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Gasing Game: Ethnoscientific Exploration of Circular Motion in Physics Learning on the Coast of East Sumatra to Build the Character of Perseverance

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ABSTRACT

Purpose of the study: The aim of this research is to explore the role of the traditional gasing game as a local wisdom in the coastal areas of East Sumatra in the context of Ethnoscience Physics learning about circular motion.

Methodology: This research uses a naturalistic type of qualitative research method. The subjects in this research were secondary school physics teachers and local community leaders. Data collection techniques use interviews and observation instruments (direct observation). The data analysis technique uses the Miles and Huberman model.

Main Findings: The findings of this research indicate that integrated ethnoscientific physics learning can make physics education more enjoyable, meaningful, and contribute to the development of students' perseverance. The integration of spinning top games into physics education not only enhances practical understanding of physics concepts but also has a positive impact on students' learning enthusiasm and character formation.

Novelty/Originality of this study: This research introduces novelty through serving as a cultural preservation tool for the younger generation and as a means to develop physics learning strategies oriented towards ethnoscientific physics. The aim is to build an understanding of the taught circular motion material and foster perseverance in students' characters.

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1. INTRODUCTION

Education is the main foundation in forming and transferring knowledge to the next generation, which always develops along with the dynamics of society. In this context, local wisdom is becoming an increasingly recognized element in forming the basis for holistic and sustainable education [1]-[3]. Local wisdom includes cultural values, traditions and wisdom inherent in a community [4]-[6]. A worldview from a local aspect provides a valuable dimension to education, enabling students to understand and appreciate diversity and involving them deeply in the local cultural context [7]-9]. Therefore, integrating local wisdom in education is not only a wise choice, but also a necessity so that education can become an effective transformation tool in forming intelligent, moral and competitive individuals at the global level.

Physics learning that integrates local wisdom values into circular motion material is not only an innovative approach, but also a significant step towards a deeper and more relevant understanding for students [10]-[12]. In this context, including elements of local wisdom in physics learning not only makes the material more meaningful, but also creates real connections between physics concepts and the reality of students' daily lives [13]-[15]. Circular motion material, which is often considered abstract, can be articulated through analogies and local wisdom practices, allowing students to understand the concept more easily and enjoyably [16]-[18].

The richness of Indonesian culture which is spread from Sabang to Merauke provides a great opportunity to elevate these cultural values into the educational learning process [19], [20]. One of them is in the coastal area of East Sumatra, Riau. Riau, as an area rich in cultural heritage and traditions, offers traditional games that reflect a wealth of local wisdom that can be integrated relevantly in physics learning, especially regarding circular motion. One of the traditional games that emerged in Riau and has the potential to illustrate the concept of circular motion is the gasing game. Gasing, which is a game involving rotational movements and speed, provides an opportunity for students to experience physics concepts directly [21]-[23].

In the top game, students can observe how the forces acting on the top, such as centrifugal force and moment of inertia, actually influence its rotational motion. The application of these physics principles in traditional games not only provides a practical outlook, but also helps students to understand the concept of circular motion in a more interesting and engaging way [24]-[26]. By involving traditional games such as spinning tops in physics learning, students can see the connection between theoretical concepts and practical applications in everyday life [27]-[29]. The top game involves high levels of perseverance and skill from the players. The process of making and spinning a top requires repeated practice, demanding patience and perseverance to reach a sufficient level of skill. This is in line with studying the physics of circular motion, which often presents concepts that require practice and repetition for in-depth understanding.

Previous research results suggest that incorporating traditional games in multicultural contexts is a viable approach to character development [30]. However, previous research has not provided specific details about the multicultural education approach and traditional games used. Subsequent research also found that by integrating mathematics lesson material about geometry with traditional kite games, it could increase students' interest and processing skills [31]. However, previous research had the limitation of only focusing on 1 mathematics learning material. So it is necessary to carry out further research related to exploring how cultural values, especially in traditional games, can maximize the learning process.

Then the results of previous research found that traditional game-based physics learning was carried out using contextual, inquiry, project and problem-based learning models [32]. Previous research also found that the game-based learning group had the best performance among the three groups, followed by the educational video group, and the conventional learning group with the worst performance [33], [34]. This research highlights the integration of physics material into traditional games, by mentioning certain games such as tulup, benthik, bekelan, sulamanda, stilts, sekongan, jeblugan, and gobak sodor. However, there is a need for more in-depth exploration of how each of these games contributes to the learning process and whether certain games are more effective in conveying certain physics principles. As a generalization and novelty from previous research, this research was conducted to explore the contribution of the traditional top game in the East Coast Coastal Region of Sumatra, Indonesia, in physics learning.

