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Literature Study: Integration of Ethnophysics through Traditional Games in Sustainable Physics Learning

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ABSTRACT

Objective: *This study aims to examine the potential integration of ethnophysics through traditional games in sustainable physics learning. This approach is expected to produce learning that is interactive, conceptual, and relevant to local cultural values while answering the challenges in education in the modern era.* ***Method:*** *This research employs a descriptive approach, utilizing a systematic literature review method or literature study. Literature review research consists of several stages, including problem formulation, research, literature search, determination of inclusion and exclusion criteria, literature selection, data presentation, data processing, and conclusion.* ***Results:*** *The results demonstrated that this method was effective in enhancing students' understanding of physics concepts while preserving local culture. Traditional games are also considered relevant in facing learning challenges, such as low digital literacy skills and limited internet access. Additionally, this integration supports the Sustainable Development Goals, particularly in achieving quality education (SDG 4) and preserving local culture (SDG 11).* ***Novelty:*** *The uniqueness of this research lies in the combination of local wisdom values with physics learning, as it creates relevant, meaningful, and sustainable learning experiences. This research can also explore the integration of traditional games in physics education across various cultural contexts and educational levels. This combination offers an innovative approach that enhances conceptual understanding and reinforces local cultural identity.*

INTRODUCTION

Education plays a crucial role not only in individual development but also in a nation's progress (Anggraini & Nugraheni, 2024). However, education also serves as a strategic key to achieving the Sustainable Development Goals (SDGs) set by the United Nations (UN) from 2016 to 2030 (Irhamsyah, 2019). The SDGs are an advanced program that builds upon the MDGs, or Millennium Development Goals, which involve many developed, developing, and less developed countries (Patiung, 2019). The SDGs, also known as the "Global Goals," are universal actions aimed at meeting the needs of a country without sacrificing the needs of current and future generations (Ramadani & Nugraheni, 2024). The SDGs contain 17 goals covering poverty, hunger, health, education, climate change, water, sanitation, energy, environment, and social justice (Syafutra et al., 2023), as well as 169 targets that become global action plans for the next 15 years to end poverty, protecting the earth and ensuring that all people can enjoy a peaceful and prosperous life (Witarti et al., 2021). One of the strategies in implementing the SDGs on education lies in the 4th goal, namely "ensuring quality education that is

equal, inclusive, and supports lifelong learning opportunities for all people" (Safitri et al., 2022). Quality education is one of the key goals of the Sustainable Development Goals (SDGs), which aim to ensure that education is inclusive and equitable and provides lifelong learning opportunities (Raharjo, 2016). Thus, education is not only considered as a means to improve the quality of human resources but also as a foundation for building a more just, equal, and sustainable society (Chankseliani & McCowan, 2021).

Additionally, education is also expected to serve as a means of preserving local cultural values, aligning with SDG 11 on sustainable cities and communities (Idrus et al., 2024). Sustainable cities and communities emphasize the importance of preserving cultural heritage, including traditional games, as a crucial element in sustainable development. Indonesia, a country with the 15th most significant area in the world, has 34 provinces, 416 districts, and 98 cities (Asra et al., 2021), which makes it rich in cultural diversity (Syahrial, 2021). This is the reason why Indonesia is a country rich in local culture. Indonesia boasts a rich cultural diversity, encompassing traditional houses, folk songs, dances, clothing, cuisine, historical sites, customs, and traditional games (Herna, 2015). Each region in Indonesia has its traditional games, reflecting the unique characteristics of its respective area (Aprilia, 2019). Local wisdom in traditional games encompasses various physics concepts that can be analyzed and integrated into physics learning materials in schools.

However, amid this wealth, reality reveals that traditional games are increasingly rarely played, especially by the younger generation. Globalization and technological advances have altered children's preferences toward modern, digital-based games, causing traditional games to be pushed aside (Hasanah et al., 2023). This situation poses a serious threat to the sustainability of local cultural heritage. Traditional games not only possess historical and cultural value but also have the potential to serve as conceptual learning tools, especially in physics lessons. This challenge highlights the importance of integrating local cultural values into formal education to support quality learning while preserving cultural heritage. In addition, although Indonesia has implemented various policies to improve the quality of education, the reality on the ground shows a significant difference between expectations and actual conditions. Although the national education curriculum continues to evolve, particularly with the introduction of the Merdeka Curriculum, the implementation of quality and inclusive education still faces numerous obstacles. One of the primary challenges is the uneven quality of teaching across different regions, particularly in remote and less developed areas (Maula et al., 2023). Access to educational technology remains limited, resulting in inequalities in learning, particularly in subjects that require a deep understanding of concepts, such as physics (Andrea et al., 2024).

