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Indonesian Journal of Physical Education and Sport Science

IJPESS
Indonesian Journal of Physical Education and Sport Science
p-ISSN 2775-765X | e-ISSN 2776-0200
Volume 6, No. 2, June 2026. Page. x-xx
http://journal.unucirebon.ac.id/index.php ijpess

Gamification-Based Adaptive Physical Education Model for Gross Motor Skills in Students with Intellectual Disabilities

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Abstract

Study purpose. Adaptive physical education for students with intellectual disabilities faces persistent challenges including low motivation, limited attention span, and suboptimal gross motor skill development. This study aimed to develop, validate, and analyze the effectiveness of a gamification-based adaptive physical education learning model for improving gross motor skills in students with intellectual disabilities.

Materials and methods. A Research and Development (R&D) approach was employed, comprising needs analysis, product design, development, small-group trials (n = 15), large-group trials (n = 60), and a product effectiveness test (n = 60) using a one-group pretest–posttest design. Instruments included expert validation sheets, observation sheets, response questionnaires, and an adaptive gross motor test. Data were analyzed using SPSS version 29.

Results. Results showed the model was highly valid (mean score 90.2%), achieved very good implementation rates (86.7% and 88.4%), and significantly improved students' gross motor skills, $t(59) = 14.87$, $p < 0.001$, with a very large effect size (Cohen's $d = 1.95$).

Conclusions. The gamification-based adaptive physical education learning model is valid, practical, and effective for students with intellectual disabilities. Future

research should employ stronger experimental designs with control groups and longer intervention durations.

Keywords: Learning Model; Adaptive Learning; Gamification; Motor Skills; Students With Intellectual Disabilities

DOI: https://doi.org/10.52188/ijpess.v6i2.2039

Introduction

Physical education (PE) has a strategic role in developing students' physical, motor, social and emotional abilities (Bailey, 2018; Férriz-Valero et al., 2020). Physical education learning for students with intellectual disabilities not only functions as a means of fitness, but also as an important medium for training gross motor skills which are very much needed in daily life activities (Ardiyanto & Sukoco, 2014; Lubis et al., 2022). However, the characteristics of students with intellectual disabilities who have cognitive limitations, easily distracted attention, and fluctuating learning motivation often cause the physical education learning process to be less than optimal (Lubis et al., 2022; Rina, 2024). Learning that is still conventional, monotonous, and lacking context has the potential to reduce student engagement and impact low gross motor skill achievement.

Various previous studies have shown that adaptive physical education learning designed according to the characteristics of students with special needs is able to increase the participation and motor development of students with intellectual disabilities (Ngaisah et al., 2023). Previous studies have emphasized the importance of modifying physical activity, using simple aids, and an individualized approach to adaptive physical education. Furthermore, research on gamification in general education contexts has also shown that implementing game elements such as points, levels, challenges, and rewards can improve student motivation, engagement, and learning outcomes (Božić et al., 2024; Liu & Lipowski, 2021; Raju et al., 2021). Several recent studies have begun to integrate gamification concepts into sports and physical activity learning for both early childhood and regular students, with positive results on motivation and motor skills. However, studies specifically developing gamification-based adaptive physical education learning models for students with intellectual disabilities are still very limited.

Theoretically, adaptive learning is based on the principles of differentiation and individualization of learning which adapts objectives, materials, methods, and evaluation to the abilities and needs of students (Rifki & Susanto, 2022; Sukriadi & Arif, 2020). Adaptive Education learning approach aims to create a safe, inclusive, and meaningful learning environment for students with special needs (Fitriatun & Irmansyah, 2023; Fitriatun & Susanto, 2024). Meanwhile, the concept of gamification is based on intrinsic motivation and behaviorist theories, emphasizing that positive reinforcement, gradual challenges, and enjoyable learning experiences can increase student engagement and persistence in learning (Camacho-Sánchez et al., 2023; Férriz-Valero et al., 2020). The integration of gamification in adaptive physical education learning is conceptually believed to be able to strengthen the motivation of students with intellectual disabilities, extend attention spans, and encourage movement repetition necessary to improve gross motor skills. Key findings from previous research indicate that a game-based approach can accelerate the mastery of basic motor skills, although most of this research has not been systematically developed into a structured learning model for students with intellectual disabilities.

