

An AI-Based Physical Literacy Model To Improve Fitness And Learning Outcomes In Physical Education Among Elementary School Students

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Abstract. This study aims to develop and analyze the effectiveness of an AI-Based Physical Literacy Model to improve physical literacy, physical fitness, and learning outcomes in Physical Education, Sports, and Health among elementary school students in Bojonegoro Regency. The study employed a Research and Development (R&D) approach using the ADDIE development model, which includes Analysis, Design, Development, Implementation, and Evaluation. The model's effectiveness was tested using a pretest–posttest control group design involving 60 students divided into an experimental group and a control group, each consisting of 30 students. The experimental group received instruction using the AI-Based Physical Literacy Model over eight sessions, while the control group participated in conventional Physical Education, Sports, and Health instruction. Data on physical literacy, physical fitness, and Physical Education learning outcomes were collected through pre- and post-instruction measurements. Data analysis included descriptive statistics, the Shapiro–Wilk normality test, Levene's test for homogeneity, the Wilcoxon Signed-Rank Test, an independent samples t-test on posttest scores, N-Gain, and Cohen's d. The results showed that the experimental group had higher *posttest* scores than the control group in Physical Literacy, physical fitness, and PJOK learning outcomes, with p-values < 0,001. The N-Gain values for the experimental group were 0,485 for Physical Literacy, 0,417 for physical fitness, and 0,549 for PJOK learning outcomes, while the control group fell into the low category. Effect sizes also indicated a large effect, with Cohen's d of 2,442 for Physical Literacy, 1,745 for physical fitness, and 2,232 for Physical Education learning outcomes. These findings suggest that the AI-Based Physical Literacy Model has the potential to serve as an adaptive, data-driven, and effective approach to Physical Education instruction for improving the achievements of elementary school students.

Keywords: Artificial Intelligence, Physical Literacy, physical fitness, learning outcomes, Physical Education, elementary school.

1 Introduction

Physical Education, Sports, and Health plays a strategic role in students' development because its curriculum is not only related to mastering motor skills but also to building physical fitness, understanding physical activity, motivation, self-confidence, and active lifestyle habits [1]. The motor experiences gained by students starting in elementary school form a crucial

foundation for their sustained engagement in physical activity. The concept of Physical Literacy expands this perspective by viewing movement ability as a construct that encompasses physical, cognitive, and affective aspects. Ke et al. [2] explain that Physical Literacy in children and adolescents includes physical ability, knowledge and understanding, motivation, and self-confidence-all of which must be comprehensively considered in the assessment process [3].

Physical Education instruction in elementary schools faces the challenge of providing learning experiences that accommodate the diversity of students' physical abilities, movement experiences, motivation, and learning needs [4]. A one-size-fits-all instructional approach may result in activities that are ill-suited to students' initial abilities, thereby limiting opportunities to optimally develop fitness and motor skills [5]. This situation is relevant to the context of elementary school students in Bojonegoro Regency, who are the subjects of this study, as Physical Education instruction at the elementary school level must take into account students' developmental characteristics and individual ability differences. Indicate that the concept of Physical Literacy involves several interrelated domains; therefore, its application in physical education must consider these multidimensional characteristics [6].

The development of Physical Literacy requires learning experiences that are not only focused on covering the curriculum but also provide students with opportunities to engage in physical activities, understand the purpose of the activities, receive feedback, and reflect on their own progress [7]. through a systematic review and meta-analysis, demonstrated that Physical Literacy interventions have the potential to enhance the development of various components of Physical Literacy [8]. Also noted that research on Physical Literacy is evolving as a field of study related to physical ability, motivation, self-confidence, knowledge, and engagement in physical activity [9]. These findings provide a basis for the argument that Physical Education instruction should be directed toward developing competencies that extend beyond motor skills alone. Physical Education instruction must also respond to the development of digital technology, which is becoming increasingly integrated into the educational environment. indicate that digital technology in Physical Education has been used to support physical, cognitive, social, and affective objectives, including enhancing motivation and motor skills [10]. Suggest that a Physical Education learning approach combining blended learning and gamification can serve as an alternative to create more engaging and adaptive physical activity experiences [11]. The use of technology in this study is positioned as part of a pedagogical strategy that supports the learning process, not as a substitute for direct physical activity.