As a complex subject, physics has a crucial role in mastering various scientific concepts that are the foundation of technological and scientific progress (Haspen et al., 2021). Physics is often regarded as a challenging and complex field of study (Berge et al., 2020). Physics learning, often associated with formulas, can lead students to perceive physics as a complex subject, requiring them to memorize and apply numerous formulas, which can

ultimately cause them to become bored and lose interest in physics lessons (Paoliana et al., 2020). Students are less enthusiastic about learning physics due to the lack of appropriate learning media in the learning process. Learning media is a tool or means that facilitates an easier and more interactive learning process, thereby attracting students' attention. Therefore, it is recommended to use authentic and interactive learning media to improve concept understanding (Pulungan, 2021). However, in physics education, learning is still dominated by conventional methods based on text and formulas, which makes it difficult for students to link theory with real phenomena in everyday life.

Traditional games are one of the learning media based on local culture and are considered a viable solution to addressing this problem (Febrianty et al., 2023). Traditional games are one of the cultural elements passed down from generation to generation, forming habits that are mutually binding among humans (Mahdeyeni et al., 2019). Traditional games that are passed down contain valuable local wisdom (Razali et al., 2023). In modern times, the existence of culture has begun to be threatened by technological developments. To maintain the existence of local culture, media or intermediaries are necessary. One medium that can be used is education. Culture can be implemented into education through traditional games. Learning based on culture and local wisdom has the potential to develop students' understanding and be effective in the learning process (Astuti et al., 2021). Physics learning should not only focus on developing thinking skills but also on understanding physics as a process, a result, and an attitude. Therefore, it is essential to apply physics learning through daily activities to maximize physics knowledge (Nurmasyitah et al., 2022). Practical physics learning can be achieved through the application of learning principles that are directly related to the material's context (Lestari et al., 2022). The use of traditional games in teaching physics can transform the rigid perspective of physics into a science that is relevant to everyday life (Sari et al., 2019). This approach not only makes the learning process more conceptual but also enriches the learning experience of students by linking physics concepts to real-life phenomena.

Learning physics related to culture is known as Ethnophysics, which explains the relationship between culture and the principles of physics. One of the relevant cultural elements to be studied as a learning medium is traditional games (Heri, 2019). Ethnophysics is a physics learning method that relies on the local culture of the community (Khoiri & Sunarno, 2018). The material to be discussed in ethnophysics includes inherited traditions and beliefs related to physics (Wulansari & Admoko, 2021). Ethnophysics requires more ability to combine indigenous knowledge with scientific knowledge (Sudarmin et al., 2017). The characteristics of ethnophysics learning are the cultural links of a region in the physics learning process, both as learning media materials (Lestari, 2023). Ethnophysics learning will be easier for students to understand because they can easily illustrate physics material based on real experiences (Astuti & Bhakti, 2021).

An example of ethnophysics learning is learning by using traditional games. In traditional games, there are various physics concepts, such as Newton's law, sound waves, friction, gravitational force, equilibrium of rigid bodies, parabolic motion, straight line motion (GLBB), temperature, and heat. By integrating econophysics, traditional games can serve as a bridge between physics theory and practical application in the context of local culture, thereby increasing students' awareness and understanding, as well as contributing to the effort to maintain cultural heritage. This literature study aims to explore the potential of ethnophysics in traditional games, adopting an approach that supports sustainable physics learning in line with the Quality Education and Sustainable Cities and Communities goals, targets explicitly 4 and 11 of the Sustainable Development Goals (SDGs). Where the use of traditional games in learning serves not only as a conceptual learning tool but also as a cultural preservation effort in line with sustainable development. Learning physics through traditional games offers several benefits, including enhancing creativity and emotional, social, and motor skills while also bringing students closer to their local culture (Rumiati, 2021). The integration of physics concepts into traditional games enhances students' understanding of these concepts in a more contextualized manner, thereby directly increasing their involvement in the learning process and motivating them to learn more effectively (Rahmawati & Ridwan, 2017). Ethnophysics, as demonstrated through traditional games, directly supports sustainable physics learning by providing significant benefits that improve the quality of education in line with the Sustainable Development Goals (SDGs). This approach also supports local wisdom-based learning models and enriches teaching methods through the exploration of physics principles contained in various traditional games (Suryanti et al., 2020). More broadly, ethnophysics through traditional games encourages interdisciplinary learning and real-world experiences that support sustainable physics learning, which not only improves understanding of physics concepts but also increases the importance of physics in everyday life, by the SDGs' goals of improving the quality of education and preserving local culture as part of sustainable development.

