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Exploring Physics Concepts in Lamongan's Silir-Silir Dance as Innovation in Physics Learning Through an Ethnophysics Approach

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Abstract

Traditional dance is a form of local wisdom that has great potential to be utilized in the development of contextual physics learning. Silir-Silir dance is a dance typical of Lamongan, East Java, inspired by the wind, the rhythm of nature, and the dynamics of body movement, presenting movement patterns that can be analyzed using the principles of physics. This study aims to identify the physics concepts contained in the Silir-Silir dance, explore how the dance can be used as a learning resource that connects scientific theory with cultural phenomena, and assess its contribution to achieving the Sustainable Development Goals (SDGs) in quality and inclusive education. The research uses a descriptive approach, with data obtained through literature studies, observation of performances and rehearsals, and in-depth interviews with trainers and dancers. The results of the analysis show that the variations in hand movements, changes in tempo, body position shifts, and balance patterns in the dance can be related to the concepts of force, momentum, acceleration, and center of mass. The physical interpretation of these movements shows that Silir-Silir Dance is not only aesthetically valuable but also contains movement structures that can be used as a medium to explain scientific phenomena while reflecting local wisdom, such as harmony with nature, simplicity of life, and the daily traditions of the Lamongan community. Thus, this study shows that the integration of Silir-Silir Dance in culture-based physics learning can strengthen ethnoscience learning, facilitate the understanding of scientific concepts, and foster students' appreciation of local cultural heritage in a contextual and meaningful way.

Keywords: *Ethnophysics, Physics Education, Silir-Silir Dance*

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INTRODUCTION

Physics education is not only oriented towards delivering material, but also towards forming meaningful understanding through a learning process that is relevant to everyday life. Mastery of physics concepts needs to be accompanied by relevance to the environment and students' daily experiences, making the learning process more contextual (Tubagus et al., 2024; Hasanah et al., 2025). This connection makes physics material easier to understand because students can relate it to situations they experience directly (Purwanti et al., 2025). This contextual approach can increase interest in learning and help students understand the real benefits of physics (Arif et al., 2025). Additionally, physics learning plays a significant role in developing students' critical thinking skills, problem-solving abilities, and creativity (Susilowati et al., 2020; Wafa et al., 2025). Thus, the development of physics learning should utilize the local context and local wisdom that exist in the community.

Local wisdom is a cultural heritage that contains important values about the relationship between humans and nature and their social environment (Jati, 2022). Local wisdom exists in the form of practices, traditions, and knowledge that have been passed down from generation to generation by local communities (Prabandani & Astuti, 2025). The integration of local wisdom into education provides students with the opportunity to become more familiar with their regional cultural identity (Rahmawati et al., 2025). This approach also serves as a bridge between modern science and ancestral traditions that are still relevant today (Deta et al., 2025). One form of local wisdom that has the potential to be used as a source of contextual physics learning is traditional dance. The movements, rhythms, and spatial patterns in traditional dance can be analyzed through physics concepts such as motion, force, balance, and energy, thus having the potential to become a contextual learning medium (Khalimah et al., 2025). Therefore, its development is relevant to be studied, especially in coastal communities that are rich in traditions resulting from their interaction with the natural environment.

In various coastal areas of Indonesia, various traditions and arts have developed from the interaction of the community with the surrounding natural environment (Asyifa et al., 2025). Traditional arts not only serve as entertainment but also as a means of conveying the cultural values and philosophy of life of coastal communities (Adityatama et al., 2024). One example of such traditional art is the Silir-Silir dance, which originated in Lamongan Regency (Fathurrahman, 2021). The Silir-Silir dance is inspired by the gentle breeze in coastal areas and depicts the calm atmosphere and gratitude of the fishing community for the bounty of the sea. The soft and rhythmic dance movements reflect the harmony between humans and their natural surroundings (Supeni et al., 2021). In addition to being an artistic expression, the Silir-Silir Dance plays a role in preserving traditions and conveying moral messages about togetherness, hard work, and care for the environment. With these characteristics, the Silir-Silir Dance has the potential to be used as a source of contextual learning that instills an understanding of the relationship between humans, nature, and science.