Advances in Artificial Intelligence (AI) offer further opportunities to develop data-driven learning that is responsive to students' needs. Developed an AI-based physical education platform that demonstrates the potential of artificial intelligence in the evaluation and management of learning [12]. Demonstrated that students and teachers hold positive perceptions toward the application of AI in personalized learning [13]. These findings provide a foundation for utilizing AI as a supportive technology in the assessment and personalization of physical education learning.

Personalization is a crucial component because students have varying prior abilities, motor experiences, and learning needs. Explains that AI in education can support a more student-centered learning system through diagnostic and predictive functions, while the teacher's role

remains essential in the decision-making process [14]. Also indicate that a personalized learning approach can provide learning pathways and feedback tailored to students' characteristics and yield better learning outcomes compared to conventional approaches [15]. This perspective is relevant to the needs of elementary school students in Bojonegoro Regency, who exhibit a wide range of abilities and experiences in physical activities.

The use of technology in Physical Education and Health must take into account the quality of the data used in the assessment process. Indicates that wearable devices can be used to gather information about students' activities as part of evaluating the quality of physical education [16]. This information can serve as a data source for AI-based learning systems to help teachers understand students' progress. The use of technology must still take into account teacher readiness, school facilities, student characteristics, as well as data security and privacy considerations [17].

Research on Physical Literacy and digital technology in Physical Education has advanced, but the integration of AI with the principles of Physical Literacy into a single learning model still requires further development. Demonstrate a positive relationship between participation in extracurricular sports and Physical Literacy, but this relationship must be understood in conjunction with students' experiences in physical education [18]. Emphasize the importance of teachers' digital competencies and the perspectives of both teachers and students regarding the use of digital technology in Physical Education [19]. These findings indicate that the development of an AI-based model must integrate pedagogical objectives, student characteristics, teacher competencies, and the technology employed.

This study proposes an AI-Based Physical Literacy Model that integrates learning analytics, computer vision, and Large Language Models into the physical education learning sequence. The model is designed through the following stages: initial assessment, analysis of student needs, personalization of activities, AI-assisted skill development, Physical Literacy practice, feedback and reflection, and progress evaluation. AI serves as a support for the learning process and pedagogical decision-making, while teachers retain control over the planning, implementation, safety, and evaluation of learning [20]. The novelty of this research lies in the integration of AI technology with the principles of Physical Literacy into a single learning model, which was tested on elementary school students in Bojonegoro Regency, with outcomes encompassing Physical Literacy, physical fitness, and Physical Education learning outcomes.

Based on these issues, gaps, and opportunities for development, this study aims to develop an AI-Based Physical Literacy Model, test the model's feasibility, and analyze the effectiveness of its implementation among elementary school students in Bojonegoro Regency in improving Physical Literacy, physical fitness, and Physical Education learning outcomes. This study is expected to provide a conceptual contribution to the development of Physical Education instruction based on Physical Literacy and AI technology, as well as offer practical guidance for teachers in designing adaptive learning experiences tailored to students' characteristics and developmental stages.

2 Research Method

This study employed a Research and Development (R&D) approach to develop the AI-Based Physical Literacy Model for Physical Education and Health instruction [21]. Model development followed the ADDIE framework, which includes the stages of Analysis, Design, Development, Implementation, and Evaluation [22]. After the model was developed and validated, its effectiveness was tested using a pretest–posttest control group design. The experimental group received instruction using the AI-Based Physical Literacy Model, while the control group followed the conventional Physical Education curriculum implemented at the school. The study involved 60 elementary school students in Bojonegoro Regency, consisting of 30 students in the experimental group and 30 students in the control group. The research data included physical literacy, physical fitness, and Physical Education learning outcomes, which were measured before and after instruction.