RESEARCH METHOD

This research employed a descriptive research approach, utilizing a systematic literature review method. A systematic literature review is a method for identifying, evaluating, and interpreting research by formulating a research question or problem (Triandini et al., 2019). Literature studies rely on library sources as the primary source of research data (Jaelani et al., 2020). The references used in this study were obtained through Google Scholar, ResearchGate, Scopus, and several relevant journals. This literature review research consists of several stages, including problem formulation, research design, literature search, determination of inclusion and exclusion criteria, literature selection, data presentation, data processing, and conclusion drawing.

At the initial stage, the formulation of research problems was carried out, namely the Integration of Ethnophysics through Traditional Games in sustainable physics learning. In the second stage, a literature search was conducted using the Google Scholar database,

ResearchGate, Scopus, and several relevant journals, with the keywords "Integration of Ethnophysics through traditional games in physics learning." This literature search was limited to the period from 2015 to 2024, with data collection conducted on January 11, 2025. In the third stage, the inclusion criteria used in the literature search encompass ethnophysics, traditional games, and published research results. The fourth stage, analyzing the literature adjusted to the inclusion and exclusion criteria, involved recording the literature in a table to facilitate the literature review, particularly in reviewing the abstract and research results and then comparing them to conclude the study's results.

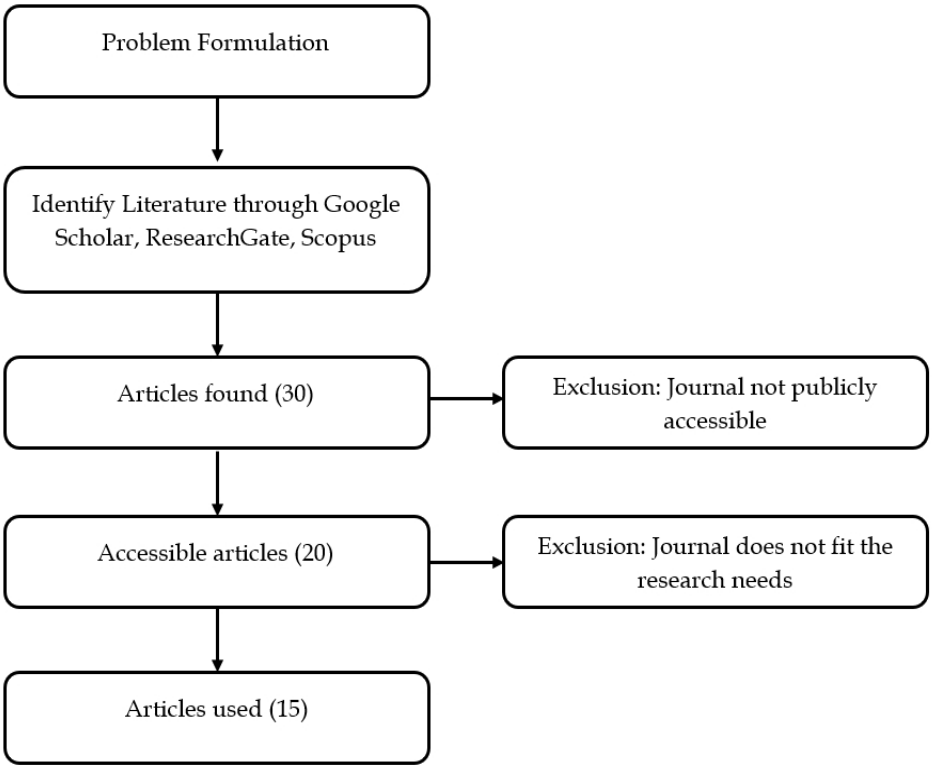

Figure 1. Literature review flow

Based on Figure 1, the flow of data extraction is shown, with year restrictions applied in this literature review from 2015 to 2024. The results of the literature search yielded 30 articles obtained through Google Scholar, ResearchGate, Scopus, and other relevant journals. Furthermore, the articles found were excluded from journals that could not be accessed generally and articles that were not by the research needs, so 15 articles were obtained.