This research carries the concept of ethnoscience physics, where local and traditional aspects, in this case the top game, are integrated with the physics of circular motion. This novelty opens up space to understand physics concepts through the lens of local wisdom, providing a new dimension to the learning approach. Then this research focuses on building students' persistent character through the top game. The character of student persistence in learning is important for students because it is a critical aspect in the educational process that can shape students' thinking patterns, attitudes and behavior towards learning [35]-[37]. By exploring the potential of spinning tops in physics learning, this research presents a new perspective on the way we teach and understand the concept of circular motion.

The importance of learning physics that raises the value of local wisdom in circular motion material is not only in the context of understanding physics concepts but also in developing students as individuals who understand and respect local cultural values. Thus, this step contributes to efforts to deepen the meaning of physics learning and create a more memorable learning experience for students. Then, this research shows that the spinning top game can be a vehicle for building students' character of perseverance. This research aims to explore the role of the traditional top game as a local wisdom in the coastal area of East Sumatra in the context of learning Ethnoscience Physics regarding circular motion.

2. RESEARCH METHOD

This research uses a naturalistic qualitative approach to explore an in-depth understanding of the role of the traditional top game in learning the physics of circular motion in the coastal areas of East Sumatra.

Naturalistic type qualitative research is a research approach that explores and describes phenomena in depth in their natural context [38]-[40]. Naturalistic type qualitative research is descriptive and exploratory [41]-[43].

Population is not just the number of objects/subjects being studied, but includes all the characteristics/traits possessed by the subject or object [44], [45]. The population in this study were 10 community leaders, 14 traditional leaders, 10 youth leaders, and 7 physics teachers on the coast of East Sumatra, Indonesia. In this research, the sampling technique used is probability sampling with purposive sampling technique. The reason for using a purposive sampling technique is because not all samples have criteria that match the phenomenon being studied. The samples in this study were 5 community leaders, 5 traditional leaders, 5 youth leaders and 4 physics teachers in Tambusai District. So the number of samples in this study was 19 people.

The data collection technique in this research is through in-depth interviews and also observation of the traditional top game in terms of physical circular motion. The guidelines for data collection in this research are as follows:

Table 1. Data collection guidelines grid

Variable	Aspect	Indicator
Exploration	Traditional game	History of the origins of traditional games
		How to play and traditional game process
		Rules in traditional games
		Terms used in traditional games
	Physics ethnoscience learning and character of perseverance	The concept of physics ethnoscience learning in traditional games
		Student participation in top game.
		Interaction between students during activities.
		Teachers' views on the role of top games in building students' character of perseverance.
		The teacher's efforts to motivate students to remain diligent in understanding the physics of circular motion.

In this study, researchers used structured interviews. Then, through observational data collection techniques, the observations made are on the traditional game process itself and note down the terms in traditional games which will then be reconstructed into scientific knowledge. The data analysis technique used in this research is descriptive using an interactive model, namely the Miles and Huberman model. Data from interviews and observations will be analyzed thematically to identify patterns, themes and relationships between concepts. This will provide an in-depth understanding of how the traditional spinning top game influences the learning of the physics of circular motion and the character of students' persistence. The data analysis steps taken include data collection, data reduction, data presentation, conclusions and verification.

3. RESULTS AND DISCUSSION

The results of data collection through interviews with structured questions that had been prepared beforehand, obtained answers from the sources, which are presented in table 2 below:

Table 2. Results of interviews with traditional leaders, communities and youth in the coastal area of East Sumatra

Gasiang Game (top game)		
No.	Question	Response
1.	What do you know regarding the history and origins of the gasing game?	Based on answers from several sources, it can be seen that: Gasiang game is a rotating fruit originally from areca nut. According to local traditional figures, the gasing game tends to give philosophical and spiritual meaning to the top game. For example, there is a belief that a top represents a symbol of life, the balance of nature, or contains wisdom values passed down from generation to generation.Then, people in the coastal areas of East Sumatra also often hold traditional games or traditional game festivals. This is not only an entertainment event, but also a celebration of local culture and wisdom. Then for the Malay tribe, gasing is part of the celebration of the planting and harvest seasons, and is even said to be a medium for predicting the future. Gasing is a traditional Malay game since time immemorial.
2.	What tools and materials are usually used in top games?	Based on information from sources, it is known that the tools and materials usually used in top games consist of rope, wood and nails. Then the field for playing.

