Exploring Physics Concepts on the "Fahombo" Stone Jumping Tradition in Nias Tribe, Indonesia

Ika Pratiwi, Yogyakarta State University, Indonesia
Heru Kuswanto, Yogyakarta State University, Indonesia

The Kyoto Conference on Arts, Media & Culture 2024
Official Conference Proceedings

Abstract
Physics learning in Indonesia is still regarded as a subject that students fear and find boring. One way to address this issue is by integrating local culture with physics concepts. This study investigates the physics concepts embedded in the traditional stone-jumping tradition, "Fahombo," practiced by the Nias tribe in Indonesia. Fahombo is a cultural ceremony where young men, transitioning into adulthood, jump over stones that are 2 to 2.5 meters high. The focus of this research is the physical mechanics of the jump, including the run-up, the jump itself, the airborne phase, and the landing. This article employs a descriptive qualitative method, combining observational analysis, YouTube video recordings, and theoretical physics calculations to identify the relevant physics concepts. The findings reveal several physics concepts within this stone-jumping tradition, including kinematics and dynamics. In kinematics, the concepts of linear and parabolic motion are present. In dynamics, the study explores the forces acting on objects, momentum, impulse, work and energy. Moreover, this study demonstrates that local culture has the potential to be integrated into various branches of science. Moving forward, it is hoped that more scientific disciplines will be linked to local cultures, not only to promote cultural heritage but also to make the learning experience more engaging.

Keywords: Local Culture, *Fahombo* Stone, Physics Concepts

Introduction

Physics learning isn't just about memorizing formulas or doing calculations; it involves truly understanding the concepts that explain the natural world. As a science, physics seeks to uncover the fundamental principles behind natural phenomena (Taurusi et al., 2024). Despite this, many students in Indonesia still find physics to be one of the most difficult subjects. This difficulty is largely due to the low interest in studying physics (Amalissholeh et al., 2023), which makes it harder for students to grasp its concepts and formulas (Sampe Daun et al., 2020). One reason for this is that physics education continues to rely on traditional, often monotonous teaching methods (Winarti et al., 2021) which only provide general examples or even those that are rarely known to students and the learning carried out is only rote, so that it has an impact on students' insensitivity to events that occur in their environment, even though these events are related to physics (Mardana et al., 2022). To overcome this challenge, a tailored strategy is needed. A promising approach could be to integrate physics education with students' everyday experiences and local culture (Yuenyong & Yuenyong, 2012). Incorporating local wisdom, culture, and traditions into physics learning is crucial (Ali & Aprilia, 2024). This is because physics often deals with abstract concepts and complex equations, which can be made more relatable and easier to understand by connecting them to local culture (Mavhunga & Kibirige, 2018). In addition, integrating physics learning with local culture can improve students' skills in examining, interpreting (Wati et al., 2020), and understanding of physics material (Elvianasti et al., 2023).

Indonesia, as a vast archipelago with thousands of islands and diverse ethnic groups, is home to a rich tapestry of cultures, each with its own unique characteristics. From traditional customs and ceremonies to art, music, language, and cuisine, every Indonesian culture offers something distinct and fascinating. There are many local cultures that can be associated with physics, one of which is the "*Fahombo*" stone jumping tradition of the Nias tribe, a tradition that has lived for generations and is strongly attached to the people of Nias Island, North Sumatra, in Indonesia (Siregar & Syamsuddin, 2015). This tradition is intended for teenagers who are approaching adulthood where they have to jump over a 2-2,5 m high stone structure with a stone thickness of 40 cm (Gea & Sazali, 2023). This tradition was born when there was a tribal conflict (between village) in the area and the community had to prepare tough young people to defend their homeland (Saputra & Kuswanto, 2018). According to (Siregar & Syamsuddin, 2015), The tradition of stone jumping also contains positive values such as dexterity, maturity, courage, tenacity, fighting spirit, and heroism.

Integrating the study of physics with cultural traditions offers a novel perspective that enriches our understanding of Nias culture while also demonstrating how scientific principles are embedded in the daily practices of traditional societies. Therefore, this study aims to investigate the physical concepts related to the "*Fahombo*" tradition in the Nias tribe and evaluate the potential of using this tradition as a more diverse and relevant physics learning source.