The Sustainable Development Goals (SDGs) provide direction for various fields to achieve equitable and sustainable development (Pangestu et al., 2021). In the field of education, the SDGs emphasize the importance of providing quality and inclusive learning for all students (Ashoumi & Yusuf, 2024). Integrating sustainability values into learning can enrich insight and foster awareness of environmental and social responsibilities (Hidayatullah, 2024). In line with these efforts, the use of traditional dance as a medium for learning physics is one form of implementing sustainable education that respects local wisdom while strengthening the cultural identity of students (Maharani et al., 2025). The contextual learning approach helps students understand science as part of real-life experiences (Muis et al., 2023). Therefore, SDGs are an important foundation for the development of meaningful education oriented towards positive change (Nurus & Nugraheni, 2024). The development of contextual learning needs to be supported by empirical evidence from research based on local culture.

Various studies show that traditional dances in Indonesia have the potential to be used as a source of contextual and interesting physics learning. Research by Nurroniah et al. (2023) shows that ethno-physics-based learning media in Lahboko Dance can improve students' science literacy and interest in learning. Putra (2024) found that the movements of Banjarkemuning Dance contain physics concepts that are relevant for contextual learning. Similar results were reported by Dawana (2023) through a study of the Remo Gagrak Anyar dance, which contains physics concepts to strengthen students' understanding. The use of traditional dance as a source of physics learning can improve students' conceptual understanding, creativity, and learning motivation (Astuti et al., 2022). Local wisdom in traditional dances also opens up opportunities to connect cultural experiences with real physics concepts (Fitriyah & Wahyuni, 2022). Thus, traditional dances have the potential to become a meaningful medium for physics learning while supporting the preservation of local culture.

Previous studies have shown that integrating local wisdom into physics learning, particularly through traditional dance, can improve students' conceptual understanding and interest in learning (Nurroniah et al., 2023; Putra et al., 2024; Dawana et al., 2023). However, studies that specifically examine the Silir-Silir dance from Lamongan are still limited, so the potential of its movements, which contain various physics concepts, has not been studied in depth. This dance has the potential to be used as a contextual and locally-based medium for physics learning. Therefore, this study aims to identify the physics concepts in the Silir-Silir dance and analyze its potential as a learning resource that connects scientific theory with cultural phenomena, while also examining its contribution to the achievement of the Sustainable Development Goals (SDGs) in quality and inclusive education.

METHOD

This study uses a descriptive qualitative approach to examine the characteristics of movement in the Silir-Silir dance, which is unique to Lamongan, while also reviewing the potential of these movements as objects of study in physics. A qualitative approach was chosen because the focus of the study was not only on the visible form of the movements, but also on their meaning, both in terms of aesthetics, cultural practices, and the values inherent in the dance (Triyono et al., 2025). The research subjects consisted of dance instructors and dancers who had a deep understanding of the movement techniques and cultural context of the Silir-Silir dance. The research flowchart can be seen in Figure 1.