RESULTS AND DISCUSSION

Results

Several articles obtained between 2015 and 2024 related to the topic of ethnophysics integration through Traditional Games in Sustainable Physics Learning were reviewed and compiled in the following table (Table 1).

Table 1. Results of article review

No	Author	Year	Method	Research Result
1	Ketang Wiyono, Rahmah Nisfi Laili, dan Syuhendri	2017	Development research	The results of this study indicate that the developed multimedia is in the very effective category, with an average total usability efficiency of 88.6%. Meanwhile, the usability of the multimedia developed is categorized as very useful, with an average rating of 87.2%. Thus, the interactive multimedia developed serves as a teaching aid for parabolic motion based on traditional physics games, which is very effective and practical.
2	Zulherman, Abidin Pasaribu, Ketang Wiyono, Saparini, Winda Oktori	2019	Development research	The results showed that the use of traditional game-based learning videos was categorized as highly valid by experts, with an average total efficiency of 88.92%. Meanwhile, according to the students, the use of this video is considered practical, with an average of 85%. Thus, the traditional game-based learning video on circular motion material is considered valid and practical for use as a physics learning medium.
3	Ella Agustina, Jeffry Handhika, Mislan Sasono	2019	Descriptive method	The results of this study indicate that the traditional game "otok-otok ship" can be effectively used as a tool for learning physics heat material in senior high school (SMK). The otok-otok boat game not only attracts students' interest but also helps link physics concepts with daily experiences. The observation shows that playing with this boat can significantly increase the temperature, which can be used to illustrate the principle of heat.
4	Yeyen Yelensi, Ketang Wiyono, Nely Andriani	2020	Pre-experimental with a research design	The results showed that the educational videos presented contained contextual images depicting real events, enabling students to elicit

			one one-group pre-test post-test research design	positive responses rather than simply imagining the events. Learning through traditional video games allows students to explore physics concepts and develop their thinking skills optimally. The use of learning videos on effort and energy material, based on traditional games, is effective in assisting learning, thereby improving student learning outcomes, as indicated by the results of n-gain analysis in the medium category.
5	Azmi Asra, Festiyed, Fatni Mufit, Asrizal	2021	Narrative literature review	The results showed that integrating ethnoscience into physics learning is important due to its significant impact on improving learning outcomes and motivation. Students explained that the habits and culture practiced daily contain the concepts and principles of physics learning. This also has the opposite impact, where integrating the culture and habits of students can strengthen, preserve, and reapply the values of local wisdom in physics learning based on local excellence.
6	Dina Afkarina, Sudarti	2021	Descriptive qualitative	The results showed that the traditional game of Kerapan Kereweng has important connections with physics concepts, especially Newton's law, Hooke's law, friction, and centripetal force. Observations and interviews indicate that spring and friction play a crucial role in the movement of Kerapan Kereweng. Incorporating this game into learning allows students to understand physics concepts through hands-on experience.
7	Rahma Dani, Jufrida, Fabrika Rahmat Basuki, Farradilla Handayani	2022	ADDIE development	The results showed that the percentage of questionnaire ratings given by Jambi State Senior High School 7 and Jambi State Senior High School 9 students for enrichment book validation had a material/content feasibility aspect of 92.49%, a material/content presentation aspect of 89.99%, a language aspect of 90, 66%, and a graphical aspect of 89.99%.