In contrast to previous studies which generally only modified physical activities or implemented simple games in adaptive physical education, this study developed a structured, systematic, and validated gamification-based adaptive physical education learning model (Kim

& Kim, 2022; Nair & Mathew, 2021). The novelty of this research lies in the integration of gamification elements (levels, points, gradual challenges, immediate feedback, and rewards) into adaptive physical education learning scenarios specifically designed to suit the cognitive, affective, and motoric characteristics of students with intellectual disabilities. In addition, this research uses a model development approach (research and development) with the stages of needs analysis, design, limited trials, and effectiveness testing, resulting in applicable learning products. The urgency of this research is based on the low gross motor skills of students with intellectual disabilities due to the lack of innovation in adaptive physical education learning in special schools. This research provides a practical contribution in the form of a new learning model that adaptive physical education teachers can use to improve the quality of learning and motoric learning outcomes of students with intellectual disabilities.

Although research on adaptive physical education and gamification has been conducted separately, there remains a significant gap in the development of gamification-based adaptive physical education learning models specifically designed for students with intellectual disabilities. Previous research tends to focus on conventional approaches to adaptive physical education or the application of gamification to regular students, without integrating the two comprehensively and contextually. The novelty of this research is the development of a structured, valid, and effective gamification-based adaptive physical education learning model to improve gross motor skills in students with intellectual disabilities. The uniqueness of this research lies in the use of gross motor assessment instruments tailored to the characteristics of students with intellectual disabilities and the implementation of a learning design that emphasizes motivational and participatory aspects.

This study aims to develop a gamification-based adaptive physical education learning model that is appropriate to the cognitive and motor characteristics of students with intellectual disabilities, which functions to improve gross motor skills, learning motivation, and active involvement of students in adaptive physical education learning in a fun, gradual, and meaningful way.

Methods

Research Design

This research uses a Research and Development (R&D) approach with the stages of needs analysis, product design, product development, small group trials, large group trials, and product effectiveness testing (Okpatrioka, 2023; Risal et al., 2023). The product developed is a gamification-based adaptive physical education learning model to improve gross motor skills of students with intellectual disabilities. The product's effectiveness was tested using a quasi-experimental one-group pretest–posttest design, namely by comparing students' gross motor skill scores before and after the implementation of the learning model.

Participants

The research subjects were students with intellectual disabilities (mental retardation) who attended Special Schools (SLB) in Palembang City, Indonesia. Subject selection was carried out using a purposive sampling technique based on the following criteria: (1) students were categorized as having mild to moderate intellectual disabilities based on school medical records with an IQ range of around 50–70; (2) were at the SDLB level with an age range of 7–12 years; (3) had the ability to follow basic instructions or simple commands from teachers; and (4) did not have complications of severe physical disabilities that inhibit motor activity, such as severe cerebral palsy or severe orthopedic disorders. Subjects were grouped based on their initial gross motor ability profile to provide a clearer picture of the characteristics of the research participants. The number and distribution of research subjects consisted of 15 students from SD SLB C Karya Ibu Palembang for small group trials, 60 students from SD SLB C Karya Ibu

Palembang, SLB C YPAC Palembang, and SD SLB B Pembina Palembang for large group trials, and 60 students from SD SLB C Karya Ibu Palembang, SLB B YPAC Palembang, and SD SLB Pembina Palembang for product effectiveness testing. In general, the subjects had motoric obstacles in the form of limited hand-eye coordination, unstable static balance, and low leg strength and propulsion in locomotor movements such as running and jumping.

Sampling Procedures

The sampling technique used purposive sampling by considering the suitability of the subject's characteristics to the objectives of the learning model development. All students who met the inclusion criteria in each school were invited to participate, and the participation rate reached more than 90% of the total students who met the criteria. The study was conducted in three Special Needs Schools in Palembang City, namely SD SLB C Karya Ibu Palembang, SLB C YPAC Palembang, and SD SLB B Pembina Palembang. All research activities were conducted during regular physical education class hours, and no financial compensation or other forms of payment were given to participants. It is important to note that the subjects in the large-group trial (n = 60) and the product effectiveness test (n = 60) were entirely different groups of students. Although some schools participated in both stages, different classes and cohorts were selected for each stage to avoid subject overlap and maintain the independence of the two phases of the study. At the product effectiveness testing stage, statistical power was considered with the assumption of a medium effect (d = 0.5), a significance level of 0.05, and a power of 0.80, which indicates that a sample size of 60 students is sufficient for inferential analysis using a paired t-test.