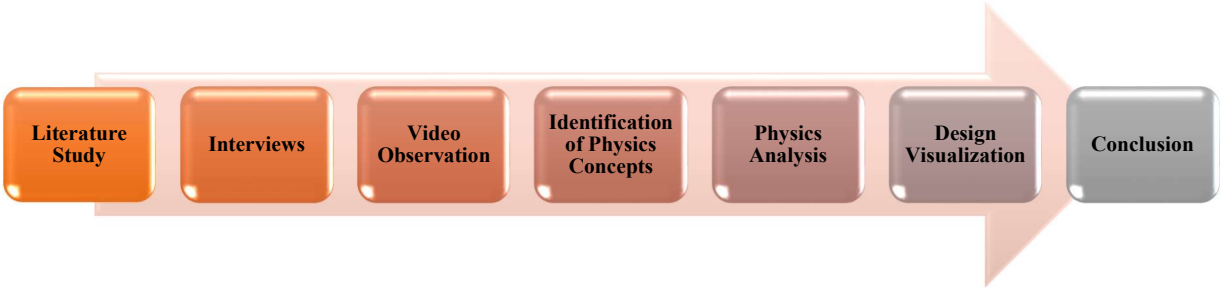

Figure 1. Research Flow Chart

Based on Figure 1, data were collected from several sources, namely written literature studies on the history and development of dance, interviews, and observations. Interview data was obtained from three sources, consisting of two main Silir-Silir dancers and one dance instructor with at least five years of performing and teaching experience. The interviews were conducted online to explore the understanding of the movement structure, symbolic meaning, and techniques used in each dance sequence. The observation of movement patterns was carried out through video recordings of the Silir-Silir dance performances available on the internet via the official YouTube channel. Through observation, the researcher examined the movement patterns, position changes, use of props, and rhythm in each scene. All information from these three sources was then recorded and organized systematically as the basis for the next stage of movement analysis.

Data analysis was conducted descriptively to examine the characteristics of the movements found and review their potential as objects of physics study. Each movement was identified based on relevant principles of physics and then classified for easier understanding. In the visualization stage, dance movement clips were taken from video recordings in the form of screenshots as the basis for compiling preliminary illustrations with the help of AI Gemini Flash 2.5. The illustrations were then manually refined through editing and the addition of physics concept markers so that the relationship between dance movements and physics principles could be displayed in a more systematic and easy-to-understand manner. The analysis results were then arranged in a logical sequence so that the interpretation remained consistent with the cultural context and characteristics of the dance movements. To ensure the accuracy of the findings, this process was supplemented with triangulation between literature, interviews, and video observations before being formulated into final conclusions.

RESULTS AND DISCUSSION

History, Cultural Meaning, and Dynamics of Silir-Silir Dance

Silir-Silir dance is one of the traditional dances that developed in Lamongan Regency and was created by Tri Kristiani (Mufidah, 2017). The creation process of this dance was relatively short, taking about a month, through collaboration with costume and music designers to form a complete performance. This dance was first performed at a dance festival in East Java and received high appreciation, even being considered one of the best dances at the provincial level. The background of its creation stems from the natural conditions of Lamongan, which is known for its hot weather, where the community's habit of fanning themselves became the main inspiration for the dance movements. Thus, the Silir-Silir Dance not only displays aesthetic beauty but also records the social and environmental realities of the Lamongan community in the form of simple and communicative movements.

Based on this background, according to the trainer, this dance is not merely presented as visual entertainment, but also contains philosophical meanings about the harmony between humans and nature and the ability to enjoy the simplicity of everyday life. The fanning movements in the dance represent a cooling breeze and reflect the habits of the coastal community of Lamongan, who often fan themselves while doing activities in their yards, markets, and school environments (Padilla et al., 2025). The dancers also feel a

closeness between the dance and their real lives, because the movements performed are adaptations of daily activities with a relaxed but structured rhythm (Setyarini et al., 2025). Over time, some movements have been adjusted to be more suitable for performance on stage or in competitions, without losing the basic character of the dance.

In Silir-Silir Dance, fans play an important role not only as decoration but also as a symbol of cooling wind and a tool for expressing gentle movements. According to the trainer, each opening and closing of the fan has its own rhythm and meaning, imitating the blowing of the wind, so dancers must master the technique of opening and closing the fan simultaneously, rotating their hands without stiffness, and adjusting their movements to the music. The dancers admit that hand-eye coordination practice was quite challenging at first, but it is important for the movements to look uniform (Dewi & Oktira, 2025). The speed and strength of the movements are also regulated to remain gentle and light; movements that are too fast or forceful make the fans appear stiff and tire the dancers quickly. In addition, balance and precise body positioning are the focus of training, where the posture of the feet, hips, and body rotation must be stable before swinging the fans, so that all movements appear neat, harmonious, and beautiful to behold.