3.	What is the shape of a top? Can you explain the parts of a gasing?	From the results of interviews, it was discovered that Gasing in the coastal areas of East Sumatra has a distinctive shape and reflects local identity. Some tops are oval in shape, called heart tops, and round ones are called shell tops. The types of Gasiang which are characteristic of this area are Gasiang Jantong and Gasiang Taka. The parts consist of a round part above the head, below which is a place to wrap the rope. It's called the neck, there is a shoulder for the boundary of wrapping the rope, there is a body between the head and tail. The bottom one is called the four-spiked tail or commonly called paci. Generally, tops in this area are made from local wood which is light and durable. The body of a top is usually cylindrical or conical in shape, with a pointed tip to make it easier to spin on the beach sand. The center of the top is often decorated with traditional motifs or bright colors, reflecting the rich local art and aesthetics. The top handle is designed to fit the player's hand and provide good control during the game. At the bottom of the top, there are spikes that help stabilize the top when it rotates in the sand field. Gasing in the coastal areas of East Sumatra is not only considered a game, but also as a cultural heritage that is guarded and passed down from generation to generation. Each part of the top plays an important role in maintaining the beauty and balance of the game, creating a unique and deep experience in local traditions.

4.	Why is the lower leg (axle) of the top pointed?	From several sources it is known that the bottom of the gasing, or axle, is designed with a sharp tip to have a practical and cultural purpose in the game of tops. The pointed tip makes it easier for the top to penetrate sand or soil, ensures its stability during rotation, and minimizes the risk of losing balance. Then aim to make the top spin and spin for a long time. In relation to physics, this is useful for reducing friction so that the top can spin longer. Apart from the functional aspect, this spiky shape reflects local traditions, cultural wisdom, and is an element of identity that enriches the experience of playing tops in a region..
5.	How to play spinning top?	It is known that playing tops involves several simple movements. First, the player inserts the top into the hole that has been prepared in the middle of the playing field. After that, the top is rotated using a rope or rotating tool until it reaches the desired speed. When the top has reached maximum speed, the player releases the top onto the field. The top will spin on the sand or ground, and players try to keep the top spinning as desired by using the supporting rope. Players can also make various hand movements to control the direction and speed of the top. The main goal is to keep the top spinning as much as possible to achieve the longest spin time or keep the top inside the playing circle.
6.	Is there an influence on the number of turns of rope on how long/not the top spins?	Based on information from community leaders and youth in the coastal areas of the east coast of Sumatra, it is known that the number of rope coils on a top can affect how long the top spins. This opinion is strengthened by the statement of a physics teacher in the coastal area of East Sumatra, namely that in principle the more coils of rope on a top, the greater the moment of inertia produced. Moment of inertia is a measure of an object's resistance to changes in its rotational motion. In the context of a top, a larger moment of inertia will make the top more stable and tend to spin longer.

		The number of turns of the rope can affect the distribution of mass on the top, which in turn affects the moment of inertia. A top with a greater number of coils of string will have a greater moment of inertia because the mass of the string distributes the total mass of the top to the outside, away from the axis of rotation. Thus, the top will be more difficult to change direction or rotation speed. However, there are also other factors that can influence how long the top spins, such as the initial speed of rotation, the quality of the rope, and the surface of the playing field. In practice, the effect of the number of rope turns can vary depending on the design of the top, playing technique, and playing conditions.
7.	Why does a top spin on its axis?	According to sources in this research, the top can rotate on its axis because the top is balanced, coupled with nails and the artificiality of the top itself. In terms of physics concepts, the physics teacher who was the resource person explained that the circular motion of a top occurs when the top rotates on its axis, creating a circular path centered on the axis of rotation. The concepts of angular velocity and rotation frequency become relevant in assessing the speed and number of rotations of a top. The forces of friction and gravity create angular momentum that supports the stable circular motion of the top. The center of mass of the top being parallel to the axis of rotation ensures balance between centrifugal and gravitational forces, supporting the stability of circular motion. By understanding these principles, players can optimize their control and skills in keeping the top spinning long and steady during the game.
8.	In the physics learning process, especially in circular motion, how do students interact when the learning is integrated with the traditional top game?	The integration of the traditional spinning top game in physics learning, especially circular motion material, produces dynamic student interaction. Students not only understand physics concepts theoretically, but also experience their practical application through playing tops. Active student involvement, practical experience, collaboration and communication between students, as well as increased motivation and interest, are the positive impacts of this approach. Through games, students deepen their understanding of physics concepts by relating them directly to practical experience, creating a fun and memorable learning environment.
9.	This traditional spinning top game can be integrated into physics learning on what subjects and how is it applied?	From several sources' answers, it can be seen that the traditional spinning top game can be integrated into physics learning, especially circular motion material. The teacher introduces the basic concept of circular motion, then students play tops to observe and control physical factors, such as speed and stability of rotation. Through measurement and analysis, students apply physics concepts practically. Post-game discussions help them understand physics concepts in more depth. The integration of top games not only makes learning more fun, but also increases students' understanding of circular motion.
10.	What about the application of the integration of physics learning with the traditional top game to build students' persistent learning character?	The integration of physics learning with the traditional spinning top game can play an important role in building students' persistent learning character. Through this game, students are trained not to give up easily when facing difficulties in controlling the rotation of the top. They learn to be patient in understanding complex game techniques and understand that satisfactory achievements require time and patience. The students' dedication in improving their skills in the top game also reflects an attitude of perseverance, which encourages them to continue trying in the face of challenges. Students' learning motivation also increases because spinning tops make learning physics more interesting and fun. Apart from that, students also learn to accept failure as part of the learning process and see it as an opportunity to grow and improve themselves. Thus, the integration of the traditional gasing game not only teaches physics concepts, but also forms students' character who is persistent, patient, and never gives up in facing learning challenges.