Materials and Apparatus

Researchers developed a gamification-based adaptive physical education learning model consisting of a teacher's guidebook, student activity modules, challenge cards, a progress board, and a simple points, levels, badges, and rewards system. This model incorporates six key gross motor skills: walking, running, jumping, throwing, catching, and kicking. All activities are structured in stages from easy to difficult and tailored to the cognitive characteristics and motor skills of students with intellectual disabilities.

Procedures

The research was conducted in three main stages. In the product development stage, researchers conducted a needs analysis through classroom observations and interviews with adaptive physical education teachers. The learning model was then designed, developed, and validated by material experts, media experts, and adaptive physical education practitioners before being tested on students. In the product trial stage, a small group trial was conducted on 15 students at SD SLB C Karya Ibu Palembang to evaluate the model's readability, activity feasibility, and initial student responses. Next, a large group trial was conducted on 60 students from three schools to evaluate the model's practicality and implementation in a real-life learning context. In the product effectiveness test stage, the research was conducted on 60 students from three schools. The independent variable in this study was the gamification-based adaptive physical education learning model, while the dependent variable was gross motor skills. Learning was carried out over eight sessions (two sessions per week, each 40 minutes long). All participants were in one experimental group. Gross motor skills tests were administered before the intervention (pretest) and after the final session (posttest). The researcher acted as a facilitator alongside the adaptive physical education teacher, and instructions were given verbally, demonstratively, and using visual cues. All parents/guardians and participants provided informed consent before the study began.

Design or Data Analysis

Data were analyzed using descriptive statistics in the form of mean values and standard deviations to describe the profile of students' gross motor skills. To test the difference in gross motor skill scores between the pretest and posttest, a paired-sample t-test was used. In addition, an effect size (Cohen's d) was calculated to determine the strength of the influence of the gamification-based adaptive physical education learning model. The significance level was set at $\alpha = 0.05$, and all analyses were conducted using SPSS version 29 software.

Table 1. Structure of Gross Motor Skills in the Learning Model

No.	Gross Motor Skills	Activity	Level 1 (Easy)	Level 2 (Medium)	Level 3 (Hard)
1	Walk	Walk in a straight line	5 m walk without obstacles	Zigzag road	Walking while carrying the ball
2	Run	short run	10m run	Zigzag running	Simple relay race
3	Jump	Two-legged jump	Jump on the spot	Jump forward	Jump over low obstacles
4	Throw	Throw the big ball	Throw it against the wall	Throw at the big target	Throw at small targets
5	Catch	Catch the high ball	Catch the rolling ball	Catch a low ball	Catch a high ball
6	Kick	Kick the ball still	Kick the ball forward	Kick to the big target	Kick to small target

Table 2. Integration of Gamification Elements in Learning

Gamification Elements	Implementation Form	Impact on Students
Points	Given each time a student completes an activity.	Increase motivation and active engagement.
Level	Stages of motor activity difficulty.	Provide gradual and progressive challenges.
Badge	Given when students complete a skill.	Increases sense of accomplishment.
Reward	Group praise, stickers, or applause.	Strengthening positive reinforcement.
Progress Board	Visualization of student learning progress.	Increase awareness of self-development.

Gross motor skills were measured using the Adaptive Gross Motor Test, developed based on the TGMD-2 and modified to suit the characteristics of students with intellectual disabilities. This instrument consists of six skill items with a rating scale of 0–3 (Putro et al., 2023; Santos et al., 2020). Internal reliability testing yielded a Cronbach's alpha coefficient of 0.87, while content validity was confirmed by three adaptive physical education experts and one special education psychologist.

Table 3. Expert Validation Results for the Gamification-Based Adaptive Physical Education Learning Model

No.	Rated aspect	Maximum Score	Average Score	Percentage (%)	Category
1	Suitability of learning objectives	4	3.7	92.5	Very valid
2	Suitability of material to student characteristics	4	3.6	90.0	Very valid
3	Clarity of syntax and learning steps	4	3.5	87.5	Very valid
4	Motor activity suitability	4	3.7	92.5	Very valid
5	Safety and feasibility of activities	4	3.8	95.0	Very valid
6	Appropriateness of gamification elements	4	3.6	90.0	Very valid
7	Media eligibility (challenge cards, progress boards)	4	3.5	87.5	Very valid
8	Practicality of implementation in schools	4	3.6	90.0	Very valid
	Overall average	—	—	90.2	Very valid

Based on validation results by three motor skills experts and two special needs teachers, the gamification-based adaptive physical education learning model was declared highly valid and suitable for use in adaptive physical education for students with intellectual disabilities. The revisions were minor and did not alter the model's main structure. Therefore, the model was deemed ready to proceed to small group trials, large group trials, and product effectiveness testing.

