution. The absence of a control group means that factors such as natural maturation, testing effects, and other external influences cannot be fully excluded.

Therefore, while the study offers encouraging preliminary evidence, stronger causal claims cannot be made at this stage. Further research employing randomized controlled trials

or quasi-experimental designs with comparison groups, larger and more diverse samples, and longer follow-up periods is necessary to confirm the effectiveness and sustainability of personal challenge-based gamification in elementary physical education. If supported by more robust evidence, this approach could serve as a valuable and practical strategy for educators seeking to improve students' physical fitness and foster healthier, more active lifestyles among school children.

Author Statement

The authors declare that this article is original work and has never been published in any other scientific journal. There are no conflicts of interest in this research. We thank the Principal of SD N 016 Sungai Kunjang for granting research permission and the Head of Sports Education Study Program for guidance and academic support.

References

- Arufe-Giráldez, V., Sanmiguel-Rodríguez, A., Ramos-Álvarez, O., & Navarro-Patón, R. (2022). Gamification in physical education: A systematic review. *Education Sciences*, 12(8), 540. <https://doi.org/10.3390/educsci12080540>
- Arufe-Giráldez, V., Sanmiguel-Rodríguez, A., Ramos-Álvarez, O., & Navarro-Patón, R. (2022). Gamification in Physical Education: A Systematic Review. *Education Sciences*, 12(8), 540. <https://doi.org/10.3390/educsci12080540>
- Anunpattana, P., Khalid, M. N. A., Iida, H., & Inchamnan, W. (2021). Capturing Potential Impact of Challenge-Based Gamification on Gamified Quizzing in the Classroom. *Heliyon*, 7(12). [https://www.cell.com/heliyon/fulltext/S2405-8440\(21\)02740-7](https://www.cell.com/heliyon/fulltext/S2405-8440(21)02740-7)
- Camacho-Sánchez, R., León, A. M., Rodríguez-Ferrer, J. M., Serna, J., & Burgués, P. L. (2023). Game-Based Learning and Gamification in Physical Education: A Systematic Review. *Education Sciences*, 13(2), 183. <https://doi.org/10.3390/educsci13020183>
- Campbell, D. T., & Stanley, J. C. (2015). *Experimental and quasi-experimental designs for research*. Ravenio books.
- Chong, K. H., Suesse, T., Cross, P. L., Ryan, S. T., Aadland, E., Aoko, O., ... & Okely, A. D. (2024). Pooled Analysis of Physical Activity, Sedentary Behavior, and Sleep Among Children From 33 Countries. *JAMA Pediatrics*, 178(11), 1199-1207. <https://doi.org/10.1001/jamapediatrics.2024.3330>
- Dartini, N. P. D. S., Artanayasa, I. W., Dantes, K. R., Divayana, D. G. H., Sudiana, I. K., & Yoda, I. K. (2026). Effectiveness and Challenges of Gamification in Physical Education: A Systematic Review. *Physical Education Theory and Methodology*, 26(2), 263-271. <https://doi.org/10.17309/tmfv.2026.2.04>
- Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From Game Design Elements to Gamefulness: Defining “Gamification.” *Proceedings of the 15th International Academic MindTrek Conference*, 9–15. <https://doi.org/10.1145/2181037.2181040>
- Donnelly, J. E., Hillman, C. H., Castelli, D., Etner, J. L., Lee, S., Tomporowski, P., Lambourne, K., & Szabo-Reed, A. N. (2016). Physical Activity, Fitness, Cognitive

