Journal of Advanced Sciences and Mathematics Education
Volume 6, Issue 2, 436-455.
e_ISSN: 2798-1606
DOI: 10.58524/jasme.v6i2.1199

Development of a game-based instructional model integrating physical activity to enhance mathematical reasoning and social interaction in elementary mathematics education

Nurhikmah*
Universitas Megarezky, INDONESIA

Suhartiwi
Universitas Halu Oleo, INDONESIA

Article Info

Article history:

Received: March 02, 2026
Revised: April 25, 2026
Accepted: June 04, 2026

Keywords:

Cogrnitive Outcome; Game-Based Learning; Physical Education; Social Interaction; Traditional Games.

Abstract

Background: Physical Education (PE) in primary schools often lacks structured integration of traditional games and social interaction, limiting opportunities for students to develop both learning outcomes and social skills. Innovative instructional models are needed to address these gaps and enhance engagement.
Aims: This study aimed to develop a PE learning model through game-based social interaction to improve students' cognitive outcomes and social competencies, while providing a structured framework for teachers.
Method: The ADDIE development framework guided the research, encompassing needs analysis, design, development, implementation, and evaluation stages. The prototype model, grounded in Joyce et al.'s instructional theory, includes structured learning guides covering traditional games, step-by-step learning syntax, implementation procedures, and assessment components. Expert judgment validated the model, and classroom trials collected teacher and student responses.
Results: Findings confirmed the model's validity, practicality, and effectiveness. Expert evaluation confirmed content validity, while teachers and students reported high practicality (89% and 92%, respectively). Effectiveness was evidenced by improvements in both cognitive learning outcomes and social skill development, with students demonstrating active participation and enhanced collaboration during PE activities.
Conclusion: The developed PE learning model successfully integrates traditional games and social interaction to enhance student outcomes. It provides an innovative, practical, and replicable approach for primary education, promoting cognitive and socio-emotional development simultaneously.

To cite this article: Nurhikmah & Suhartiwi (2026). Development of a game-based instructional model integrating physical activity to enhance mathematical reasoning and social interaction in elementary mathematics education. *Journal of Advanced Sciences and Mathematics Education, 6*(2), 436-455.

INTRODUCTION

Games have played a significant role in education, evolving from traditional play activities to modern, technology-based entertainment. Despite technological advancements, traditional games remain highly effective in promoting children's learning, creativity, and social skills (Behnamnia et al., 2020; Garaigordobil et al., 2022). These games are integral to preserving local cultural heritage, yet their presence in Indonesia is declining. Many traditional games have nearly disappeared due to globalization and the rise of alternative entertainment, reducing the opportunities for children to engage in culturally meaningful play (Dezfoulian & Nemati, 2025). Limited play spaces, decreased leisure time, and changing social habits further threaten the survival of these educational games. Traditional games, however, offer physical, cognitive, and social benefits that extend beyond mere recreation (ismoyo et al., 2024; Lavega-Burgués et al., 2021; Prabucki & Rozmiarek, 2025). In the context of Physical Education (PE), these games can foster character development, teamwork, and

***Corresponding author:**
Nurhikmah, Universitas Megarezky, Indonesia
nurpratama7@gmail.com

emotional regulation among students (Dudley, 2025; Espoz-Lazo et al., 2020; Merino-Campos, 2025; Nazari et al., 2025; Rico-González, 2023). Observations in South Sulawesi reveal that traditional games are underutilized in formal PE curricula and teaching materials. The absence of structured integration diminishes opportunities for students to benefit from these culturally rich and developmentally supportive activities. Thus, designing an instructional model that incorporates traditional games is crucial for both educational outcomes and cultural preservation.

Traditional games also contribute to holistic social development by enhancing cooperation, empathy, and discipline among children. When integrated into PE learning, they encourage physical activity while promoting engagement in collaborative tasks. Activities such as Ma'hadang, Ma'longga, Massantok, and Maccukke provide structured contexts where students can interact, negotiate, and solve problems collectively. These interactions improve self-confidence, emotional well-being, and interpersonal skills, which are essential for academic and personal success. Furthermore, social interaction within the classroom supports democratic participation and prepares students for broader societal engagement (de Groot & Lo, 2021; Heid et al., 2023; Holbein et al., 2020; Levy et al., 2023). The social interaction model emphasizes learning through group work, role-playing, discussions, and simulations, creating authentic and meaningful learning experiences. Using traditional games in this framework allows students to connect physical actions with cognitive and social processes. Teachers facilitate these activities by providing guidance, scaffolding, and opportunities for reflection. By embedding games into PE, students not only engage in enjoyable activities but also develop transferable skills applicable across various life contexts. This approach underscores the value of culturally grounded, socially interactive, and physically active learning strategies.

Despite the potential benefits, current PE practices in South Sulawesi rarely integrate traditional games systematically. Teachers rely predominantly on standard curriculum resources, and traditional games seldom appear in lesson plans or worksheets (Jukić Matić & Glasnović Gracin, 2021; Sawyer et al., 2020). This lack of integration limits the opportunities for students to engage in meaningful play that enhances both learning and cultural understanding (Greipl et al., 2020; Hossain, 2024; Parker et al., 2022; Samuelsson, 2023). Additionally, many educators lack training in incorporating game-based strategies effectively. The absence of structured models prevents the systematic evaluation of outcomes related to cognitive, social, and physical development (Araújo et al., 2021; Brown et al., 2024; Fong Yan et al., 2024; Hu et al., 2021; Rossoni et al., 2024). Students miss chances to experience collaborative problem-solving and social skill-building through play. The limited use of traditional games also reduces cultural continuity and diminishes the richness of experiential learning (Ahdhianto et al., 2025; Dezfoulian & Nemati, 2025; Quispe Munares et al., 2025; Rakhoveio et al., 2025; Zhu et al., 2024). Therefore, developing an instructional model that combines PE, traditional games, and social interaction is essential. The model should align with local cultural practices while supporting student learning outcomes. Such integration ensures that physical activity, cognitive development, and social competence are simultaneously addressed.

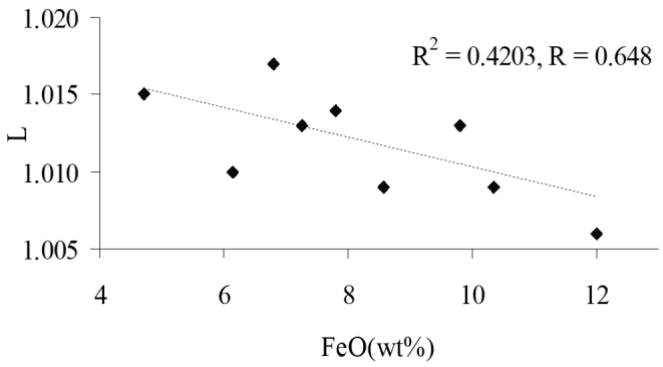

Figure 1. Plots of lineation (L) and FeO content showing negative correlation.

Although extensive research has examined physical activity, game-based learning, and social interaction in education, existing studies often treat these components in isolation, failing to explore their combined effects on elementary mathematics learning (Bado, 2022; Kalajas-Tilga et al., 2020), while most interventions focus either on upper-grade mathematics or specific domains such as geometry without addressing holistic mathematical reasoning across curricula (Schoevers et al., 2020). Prior research on project-based learning has demonstrated improvements in engagement and achievement, yet few studies integrate game-based physical activities with structured instructional models to simultaneously enhance cognitive outcomes, social interaction, and student motivation (Es-Sajjade & Paas, 2020; Lazi et al., 2021). Furthermore, research on social interaction and collaboration often emphasizes adult or online learning environments, leaving a gap in understanding how peer-to-peer interaction in physical, game-based mathematics activities can influence conceptual understanding in young learners (De Felice et al., 2022; Li & Jeong, 2020). Despite evidence that project-based or experiential learning benefits mathematics achievement, empirical classroom-based studies validating replicable instructional models that integrate cognitive, social, and physical components in elementary mathematics are scarce (Fauzan et al., 2024; Pellegrini et al., 2021). Consequently, there is a critical need to develop, implement, and evaluate a comprehensive, game-based instructional model that fosters mathematical reasoning, active engagement, and social skills, providing both practical and empirical guidance for educators in primary mathematics education.