Physical preparation and training are an important foundation in dance (Juliadrini et al., 2025). Training begins with the ability to stand steadily, step slowly while opening and closing the fan, and then performing rotations, with the main focus on coordination, feet, hands, and body balance. Dancers also need to have adequate arm strength and a flexible body so that the fan movements can be performed lightly, smoothly, and without tiring quickly (Ariani et al., 2023). In addition, adjusting the movements to the music is an important stage in which dancers practice listening to the beat of the song first and then gradually swing the fan from slow to fast so that the movements remain in sync with the rhythm and appear graceful (Rahmawati & Rihwatun, 2025).

The fan movements in the Silir-Silir Dance are related to a simple but real principle of physics. When dancers swing the fan, the air around them moves, causing a small change in pressure, similar to a gentle breeze (Hamid & Dayana, 2022). Fast yet light movements teach dancers to regulate their energy so that the fan continues to move smoothly without causing the body to tire quickly (Gusmail & Nugra, 2021). In addition, balance and force control are key, where the position of the hands, body, and foot steps must be in harmony so that the movements are neat and stable. According to the trainer, these things show the potential of dance as a medium for science learning, because the movements naturally reflect the concepts of thrust, torque when turning the fan, and body balance.

Exploring Physics Concepts in Silir-Silir Dance

The results of the exploration of the Silir-Silir dance show that the various movements of the dancers are related to the basic principles of physics (Tandipau et al., 2024). The movements of opening the fan from closed to open, swinging the fan, raising and lowering the hands, spinning smoothly while holding the fan, swinging up and down, and following the rhythm with the body moving up and down, reveal a regular movement pattern that reflects the dynamics of movement in physics. In general, this series of movements illustrates that the aesthetic elements of dance also contain physical concepts that arise naturally in every movement (Agustina & Desstya, 2022). Each series of movements in the Silir-Silir dance not only presents visual beauty but also reflects the application of physical principles that occur intuitively in the dancer's body.

The movement of pushing the fan from a closed to an open position shows the force exerted by the dancer on the fan frame (Rochayati et al., 2022). At this stage, the dancer must push outward so that the fan blades, which were initially close together, can move and open. The magnitude of the force exerted can be explained by Equation 1.

$$F = m \cdot a \tag{1}$$

where m is the mass of the fan blades, and a is the acceleration when the fan begins to open. This push also serves to overcome the friction force that arises at the fan hinges. When the dancer opens the fan with a faster movement, the acceleration of the fan increases so that the force required is also greater (Rochayati, 2020). This simple movement shows how force works directly in dance activities, as illustrated in Figure 2.

Figure 2. Illustration of The Movement of Pushing the Fan from A Closed to An Open Position
(Source: created using AI Gemini Flash 2.5 and physics concepts added manually)

In some parts of the Silir-Silir dance, especially when the dancers swing their fans to the rhythm, the movement pattern appears to be a simple harmonic motion because it occurs repeatedly and regularly. The swinging of the fan from one side to the other following the beat of the song shows a continuous repetition of movement in the same pattern (Purwaningsari & Dhony, 2022). This movement can be understood through Equation 2.

$$y = A\cos(\omega t + \varphi) \tag{2}$$

y describes the position of the arm or fan at a certain time. The amplitude A reflects how wide the swing is, while the angular frequency ω indicates how fast the swing occurs, which can be analogized to the characteristics of a simple pendulum. The length of the dancer's arm or the length of the fan can be considered as a factor that affects the speed of the swing (Finahari & Rubiono, 2021). Through this rhythmic pattern, it can be seen that dance movements are not only aesthetic but also have periodic motion characteristics similar to harmonic motion in physics, as shown in Figure 3.