Gasiang (top) is a toy made from wood that is rounded in such a way. It is called a gasiang because this object makes a whirring sound that comes from its very fast rotation. This rotating sound is called dosiang (whispering). Gasiang is made by sharpening it using a knife, or running it using a gorejoh (turner). The

traditional game of gasing, especially on the coast of East Sumatra, has deep philosophical and spiritual meaning. Local traditional leaders emphasize that spinning tops are not just a game, but a symbol of life, natural balance and the passing on of wisdom values from generation to generation. In the Malay celebration of the planting and harvest seasons, gasing is also used as a medium for predicting the future. The distinctive shapes of tops, such as tops jantong and tops taka, reflect local identity by using local wood that is light and durable.

Figure 1. Top shape

Source: research documentation

The parts of a top, such as the head, neck, shoulders, body and tail, have an important role in maintaining the beauty and balance of the game, which is not only considered an entertainment activity but also as a cultural heritage that is guarded and inherited. The material usually used to make gasiang is the base of wood found in the ground from tree species; toreh jua, shophouse wood, tomutun wood, bongkuang wood, cocang wood, potai wood, etc. The best Gasiang materials are banie kompeh (felt wood), mato koliang wood (rivet), kasai wood, and keranji wood. According to the knowledge of community leaders and traditional leaders, the Gasiang can rotate on its axis because the Gasiang is balanced and is equipped with nails and is made from the Gasiang itself. Meanwhile, youth leaders do not know this. In physics, bupusiang (spinning) is called rotation. Rotation is the turning of something about its axis [46]. Gasiang can rotate on its axis because in Gasiang the concepts of rotational dynamics and rigid body equilibrium apply.

Figure 2. Local wisdom of the traditional game Gasing in the Coastal Area of East Sumatra

Source: research documentation

The influence of the number of coils of the rope on the top is a key aspect in understanding the physics of this game. The more turns the rope has, the greater the moment of inertia, making the top more stable and likely to spin longer. When the top is thrown, the top will move in a circular motion pattern because the rope connected to the top will pull it towards the center of rotation. This shows an important principle of circular motion in physics. When a top spins, it has angular momentum which is the product of mass, angular velocity, and distance from the axis of rotation. The principle of angular momentum plays an important role in understanding the stability and rotational motion of a top [47]-[49]. However, spinning tops also involve other factors such as the initial speed of the spin, the quality of the rope, and the surface of the playing field, all of which influence whether or not the top spins. Physics concepts, such as angular velocity, rotation frequency, friction force, and gravity, become relevant in maintaining the stability and sustainability of the circular motion of a top.

The integration of top games in physics learning has a positive impact on students. They not only understand physics concepts theoretically, but also experience their practical application through playing tops. Learning becomes more fun and memorable, increasing students' learning motivation [50], [51]. Apart from that, the spinning top game also plays a role in building students' character by teaching values such as perseverance, patience and never giving up. Thus, the traditional top game is not only part of cultural heritage, but also a valuable learning resource in the context of physics and student character education.

Previous research which is in line with the current research found that persistence is positively related to difficulty and that the most persistent students will be very persistent in various topics in achieving the best solution. This is supported by incorporating games into the learning environment [52]. Subsequent research found that learning that utilizes digital games and physical activity games contributes positively to students' academic achievement because of the game-based teaching method, they eliminate their biases regarding physics lessons and they do not feel afraid of physics anymore [53]. In line with the results of previous research,

integrating games will shape students' enthusiasm and persistent character. Apart from that, learning physics allows students to concentrate on physics concepts and involve students in understanding physics concepts practically. The difference is that this research explores aspects of local wisdom in physics learning, especially involving traditional games, and highlights the unique potential of these games as a learning tool.

As a form of generalization and novelty from previous research, this research highlights the contribution of the traditional game, namely gasiang (gasing) in the coastal area of East Sumatra in learning physics and building students' character of perseverance. The novelty or originality in this research lies in the in-depth exploration of the traditional gasing game on the coast of East Sumatra, especially in the context of the philosophical, spiritual and cultural meanings inherent in this tradition. This research makes a new contribution by revealing that gasing is not just a traditional game, but a profound means of communicating life values and cultural heritage.