This study aims to develop a Physical Education learning model through traditional games and social interaction to enhance students' cognitive, social, and physical outcomes. It seeks to design a structured framework that is culturally grounded, practical for teachers, and replicable in elementary schools. The research evaluates the model's effectiveness in improving students' learning engagement, collaboration, and social skills. It also examines teachers' and students' perceptions of the model's practicality and usability. The study aims to preserve traditional games while embedding them within PE curricula to support holistic student development. It explores the implementation of games such as Ma'hadang, Ma'longga, Massantok, and Maccukke as pedagogical tools. The research evaluates whether structured guidance, role-playing, and group interactions enhance learning outcomes. It investigates the impact on students' social competence, including empathy, teamwork, and communication. The study also examines how traditional games influence students' motivation and active participation in PE. Ultimately, the aim is to provide an innovative, culturally informed PE learning model that promotes cognitive, social, and physical development simultaneously.

LITERATURE REVIEW

Development in education involves the creation or enhancement of instructional processes, materials, and learning environments aimed at improving student outcomes. It is a dynamic process requiring systematic application of knowledge to design, test, and refine strategies for effective learning. Development emphasizes both adaptation to contextual needs and continuous improvement based on feedback and evaluation (Chinoperekweyi et al., n.d.; Gutierrez-Gutierrez & Antony, 2019; Yurkofsky et al., 2020). Scholars suggest that instructional development should address cognitive, social, and physical dimensions of learning to be comprehensive. The integration of theory and practice is essential to produce usable, effective, and replicable educational models (Abuhassna et al., 2024; Mallek et al., 2024; Tondeur et al., 2021; Yang et al., 2024). Effective development requires clear objectives, structured procedures, and iterative testing to ensure the reliability and applicability of innovations. Development processes often include stages such as needs assessment, design, implementation, and evaluation. This systematic approach ensures that interventions are evidence-based and aligned with curricular goals. In the context of elementary education, development efforts should also incorporate cultural and community-relevant elements. Overall, development serves as a foundation for designing instructional models that enhance learning effectiveness, engagement, and holistic student growth.

A learning model represents a structured approach to facilitate teaching and learning processes. It functions as a framework encompassing objectives, instructional steps, learning environments, and assessment strategies. Models can be tangible or conceptual, such as physical prototypes or metaphorical representations, to illustrate complex concepts (Kim & Maher, 2020; Mayr & Thalheim, 2021; H. Zhang et al., 2024). Effective models include essential components such as syntax, social systems, instructional principles, support systems, and nurturing strategies (Luo et al., 2023). Learning models guide educators in designing experiences that foster both cognitive and socio-emotional development (Gonzalez, 2023; Parra et al., 2025). They also provide a blueprint for systematic instruction, ensuring consistency, clarity, and alignment with learning goals. Social interaction, information processing, personal development, and behavioral modification are commonly recognized model categories (Jabeen et al., 2022; Rahmani et al., 2020; Renninger & Hidi, 2022). The use of models enables replication, evaluation, and refinement across different contexts and learners. Implementing well-defined models increases the likelihood of achieving desired outcomes in students' reasoning, problem-solving, and collaboration. Consequently, learning models are critical for bridging theory and practice in education, providing structure for both teachers and students.

Physical Education is a multidimensional discipline focused on human movement and its role in holistic development. It draws on natural sciences such as anatomy, physiology, kinesiology, biomechanics, and nutrition, as well as social sciences including psychology, sociology, and philosophy of sport (Corbin et al., 2022). The primary objectives of PE in schools include developing motor skills, health, fitness, and character, as well as promoting responsibility, cooperation, and discipline (Fizi et al., 2023; Jadwiszczak et al., 2025; Muhtar et al., 2020). PE provides opportunities for experiential learning through physical activity, supporting both cognitive and socio-emotional development (Baena-Morales et al., 2021; Habyarimana et al., 2022). Effective PE instruction integrates suitable learning models to structure activities, facilitate engagement, and optimize outcomes (Hodges-Kulinna et al., 2024; Shen & Shao, 2022; Simonton et al., 2021; J. Zhang et al., 2024). Physical activities enhance attention, motivation, and memory, providing concrete experiences that support abstract reasoning. Integrating learning objectives with movement ensures that students develop both skill proficiency and conceptual understanding. Teachers play a central role in guiding, scaffolding, and evaluating student performance in PE contexts. PE also provides a

platform for embedding culturally relevant games and activities that promote social interaction. Holistic PE approaches foster physical, cognitive, and emotional growth in elementary learners.

Social interaction in learning emphasizes collaboration, communication, and interpersonal engagement among students. Rooted in Gestalt learning theory, this approach encourages students to perceive knowledge as integrated wholes rather than fragmented components. Instructional strategies include group work, class discussions, social inquiry, role-playing, and social simulations (Doğantan, 2020; Fallah-Karimi et al., 2025). These activities develop empathy, problem-solving skills, and adaptability, fostering collaborative learning experiences. Social interaction also promotes responsibility, self-awareness, and democratic participation in classroom contexts (Carro et al., 2022; Dasci Sonmez & Cemaloglu, 2024). In mathematics and PE, peer collaboration enhances reasoning, critical thinking, and engagement in tasks (Bassachs et al., 2022; Hidayat et al., 2023). Structured social interaction allows students to negotiate ideas, share knowledge, and support each other's learning. Teachers facilitate these processes by designing interactive activities, providing guidance, and monitoring group dynamics. Effective social interaction strengthens both cognitive achievement and socio-emotional competencies. Integrating social interaction into educational models ensures that learning is meaningful, collaborative, and reflective of real-world social contexts.

Traditional games are culturally rooted recreational activities that support children's physical, cognitive, and social development. They encourage decision-making, problem-solving, cooperation, and adherence to rules, contributing to discipline and moral values. Traditional games also preserve cultural heritage and provide meaningful contexts for experiential learning. In educational settings, these games can be adapted to enhance cognitive skills, social interaction, and character development simultaneously. Incorporating traditional games into PE or mathematics instruction fosters engagement, motivation, and practical understanding of abstract concepts. Games such as Ma'hadang, Ma'longga, Massantok, and Maccukke offer structured activities that develop teamwork, empathy, and emotional regulation. Using culturally relevant games strengthens students' identity, social connectedness, and appreciation for heritage. Traditional games can be combined with instructional models to provide scaffolding, assessment, and structured learning outcomes. Integrating physical activity with cognitive tasks ensures that learning is holistic, active, and socially engaging. Overall, traditional games are a valuable medium for designing educational models that cultivate cognitive, social, and physical competencies in elementary learners.

METHOD

Research Design

This study employed a Research and Development (R&D) methodology to create, validate, and evaluate the effectiveness of a Physical Education (PE) learning model through game-based social interaction. The ADDIE model, consisting of Analysis, Design, Development, Implementation, and Evaluation, served as the guiding framework. Each phase was adapted to the context of elementary PE, starting from needs assessment and curriculum review to design of instructional components, model development, expert validation, classroom implementation, and evaluation of practicality and effectiveness. The PE model consisted of a handbook and structured instructional guide integrating traditional games to foster both cognitive and social outcomes. The model emphasized active, student-centered learning with collaborative problem-solving. Iterative feedback from classroom trials and expert reviews informed model refinement. Data were collected to assess cognitive achievement, social interaction, and engagement. The approach ensured alignment with educational objectives while incorporating culturally relevant games. This systematic design aimed to produce a replicable and practical instructional model suitable for elementary PE.

Participants

Participants included twelve PE teachers and their students from selected elementary schools in Bulukumba Regency, South Sulawesi. Schools were selected purposively based on accessibility and adequacy of educational facilities. Student participants represented both genders and diverse academic performance levels to provide a representative sample. For in-depth classroom observation, a smaller group of fifteen students and one PE teacher was selected. Teachers had prior experience in PE and familiarity with traditional games. Informed consent was obtained from all participants and parents prior to participation. Participants were actively involved in model implementation, completing questionnaires and interviews. Demographic information, including age, gender, and school background, was recorded. This participant composition allowed for both generalizable quantitative data and rich qualitative insights. Active involvement enabled evaluation of model practicality, usability, and effectiveness in real classroom contexts.