				The overall average percentage of the student perception questionnaire is 90.78%. Aspects of the material, content, presentation, language, and graphics of physics enrichment books on traditional games, such as Catfish PatokCatfish Patok and Global Sodor, are outstanding.
8	Nurmasyita, Virnalita, Nur Azizah Lubis	2022	Descriptive qualitative quantitative	The results showed that the Geulengkue Teu Pue Poe game has a relationship with the observed physics concepts, such as those observed from the y-axis, including Regularly Changing Straight Motion (RCSM), which involves motion in a straight line with a constant acceleration, resulting in speed changes. This demonstrates that the game can serve as a practical learning tool to teach physics concepts, particularly those related to parabolic motion while introducing and preserving Acehnese culture.
9	Siti Desy Rahmadhani, Nurmasyitah	2022	Experimental method	The results showed that the traditional game Seurune could be used as one of the learning media in schools for econophysics-based sound waves. The relationship between wavelength and frequency in the Secure the Yougehog game is inversely proportional; namely, the greater the wavelength, the lower the frequency, as per the theory of the sound propagation speed equation.
10	Wanda Febrianty, Ramadani Dwi Saputra, Hanif Al Amri, Firdaus Nur Rahmat, Rifati Dina Handayani, Pramudya Dwi Aristya Putra	2023	Descriptive qualitative	The traditional game of Engklek contains the concept of physics in the material of the equilibrium of rigid bodies. The traditional Engklek game, which is played using one footstool, requires players to maintain their body balance to complete the game properly. Three factors affect body balance: the position of the player's feet, the player's arms, and the mass of the Engklek player.

11	Dia Sukma Melati, Fiza Hairu Lira, Radiati, Nur Azizah Lubis, Nurmasyitah	2023	Experimental method	The results show that Tarek Siteuk, a traditional Acehnese game, is effective in applying physics concepts, particularly in understanding friction force and effort. Three different angles (30°, 45°, and 60°) were used in the experiment, and their effects on acceleration, time, friction force, and effort were observed. The results showed that the friction force and effort increased with the angle used, with the friction force reaching 612 N and the maximum effort 32.2 J at a 45° angle. This research discusses the importance of traditional games in physics learning in utilizing local wisdom.
12	Anatasija Limba, Juliana Nirahua, Imanuel Vito Huwae, Anastasya Ohoiwutun	2023	One-group pretest-posttest	The results showed that mastery of the material after the learning process using the CTR approach in the Boi game was as follows: 25% achieved good qualifications, 33.3% achieved sufficient qualifications, and 41.7% achieved failing qualifications. The average achievement of students' mastery of the material after the learning process is 66.7, which is sufficient qualification. The increase in mastery of the material shows that 10 out of 12 students (83.3%) experienced an increase in mastery of momentum, impulse, and impact material in moderate qualifications after the entire learning process using the CRT approach integrated with Boi games took place.
13	Shifa Yuliana Sabitafh	2024	Qualitative descriptive	The results showed that the traditional game of bezel ball can be used as an effective learning medium for teaching the concept of the Earth's gravitational force to students. In physics learning, the game can provide a direct learning experience that is both fun and interactive, thereby enhancing students' understanding of the concept of gravitational force.

14	Widi Nugraha Ady, Siti Nurdianti Muhajir, Asep Irvan Irvani	2024	Systematic Literature Review (SLR)	This research demonstrates that a problem-based learning (PBL) model, supported by traditional games, can significantly enhance students' critical thinking skills. The integration of games makes learning more engaging and contextualized in the face of challenges such as low digital literacy and unstable internet connections. Of the 412 papers identified, 15 relevant papers were analyzed, highlighting the importance of teacher support and the need for further research to explore the applicability of this model in a broader context.
15	Yosefa Lama Uran, Isabel Coryunitha Panis, Maria Ursula Jawa Mukin	2024	Descriptive analysis	The results showed that the application of physics learning modules based on local wisdom on sound waves material could improve the learning outcomes of students in class XI IPA at Sint Carolus Catholic High School. The average posttest score reached 85, which is classified as significantly higher, compared to the average pretest score of 29.44, which is classified as low. Additionally, student responses to the module showed a percentage of 70.41% in the practical category. This indicates that the module is effective in enhancing students' understanding of physics concepts.

Discussion

Table 1 shows that integrating ethnophysics through traditional games in sustainable physics learning consistently has a positive impact on increasing students' awareness and understanding of various physics concepts. Traditional games in Indonesia are rooted in regional traditions, deriving from local customs and practices. The incorporation of local culture into traditional games during physics learning can shift the views of students with a rigid perspective on physics, transforming it into a more engaging science that is applicable in everyday life (Setiawan, 2020). According to Wiyono et al. (2017), interactive multimedia can be used in traditional game-based parabolic motion materials for physics subjects in high school. According to Zulherman et al. (2019), the use of traditional game-based learning video media has more appeal than conventional learning, producing more effective learning that increases student motivation and learning outcomes. This is evidenced by the testing of the validity of traditional game-based learning media, conducted through expert review, which yielded very valid data for use. Additionally,

through small group implementation, students stated that traditional game-based learning media are efficient in increasing interest, learning outcomes, and understanding of physics concepts.