Results

Small Group Trial Results

A small group trial was conducted on 15 students at Karya Ibu Elementary School (SD SLB C) in Palembang to evaluate the model's readability, activity feasibility, and initial student responses to the gamification-based adaptive physical education learning model. Data were collected through implementation observation sheets and teacher and student response questionnaires. The observation results showed that all learning stages were implemented well. The average learning implementation score reached 86.7%, which is in the "very good" category. Teachers stated that the instructions were easy for students to understand, the activities were appropriate for the motor skills of students with intellectual disabilities, and the gamification elements were able to increase student attention and motivation during learning. Student responses showed that 93.3% of students appeared enthusiastic about participating in the learning and showed active involvement in each motor activity. Based on these findings, the model was declared suitable to proceed to the large group trial stage with minor revisions to the activity duration and challenge card visualization.

Table 4. Results of Observations on Learning Implementation in Small Group Trials (N = 15)

Observed Aspects	Maximum Score	Average Score	Percentage (%)	Category
Suitability of learning objectives	4	3.6	90.0	Very good
Clarity of teacher instructions	4	3.5	87.5	Very good
Suitability of activities to student abilities	4	3.4	85.0	Very good
Student involvement in activities	4	3.5	87.5	Very good
Use of gamification elements	4	3.4	85.0	Very good
Learning time management	4	3.3	82.5	Very good
Overall average	—	—	86.7	Very good

Student responses indicated that most students appeared enthusiastic about participating in the learning and actively engaged in each motor activity. A total of 93.3% of students responded positively to the learning, while 6.7% responded moderately positively.

Table 5. Student Responses to the Learning Model in Small Group Trials (N = 15)

Response Categories	Number of Students	Percentage (%)
Very positive	9	60.0
Positive	5	33.3
Quite positive	1	6.7
Less positive	0	0.0
Total	15	100

Large Group Trial Results

A large-group trial was conducted on 60 students from Karya Ibu Elementary School C, YPAC Elementary School C, and Pembina Elementary School B. The objective of this phase was to evaluate the practicality and implementation of the model in a real classroom learning context. The implementation observation results showed that the average learning implementation reached 88.4%, with a "very good" category. Teachers stated that the model was easy to implement, did not require difficult-to-obtain equipment, and was flexible to adapt to classroom conditions and student characteristics. The majority of students (91.7%) showed a positive response to the learning, marked by increased participation, courage to try new movements, and perseverance in completing challenges at each level. Based on these results, the model was declared practical and ready to be tested for its effectiveness.

Table 6. Results of Observations on Learning Implementation in Large Group Trials (N = 60)

Observed Aspects	Maximum Score	Average Score	Percentage (%)	Category
Suitability of learning objectives	4	3.7	92.5	Very good
Clarity of teacher instructions	4	3.6	90.0	Very good
Suitability of activities to	4	3.5	87.5	Very

student abilities				good
Student involvement in activities	4	3.6	90.0	Very good
Use of gamification elements	4	3.5	87.5	Very good
Learning time management	4	3.4	85.0	Very good
Overall average	—	—	88.4	Very good

Student responses in the large-group trial showed that the majority of students responded positively to the gamification-based adaptive physical education learning. A total of 91.7% of students responded positively to very positively, characterized by increased active participation, courage to try new movements, and persistence in completing challenges at each level. Only a small proportion (8.3%) responded moderately positively, and no students responded negatively.

In addition to student responses, adaptive physical education teachers also assessed the model's practicality. The questionnaire results showed an average practicality score of 89.1%, categorized as "very practical." Teachers stated that the learning steps were easy to follow, activities were easily modified to suit classroom conditions, and supporting media (challenge cards and progress boards) were very helpful in managing learning.