Instruments

Data were collected using multiple instruments, including expert validation sheets, classroom observation forms, student learning tests, questionnaires, and interview protocols. Observation forms recorded teacher instructional strategies, student participation, and interactions during game-based activities. Questionnaires measured cognitive outcomes, social skills, engagement, and satisfaction using a Likert scale. Interviews captured teacher and student perspectives on model implementation and effectiveness. Expert validators assessed content accuracy, instructional quality, and alignment with PE objectives. Documentation, including lesson plans and student work, provided further evidence of model implementation. All instruments underwent validation and pilot testing to ensure reliability and clarity. Data collection occurred throughout multiple classroom sessions where the model was implemented. Triangulation of sources ensured comprehensive and credible data. Instruments were designed to capture both measurable outcomes and qualitative insights into social and cognitive engagement.

Data Analysis

Quantitative data were analyzed using descriptive statistics, including mean, standard deviation, and percentage agreement. Validity was determined based on expert assessments, with models considered valid if they reached the established “valid” category. Practicality was measured through teacher and student questionnaire responses and interpreted using pre-determined criteria. Effectiveness was evaluated via cognitive outcomes (learning test scores) and affective outcomes (social skills rubrics assessing responsibility, cooperation, discipline, and confidence). Classroom observations recorded student participation levels, categorized from very active to inactive. Qualitative data from observations, interviews, and documentation were analyzed thematically to identify recurring patterns. Coding and categorization highlighted trends in engagement, collaboration, and learning. Triangulation between quantitative and qualitative data enhanced credibility. Data integration allowed comprehensive assessment of model validity, practicality, and effectiveness. Overall, this approach ensured a rigorous evaluation of the instructional model’s impact on learning and social interaction.

Procedure

The research was conducted in three stages: preparation, implementation, and data processing. Preparation included needs assessment, literature review, and expert consultation to inform model design. Implementation involved developing, trialing, and refining the PE learning model in classrooms. Data collection occurred simultaneously, including observations, questionnaires, interviews, and document analysis. The model was applied through structured PE lessons incorporating traditional games and social interaction strategies. Student engagement, collaborative behaviors, and learning outcomes were continuously monitored. Data were processed

to analyze cognitive achievement, social skills, and participation levels. Iterative refinements ensured the model met educational objectives and practical classroom needs. Effectiveness was evaluated through post-test scores, rubrics, and participation data. Findings were synthesized to provide recommendations for replication and broader implementation. The procedure ensured systematic development, validation, and evaluation of a culturally and contextually relevant PE instructional model.

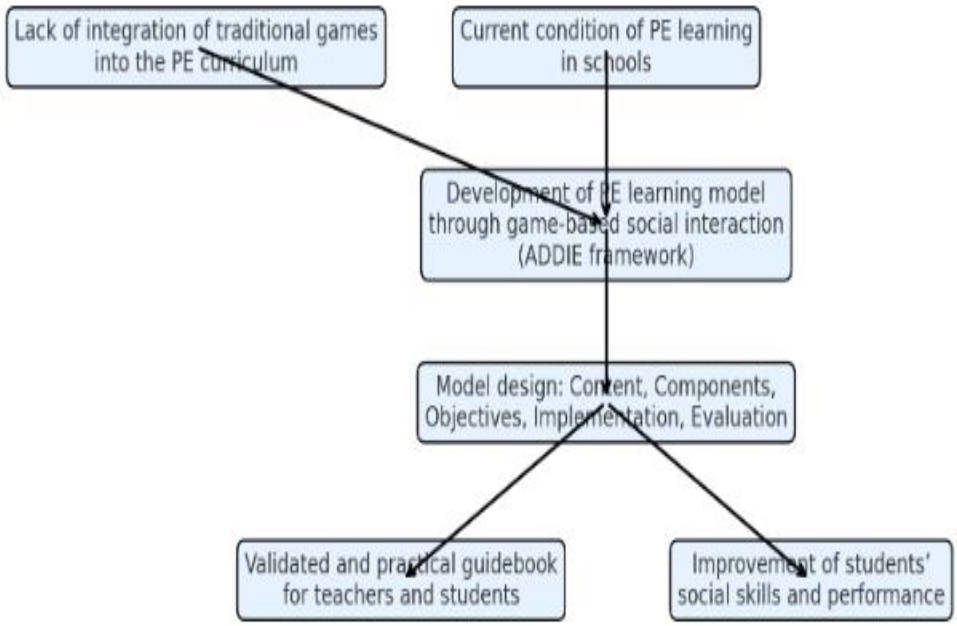

Figure 2. Conceptual framework

RESULTS AND DISCUSSION

Results

Analysis Stage

The initial analysis focused on curriculum implementation, student characteristics, and learning materials to inform the development of the game-based PE instructional model. Interviews with teachers indicated that the 2013 curriculum with integrated thematic learning was applied, emphasizing group discussions and assignments while minimizing lecture methods. Teachers reported the need for greater variety in PE learning, but extracurricular tasks often caused students to work independently, resulting in suboptimal outcomes and unclear understanding of some materials. Many students had no outstanding achievements in PE, and traditional games were largely unfamiliar due to limited facilities. This analysis highlighted the need for a PE learning model based on traditional games to enhance engagement and learning outcomes.

Table 1. Interview results on the curriculum used

No	Question Topic	Response
1	Applied Curriculum	2013 curriculum with integrated thematic learning
2	Frequently Applied PE Learning Methods	Group discussion and assignments; lecture minimized
3	Issues Regarding the Curriculum	PE learning needs variety; extracurricular tasks affect outcomes
4	Content/Material Requiring Development	Traditional game-based PE model needed; students unfamiliar with games

Analysis of student characteristics revealed that the class consisted of 20 fourth-grade students. Learning outcomes were generally satisfactory but varied, with some students progressing slower than others. Interest in PE depended heavily on activity type, with preferences toward modern games such as video games. Lessons required careful preparation to maintain student engagement, and social skill reinforcement was limited. Students expected more varied and complete PE materials to enhance motivation and participation.

Table 4.2. Interview results on student characteristics

No	Question Topic	Response
1	Number of Students	One class of 20 students
2	Student Learning Outcomes	Fairly good on average, but some slower learners
3	Student Interest in PE	Activity enjoyment influences interest; preference for modern games
4	Common Problems	Lessons must be well-prepared; students get bored easily
5	Expectations	Desire for varied and complete PE materials

Interviews regarding learning materials indicated that available resources included government-provided integrated PE textbooks but lacked traditional games and sufficient supporting media. Teachers often relied solely on textbooks, which could make lessons monotonous. The development of instructional materials, including teacher guides and student books that integrate traditional games, was deemed necessary to enhance learning effectiveness.

Table 3. Interview results on learning materials

No	Question Topic	Response
1	Availability of Teaching Materials	Limited; textbooks provided by government lack traditional games
2	Frequency of Use	Textbooks used most; limited play equipment or blackboards
3	Issues	Lessons become monotonous; teacher guide for traditional games needed
4	Expectations	Materials should be comprehensive and varied to enhance motivation
5	Desired Elements	Include PE guidelines based on traditional games, competency links, illustrations, assessment

Design Stage

During the design phase, the instructional model was structured to align basic competencies with social skill development. Lesson plans (RPP) were formulated to integrate objectives with traditional game activities, while student textbooks and teacher guides were drafted to facilitate implementation and assessment. The design ensured cultural relevance, physical engagement, and social interaction.

Table 4. Basic competency development and learning plan

Design Component	Description
Basic Competency Analysis	Identification of competencies and social skill values compatible with traditional games
Lesson Plan (RPP)	Formulated lesson plans aligned with competencies and objectives
Student Textbook	Drafting of learning books focusing on traditional games
Teacher's Guidebook	Preparation of PE guides to facilitate implementation

Development Stage

Validation of the PE learning model, teacher guides, and instructional instruments confirmed all aspects were valid. Mean scores exceeded thresholds for validity across categories including development foundation, language, material-model alignment, planning, implementation, and

assessment. Validation of teacher and student response questionnaires also demonstrated high practical feasibility.