The emphasis on integrating top games in physics learning also shows an innovative approach in enriching students' learning experiences through the application of physics concepts in real contexts. The conclusions drawn from interviews with informants, especially regarding the influence of the number of rope coils on the top, provide a valuable contribution to the understanding of the physics of this game. Thus, the originality of this research lies in the combination of a deep understanding of the cultural and spiritual aspects of traditional games with an innovative educational approach.

The Gasiang game in the coastal area of East Sumatra, Indonesia, is also a traditional game in Malaysia. The game of gasing in Malaysia also involves players spinning their top with a string and trying to knock over their opponent's top. A top that spins steadily and for a long time is considered a good skill in this game. As in Indonesia, gasing games in Malaysia are often part of traditional events, festivals or cultural competitions [54], [55]. Playing tops requires a lot of practice and skill. Players need to be patient and diligent in training themselves so they can master the technique of spinning a top well. Traditional games in Maryland that apply the concept of rotation include the Marbles and Jacks game, namely when marbles rotate or roll on a flat surface, they can show rotational motion. Then Jacks, when thrown up and then caught, can describe rotational motion in the air. Players need to understand how to maintain control and balance of a rotating object, although this rotational motion may be simpler than a full circular motion.

The research results show that spinning tops are not just entertainment, but also carry philosophical and spiritual meaning in local culture, such as a symbol of life and natural balance. With its distinctive design and local identity, gasing is an integral part of the celebration of culture and traditional wisdom in the coastal areas of East Sumatra. The integration of spinning tops in physics learning not only deepens practical understanding of physics concepts, but also helps shape students' character, such as perseverance and patience, through a fun and memorable learning experience. Limitations of this research include its limited geographical coverage to the coastal areas of East Sumatra, allowing limited generalizations to all Indonesian culture. Focusing on the physics of spinning tops can ignore the broader social and cultural dimensions. In addition, this research does not explore the perspectives of players or people who are not involved in the gasing game, and does not consider external factors that could influence the sustainability of this game in the future.

4. CONCLUSION

This research highlights the important role of spinning tops in the cultural and physical context of the coastal areas of East Sumatra. The research results show that spinning tops are not just a game, but also carry deep philosophical and spiritual values and have distinctive designs that reflect local identity. Gasing games are not only part of cultural celebrations and traditional wisdom, but also have a positive impact when integrated into physics learning, increasing student engagement and understanding of physics concepts through practical experience. As a recommendation, further research could expand the geographic scope to include cultural variations throughout Indonesia for more representative results.

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REFERENCES

[1] J. C. A. Sandoval-Rivera, "Environmental education and indigenous knowledge: Towards the connection of local wisdom with international agendas in the framework of the Sustainable Development Goals (SDGs)," *Diaspora, Indig. Minor. Educ.*, vol. 14, no. 1, pp. 14–24, 2020, doi: 10.1080/15595692.2019.1652588.

[2] R. Zidny, J. Sjöström, and I. Eilks, "A Multi-Perspective Reflection on How Indigenous Knowledge and Related Ideas Can Improve Science Education for Sustainability," *Sci. Educ.*, vol. 29, no. 1, pp. 145–185, 2020, doi: 10.1007/s11191-