Table 7. Student Responses to the Learning Model in Large Group Trials (N = 60)

Response Categories	Number of Students	Percentage (%)
Very positive	28	46.7
Positive	27	45.0
Quite positive	5	8.3
Less positive	0	0.0
Total	60	100

Table 8. Teachers' Assessment of Model Practicality in Large Group Trials (N = 6 teachers)

Practical Aspects	Maximum Score	Average Score	Percentage (%)	Category
Ease of use of the model	4	3.6	90.0	Very practical
Clarity of learning steps	4	3.5	87.5	Very practical
Matching activities with time	4	3.5	87.5	Very practical
Flexibility of implementation in the classroom	4	3.7	92.5	Very practical
Benefits of models for learning	4	3.6	90.0	Very practical
Overall average	—	—	89.1	Very practical

Product Effectiveness Test Results

The effectiveness test was conducted on 60 students from SD SLB C Karya Ibu Palembang, SLB B YPAC Palembang, and SD SLB Pembina Palembang using a one-group pretest–posttest design. Students' gross motor skills were measured before and after the

implementation of the adaptive gamification-based physical education learning model for eight sessions.

Table 9. Descriptive Statistics of Gross Motor Skills Scores (N = 60)

Measurement	Mean	SD	Minimum	Maximum
Pretest	41.32	6.85	28	55
Posttest	52.87	7.14	36	66

Table 9 shows an increase in the average gross motor skill score from 41.32 in the pretest to 52.87 in the posttest. This indicates that after participating in gamification-based adaptive physical education learning, students' gross motor skills experienced significant improvement. A more detailed examination of improvement by motor skill item revealed consistent gains across all six skills measured. Walking improved from a mean of 7.21 (pretest) to 9.14 (posttest), running from 6.85 to 8.67, jumping from 6.43 to 8.52, throwing from 7.12 to 8.93, catching from 6.98 to 9.01, and kicking from 6.73 to 8.60. These item-level results indicate that the gamification-based model was effective in promoting development across all targeted gross motor domains, with particularly notable gains observed in catching and walking skills.

Paired t-Test Results

Table 10. Paired t-Test Results for Gross Motor Skills Scores (N = 60)

Variables	Mean Difference	SD Difference	t	df	p-value
Posttest–Pretest	11.55	5.92	14.87	59	<0.001

The results of the paired t-test showed that there was a significant difference between the pretest and posttest scores of students' gross motor skills, $t(59) = 14.87$, $p < 0.001$. Thus, the null hypothesis stating that there was no difference in gross motor skills before and after the implementation of the learning model was rejected. This finding indicates that the adaptive physical education learning model based on gamification significantly improved the gross motor skills of students with intellectual disabilities. To determine the strength of the influence of the learning model, the effect size was calculated using Cohen's d.

$$d = Mean\ Difference / SD\ Difference = 11.55 / 5.92 = 1.95$$

Cohen's d value of 1.95 indicates that the influence of the gamification-based adaptive physical education learning model on students' gross motor skills is in the very large effect category.

Discussion

Adaptive physical education for students with intellectual disabilities still faces various fundamental challenges, particularly low motivation to learn, limited attention span, and students' difficulty understanding instructions and repeating movements consistently. Learning practices in many special needs schools (SLB) are still dominated by conventional approaches that lack variety and lack positive reinforcement, resulting in students quickly becoming bored and less actively engaged. This condition directly impacts the low development of gross motor skills, even though these skills are crucial for the independence and daily functioning of students with intellectual disabilities. Therefore, a learning model is needed that is not only adaptive to student characteristics but also able to increase motivation, engagement, and the intensity of movement exercises through a fun and meaningful approach.

The findings of this study indicate that a gamification-based adaptive physical education learning model can be consistently and practically applied in real-life learning contexts at special needs schools (SLB). This reinforces the core principles of adaptive learning, which

emphasize activity differentiation, matching the workload to students' abilities, and flexibility in classroom implementation (Hardiyono et al., 2023). The clarity of the learning syntax and the suitability of activities to the characteristics of students with intellectual disabilities support the view that a simple, visual, and gradual learning structure is crucial for students with intellectual disabilities (Ardiyanto & Sukoco, 2014; Hidayat et al., 2024).

From the perspective of instructional design theory, the high feasibility of the model indicates that the integration of gamification elements does not disrupt the pedagogical flow, but rather strengthens the systematic learning structure. This finding is in line with the view of Fernández-Vázquez, (2024); Gil-Madrona et al., (2022) which states that properly designed gamification can increase usability and engagement without sacrificing instructional objectives. One of the key findings of this study was increased student engagement and enthusiasm during learning. This supports the theory of intrinsic motivation in Self-Determination Theory. Cronin et al., (2020); Evans, (2024), which emphasizes that learning experiences that provide a sense of achievement, positive feedback, and visualization of progress can increase students' learning motivation.