- Function, and Academic Achievement in Children: A Systematic Review. *Medicine & Science in Sports & Exercise*, 48(6), 1197–1222. <https://doi.org/10.1249/MSS.0000000000000901>
- Ezeddine, G., Souissi, N., Abaidia, R., Masmoudi, L., Trabelsi, K., Ammar, A., ... & Mrayah, M. (2025, October). Game-based physical education: a pathway to increased student motivation and greater learning outcomes. In *Frontiers in Education* (Vol. 10, p. 1531651). Frontiers Media SA. <https://doi.org/10.3389/educ.2025.1531651>
- Edwards, L. C., Bryant, A. S., Keegan, R. J., Morgan, K., & Jones, A. M. (2017). Definitions, foundations and associations of physical literacy: A systematic review. *Sports Medicine*, 47(1), 113–126. <https://doi.org/10.1007/s40279-016-0560-7>
- Fernandez-Rio, J., De Las Heras, E., González, T., Trillo, V., & Palomares, J. (2020). Gamification and Physical Education. Viability and Preliminary Views from Students and Teachers. *Physical Education and Sport Pedagogy*, 25(5), 509–524. <https://doi.org/10.1080/17408989.2020.1743253>
- Guthold, R., Stevens, G. A., Riley, L. M., & Bull, F. C. (2020). Global Trends in Insufficient Physical Activity Among Adolescents: A Pooled Analysis of 298 Population-Based Surveys With 1.6 Million Participants. *The Lancet Child & Adolescent Health*, 4(1), 23–35. [https://doi.org/10.1016/S2352-4642\(19\)30323-2](https://doi.org/10.1016/S2352-4642(19)30323-2)
- Hanus, M. D., & Fox, J. (2015). Assessing the effects of gamification in the classroom: A longitudinal study on intrinsic motivation, social comparison, satisfaction, effort, and academic performance. *Computers & Education*, 80, 152–161. <https://doi.org/10.1016/j.compedu.2014.08.019>
- Harahap, A. M., & Febriansyah, W. (2025). Impact of Game-Based Physical Education on Health Literacy and Physical Fitness in Primary School Children: A Scoping Review. *Journal of Foundational Learning and Child Development*, 1(02), 77–89. <https://doi.org/10.53905/ChildDev.v1i02.12>
- McAuley, E., Duncan, T., & Tammen, V. V. (1989). Psychometric properties of the Intrinsic Motivation Inventory in a competitive sport setting: A confirmatory factor analysis. *Research Quarterly for Exercise and Sport*, 60(1), 48–58. <https://doi.org/10.1080/02701367.1989.10607413>
- Mulyawan, A., Santoso, J. A., Betty, J., & Jusuf, K. (2025). The relationship of physical activity intensity with cardiorespiratory fitness and sleep duration of sport education students. *Jurnal Porkes*, 8(2), 782–798. <https://doi.org/10.29408/PORKES.V8I2.30303>
- Mahendra, A., Triwibowo, H., Simbizi, P., Rajagukguk, M., & Indasari, S. (2026). Physical Activity and Healthy Nutrition Campaign for Primary School Children in Developing Countries: Implementation of the Build Our Kids' Success (BOKS) Program in Indonesia. *Physical Activity and Nutrition*, 30(1), 92–101. <https://europepmc.org/article/pmc/pmc13065377>
- Nicholson, S. (2015). A Recipe for Meaningful Gamification. In T. Reiners & L. C. Wood (Eds.), *Gamification in Education and Business* (pp. 1–20). Springer. https://doi.org/10.1007/978-3-319-10208-5_1

- Onea, G. A. (2025). The relationship between gamification experience, fitness performance, and physical activity patterns: Gender differences. *Education Sciences*, 15(12), 1651. <https://doi.org/10.3390/educsci15121651>
- Plowman, S. A., & Meredith, M. D. (Eds.). (2013). *FitnessGram reference guide* (4th ed.). The Cooper Institute.
- Rice, J., Fowweather, L., Foulkes, J., Magill, C., De Meester, A., Stodden, D., Lenoir, M., & Fitton Davies, K. (2025). Co-development of a gamified physical education movement competence intervention with school stakeholders. *European Physical Education Review*. Advance online publication. <https://doi.org/10.1177/1356336X241301352>
- Ryan, R. M., & Deci, E. L. (2024). Self-determination theory. In *Encyclopedia of quality of life and well-being research* (pp. 6229-6235). Cham: Springer International Publishing. https://link.springer.com/rwe/10.1007/978-3-031-17299-1_2630
- Ryan, R. M., & Deci, E. L. (2024). Self-determination theory. In *Encyclopedia of quality of life and well-being research* (pp. 6229-6235). Cham: Springer International Publishing. https://link.springer.com/rwe/10.1007/978-3-031-17299-1_2630
- Sailer, M., Hense, J. U., Mayr, S. K., & Mandl, H. (2017). How gamification motivates: An experimental study of the effects of specific game design elements on psychological need satisfaction. *Computers in Human Behavior*, 69, 371–380. <https://doi.org/10.1016/j.chb.2016.12.033>
- Santoso, J. A., et al. (2022). Peran Penjas dalam Implementasi Program Full Day School (FDS) Dilihat dari Tingkat Kehadiran dan Prestasi Belajar Siswa. *Jurnal Pendidikan Modern*, 7(2), 60–66. <https://doi.org/10.37471/JPM.V7I2.384>
- Sharma, A. V. N. S., Jayalakshmi, S., Tripathy, A., Katekhaye, D., & Sharma, A. (2024). Exploring Innovative Pedagogical Approaches for Enhanced Student Engagement. *Decision Making: Applications in Management and Engineering*, 7(1), 175-188. <https://dmame-journals.org/index.php/dmame/article/view/20>
- Sousa, A. C., Ferrinho, S. N., & Travassos, B. (2022). The use of technology and sampling in physical education: A systematic review. *International Journal of Environmental Research and Public Health*, 19(9), 5573. <https://doi.org/10.3390/ijerph19095573>
- Telama, R., Yang, X., Leskinen, E., Kankaanpää, A., Hirvensalo, M., Tammelin, T., Viikari, J. S., & Raitakari, O. T. (2014). Tracking of physical activity from early childhood through youth into adulthood. *Medicine & Science in Sports & Exercise*, 46(5), 955–962. <https://doi.org/10.1249/MSS.0000000000000181>
- Zhao, M., Lu, X., Zhang, Q., et al. (2024). Effects of exergames on student physical education learning in the context of the artificial intelligence era: a meta-analysis. *Scientific Reports*, 14, 7115. <https://doi.org/10.1038/s41598-024-57357-8>