The analysis phase was conducted through a literature review, observations of Physical Education and Health lessons, interviews with teachers, student questionnaires, and an analysis of curriculum documents. The analysis aimed to identify the conditions of PJOK instruction, student characteristics, levels of physical fitness, learning outcomes, the application of Physical Literacy principles, and the need for technology integration in instruction [23]. The results of the analysis were used to determine the model characteristics, instructional syntax, instructional tools, assessment formats, and AI technology needs relevant to the characteristics of elementary school students in Bojonegoro Regency.

The Design phase produced a conceptual design for the AI-Based Physical Literacy Model, which includes learning syntax, social systems, teacher response principles, support systems, as well as instructional and accompanying impacts. The instructional design focuses on the initial assessment process, identification of student needs, personalization of activities, practice of motor skills, provision of feedback, reflection, and evaluation of progress. The designed tools include instructional modules, digital media, teacher guides, assessment instruments, and a plan for integrating AI into Physical Education instruction.

The Development phase produced a prototype of the AI-Based Physical Literacy Model along with its supporting tools. The products include Physical Literacy instruments, physical fitness instruments, Physical Education learning outcome instruments, and an AI system used to support the assessment process, student data analysis, activity recommendations, and feedback provision. The products were reviewed by experts in Physical Education, learning technology, AI, and educational evaluation. Validation covered content, construct, language, instructional syntax, technology integration, and tool feasibility. The validation results were used as the basis for revisions before the model was implemented with students.

The Implementation phase involved 60 elementary school students in Bojonegoro Regency. The experimental group consisted of 30 students, and the control group consisted of 30 students. The experimental group comprised 15 male students and 15 female students, while the control group comprised 12 male students and 18 female students. Instruction was conducted over eight sessions. A pretest was administered before instruction began, and a posttest was administered

after the entire instructional series was completed. The variables measured included physical literacy, physical fitness, and Physical Education learning outcomes.

The evaluation phase was conducted to determine changes in student achievement and the relative effectiveness of the model. Data were analyzed using descriptive statistics, specifically the mean and standard deviation. Normality was tested using the Shapiro–Wilk test. For the analysis of paired score changes, normality was examined for the difference scores—that is, the difference between posttest and pretest scores. The results indicated that most difference scores did not meet the assumption of normality; therefore, changes within groups were analyzed using the Wilcoxon Signed-Rank Test. The difference in posttest scores between the experimental and control groups was analyzed using an independent samples t-test because the distribution of posttest scores met the assumption of normality and the variances of the two groups were homogeneous based on Levene’s test. The level of improvement was analyzed using N-Gain, while the effect size of the posttest difference between groups was analyzed using Cohen’s d. The significance level was set at $\alpha = 0,05$.

3 Research Results

The study involved 60 students, consisting of 30 students in the experimental group and 30 students in the control group. The experimental group received the AI-Based Physical Literacy Model, while the control group participated in conventional physical education (PJOK) instruction. The composition of students in the experimental group consisted of 15 males and 15 females, while the control group consisted of 12 males and 18 females. Overall, there were 27 male students and 33 female students. This composition ensured an equal number of subjects in both groups, allowing for a comparison of final achievements between groups of balanced sizes.

Table 1. Respondent Characteristics

Characteristics	Experimental (n=30)	Control (n=30)	Total
Male	15	12	27
Women	15	18	33
Total	30	30	60

Table 1 shows that the number of students in both groups is the same, with 30 students in each group. The experimental group has a balanced gender composition with 15 boys and 15 girls. The control group consists of 12 boys and 18 girls. Overall, there were more female students than male students, 33 to 27. This difference in gender composition did not alter the sample size between the groups. The equal number of students in both groups provided a balanced basis for the comparative analysis of posttest scores.