In Agustina et al.'s research (2019), apperception using the traditional game of otok-otok ship in physics learning is considered adequate. Based on the results of their observations using traditional games, it is easier to illustrate the principle of heat in everyday life. The effectiveness of using learning videos on effort and energy material conducted by Yelensi et al. (2020) by conducting normality tests and homogeneity tests so that the n-gain value is obtained in the moderate category so that the application of traditional games is efficacious in improving student learning outcomes with moderate effectiveness categories. Integrating ethnoscience in physics learning has a significant influence on improving student learning outcomes and motivation by directly engaging students in traditional games, which makes them feel more engaged and happy. Through traditional games, students will develop logical and critical thinking skills by observing one another while interacting in play (Asra et al., 2021). Afkarina's research (2021) on the traditional game of keratan crewing reveals several physics concepts, including Newton's law, Hooke's law, friction, and centripetal force. By integrating this game into the learning process, students can gain a deeper understanding of physics principles through direct observation.

The development of physics enrichment books with an ethnoscience context on traditional games received excellent ratings from students. Through these enrichment books, students can increase their knowledge of various traditional games related to physics concepts (Dani et al., 2022). This demonstrates that traditional games can be utilized as an effective learning medium to teach physics concepts, as well as introduce and preserve local culture (Numasyitah et al., 2022). According to Rahmadani (2022), the traditional game Seurune can be used as a learning medium in schools for econophysics-based sound wave material. This is evidenced by the experiment on the relationship between wavelength and frequency in the game series, where the wavelength and frequency are inversely proportional: the greater the wavelength, the lower the frequency. This is to the theory of the sound propagation speed equation.

Traditional games have great potential for integration into a sustainable physics learning process, mainly through an ethnophysics approach. For example, the Engklek game involves physics concepts related to the balance of rigid bodies. In this game, players must maintain their body balance by utilizing one leg as a fulcrum, where the position of the legs, arms, and body mass are the primary factors affecting balance (Febrianty et al., 2023). In addition, the traditional game Tarek Siteuk from Aceh is considered effective in teaching the concepts of friction force and effort. This study revealed that the angle of the trajectory affects acceleration, friction force, and effort, with optimal results at an angle of 45°, which produces a friction force of 612 N and a maximum effort of 32.2 J. This highlights the importance of incorporating local wisdom into the physics learning process (Melati et al., 2023). Meanwhile, the implementation of the Contextual Teaching and Learning (CTL) approach in the Boi game demonstrated an increase in understanding of physics material, particularly in the concepts of momentum, impulse, and collision. A total of 83.3% of students experienced an increase in understanding of moderate qualifications, although the average results remained at the level of sufficient qualifications (Limba et al., 2023).

The integration of traditional games into sustainable physics learning has proven effective in improving students' understanding of physics. In a study conducted by Sabitafh (2024), the bezel ball game can teach the concept of the Earth's gravitational force in an interactive and fun way. Then, in another study using the Problem-Based Learning (PBL) model supported by traditional games can also improve students' critical thinking skills and make the learning process more interesting and relevant, especially amid challenges such as low digital literacy and unstable internet connections (Ady et al., 2024). In addition, a module based on local wisdom in sound waves demonstrated a significant improvement in learning outcomes, with the average post-test score reaching 85, which is significantly higher than the pre-test score (Uran et al., 2024). This approach also emphasizes the importance of traditional games as one of the local pearls of wisdom to shape practical and sustainable physics learning.

Based on the reviewed articles, it is evident that integrating traditional games into physics learning not only enriches teaching methods but also supports the preservation of local culture. This aligns with the Sustainable Development Goals (SDGs), particularly Goal 4 on quality education, by creating innovative and relevant learning processes for students. In addition, this integration also supports Goal 11 on sustainable cities and communities by preserving local wisdom through traditional games, which are an integral part of cultural identity. By leveraging traditional games, physics learning becomes more contextual and inclusive, thereby contributing significantly to sustainable development that respects local cultural values.