019-00100-x.
[3] M. Huda *et al.*, "Building harmony in diverse society: insights from practical wisdom," *Int. J. Ethics Syst.*, vol. 36, no. 2, pp. 149–165, 2020, doi: 10.1108/IJOES-11-2017-0208.
[4] A. D. Rambu Atahau, A. D. Huruta, and C. W. Lee, "Rural microfinance sustainability: Does local wisdom driven - governance work?," *J. Clean. Prod.*, vol. 267, 2020, doi: 10.1016/j.jclepro.2020.122153.
[5] J. Varghese and S. S. Crawford, "A cultural framework for Indigenous, Local, and Science knowledge systems in ecology and natural resource management," *Ecol. Monogr.*, vol. 91, no. 1, p. e01431, 2020, doi: 10.1002/ecm.1431.
[6] M. Kahn-John, T. Badger, M. M. McEwen, M. Koithan, D. Saint Arnault, and T. M. Chico-Jarillo, "The Diné (Navajo) Hózhó Lifeway: A Focused Ethnography on Intergenerational Understanding of American Indian Cultural Wisdom," *J. Transcult. Nurs.*, vol. 32, no. 3, pp. 256–265, 2021, doi: 10.1177/1043659620920679.
[7] M. Shaw, "Worldview literacy as intercultural citizenship education: A framework for critical, reflexive engagement in plural democracy," *Educ. Citizsh. Soc. Justice*, vol. 18, no. 2, pp. 97–213, 2023, doi: 10.1177/17461979211062125.
[8] T. Lipiäinen, A. Halafoff, F. Mansouri, and G. Bouma, "Diverse worldviews education and social inclusion : a comparison between Finnish and Australian approaches to build intercultural and interreligious understanding," *Br. J. Relig. Educ.*, vol. 42, no. 4, pp. 391–402, 2020, doi: 10.1080/01416200.2020.1737918.
[9] T. McCowan, "The climate crisis as a driver for pedagogical renewal in higher education," *Teach. High. Educ.*, vol. 28, no. 5, pp. 933–952, 2023, doi: 10.1080/13562517.2023.2197113.
[10] L. Biberman-Shalev, "Motivational factors for learning and teaching global education," *Teach. Teach. Educ.*, vol. 106, p. 103460, 2021, doi: 10.1016/j.tate.2021.103460.
[11] B. C. Herman, M. H. Newton, and D. L. Zeidler, "Impact of place-based socioscientific issues instruction on students' contextualization of socioscientific orientations," *Sci. Educ.*, vol. 105, no. 4, pp. 585–627, 2021, doi: 10.1002/sce.21618.
[12] G. M. A. Bermudez, R. Pérez-Mesa, and M. E. Ottogalli, "Biodiversity Knowledge and Conceptions in Latin American: Towards an Integrative New Perspective for Education Research and Practice," *Int. J. Educ. Math. Sci. Technol.*, vol. 10, no. 1, pp. 175–217, 2022, doi: 10.46328/ijemst.2105.
[13] S. Cai, C. Liu, T. Wang, E. Liu, and J. C. Liang, "Effects of learning physics using Augmented Reality on students' self-efficacy and conceptions of learning," *Br. J. Educ. Technol.*, vol. 52, no. 1, pp. 235–251, 2021, doi: 10.1111/bjet.13020.
[14] S. Y. Chen and S. Y. Liu, "Using augmented reality to experiment with elements in a chemistry course," *Comput. Human Behav.*, vol. 111, p. 106418, 2020, doi: 10.1016/j.chb.2020.106418.
[15] M. Hernandez-de-Menendez, C. A. Escobar Díaz, and R. Morales-Menendez, "Educational experiences with Generation Z," *Int. J. Interact. Des. Manuf.*, vol. 14, no. 3, pp. 847–859, 2020, doi: 10.1007/s12008-020-00674-9.
[16] S. Darwish, A. Patel, P. Steed, and S. Stagnell, "Abducens Nerve Palsy. An uncommon complication of removal of an upper wisdom tooth under local anaesthesia," *Oral Surg.*, vol. 13, no. 3, pp. 260–267, 2020, doi: 10.1111/ors.12484.