Table 5. Validation results of pe learning model and teacher's guidebook

No	Assessment Aspect	Mean Score ($\bar{x}$)	Ideal Score (Ai)	Category
1	Development Foundation	3.32	3.7	Valid
2	Language	3.32	3.3	Valid
3	Material-Model Alignment	3.32	3.6	Valid
4	Planning of Model	3.32	3.0	Valid
5	Implementation	3.32	3.3	Valid
6	Assessment	3.32	3.1	Valid

Tables 6–10 (Validation of Implementation Instruments, Teacher and Student Questionnaires, Learning Outcome Test, RPP) also confirmed all components as valid, with mean scores consistently above required thresholds, demonstrating readiness for classroom implementation.

Table 6. Validation results of implementation instrument

No	Assessment Aspect	Mean Score ($\bar{x}$)	Ideal Score (Ai)	Category
1	Format	3.44	3.8	Valid
2	Content	3.44	3.5	Valid
3	Language	3.44	3.0	Valid

Table 7. Validation results of teacher response questionnaire

No	Assessment Aspect	Mean Score ($\bar{x}$)	Ideal Score (Ai)	Category
1	Format	3.83	4.0	Valid
2	Content	3.83	3.7	Valid
3	Language	3.83	3.8	Valid

Table 8. Validation results of student response questionnaire

No	Assessment Aspect	Mean Score ($\bar{x}$)	Ideal Score (Ai)	Category
1	Format	3.76	4.0	Valid
2	Content	3.76	3.6	Valid
3	Language	3.76	3.7	Valid

Table 9. Validation results of learning outcome test instrument

No	Assessment Aspect	Mean Score ($\bar{x}$)	Ideal Score (Ai)	Category
1	Content	3.53	4.0	Valid
2	Presentation Format	3.53	3.3	Valid
3	Language	3.53	3.4	Valid
4	Time Allocation	3.53	3.5	Valid

Table 10. Validation Results of Lesson Plan (RPP)

No	Assessment Aspect	Mean Score ($\bar{x}$)	Ideal Score (Ai)	Category
1	Format Component	3.59	3.1	Valid
2	Content Component	3.59	3.7	Valid
3	Language Component	3.59	4.0	Valid

Implementation Stage

During implementation, teacher response questionnaires revealed practicality scores ranging 78–94%, with an average of 89%, indicating high feasibility. Student response questionnaires averaged 92.06%, rated very good. Teachers reported alignment with core competencies, indicators, materials, and evaluation tools. Students actively participated in traditional game-based PE sessions, exhibiting engagement, cooperation, and problem-solving skills.

Table 11. Teacher response questionnaire results

No	Assessment Aspect	Teacher Assessment (SD1–SD5)
1	Thematic Cover Design	5–5 across schools
2	Relevance of Core Competencies and Basic Competencies	4–5 across schools
3	Alignment of Indicators and Objectives	3–5 across schools
4	Alignment of Materials and Learning Objectives	4–5 across schools
5	Alignment of Materials and Learning Evaluation	3–5 across schools
6	Practical and Understandable Teaching Materials	4–5 across schools
7	Suitability of Learning Materials with Student Characteristics	4–5 across schools
8	Clarity and Appropriateness of Language	3–5 across schools
9	Illustrations Supporting Student Understanding	5–5 across schools
10	Relevance of Learning Materials with Achievement Indicators	3–5 across schools

Total Score: 41–47 out of 50

Percentage: 78–94% (Average = 89%)

Source: Appendix 9

Table 12. Student response questionnaire results

No	Trial School	Percentage (%)	Average Percentage (%)
1	SDN 27 Matekko	88.9	92.06
2	SDN 41 Matekko	92.4	
3	SDN 26 Matekko	93.0	
4	SDN 31 Bontomacinna	93.0	
5	SDN 22 Babana	93.0	

Source: Appendix 8

Result: Final average score = **92.06% (Very Good)**.

Table 13. Recapitulation of practicality questionnaire

No	Test Subjects	Percentage (%)	Evaluation Criteria
1	Teachers	89.0	Very Good
2	Students	92.06	Very Good
	Average Score	90.5%	Very Good

Source: Field Test Results

Evaluation Stage

Post-test results demonstrated significant cognitive improvements. The majority of students scored 85–92, surpassing the minimum mastery criterion of 70. Specifically, 65% scored 85–88, and 35% scored 89–92. Social skill assessment indicated an average participation rate of 92.03%, classified as "very active."

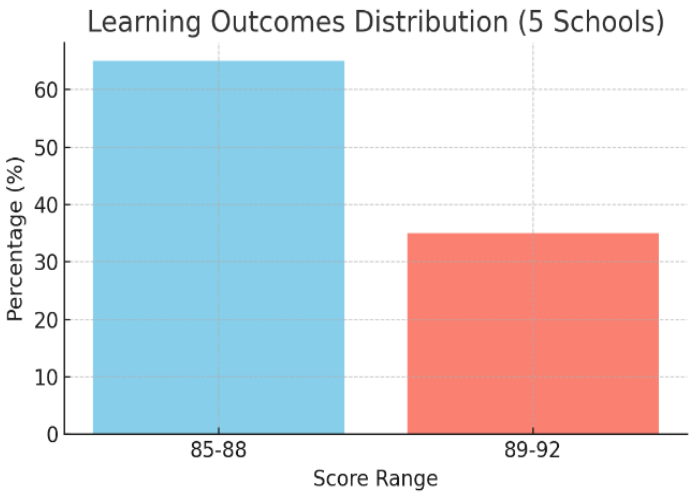

Figure 3. Learning Outcomes Distribution
Most students scored between 85–92, exceeding the minimum mastery criterion (≥70).

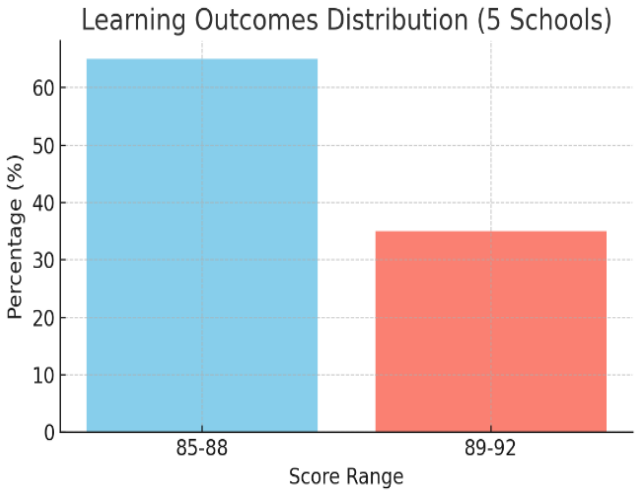

Figure 4. Social Skills Activity Percentage by School
Average participation in social activities reached 92.03%, categorized as very active.

These results indicate that the PE learning model based on traditional games and social interaction was valid, practical, and effective. Students demonstrated both improved cognitive achievement and active engagement in collaborative activities, confirming the model's success in enhancing learning outcomes and social skills.

Discussion

The findings of this study demonstrate the critical importance of conducting a comprehensive needs analysis at the initial stage of research and development in Physical Education (PE). Teachers and students in the examined elementary schools in Bulukumba, South Sulawesi, expressed a need for an innovative PE learning model that simultaneously enhances cognitive outcomes and social skills. Observations revealed that the 2013 Curriculum was applied rigidly without integrating traditional games or social interaction strategies, reflecting a misalignment with students' learning needs. This gap highlights the necessity of designing a learning model that is responsive, culturally relevant, and pedagogically sound. Similar evidence from previous studies supports the idea that educational products must be adapted to student needs to maximize engagement and learning outcomes (Bond et al., 2020; El-Sabagh, 2021; Md Sabri et al., 2024; Plooy et al., 2024). The incorporation of traditional games into PE represents a practical strategy to bridge the gap between

curriculum requirements and student-centered learning. Needs analysis also revealed that students' motivation and interest depended heavily on the interactive and enjoyable nature of the activities, emphasizing the role of engagement in learning effectiveness. Furthermore, a well-structured instructional model can mitigate challenges related to limited teaching resources and classroom constraints. This confirms prior findings indicating that careful situational analysis is essential for developing effective learning interventions. Overall, the study underscores the relevance of aligning instructional models with contextual and learner-specific factors.