Table 2. Descriptive Statistics for Physical Literacy

Group	Pretest (Mean $\pm$ SD)	Posttest (Mean $\pm$ SD)	Improvement
Experimental	57,17 $\pm$ 5,69	77,63 $\pm$ 6,17	20,47
Control	57,93 $\pm$ 5,00	63,93 $\pm$ 4,99	6,00

Table 2 shows an increase in Physical Literacy in both groups after the intervention. The mean score for the experimental group increased from 57,17 to 77,63, a change of 20,47 points. The control group's score increased from 57,93 to 63,93, a change of 6,00 points. The magnitude of the change in the experimental group was more than three times that of the control group. The difference in posttest means also indicates that the experimental group achieved a higher final score. This pattern suggests a difference in Physical Literacy achievement, which was subsequently tested using inferential statistics.

Table 3. Descriptive Statistics for Physical Fitness

Group	Pretest (Mean $\pm$ SD)	Posttest (Mean $\pm$ SD)	Increase
Experimental	56,63 $\pm$ 6,68	74,30 $\pm$ 7,58	17,67
Control	56,10 $\pm$ 6,60	61,63 $\pm$ 6,93	5,53

Table 3 shows that the physical fitness of the experimental group increased from an average of 56,63 to 74,30. This change amounted to 17,67 points. The control group experienced a change from 56,10 to 61,63, an increase of 5,53 points. The difference in improvement between the two groups was 12,13 points. The *posttest* mean for the experimental group was also higher than that of the control group. These descriptive findings indicate a stronger pattern of change among students who participated in the AI-Based Physical Literacy Model.

Table 4. Descriptive Statistics of Physical Education Learning Outcomes

Group	Pretest (Mean $\pm$ SD)	Posttest (Mean $\pm$ SD)	Increase
Experimental	61,86 $\pm$ 6,76	82,06 $\pm$ 8,07	20,20
Control	59,56 $\pm$ 5,97	65,83 $\pm$ 6,36	6,27

Table 4 shows an increase in Physical Education learning outcomes in both groups. The average learning outcome of the experimental group increased from 61,87 to 82,07, a change of 20,20 points. The control group's average increased from 59,57 to 65,83, a change of 6,27 points. The change in the experimental group was greater than that in the control group, with a difference of 13,93 points. The experimental group's average posttest score was also 16,23 points higher. These results indicate that students who participated in the AI-Based Physical Literacy Model achieved higher learning outcomes.

Table 5. Normality Test of Posttest Scores

Variable	Group	W	Sig.
Physical Literacy	Experimental	0,965	0,418
	Control	0,960	0,319
Physical Fitness	Experimental	0,962	0,354
	Control	0,966	0,431
Physical Education Learning Outcomes	Experimental	0,953	0,198
	Control	0,947	0,139

Table 5 shows that all posttest scores have significance values greater than 0,05. The significance value for Physical Literacy was 0,418 in the experimental group and 0,319 in the control group. Physical fitness had significance values of 0,354 and 0,431, respectively. Physical Education learning outcomes had significance values of 0,198 in the experimental group and 0,139 in the control group. All of these values indicate that the distribution of posttest scores does not deviate significantly from a normal distribution. These results support the use of an independent samples t-test to compare posttest scores between groups.

Further examination of the difference scores revealed that not all score changes met the assumption of normality. Physical Literacy in the experimental group had a p-value of 0,066, while the control group had a p-value of <0,001. Physical fitness showed a p-value of 0,031 in the experimental group and 0,002 in the control group. Physical education learning outcomes showed $p = 0,005$ in the experimental group and $p = 0,003$ in the control group. These conditions formed the basis for using the Wilcoxon Signed-Rank Test to examine pretest–posttest changes within each group.

Table 6. Levene's Test of Homogeneity

Variable	Sig.
Physical Literacy	0,152
Physical Fitness	0,446
Physical Education Learning Outcomes	0,104

Table 6 shows that all Levene's significance values are greater than 0,05. The significance value for *Physical Literacy* is 0,152, for physical fitness is 0,446, and for Physical Education learning outcomes is 0,104. These results indicate that *the variances* in the posttest scores of the experimental and control groups do not differ significantly. The assumption of homogeneity of variances was met for all three variables. This condition allows for a comparison of posttest scores using an independent samples t-test under the assumption of equal variances. The results of the homogeneity test support the validity of analyzing differences in final achievement between groups.