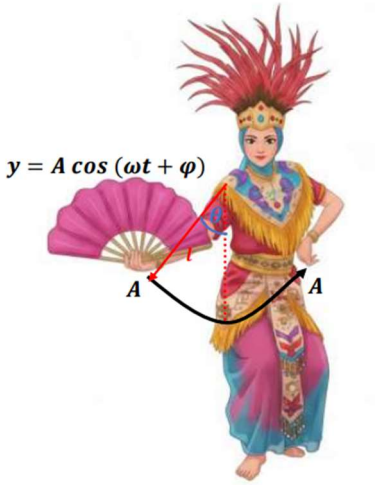

Figure 3. Illustration of Fan Swinging Movements
(Source: created using AI Gemini Flash 2.5 and physics concepts added manually)

When dancers make small turns or gently change direction, their bodies undergo rotational motion influenced by inertia. The magnitude of inertia can be explained by Equation 3.

$$I = \sum mr^2 \tag{3}$$

which shows that the further the mass is from the center of rotation, the greater the effort required to rotate (Digdoyo et al., 2022). When the dancer brings their arms closer to their body, the value of r decreases so that the body can rotate faster. Conversely, opening the arms increases the moment of inertia and slows down the rotation. The smooth change of direction in this dance occurs thanks to the dancer's ability to regulate angular momentum, which follows Equation 4.

$$L = I\omega \tag{4}$$

This ensures that the transition between movements remains stable and graceful. An illustration of this can be seen in Figure 4.

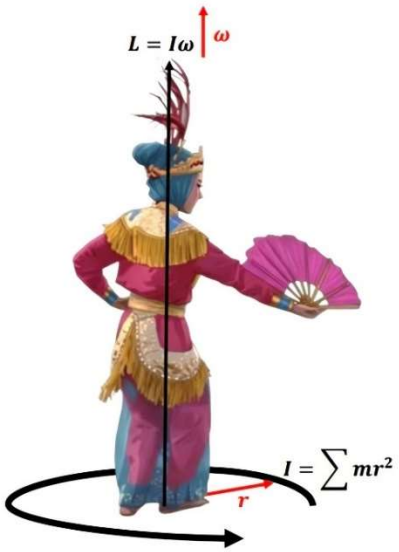

Figure 4. Illustration of Rotational Motion
(Source: created using AI Gemini Flash 2.5 and manually added physics concepts)

The rotational movement of the fan through the wrist also involves the same concept of rotation, only that it occurs on a lighter object. The fan blades, which are at a certain distance from the center of rotation, have a moment of inertia according to equation (3), so that the further the fan is from the wrist axis, the greater the effort required to rotate it (Digdoyo et al., 2022). When the fan begins to rotate, its angular momentum, formulated as in equation (4), makes the rotation appear smooth and rhythmic. The dancer's control of the force on the wrist is what makes the fan's rotation appear stable and in sync with the rhythm of the body's movements. This can be seen in Figure 5.

Figure 5. Illustration of The Fan Rotation Movement
(Source: created using AI Gemini Flash 2.5 and manually added physics concepts)

The movement of raising and lowering the arms in front of the chest during the Silir-Silir dance also involves changes in kinetic and potential energy (Pulung et al., 2024). When the arms are raised upward, the height of the hands increases, which causes the potential energy to rise, according to Equation 5.

$$Ep = mgh \tag{5}$$

When the arm is lowered again, this potential energy is transformed into kinetic energy, with its magnitude calculated by Equation 6.

$$Ek = \frac{1}{2}mv^2 \tag{6}$$

where v is the speed of the arm's movement. This rhythmic transfer of potential and kinetic energy makes the arm movements smooth and controlled, and creates a waving pattern in front of the chest, as shown in Figure 6.