The validity of the developed PE learning model was confirmed through expert evaluation, with lesson plans and guidebooks achieving mean scores of 3.59 and 3.32, respectively. These results indicate that the instructional materials meet established quality standards for content accuracy, coherence, and alignment with learning objectives. Prior research has similarly emphasized that expert validation is essential to ensure that instructional products are theoretically and practically sound (Abuhassna & Alnawajha, 2023; Suh et al., 2023). The inclusion of culturally appropriate traditional games enhanced model relevance while maintaining pedagogical rigor. Expert assessments focused on clarity, appropriateness, and usability, consistent with standards for educational product validation. The iterative process of review and revision contributed to refining the learning model to suit classroom realities. This step aligns with literature highlighting that validated instructional resources increase teacher confidence and improve implementation fidelity. Moreover, model validity ensures that the designed activities can reliably support intended learning outcomes. Comparisons with other studies of PE instructional design demonstrate that expert validation strengthens both cognitive and affective learning results. Therefore, the high validation scores confirm the model's robustness and readiness for practical application.

Practicality testing indicated that the model was highly feasible, with teachers rating it at 89% and students at 92.06%, both categorized as "very practical". These results suggest that the learning model can be readily applied within typical classroom conditions. Teachers reported that the model's step-by-step instructions, integration of traditional games, and alignment with competencies facilitated lesson delivery. Student responses confirmed engagement, motivation, and enjoyment during activities, demonstrating the model's adaptability to learners' needs. Prior studies on instructional model practicality support the notion that user-friendly and contextually appropriate materials enhance classroom implementation (Ondrada et al., 2024). The positive feedback also highlights the ability of traditional game-based approaches to stimulate active participation, collaboration, and self-directed learning (Asyhari et al., 2023; Butcher & Ferguson, 2023; Cheng et al., 2026; Pacheco-Velazquez et al., 2024). Practicality is crucial for sustainability, as models that are easy to implement are more likely to be adopted consistently. Classroom trials showed that the model accommodated differences in students' abilities and maintained participation across all learners. Furthermore, teachers could implement the activities without extensive additional resources, ensuring cost-effectiveness and accessibility. Overall, practicality results confirm that the model is suitable for real educational settings and capable of supporting sustained use.

Effectiveness testing demonstrated that the game-based social interaction model significantly improved both cognitive learning outcomes and social skills. Students achieved average social skill scores between 3.6 and 3.7, placing them in the "very effective" category. These results align with prior research indicating that traditional games enhance cognitive performance while promoting responsibility, cooperation, and confidence among students. Classroom observations confirmed that students actively engaged in collaborative tasks, applied problem-solving strategies, and exhibited interpersonal skills throughout PE activities. The integration of traditional games created a meaningful context, allowing students to internalize social norms and apply learned skills. Effectiveness was observed not only in measured outcomes but also in students' attitudes,

motivation, and engagement during lessons. Comparisons with conventional PE practices indicate that static, lecture-based instruction fails to achieve similar gains in both social and cognitive domains. These findings are consistent with the literature suggesting that experiential and activity-based learning approaches are more effective in promoting holistic development. The results reinforce the value of combining cognitive, social, and physical elements to maximize learning outcomes. Thus, the model demonstrates both pedagogical and practical effectiveness in elementary PE.

Finally, the overall findings demonstrate that the PE learning model is valid, practical, and effective in enhancing students' holistic development. Social skills such as empathy, cooperation, communication, and problem-solving were reinforced alongside cognitive learning, indicating that traditional games serve as a conduit for comprehensive education. The study highlights the integration of student-centered, culturally relevant, and interactive strategies in promoting both engagement and learning outcomes. Comparisons with similar research indicate that embedding cultural and social elements in instructional models significantly improves students' motivation, participation, and achievement. Teacher and student feedback confirmed that the model was user-friendly, contextually adaptable, and effective across varying classroom conditions. The findings emphasize that holistic learning in PE requires a balance of cognitive, affective, and social components. Moreover, traditional games serve as an accessible and low-cost medium to achieve these objectives. The study contributes to the growing literature on culturally grounded, interactive PE learning models in elementary education. Overall, the model offers a replicable and effective approach to integrate cognitive and social skill development through engaging and meaningful activities.

Implications

The findings of this study have several significant implications for the design and implementation of Physical Education (PE) programs in elementary schools. First, integrating traditional games into PE lessons provides a culturally relevant framework that enhances student engagement and motivation, demonstrating the potential to bridge the gap between curriculum requirements and students' learning needs. Second, the incorporation of game-based social interaction supports the development of essential social skills such as cooperation, empathy, communication, and responsibility, which are critical for holistic student development. Third, the validated model serves as a practical tool for teachers, offering structured lesson plans, instructional guides, and assessment rubrics that can be readily applied in classroom settings. Fourth, the model highlights the importance of aligning cognitive, affective, and physical learning objectives to create meaningful and immersive learning experiences. Fifth, positive teacher and student responses indicate that contextually grounded and student-centered approaches can be successfully implemented even with limited resources. Sixth, the study provides evidence that experiential learning through traditional games can improve both cognitive outcomes and social competencies simultaneously. Seventh, the findings underscore the role of iterative validation and expert feedback in ensuring instructional quality and classroom feasibility. Eighth, implementing such models encourages teachers to adopt innovative strategies, moving away from rigid, lecture-based approaches toward active and participatory learning. Ninth, the study reinforces the value of culturally embedded educational practices for fostering identity, motivation, and engagement. Tenth, the model can inform policymakers and curriculum designers seeking to enhance PE programs by integrating both cognitive and social development outcomes. Eleventh, the approach is adaptable and scalable to other schools with similar contexts, offering a replicable framework for broader educational application. Finally, these results suggest that combining traditional games, social

interaction, and structured instructional design can serve as a model for improving holistic educational outcomes in primary education.

Limitations and Suggestions for Future Research

This study presents several limitations that should be considered when interpreting the findings. First, the research was conducted in a limited geographical context, involving a small number of elementary schools in Bulukumba, South Sulawesi, which may affect the generalizability of the results. Second, the sample size for both teachers and students was relatively small, potentially limiting statistical robustness and the diversity of responses. Third, the study focused primarily on traditional games and did not compare the model with other innovative or digital game-based approaches. Fourth, the evaluation of social skills relied on teacher observation and self-report questionnaires, which may be influenced by subjectivity or social desirability bias. Fifth, the study was conducted over a relatively short implementation period, limiting insights into long-term effects on cognitive and social outcomes. Sixth, resource limitations such as available play equipment and classroom space may have affected the fidelity of implementation. Seventh, the model's effectiveness was tested in a controlled classroom setting, and results may differ in larger or less structured environments. Eighth, cultural specificity may restrict the applicability of traditional games in regions with different local games or customs. Ninth, the research did not explore potential gender differences in engagement or social skill development, which could provide deeper understanding of instructional effects. Tenth, interactions between cognitive and affective learning outcomes were not examined in detail. Eleventh, future studies could incorporate longitudinal designs to assess sustained impacts of the PE model on social and academic development. Finally, further research should explore integration with digital or hybrid game-based interventions, cross-cultural adaptations, and comparative effectiveness studies to expand the model's applicability and validate its impact across diverse educational settings.