Table 7. Results of the Wilcoxon Signed-Rank Test

Variable	Group	Wilcoxon Statistic (V)	Sig.
Physical Literacy	Experimental	0	<0,001
	Control	0	<0,001
Physical Fitness	Experimental	0	<0,001
	Control	0	<0,001
Physical Education Learning Outcomes	Experimental	0	<0,001
	Control	0	<0,001

Table 7 shows significant changes between *pretest* and *posttest* scores in both groups for all research variables. Physical Literacy showed $p < 0,001$ in both the experimental and control groups. Physical fitness also showed $p < 0,001$ in both groups. Physical education learning outcomes showed the same pattern with $p < 0,001$ in both groups. These findings indicate that both groups experienced changes during the learning period. The magnitude of the change, based on descriptive statistics, remained higher in the experimental group; therefore, a comparative analysis of posttest scores is necessary to determine differences in final achievement.

Table 8. Intergroup Comparison

Variable	t	Sig.
Physical Literacy	9,460	<0,001
Physical Fitness	6,757	<0,001
Physical Education Learning Outcomes	8,644	<0,001

Table 8 shows significant differences in posttest scores between the experimental and control groups for all variables. Physical Literacy showed $t = 9,460$ with $p < 0,001$. Physical fitness showed $t = 6,757$ with $p < 0,001$. Physical Education learning outcomes showed $t = 8,644$ with $p < 0,001$. The experimental group's posttest mean scores were higher across all three variables. These results indicate that after instruction, the achievements of students who received the AI-Based Physical Literacy Model differed significantly from those of students who followed conventional instruction.

Table 9. N-Gain Values

Variable	Group	Value	Category
Physical Literacy	Experiment	0,485	Moderate
	Control	0,143	Low
Physical Fitness	Experiment	0,417	Moderate
	Control	0,129	Low
Physical Education Learning Outcomes	Experiment	0,549	Moderate
	Control	0,159	Low

Table 9 shows that all variables in the experimental group fell into the moderate improvement category. The N-Gain for Physical Literacy was 0,485, for physical fitness 0,417, and for Physical Education learning outcomes 0,549. The control group achieved N-Gains of 0,143, 0,129, and 0,159, respectively, all of which fell into the low category. The highest score in the experimental group was in Physical Education learning outcomes. The differences in N-Gain categories indicate that the relative improvement of students in the experimental group was higher than that of the control group. These findings reinforce the inferential statistical results, which show differences in final achievement between the groups.

Table 10. Effect Sizes of the AI-Based Physical Literacy Model

Variable	Cohen's d	Interpretation
Physical Literacy	2,442	High
Physical Fitness	1,745	High
Physical Education Learning Outcomes	2,232	High

Table 10 shows that the implementation of the AI-Based Physical Literacy Model produced very strong effect sizes for all three variables. The largest effect was observed in Physical Literacy, with a Cohen's d of 2,442. The effect on Physical Education learning outcomes reached $d = 2,232$, while that on physical fitness reached $d = 1,745$. All values are well above the conventional threshold of 0,80, which is often used to indicate a large effect. These results indicate that the differences in posttest scores are not only statistically significant but also represent substantive differences between the experimental and control groups. The highest effect size for Physical Literacy suggests that the outcome most closely aligned with the model's core construct exhibited the strongest difference in achievement.

4 Discussion

The research results show that the implementation of the AI-Based Physical Literacy Model produced higher posttest achievements compared to the control group in Physical Literacy, physical fitness, and Physical Education learning outcomes. These differences were demonstrated by the results of the independent samples t-test, which yielded $p < 0,001$ for all three variables. These findings indicate that the developed model not only produces changes during the learning process but also yields different final outcomes compared to conventional Physical Education instruction. This pattern is reinforced by the N-Gain values, which fell into the moderate category for the experimental group and the low category for the control group. These results demonstrate the relative superiority of the AI-Based Physical Literacy Model in supporting students' learning outcomes.