The integration of Ethnophysics through traditional games in sustainable physics learning offers several advantages that are relevant to the Sustainable Development Goals (SDGs), particularly the 4th goal on quality education and the 11th goal on sustainable urban communities. Ethnophysics through traditional games supports SDG goal 4 by creating an interactive learning atmosphere relevant to local culture. Traditional games can enhance learner participation, foster experiential learning, and connect physics concepts to everyday life. In addition, ethnophysics through traditional games also supports the 11th Sustainable Development Goals (SDGs) goal by preserving local cultural heritage through education, which further affirms community identity and the cultural sustainability of the nation (Egana del Sol, 2020). The weakness of econophysics integration through traditional games is the difficulty in adapting traditional games to be in line with the physics curriculum, which is usually dense and organized considering that each traditional game contains different physics concepts so that major adjustments are needed to be coupled with limited time in learning to conduct experiments complicating the integration of econophysics through traditional games in learning. Future research is recommended to investigate how to adapt traditional games that are more suitable for specific physics concepts, as well as to create practical guidelines for teachers on integrating ethnophysics. In addition, a long-term study is needed to assess the impact of this integration on student learning outcomes and the preservation of local culture, mainly traditional games.

CONCLUSION

Fundamental Finding: This literature study demonstrates that integrating econophysics into traditional physics games is efficacious in improving students' understanding of physics concepts while supporting the preservation of local culture. Games such as Engklek, Tarek Siteuk, Bola Bekel, Boi, and others have been proven to teach physics

concepts, including balance, friction, gravity, momentum, and other related materials, in an interactive and conceptual way. The approach based on local wisdom has also been proven to improve student learning outcomes significantly. **Implication:** These results confirm the importance of integrating local wisdom in the learning process to produce relevant, fun, and meaningful learning experiences. The integration of traditional games supports the goals of the SDGs, particularly in quality education (SDG 4) and the preservation of local culture (SDG 11), by creating sustainable learning experiences based on local values. **Limitation:** Existing research is still limited to specific contexts, such as specific cultural regions, specific education levels, and the continuity between physics learning through traditional games and the Sustainable Development Goals (SDGs), so the results obtained cannot be widely generalized. In addition, most studies have not investigated the long-term effectiveness of this approach in improving understanding of physics concepts, as well as preserving local culture. **Future Research:** Future research could explore the integration of traditional games in physics education across different cultural contexts and educational levels. Additionally, the development of new ways to support ethnophysics through local culture as a medium has greater learning appeal. Through a multidisciplinary approach that incorporates aspects of science, culture, and sustainability, this research creates a holistic, culturally relevant, and globally impactful education. Further research is also needed to assess the long-term impact of this approach on student learning outcomes and the preservation of local culture.

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AUTHOR CONTRIBUTIONS

Mutiara Rizqi Hadi Ningrum*: Conceptualization, Methodology, Investigation, Formal Analysis, Writing – Original Draft, Visualization. **Nanda Nur Maulidiya Citra Dewi**: Investigation, Data Curation, Writing – Review & Editing. **Nina Fajriyah Citra**: Validation, Resources, Supervision. **Joana Paula Gerabella da Costa Moniz**: Supervision, Writing – Review & Editing, Project Administration. All authors have read and approved the final version of this manuscript.

DECLARATION OF COMPETING INTEREST

The authors declare no known financial conflicts of interest or personal relationships that could have influenced the work reported in this manuscript.

DECLARATION OF ETHICS

The authors declare that the research and writing of this manuscript adhere to ethical standards of research and publication, in accordance with scientific principles, and are free from plagiarism.

DECLARATION OF ASSISTIVE TECHNOLOGIES IN THE WRITING PROCESS

The authors declare that generative artificial intelligence (Gen AI) and other AI-assisted tools were used prudently, not excessively, during the research and preparation of this manuscript. Specifically, ChatGPT was used for brainstorming ideas, structuring paragraphs, and refining academic language; Grammarly for grammar and style correction; and ChatPDF for extracting key points and summarizing reference articles. All AI-generated material was reviewed and edited for accuracy, completeness, and compliance with ethical and scholarly standards. The authors accept full responsibility for the final content of the manuscript.

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