CONCLUSION

The development of a Physical Education (PE) learning model through social interaction based on traditional games successfully addressed both cognitive and social skill needs of fourth-grade students. The needs analysis revealed the necessity for a structured PE learning guide, integration of traditional game materials, and reinforcement of character and social skills within the curriculum. The prototype model was designed with a comprehensive guidebook, including an introduction, theoretical background, learning concepts and syntax, planning and implementation procedures, assessment, and references. Expert validation confirmed the model's content, structure, and instructional quality, establishing its validity for classroom use. Practicality assessments from both teachers and students demonstrated high feasibility and usability, with average scores of 89% and 92%, respectively. Implementation of the model showed significant improvements in student learning outcomes and social skills, indicating that the approach effectively enhances both academic and interpersonal development. Traditional games provided a culturally relevant and engaging context that promoted active participation, collaboration, and experiential learning. The model also allowed teachers to deliver student-centered, interactive lessons efficiently, even within limited resource settings. Overall, the model proved to be valid, practical, and effective, offering a holistic framework that integrates cognitive, social, and physical development. Its success highlights the importance of culturally grounded and interactive PE approaches for enhancing student engagement and learning outcomes. This model provides a replicable and sustainable framework for improving PE instruction in elementary education. Finally, it demonstrates that combining structured learning guidance with traditional games can effectively foster holistic development and lifelong skills in students.

AUTHOR CONTRIBUTIONS STATEMENT

Nurhikmah was responsible for the research conceptualization, development of the game-based PE instructional model, design and structuring of learning guides, classroom implementation, data collection, and drafting of the manuscript. Suhartiwi contributed to research supervision, methodological validation, instructional evaluation, interpretation of research findings, and critical revision of the manuscript. Both authors participated in the development of the theoretical framework, validation of instructional materials, analysis and triangulation of qualitative and quantitative data, and final manuscript review. All authors actively discussed the findings, approved the final version of the manuscript, and agreed to be accountable for all aspects of the research.

REFERENCES

Abuhassna, H., Adnan, M. A. B. M., & Awae, F. (2024). Exploring the synergy between instructional design models and learning theories: A systematic literature review. *Contemporary Educational Technology, 16*(2), ep499. https://doi.org/10.30935/cedtech/14289

Abuhassna, H., & Alnawajha, S. (2023). Instructional design made easy! Instructional design models, categories, frameworks, educational context, and recommendations for future work. *European Journal of Investigation in Health, Psychology and Education, 13*(4), 715–735. https://doi.org/10.3390/ejihpe13040054

Ahdhianto, E., Barus, Y. K., & Thohir, M. A. (2025). Augmented reality as a game changer in experiential learning: Exploring its role in cultural education for elementary schools. *Journal of Pedagogical Research, 9*(1), 296–313. https://doi.org/10.33902/JPR.202533573

Araújo, L. A. de, Veloso, C. F., Souza, M. de C., Azevedo, J. M. C. de, & Tarro, G. (2021). The potential impact of the COVID-19 pandemic on child growth and development: A systematic review. *Jornal de Pediatria, 97*(4), 369–377. https://doi.org/10.1016/j.jped.2020.08.008

Asyhari, A., Sunyono, S., Haenilah, E. Y., & Hariri, H. (2023). A systematic review of self-directed learning: Empirical evidence from STEM teaching and learning. *Review of Science, Mathematics and ICT Education, 17*(2), 47–74. https://doi.org/10.26220/rev.4501

Bado, N. (2022). Game-based learning pedagogy: A review of the literature. *Interactive Learning Environments, 30*(5), 936–948. https://doi.org/10.1080/10494820.2019.1683587

Baena-Morales, S., Jerez-Mayorga, D., Delgado-Floody, P., & Martínez-Martínez, J. (2021). Sustainable development goals and physical education: A proposal for practice-based models. *International Journal of Environmental Research and Public Health, 18*(4). https://doi.org/10.3390/ijerph18042129

Bassachs, M., Serra, T., Bubnys, R., Cañabate, D., & Colomer, J. (2022). Multimodal approaches to math and physical education within cooperative learning to enhance social attitudes. *Sustainability, 14*(24). https://doi.org/10.3390/su142416961

Behnamnia, N., Kamsin, A., & Ismail, M. A. B. (2020). The landscape of research on the use of digital game-based learning apps to nurture creativity among young children: A review. *Thinking Skills and Creativity, 37*, 100666. https://doi.org/10.1016/j.tsc.2020.100666

Bond, M., Buntins, K., Bedenlier, S., Zawacki-Richter, O., & Kerres, M. (2020). Mapping research in student engagement and educational technology in higher education: A systematic evidence map. *International Journal of Educational Technology in Higher Education, 17*(1), 2. https://doi.org/10.1186/s41239-019-0176-8

Brown, C. E. B., Richardson, K., Halil-Pizzirani, B., Atkins, L., Yücel, M., & Segrave, R. A. (2024). Key influences on university students' physical activity: A systematic review using the theoretical domains framework and the COM-B model of human behaviour. *BMC Public Health, 24*(1), 418. https://doi.org/10.1186/s12889-023-17621-4

Butcher, L., & Ferguson, G. (2023). Harnessing "play" (beyond games) to enhance self-directed learning in VET. *Journal of Vocational Education & Training, 75*(5), 971–990. https://doi.org/10.1080/13636820.2021.1989621

Carro, N., Kuperman, M., D'adamo, P., & Lozada, M. (2022). Social relationships in children: Favourable influence of activities promoting self-awareness and empathic interaction. *Journal of Complex Networks, 10*(1), cnab049. https://doi.org/10.1093/comnet/cnab049

Cheng, C.-Y., Chang, C.-Y., & Hwang, G.-J. (2026). Metaverse game-based self-directed learning in professional education: A multimethod analysis of learning achievement, self-efficacy, empathy, critical thinking, and behavioral analytics. *Journal of Educational Computing Research*, 07356331261450650. https://doi.org/10.1177/07356331261450650

Chinoperekweyi, J., Ojung'a, A. M., & Tonodzai, T. D. (n.d.). Fostering strategic change through organization learning and continuous improvement.

Corbin, C. B., Yu, H., & Gill, D. L. (2022). The importance of textbooks in kinesiology. *Kinesiology Review, 11*(3), 261–269. https://doi.org/10.1123/kr.2022-0001

Dasci Sonmez, E., & Cemaloglu, N. (2024). Distributed leadership, self-awareness, democracy, and sustainable development: Towards an integrative model of school effectiveness. *Educational Research and Evaluation, 29*(7–8), 538–565. https://doi.org/10.1080/13803611.2024.2386638

De Felice, S., Hamilton, A. F. de C., Ponari, M., & Vigliocco, G. (2022). Learning from others is good, with others is better: The role of social interaction in human acquisition of new knowledge. *Philosophical Transactions of the Royal Society B: Biological Sciences, 378*(1870), 20210357. https://doi.org/10.1098/rstb.2021.0357

de Groot, I., & Lo, J. (2021). The democratic school experiences framework: A tool for the design and self-assessment of democratic experiences in formal education. *Education, Citizenship and Social Justice, 16*(3), 211–226. https://doi.org/10.1177/1746197920971810

Dezfoulian, D., & Nemati, A. (2025). From playground to cultural ground: The youth-driven revival of traditional Iranian games for intangible cultural heritage preservation. *Museum International, 77*(1–2), 118–131. https://doi.org/10.1080/13500775.2025.2540217

Doğantan, D. E. (2020). An interactive instruction model design with role play technique in distance education: A case study in open education system. *Journal of Hospitality, Leisure, Sport & Tourism Education, 27*, 100268. https://doi.org/10.1016/j.jhlste.2020.100268

Dudley, D. A. (2025). Educating character through quality physical education: A pedagogical model. *Quest, 77*(3), 449–466. https://doi.org/10.1080/00336297.2025.2473423

El-Sabagh, H. A. (2021). Adaptive e-learning environment based on learning styles and its impact on development students' engagement. *International Journal of Educational Technology in Higher Education, 18*(1), 53. https://doi.org/10.1186/s41239-021-00289-4

Espoz-Lazo, S., Huete, R. R., Espoz-Lazo, P., Farías-Valenzuela, C., & Valdivia-Moral, P. (2020). Emotional education for the development of primary and secondary school students through physical education: Literature review. *Education Sciences, 10*(8). https://doi.org/10.3390/educsci10080192

Es-Sajjade, A., & Paas, F. (2020). Educational theories and computer game design: Lessons from an experiment in elementary mathematics education. *Educational Technology Research and Development, 68*(5), 2685–2703. https://doi.org/10.1007/s11423-020-09799-w