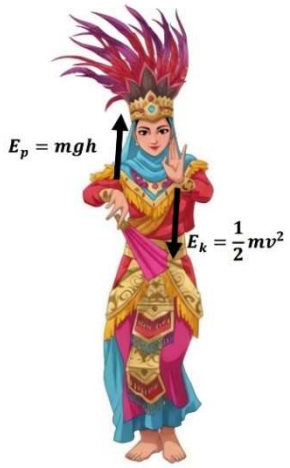

Figure 6. Illustration of The Fan-Turning Movement
(Source: created using AI Gemini Flash 2.5 and manually added with physics concepts)

Overall, the exploration of movement in the Silir -Silir demonstrates that every movement, from opening the fan, swinging the arms, rotating the body and fan, to raising and lowering the arms, not only has aesthetic value but also incorporates real physical concepts such as force, harmonic motion, moment of inertia, angular momentum, as well as kinetic and potential energy (Putra et al., 2022). These movements illustrate the intuitive application of the laws of physics in dance rhythms and patterns, where dancers naturally regulate their energy, balance, and coordination to produce smooth, controlled, and harmonious movements. By understanding these principles, Silir-Silir Dance can be viewed as a living physics laboratory that connects culture, science, and contextual education.

These findings are in line with previous research on Lahboko Dance, which shows that ethnophysicaly-based learning media can improve understanding of the concepts of force and simple harmonic motion through traditional movements (Nurroniah et al., 2023); in Banjarkemuning Dance, traditional dance movements can reflect the principles of momentum and torque, while improving students' ability to observe real physical phenomena (Putra et al., 2024); and in the Remo Gagrak Anyar dance, rhythmic and periodic movements help students understand the concepts of kinetic and potential energy in the context of everyday cultural activities (Dawana et al., 2023). The Silir-Silir Dance research adds a unique dimension through the integration of Lamongan's local culture, so that dance is not only an expression of art but also a learning medium that allows students to understand physics concepts through real cultural activities while fostering appreciation for local cultural heritage.

The Application of Silir-Silir Dance in Physics Education and SDGs Achievement

The Silir-Silir dance has great potential to be applied in physics learning in a creative and contextual manner. The use of dance as a learning medium allows students to directly observe the application of physics

principles in real activities, making abstract concepts easier to understand and more enjoyable (Putri et al., 2022). The integration of dance movements with physics concepts enables students to build a deeper understanding through activity-based learning experiences, where they not only memorize theories but also relate scientific concepts to the actual movements they perform or observe (Nugroho et al., 2024). This approach encourages students' sensory and motor involvement, enhances creativity, and strengthens memory through kinesthetic and interactive learning.

In addition to supporting the understanding of physics, the integration of Silir-Silir Dance in learning also helps preserve local culture. Students not only learn about science, but also learn about the history, philosophy, and cultural values of the Lamongan community (Febriani & Riyadi, 2022). Through this direct experience, students can understand the meaning of the movements and symbols in the dance, making learning more lively and contextual (Perdana & Harsiwi, 2025). This approach is in line with the principle of local wisdom-based learning, where learning activities are closely related to students' daily lives, while fostering appreciation for unique, authentic, and sustainable cultural heritage. This kind of integration not only enriches the learning experience but also builds students' awareness of the importance of preserving and continuing cultural traditions.

The contribution of using dance is also relevant to the Sustainable Development Goals (SDGs), especially in terms of improving the quality of inclusive and creative education (SDG 4) and preserving local culture (SDG 11.4). The integration of dance movements in physics learning makes the learning process more interesting and contextual, while also developing the cognitive, motor, social, and emotional competencies of students (Lubis et al., 2024). The use of cultural elements such as the Silir-Silir dance not only serves as a visual and kinesthetic medium but also plays a role in shaping students' character (Susiani et al., 2025). Through these learning practices, students are encouraged to realize the importance of the interconnection between science, culture, and daily life, so that education is not only oriented towards academic achievement but also towards the formation of attitudes of caring for the environment and preserving traditions.