The improvement in Physical Literacy was a key finding because this construct forms the basis for the model's development. The average Physical Literacy score in the experimental group increased from 57,17 to 77,63, while that of the control group increased from 57,93 to

63,93. A Cohen's d of 2,442 indicates a very large effect size for the posttest difference. These results demonstrate that the model produced substantial changes in the abilities targeted by the intervention. The findings of the study [24] provide empirical support that interventions integrating physical literacy into school activities can have a positive impact on children's physical fitness and academic achievement. That study involved 357 children and found better posttest scores on several fitness indicators as well as academic achievement in the intervention group.

The improvement in physical fitness in the experimental group also indicates that the model is not solely focused on knowledge and motor skills. The average physical fitness score increased from 56,63 to 74,30, while the control group's score increased from 56,10 to 61,63. The experimental group's N-Gain value of 0,417 fell into the moderate category, while the control group's value of 0.129 fell into the low category. Cohen's d of 1,745 indicated a very large effect size. These results demonstrate that the activities designed within the model were able to provide a more intensive and targeted movement experience compared to the learning in the control group.

The improvement in Physical Education learning outcomes indicates that the integration of physical activity, assessment, feedback, and reflection can support learning achievements. The experimental group experienced an average increase of 20.02 points, while the control group experienced an increase of 6,27 points. The experimental group's N-Gain value of 0.549 was the highest compared to Physical Literacy and physical fitness. Cohen's d of 2,232 also indicates a very large effect size. These findings demonstrate that the model has the potential to link physical activity experiences to Physical Education learning objectives in a more structured manner.

The use of AI in the model can facilitate more adaptive learning. Wang and Wang [25] explain that AI in physical education can be used to support the planning of learning strategies, tracking of the learning process, and evaluation of learning outcomes. AI can help process student data so that teachers obtain more systematic information when determining next steps in the learning process. The findings of this study expand on these applications through the integration of AI with Physical Literacy, so that data is not only used for evaluation but also serves as the basis for personalizing activities and providing feedback.

The integration of technology into the AI-Based Physical Literacy Model also has implications for the quality of students' learning experiences. Technology can help provide faster information regarding student progress, but pedagogical decisions still require teacher interpretation. The developed model positions the teacher as the controller of the learning process, while AI functions as a support system for data analysis, recommendations, and feedback. This role is crucial to ensure that the use of AI remains aligned with learning objectives, children's developmental characteristics, and safety considerations in physical activities.

The research results also show that the control group experienced significant improvements in all three variables. This indicates that conventional physical education continues to contribute to students' development. The main difference lies in the magnitude of the improvement and the higher final achievements observed in the experimental group. This interpretation is

important because the effectiveness of the AI-Based Physical Literacy Model does not imply that conventional instruction is ineffective; rather, it demonstrates the model's relative advantage in achieving higher outcomes.

The magnitude of the effect sizes reinforces the practical significance of the research findings. Cohen's *d* values of 2,442 for Physical Literacy, 1,745 for physical fitness, and 2,232 for Physical Education learning outcomes indicate a very large difference between the two groups. These findings demonstrate that statistical significance does not stand alone but is accompanied by substantive differences in achievement. The large effect size, particularly in Physical Literacy, can be understood because this construct is the model's primary target and is directly integrated into the learning syntax.

The implementation of the model with elementary school students in Bojonegoro Regency provides an important context for interpreting the research results. The model was not only tested in a technology-based learning environment but was also applied in the context of elementary school Physical Education with a diverse student population. These conditions demonstrate that technology integration must preserve the characteristics of Physical Education as learning oriented toward physical activity. The use of AI should enhance the movement experience, not replace it.

The practical implications of this research indicate that Physical Education teachers can utilize a data-driven approach to identify students' needs, determine appropriate activities, provide feedback, and monitor progress. The use of AI must also be accompanied by improvements in teachers' digital competencies to ensure technology is used appropriately. The implementation of technology without a clear pedagogical design has the potential to result in digital activities that are not directly related to learning objectives. The model developed in this study treats the integration of technology and pedagogy as a single unit.