Fallah-Karimi, S., Ghaljaie, F., & Khalilzadeh-Farsangi, Z. (2025). Comparison of the effects of role-playing, small group discussion, and traditional teaching methods on nursing students' self-efficacy. *BMC Medical Education, 25*(1), 1354. https://doi.org/10.1186/s12909-025-07996-w

Fauzan, A., Harisman, Y., Yerizon, Y., Suherman, S., Tasman, F., Nisa, S., Sumarwati, S., Hafizatunnisa, H., & Syaputra, H. (2024). Realistic mathematics education (RME) to improve literacy and numeracy skills of elementary school students based on teachers' experience. *Infinity Journal, 13*(2), 301–316. https://doi.org/10.22460/infinity.v13i2.p301-316

Fizi, R. M., Winarni, S., Guntur, & Hartanto, A. (2023). A game model in physical education to improve motor skills, cooperation, and discipline of primary school learners. *Pedagogy of Physical Culture and Sports, 27*(6), 448–455. https://doi.org/10.15561/26649837.2023.0602

Fong Yan, A., Nicholson, L. L., Ward, R. E., Hiller, C. E., Dovey, K., Parker, H. M., Low, L.-F., Moyle, G., & Chan, C. (2024). The effectiveness of dance interventions on psychological and cognitive health outcomes compared with other forms of physical activity: A systematic review with meta-analysis. *Sports Medicine, 54*(5), 1179–1205. https://doi.org/10.1007/s40279-023-01990-2

Garaigordobil, M., Berrueco, L., & Celume, M.-P. (2022). Developing children's creativity and social-emotional competencies through play: Summary of twenty years of findings of the evidence-

based interventions "Game Program." *Journal of Intelligence, 10*(4). https://doi.org/10.3390/jintelligence10040077

Gonzalez, F. H. (2023). Exploring the affordances of place-based education for advancing sustainability education: The role of cognitive, socio-emotional and behavioural learning. *Education Sciences, 13*(7). https://doi.org/10.3390/educsci13070676

Greipl, S., Moeller, K., & Ninaus, M. (2020). Potential and limits of game-based learning. *International Journal of Technology Enhanced Learning, 12*(4), 363–389. https://doi.org/10.1504/IJTEL.2020.110047

Gutierrez-Gutierrez, L., & Antony, J. (2019). Continuous improvement initiatives for dynamic capabilities development: A systematic literature review. *International Journal of Lean Six Sigma, 11*(1), 125–149. https://doi.org/10.1108/IJLSS-07-2018-0071

Habyarimana, J. de D., Tugirumukiza, E., & Zhou, K. (2022). Physical education and sports: A backbone of the entire community in the twenty-first century. *International Journal of Environmental Research and Public Health, 19*(12). https://doi.org/10.3390/ijerph19127296

Heid, H., Jüttler, M., & Kärner, T. (2023). Participation in the classroom as a basis for democracy education? A conceptual analysis of the concept of student participation. *Frontiers in Political Science, 5*. https://doi.org/10.3389/fpos.2023.1225620

Hidayat, C., Lengkana, A. S., Rohyana, A., Purwanto, D., Razali, & Rosalina, M. (2023). Motivating active learning in physical education: Critical thinking. *European Journal of Educational Research, 12*(2), 1137–1151. https://doi.org/10.12973/eu-jer.12.2.1137

Hodges-Kulinna, P., Wahl-Alexander, Z., Nam, K., & Kinder, C. (2024). Effective instruction and curricular models: What do we know about student learning outcomes in physical education? *Kinesiology Review, 13*(2), 161–175. https://doi.org/10.1123/kr.2024-0009

Holbein, J. B., Hillygus, D. S., Lenard, M. A., Gibson-Davis, C., & Hill, D. V. (2020). The development of students' engagement in school, community and democracy. *British Journal of Political Science, 50*(4), 1439–1457. https://doi.org/10.1017/S000712341800025X

Hossain, K. I. (2024). Reviewing the role of culture in English language learning: Challenges and opportunities for educators. *Social Sciences & Humanities Open, 9*, 100781. https://doi.org/10.1016/j.ssaho.2023.100781

Hu, D., Zhou, S., Crowley-McHattan, Z. J., & Liu, Z. (2021). Factors that influence participation in physical activity in school-aged children and adolescents: A systematic review from the social ecological model perspective. *International Journal of Environmental Research and Public Health, 18*(6). https://doi.org/10.3390/ijerph18063147

Ismoyo, I., Nasrulloh, A., Hermawan, H. A., & Ihsan, F. (2024). Health benefits of traditional games: A systematic review. *Retos: Nuevas Tendencias En Educación Física, Deporte y Recreación, 59*, 843–856. https://doi.org/10.47197/retos.v59.107467

Jabeen, Q., Nadeem, M. S., Raziq, M. M., & Sajjad, A. (2022). Linking individuals' resources with (perceived) sustainable employability: Perspectives from conservation of resources and social information processing theory. *International Journal of Management Reviews, 24*(2), 233–254. https://doi.org/10.1111/ijmr.12276

Jadwiszczak, M., Wawrzyniak, S., & Pezdek, K. (2025). More than movement: A systematic review of moral and social development in adolescents physical education. *BMC Public Health, 25*(1), 2076. https://doi.org/10.1186/s12889-025-23169-2

Jukić Matić, L., & Glasnović Gracin, D. (2021). How do teacher guides give support to mathematics teachers? Analysis of a teacher guide and exploration of its use in teachers' practices. *Research in Mathematics Education, 23*(1), 1–20. https://doi.org/10.1080/14794802.2019.1710554

Kalajas-Tilga, H., Koka, A., Hein, V., Tilga, H., & Raudsepp, L. (2020). Motivational processes in physical education and objectively measured physical activity among adolescents. *Journal of Sport and Health Science, 9*(5), 462–471. https://doi.org/10.1016/j.jshs.2019.06.001

Kim, J., & Maher, M. L. (2020). Conceptual metaphors for designing smart environments: Device, robot, and friend. *Frontiers in Psychology, 11*. https://doi.org/10.3389/fpsyg.2020.00198

Lavega-Burgués, P., Bortoleto, M. A. C., & Pic, M. (2021). Editorial: Traditional sporting games and play: Enhancing cultural diversity, emotional well-being, interpersonal relationships and intelligent decisions. *Frontiers in Psychology, 12*. https://doi.org/10.3389/fpsyg.2021.766625

Lazić, B. D., Knežević, J. B., & Maričić, S. M. (2021). The influence of project-based learning on student achievement in elementary mathematics education. *South African Journal of Education, 41*(3), 1–10. https://doi.org/10.15700/saje.v41n3a1909

Levy, B. L. M., Busey, C. L., Cuenca, A., Evans, R. W., Halvorsen, A.-L., Ho, L.-C., Kahne, J., Kissling, M. T., Lo, J. C., McAvoy, P., & McGrew, S. (2023). Social studies education research for sustainable democratic societies: Addressing persistent civic challenges. *Theory & Research in Social Education, 51*(1), 1–46. https://doi.org/10.1080/00933104.2022.2158149

Li, P., & Jeong, H. (2020). The social brain of language: Grounding second language learning in social interaction. *npj Science of Learning, 5*(1), 8. https://doi.org/10.1038/s41539-020-0068-7

Luo, M., Chano, J., Chittranun, T., Shu, Y., & Nithideechaiwarachok, B. (2023). The development of an instructional model to promote Chinese reading and writing skills for university students. *Frontiers in Education, 8*. https://doi.org/10.3389/feduc.2023.1189016

Mallek, F., Mazhar, T., Shah, S. F. A., Ghadi, Y. Y., & Hamam, H. (2024). A review on cultivating effective learning: Synthesizing educational theories and virtual reality for enhanced educational experiences. *PeerJ Computer Science, 10*, e2000. https://doi.org/10.7717/peerj-cs.2000

Mayr, H. C., & Thalheim, B. (2021). The triptych of conceptual modeling. *Software and Systems Modeling, 20*(1), 7–24. https://doi.org/10.1007/s10270-020-00836-z