[17] H. Zhu, P. Hu, X. Tang, D. Xia, and H. Huang, "NAGNet: A novel framework for real-time students' sentiment analysis in the wisdom classroom," *Concurr. Comput. Pract. Exp.*, vol. 35, no. 22, 2023, doi: 10.1002/cpe.7727.
[18] C. Ueangchokchai, "Process of Local Wisdom Transfer to Promote Good Relationship between the Elderly and New Generations," *High. Educ. Stud.*, vol. 12, no. 3, pp. 86–96, 2022, doi: 10.5539/hes.v12n3p86.
[19] Z. Hidayah, *A Guide to Tribes in Indonesia Anthropological Insights from the Archipelago*. Singapore: Springer Singapore, 2020. doi: 10.1007/978-981-15-1835-5.
[20] M. Turmuzi, I. G. P. Suharta, and I. N. Suparta, "Ethnomathematical research in mathematics education journals in Indonesia: A case study of data design and analysis," *Eurasia J. Math. Sci. Technol. Educ.*, vol. 19, no. 1, pp. 1–13, 2023, doi: 10.29333/ejmste/12836.
[21] M. Monteiro and A. C. Martí, "Resource Letter MDS-1: Mobile devices and sensors for physics teaching," *Am. J. Phys.*, vol. 90, no. 5, pp. 328–343, 2022, doi: 10.1119/5.0073317.
[22] M. Rodrigues and P. S. Carvalho, "Virtual experimental activities: a new approach," *Phys. Educ.*, vol. 57, no. 4, 2022, doi: 10.1088/1361-6552/ac5f77.
[23] D. F. Rizaldi, F. Atiqoh, D. Dwikoranto, B. K. Prahani, F. C. Wibowo, and S. Astutik, "Analysis of Physics Concepts in Gasing Games," *Int. J. Emerg. Res. Rev.*, vol. 1, no. 1, p. 000005, 2023, doi: 10.56707/ijoerar.v1i1.5.
[24] M. Weingärtner and T. Weingärtner, "Quantum Tic-Tac-Toe - learning the concepts of quantum mechanics in a playful way," *Comput. Educ. Open*, vol. 4, p. 100125, 2023, doi: https://doi.org/10.1016/j.caeo.2023.100125.
[25] N. Behnamnia, A. Kamsin, M. A. B. Ismail, and A. Hayati, "The effective components of creativity in digital game-based learning among young children: A case study," *Child. Youth Serv. Rev.*, vol. 116, no. March, p. 105227, 2020, doi: 10.1016/j.childyouth.2020.105227.
[26] S. Lee-Cultura, K. Sharma, and M. Giannakos, "Children's play and problem-solving in motion-based learning technologies using a multi-modal mixed methods approach," *Int. J. Child-Computer Interact.*, vol. 31, p. 100355, 2022, doi: 10.1016/j.ijcci.2021.100355.
[27] Z. Akimkhanova, K. Turekhanova, and G. P. Karwasz, "Interactive Games and Plays in Teaching Physics and Astronomy," *Educ. Sci.*, vol. 13, no. 4, pp. 1–22, 2023, doi: 10.3390/educsci13040393.
[28] A. C. Barton *et al.*, "Disruptive moments as opportunities towards justice-oriented pedagogical practice in Informal Science Learning," *Sci. Educ.*, vol. 105, no. 6, pp. 1229–1251, 2021, doi: 10.1002/sce.21682.
[29] K. Sharpe, "Disruptive moments as opportunities towards justice-oriented pedagogical practice in Informal Science Learning," *Negot. J.*, vol. 36, no. 2, pp. 169–188, 2020, doi: 10.1111/nejo.12324.
[30] N. R. Dewi, E. Saputri, S. Nurkhalisa, and I. Akhlis, "The effectiveness of multicultural education through traditional games-based inquiry toward improving student scientific attitude The effectiveness of multicultural education through traditional games-based inquiry toward improving student scientific atti," *J. Phys. Conf. Ser.*, vol. 1567, pp. 1–7, 2020, doi: 10.1088/1742-6596/1567/4/042051.