Points, badges, and levels are effective in increasing student participation and persistence in learning tasks. However, this study extends these findings to a relatively understudied context: adaptive physical education for students with intellectual disabilities. The results not only confirm the effectiveness of gamification in general education but also demonstrate its relevance in special education. The gross motor skill improvements found in this study reinforce motor learning theories that emphasize the importance of repetition, immediate feedback, and gradual practice (Aliriad, Da'i, et al., 2023; Aliriad, Soegiyanto, et al., 2023; Endrawan & Aliriad, 2023). This model implicitly facilitates all three principles through tiered activities, repeated challenges, and a reward system as positive reinforcement. These results are consistent with the findings of Aliriad et al., (2025) which states that structured motor intervention can significantly improve the motor skills of children with developmental delays. However, this study adds a new dimension by integrating gamification as a mechanism to maintain practice intensity and student interest throughout the intervention period.

The main contribution of this research lies in the development of a structured, validated, and applicable gamification-based adaptive physical education learning model specifically for students with intellectual disabilities. Unlike previous studies that generally only modified physical activities or implemented simple games, this study systematically integrates gamification elements into the syntax of adaptive physical education learning. Furthermore, this study provides empirical evidence that gamification impacts not only the affective aspect (motivation and interest) but also the psychomotor aspect (gross motor skills). Thus, these findings expand the conceptual framework of gamification use from merely a motivational strategy to a pedagogical approach that impacts motor learning outcomes. Practically, this model offers an innovative, affordable, and easily implemented learning alternative for adaptive physical education teachers in special needs schools. The use of challenge cards, progress boards, and simple rewards does not require sophisticated technology, making it relevant for school contexts with limited resources.

The pedagogical implications of this study suggest that teachers should shift their approach to adaptive physical education learning from a passive instructional approach to a participatory, visual, and positive reinforcement-based approach. Furthermore, the results can inform school policy development regarding the adoption of gamification-based learning models for special education. While the findings of this study are promising, several limitations warrant consideration. First, the study design employed a one-group pretest–posttest, which does not allow for strong causal conclusions compared to experimental designs with a control group. Second, the intervention duration was relatively short, thus understating the long-term impact on students' motor development. Third, the subjects were limited to students with mild

to moderate intellectual disabilities in the Palembang area, requiring caution in generalizing the findings to a broader population. Fourth, this study did not explore the model's impact on other aspects such as social skills, self-confidence, and physical fitness.

Based on these limitations, further research is recommended to use an experimental design with a control group, extend the intervention duration, and involve subjects from different regions and disability categories. Furthermore, developing a digital or hybrid version of this model is also worth exploring to expand the reach and flexibility of its application.

Conclusion

This study successfully developed, validated, and demonstrated the effectiveness of a gamification-based adaptive physical education learning model in improving gross motor skills in students with intellectual disabilities, achieving all research objectives. The novelty of this study lies in the systematic integration of gamification elements into the adaptive physical education learning syntax, making it a core part of the pedagogical design, rather than simply a motivational strategy. Theoretically and methodologically, these findings broaden the understanding of the role of gamification in motor learning and demonstrate that the R&D approach yields a valid, practical, and effective model. Practically, this model offers an innovative, affordable, and easily implemented learning alternative in special needs schools. Therefore, it is recommended that this model be adopted and further developed by adaptive physical education teachers, and tested in more robust experimental designs and broader subject contexts in future research.

Acknowledgment

The authors would like to thank all principals, adaptive physical education teachers, and students at SD SLB C Karya Ibu Palembang, SLB C YPAC Palembang, SLB B YPAC Palembang, SD SLB B Pembina Palembang, and SD SLB Pembina Palembang who participated in this research. The authors also thank the expert validators who provided valuable input and evaluation throughout the product development process.

Conflict of interest

The author states that there is no conflict of interest in the implementation and publication of this research. The entire research process was conducted independently and objectively in accordance with scientific principles.

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Cite this article as:
Septaliza, D. et all. (2026). Gamification-Based Adaptive Physical Education Model for Gross Motor Skills in Students with Intellectual Disabilities. *Indonesian Journal of Physical Education and Sport Science. 6* (2). Xx-xx. doi