Md Sabri, S., Ismail, I., Annuar, N., Abdul Rahman, N. R., Abd Hamid, N. Z., & Abd Mutalib, H. (2024). A conceptual analysis of technology integration in classroom instruction towards enhancing student engagement and learning outcomes. *International Journal of Education, Psychology and Counseling, 9*(55), 750–769. https://doi.org/10.35631/IJEPC.955051

Merino-Campos, C. (2025). Emotions in motion: A literature review of emotional experiences in physical education through video game practices. *Social Sciences & Humanities Open, 11*, 101415. https://doi.org/10.1016/j.ssaho.2025.101415

Muhtar, T., Supriyadi, T., & Lengkana, A. S. (2020). Character development-based physical education learning model in primary school. *International Journal of Human Movement and Sports Sciences, 8*(6), 337–354. https://doi.org/10.13189/saj.2020.080605

Nazari, S., Hossini, R. N. S., Norouzi, E., Manzano-Sánchez, D., & Pill, S. (2025). Combined teaching games for understanding and sport education in PE can improve student emotion regulation, intrapersonal intelligence and psychomotor skills. *Acta Psychologica, 261*, 105812. https://doi.org/10.1016/j.actpsy.2025.105812

Ondrada, J., Mario, J., Makilan, N., Langcoy, M., & Acanto, R. (2024). Innovative contextualized instructional materials utilizing ethanolic crude extract from blue porter weed (*Stachytarpheta Jamaicensis*) for enhancing science learning in the Philippines. *Edelweiss Applied Science and Technology, 8*, 1740–1772. https://doi.org/10.55214/25768484.v8i5.1894

Pacheco-Velazquez, E., Rodés Paragarino, V., Glasserman, L. D., & Carlos Arroyo, M. (2024). Playing to learn: Developing self-directed learning skills through serious games. *Journal of International Education in Business, 17*(3), 416–430. https://doi.org/10.1108/JIEB-08-2023-0054

Parker, R., Thomsen, B. S., & Berry, A. (2022). Learning through play at school - A framework for policy and practice. *Frontiers in Education, 7*. https://doi.org/10.3389/feduc.2022.751801

Parra, P. A. S., López, A. B., Rojas, M. A., & Hurtado, K. S. C. (2025). Socio-emotional development in childhood - Playful-pedagogical strategies: A review of the literature. *TPM - Testing, Psychometrics, Methodology in Applied Psychology, 32*(S5), 888–900.

Pellegrini, M., Lake, C., Neitzel, A., & Slavin, R. E. (2021). Effective programs in elementary mathematics: A meta-analysis. *AERA Open, 7*, 2332858420986211. https://doi.org/10.1177/2332858420986211

Plooy, E. du, Casteleijn, D., & Franzsen, D. (2024). Personalized adaptive learning in higher education: A scoping review of key characteristics and impact on academic performance and engagement. *Heliyon, 10*(21). https://doi.org/10.1016/j.heliyon.2024.e39630

Prabucki, B., & Rozmiarek, M. (2025). Integrating traditional sports and games into outdoor recreation for sustainable development: Current approaches and future directions. *Sustainability, 17*(22). https://doi.org/10.3390/su172210343

Quispe Munares, M. L., Christian Pérez-Ruiz, J., Álvarez Chávez, W., Choccata Cruz, E. A., Los Ríos, T. C.-D., & Caira Huanca, L. A. (2025). Traditional games in basic education: A literature review on

their impact on integral development and cultural identity. *TPM: Testing, Psychometrics, Methodology in Applied Psychology, 32*, 371.

Rahmani, P., Peruani, F., & Romanczuk, P. (2020). Flocking in complex environments—Attention trade-offs in collective information processing. *PLOS Computational Biology, 16*(4), e1007697. https://doi.org/10.1371/journal.pcbi.1007697

Rakhoveio, P. S., Gill, R., & Veimy, M. (2025). Role of traditional games in shaping cultural identity and strengthening community cohesion. *Human Arenas.* https://doi.org/10.1007/s42087-025-00534-6

Renninger, K. A., & Hidi, S. E. (2022). Interest development, self-related information processing, and practice. *Theory Into Practice, 61*(1), 23–34. https://doi.org/10.1080/00405841.2021.1932159

Rico-González, M. (2023). Developing emotional intelligence through physical education: A systematic review. *Perceptual and Motor Skills, 130*(3), 1286–1323. https://doi.org/10.1177/00315125231165162

Rossoni, A. L., de Vasconcellos, E. P. G., & de Castilho Rossoni, R. L. (2024). Barriers and facilitators of university-industry collaboration for research, development and innovation: A systematic review. *Management Review Quarterly, 74*(3), 1841–1877. https://doi.org/10.1007/s11301-023-00349-1

Samuelsson, R. (2023). Leveraging play for learning and development: Incorporating cultural-evolutionary insights into early educational practices. *Mind, Brain, and Education, 17*(2), 75–85. https://doi.org/10.1111/mbe.12347

Sawyer, A. G., Dredger, K., Myers, J., Barnes, S., Wilson, R., Sullivan, J., & Sawyer, D. (2020). Developing teachers as critical curators: Investigating elementary preservice teachers' inspirations for lesson planning. *Journal of Teacher Education, 71*(5), 518–536. https://doi.org/10.1177/0022487119879894

Schoevers, E. M., Leseman, P. P. M., & Kroesbergen, E. H. (2020). Enriching mathematics education with visual arts: Effects on elementary school students' ability in geometry and visual arts. *International Journal of Science and Mathematics Education, 18*(8), 1613–1634. https://doi.org/10.1007/s10763-019-10018-z

Shen, Y., & Shao, W. (2022). Influence of hybrid pedagogical models on learning outcomes in physical education: A systematic literature review. *International Journal of Environmental Research and Public Health, 19*(15). https://doi.org/10.3390/ijerph19159673

Simonton, K. L., Layne, T. E., & Irwin, C. C. (2021). Project-based learning and its potential in physical education: An instructional model inquiry. *Curriculum Studies in Health and Physical Education, 12*(1), 36–52. https://doi.org/10.1080/25742981.2020.1862683

Suh, J. K., Hand, B., Dursun, J. E., Lammert, C., & Fulmer, G. (2023). Characterizing adaptive teaching expertise: Teacher profiles based on epistemic orientation and knowledge of epistemic tools. *Science Education, 107*(4), 884–911. https://doi.org/10.1002/sce.21796

Tondeur, J., Petko, D., Christensen, R., Drossel, K., Starkey, L., Knezek, G., & Schmidt-Crawford, D. A. (2021). Quality criteria for conceptual technology integration models in education: Bridging research and practice. *Educational Technology Research and Development, 69*(4), 2187–2208. https://doi.org/10.1007/s11423-020-09911-0

Yang, Y., Chen, Y., & Shi, J. (2024). A study on the application of the integrated theory and practice teaching model in public administration: A case study of the course "Simulated Training in Public Administration." *Higher Education and Practice, 1*(3), 103–110. https://doi.org/10.62381/H241319

Yurkofsky, M. M., Peterson, A. J., Mehta, J. D., Horwitz-Willis, R., & Frumin, K. M. (2020). Research on continuous improvement: Exploring the complexities of managing educational change. *Review of Research in Education, 44*(1), 403–433. https://doi.org/10.3102/0091732X20907363

Zhang, H., Chen, P., Xie, X., Jiang, Z., Zhou, Z., & Sun, L. (2024). A hybrid prototype method combining physical models and generative artificial intelligence to support creativity in conceptual design. *ACM Transactions on Computer-Human Interaction, 31*(5), 65:1–65:34. https://doi.org/10.1145/3689433

Zhang, J., Soh, K. G., Bai, X., Anuar, M. A. M., & Xiao, W. (2024). Optimizing learning outcomes in physical education: A comprehensive systematic review of hybrid pedagogical models

integrated with the Sport Education Model. *PLOS ONE, 19*(12), e0311957. https://doi.org/10.1371/journal.pone.0311957

Zhu, L., Wu, L., Xu, X., & Chen, X. (2024). Exploring pathways for stimulating cultural services in rural ecosystems through experiential learning education. *Sustainability, 16*(18). https://doi.org/10.3390/su16188117