The study's limitations must be considered when interpreting the results. The sample size was limited to 60 elementary school students in Bojonegoro Regency, so generalizations Generalizing the results to other regions must be done with caution. The duration of the intervention was also limited to eight sessions, so further research is needed to determine the sustainability of the model's effects. Future studies could involve a larger number of schools and students, more diverse regional characteristics, and a longer intervention period. It is also important to evaluate teacher acceptance, student experiences, data security, and the sustainability of AI use.

Overall, the study results indicate that the AI-Based Physical Literacy Model has strong potential to improve physical literacy, physical fitness, and physical education learning outcomes among elementary school students in Bojonegoro Regency. The model's strengths are evident in the consistent improvements in descriptive statistics, N-Gain, posttest score differences, and effect sizes. The integration of AI with Physical Literacy provides a learning approach that combines data-driven assessment, personalized activities, movement practice, feedback, and reflection. These findings reinforce the position of the AI-Based Physical Literacy Model as an innovative alternative in the development of adaptive Physical Education instruction that is oriented toward student development.

5 Conclusion

This study demonstrates that the AI-Based Physical Literacy Model can be used as a Physical Education learning approach that supports improvements in Physical Literacy, physical fitness, and physical education learning outcomes among elementary school students in Bojonegoro Regency. The development of the model through the ADDIE stages resulted in a learning design that integrates initial assessment, personalized activities, motor skill practice, the use of Artificial Intelligence technology, feedback, reflection, and evaluation of student progress. This integration positions Artificial Intelligence as a support for the learning process and pedagogical decision-making, while teachers continue to play a primary role in planning, supervising activities, ensuring safety, and evaluating learning.

The results of the implementation with 60 students showed that the experimental group achieved higher improvements compared to the control group. The difference in posttest scores between the two groups was found to be statistically significant for Physical Literacy, physical fitness, and Physical Education learning outcomes, with a p -value $< 0,001$. The N-Gain values for the experimental group fell into the moderate category for all three variables, while those for the control group were in the low category. The effect sizes also showed large values for Physical Literacy, physical fitness, and Physical Education learning outcomes. These findings indicate that the superiority of the AI-Based Physical Literacy Model is evident not only from statistical significance but also from the magnitude of the achievement differences between the groups.

Physical Literacy showed the highest effect size with a Cohen's d of 2,442. Physical Education learning outcomes had an effect size of 2,232, while physical fitness had an effect size of 1,745. These findings indicate that the integration of Physical Literacy with Artificial Intelligence-based technology makes a strong contribution to the model's primary outcomes, while also supporting the development of physical fitness and Physical Education learning outcomes. Learning that combines data-driven assessment, personalized activities, movement experiences, feedback, and reflection offers an alternative to Physical Education instruction that is more responsive to students' diverse characteristics.

The application of this model to elementary school students in Bojonegoro Regency offers practical insights for developing technology-based Physical Education and Health instruction that remains focused on physical activity. This model can serve as an alternative for Physical Education and Health teachers in identifying students' needs, adapting learning activities, monitoring progress, and providing feedback in a more systematic manner. The use of Artificial Intelligence should still be viewed as a supporting technology and accompanied by teacher supervision, particularly regarding the appropriateness of activities, children's developmental characteristics, safety, and the management of student data.

This study has limitations regarding the sample size, which involved only 60 elementary school students in Bojonegoro Regency, and the implementation duration, which spanned eight sessions. These conditions limit the generalizability of the study's findings to broader school and regional characteristics. Future research should involve a larger number of students and schools, a more diverse range of regions, and a longer intervention duration to test the

consistency and sustainability of the model's effectiveness. Further studies could also focus on teacher and student acceptance, infrastructure readiness, data security, and the effectiveness of each Artificial Intelligence technology component in supporting Physical Education and Health learning.

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