Limitations and Potential Research Impacts

This study uses a descriptive qualitative approach with data sources in the form of interviews, literature studies, and observations through video recordings of Silir-Silir dance performances. This approach allows researchers to gain a deep understanding of the meaning of movement, cultural context, and its relationship with the concepts of physics that arise naturally in dance (Zahara et al., 2025). However, this study is not equipped with quantitative data or direct experimental measurements, such as measurements of angles, speed, acceleration, or forces acting on the dancers' movements. These limitations mean that the physics analysis is still at a conceptual and illustrative level, with an emphasis on the meaning of the phenomenon rather than numerical proof.

Another limitation relates to the scope of the research subjects and the visualization techniques used. The research subjects only involved trainers and dancers, so the perspectives of physics teachers and students as direct users of the learning media were not accommodated. This means that the effectiveness of applying the Silir-Silir dance in physics learning in the classroom cannot yet be evaluated empirically. In addition, the research results are still contextual and attached to the culture of the Lamongan community. The visualization of dance movements generated through AI-assisted visuals and enriched with physics concepts manually also does not fully represent the details of the movements accurately (Setiyanto et al., 2023). Therefore, further research involving biomechanics-based motion analysis and learning trials is recommended to make the study more comprehensive and applicable.

Despite its limitations, this research has the potential to have a significant impact on the development of environmental education and ethnophysics. The use of Silir-Silir Dance as a source of contextual physics learning shows that natural phenomena, culture, and science can be harmoniously integrated into the learning process. Through the introduction of physics concepts that emerge from dance movements inspired by the coastal environment, students are encouraged to understand the relationship between human activities, nature, and scientific principles more holistically. This approach has the potential to foster environmental awareness and a caring attitude towards ecosystem sustainability and the preservation of local culture (Ningrum et al., 2026). Furthermore, the integration of ethnophysics in physics learning can strengthen students' cultural identity while making learning more meaningful, contextual, and relevant to everyday life. Thus, this research can serve as a starting point for the development of a local wisdom-based physics learning model that supports environmental education and sustainability.

CONCLUSION

The Silir-Silir dance has the potential to be used as a medium for teaching physics by linking scientific concepts with culture in a contextual manner. The movements of opening and closing the fan, swinging the arms, rotating the body and fan, and raising and lowering the arms can help students understand the principles of force, harmonic motion, moment of inertia, angular momentum, and kinetic and potential energy. In addition to conveying physics in a tangible way, this dance reflects the local wisdom of the Lamongan community and supports cultural preservation, making learning more contextual, interesting, and relevant to the SDGs. Although the research was limited in scope and used qualitative methods based on observation and interviews without direct testing of learning in the classroom, the results are exploratory in nature. Therefore, further research needs to be developed through direct implementation in physics learning, measurement of the impact on student understanding, and the development of interactive teaching media based on dance movements and technology, so that the potential of the Silir-Silir Dance as a source of physics learning can be utilized more optimally and practically.

AUTHOR CONTRIBUTIONS

Ananda Dwi Pratiwi: Software, Formal Analysis, Data Curration, Writing - Original Draft, dan Visualization; **Heny Aryani**: Conceptualization, Investigation, Resources, Writing - Review & Editing, dan Project Administration; **Salsa Ayu Fajriyah**: Methodology, Validation, Investigation, Resources, Writing - Review & Editing; **Suliyanah**: Validation dan Supervision; **Khaled Issa Khalifa Alemgadmi**: Validation and Supervision and **Utama Alan Deta**: Conceptualization, Validation, and Supervision. All authors have read and approved the final version of this manuscript.

DATA AVAILABILITY STATEMENT

The data supporting the findings of this study are available from the authors upon reasonable request, subject to ethical approval and institutional regulations.

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, Gemini as a tool for creating visual illustrations based on dance movement clips, DeepL for translation assistance, and Grammarly for grammar and style correction. 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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