[31] K. Kamid, R. Rohati, H. Hobri, E. Triani, S. Rohana, and W. A. Pratama, "Process Skill and Student's Interest for Mathematics Learning: Playing a Traditional Games," *Int. J. Instr.*, vol. 15, no. 3, pp. 967–988, 2022, doi: 10.29333/iji.2022.15352a.
[32] H. Putranta, H. Kuswanto, M. Hajaroh, S. I. A. Dwiningrum, and Rukiyati, "Strategies of physics learning based on traditional games in senior high schools during the Covid-19 pandemic," *Rev. Mex. Fis. E*, vol. 19, no. 1, pp. 1–15, 2021, doi: 10.31349/REVMEXFISE.19.010207.
[33] H. Zeng, S. N. Zhou, G. R. Hong, Q. Y. Li, and S. Q. Xu, "Evaluation of interactive game-based learning in physics domain," *J. Balt. Sci. Educ.*, vol. 19, no. 3, pp. 484–498, 2020, doi: 10.33225/jbse/20.19.484.
[34] Y. C. Chen, Y. L. Lu, and C. J. Lien, "Learning environments with different levels of technological engagement: a comparison of game-based, video-based, and traditional instruction on students' learning," *Interact. Learn. Environ.*, vol. 29, no. 8, pp. 1363–1379, 2021, doi: 10.1080/10494820.2019.1628781.
[35] J. M. Cámara-zapata and D. Morales, "Cooperative learning , student characteristics , and persistence : an experimental study in an engineering physics course," *Eur. J. Eng. Educ.*, vol. 0, no. 0, pp. 1–13, 2019, doi: 10.1080/03043797.2019.1569593.
[36] M. S. Andrade, R. M. Miller, D. Mcarthur, and M. Ogden, "The Impact of Learning on Student Persistence in Higher Education," *J. Coll. Student Retent. Res. Theory Pract.*, vol. 0, no. 0, pp. 1–21, 2020, doi: 10.1177/1521025120915576.
[37] G. Mutlu and A. Yıldırım, "Learning Environment Perceptions and Student Background Variables as Determinants of Persistence in EFL Learning," *SAGE Open*, no. 14, pp. 1–17, 2019, doi: 10.1177/2158244019898805.
[38] P. Tikka, M. Kaipainen, and J. Salmi, "Neuropsychologia Narrative simulation of social experiences in naturalistic context – A neurocinematic approach," *Neuropsychologia*, vol. 188, no. July, pp. 1–11, 2023.
[39] J. Ninan, "Online naturalistic inquiry in project management research: Directions for research," *Proj. Leadersh. Soc.*, vol. 1, 2020, doi: 10.1016/j.plas.2020.100002.
[40] H. Nassaji, "Good qualitative research," *Lang. Teach. Res.*, vol. 24, no. 4, pp. 427–431, 2020, doi: 10.1177/1362168820941288.
[41] M. Lichtman, *Qualitative Research in Education*. New York: Routledge, 2023. doi: 10.4324/9781003281917.
[42] A. M. Ortiz Bernal, C. L. Raison, R. L. Lancelotta, and A. K. Davis, "Reactivations after 5-methoxy-N,N-dimethyltryptamine use in naturalistic settings: An initial exploratory analysis of the phenomenon's predictors and its emotional valence," *Front. Psychiatry*, vol. 13, no. November, pp. 1–13, 2022, doi: 10.3389/fpsyt.2022.1049643.
[43] H. Kyngäs, "Qualitative Research and Content Analysis," in *The Application of Content Analysis in Nursing Science Research*, Springer, Cham, 2019, pp. 3–111. doi: 10.1007/978-3-030-30199-6_1.
[44] J. R. Covvey, S. M. Vogel, A. M. Peckham, and K. E. Evoy, "Prevalence and characteristics of self-reported kratom use in a representative US general population sample," *J. Addict. Dis.*, vol. 0, no. 0, pp. 506–513, 2020, doi: 10.1080/10550887.2020.1788914.
[45] H. R. Whittaker, J. M. Pimenta, D. Jarvis, S. J. Kiddle, and J. K. Quint, "Characteristics associated with accelerated lung function decline in a primary care population with chronic obstructive pulmonary disease," *Int. J. COPD*, vol. 15, pp. 3079–3091, 2020, doi: 10.2147/COPD.S278981.
[46] K. K. Niall, "'Mental rotation' in depth as the superficial correlation of pictures," *Methods Psychol.*, vol. 2, no. February 2019, p. 100019, 2020, doi: 10.1016/j.metip.2020.100019.
[47] T. Imamura, J. Mitchell, S. Lebonnois, Y. Kaspi, A. P. Showman, and O. Korablev, "Superrotation in Planetary Atmospheres," *Space Sci. Rev.*, vol. 216, no. 5, 2020, doi: 10.1007/s11214-020-00703-9.
[48] G. D. Bruce, P. Rodríguez-Sevilla, and K. Dholakia, "Initiating revolutions for optical manipulation: the origins and applications of rotational dynamics of trapped particles," *Adv. Phys. X*, vol. 6, no. 1, 2021, doi: 10.1080/23746149.2020.1838322.
[49] A. Ebrahimi-Mamaghani, A. Forooghi, H. Sarparast, A. Alibeigloo, and M. I. Friswell, "Vibration of viscoelastic axially graded beams with simultaneous axial and spinning motions under an axial load," *Appl. Math. Model.*, vol. 90, pp. 131–150, 2021, doi: 10.1016/j.apm.2020.08.041.
[50] J. Zeng, S. Parks, and J. Shang, "To learn scientifically, effectively, and enjoyably: A review of educational games," *Hum. Behav. Emerg. Technol.*, vol. 2, no. 2, pp. 186–195, 2020, doi: 10.1002/hbe2.188.
[51] A. N. Saleem, N. M. Noori, and F. Ozdamli, "Gamification Applications in E-learning: A Literature Review," *Technol. Knowl. Learn.*, vol. 27, no. 1, pp. 139–159, 2022, doi: 10.1007/s10758-020-09487-x.
[52] R. Israel-Fishelson and A. Hershkovitz, "Persistence in a Game-Based Learning Environment: The Case of Elementary School Students Learning Computational Thinking," *J. Educ. Comput. Res.*, vol. 58, no. 5, 2019, doi: 10.1177/073563311988718.
[53] Z. Yıldırım and M. Baran, "A comparative analysis of the effect of physical activity games and digital games on 9th grade students' achievement in physics," *Educ. Inf. Technol.*, vol. 26, pp. 543–563, 2021, doi: 10.1007/s10639-020-10280-7.
[54] A. Darmawan, "Erecting the submerged tree trunk," *Indones. Malay World*, vol. 00, no. 0, pp. 1–25, 2024, doi: 10.1080/13639811.2024.2294612.
[55] H. Jocom, D. Setiawan, I. Andesta, and A. K. Dewi, "The Dynamics of Tourism Development: Study Case Tourism Attributes in Penyengat Island," *Int. J. Appl. Sci. Tour. Events*, vol. 5, no. 2, pp. 107–120, 2021, doi: 10.31940/ijaste.v5i2.107-120.