Methods

This research employs a descriptive qualitative method. This study aims to examine and clarify the existence of a phenomenon that occurs in society (Moleong, 2018). The technique used is combining observational analysis of YouTube video recordings about Fahombo Stone Jumping with theoretical physics calculations to identify relevant physics concepts. The data collected is then analyzed through three stages: first, reducing the data by correlating the

video identifications with the appropriate physics concepts; second, presenting the data in a descriptive textual format; and third, drawing conclusions.

Results and Discussion

"Fahombo" Stone Jumping

Fahombo is a stone-jumping tradition originating from Bawomataluo village in South Nias Regency, North Sumatra Province, Indonesia. This tradition is intended for teenagers who are approaching adulthood where they have to jump over a 2-2,5 m high stone structure with a stone thickness of 40 cm (Gea & Sazali, 2023). There is a smaller stone beside the main stone, used as a stepping point before leaping over the main one. Originally, this tradition was carried out to demonstrate that young men who successfully completed the jump were considered physically mature, agile, and courageous. (Kemdikbud, 2023). This is because, there was a tribal conflict (between village) in the area and the community had to prepare tough young people to defend their homeland (Saputra & Kuswanto, 2018).

The physics analysis of the *Fahombo* tradition is conducted using various images and video clips to clearly illustrate the different physics concepts involved in the ritual. This analysis begins with the moment the young man prepares to jump, starting with a slow run, gradually increasing his speed, leaping over the stone, and finally landing on the ground. The sequence of events in the *Fahombo* Stone Jumping process is depicted in Figure 1.

Figure 1: *Fahombo* Stone Jumping

The results of the exploration are divided into two main classical physics themes, including kinematics dan dynamics. The results of the physics concept analysis can be seen in Table 1.

Table 1: Analysis Physics Concepts in *Fahombo* Stone Jumping

Phenomena in *Fahombo* Stone Jumping	Main Themes	Sub-themes
A man runs toward the stone at a certain speed	Kinematics	Uniform Rectilinear Motion (URM) or Uniformly Accelerated Rectilinear Motion (UARM) n
A man jumps over the stone in a parabolic motion.		Parabolic Motion
A man maintains his balance to avoid falling when landing.		Newton's 1st Law
A man runs toward the stone at a specific speed, taking into account his body mass.		Newton's 2nd Law
An action-reaction force occurs in his legs while running, as his feet push off the stone just before jumping		Newton's 3rd Law
His legs act as a support, propelling him upward during the jump		Momentum and Impulse
A man runs from the starting point, jumps, and lands on the ground		Work and Energy

Source: (Saputra, 2018), with further development

Physics Concepts on "*Fahombo*"

Kinematics

Kinematics in physics is a branch of science that studies the motion of objects without considering the causes (Giancoli, 2014). Kinematics always discusses distance and displacement, speed, acceleration, and time. Subfields within kinematics include Uniform Linear Motion (ULM), Uniformly Accelerated Linear Motion (UALM), Uniform Circular Motion, and Projectile Motion. The forms of kinematics in *Fahombo* Stone Jumping include:

1. Uniform Linear Motion (ULM) and Uniformly Accelerated Linear Motion (UALM)

Uniform linear motion (ULM) is the motion of an object in a straight line with a constant speed. On the other hand, uniformly accelerated linear motion (UALM) is the motion of an object in a straight line with a constant acceleration, meaning its speed is changing at a constant rate. This can be observed when a jumper takes a running start before jumping over a stone. An illustration of this can be seen in Figure 2 below.

Figure 2: ULM and UALM in *Fahombo* Stone Jumping

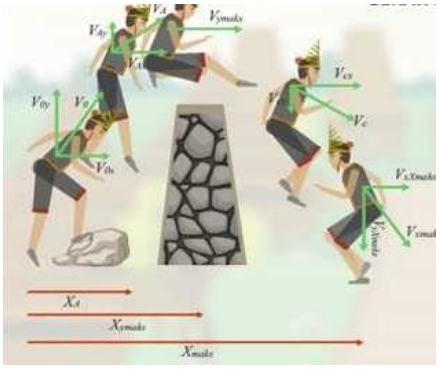
This phenomenon can be attributed to the principles of ULM and UALM, as any object in motion must exhibit velocity and acceleration.

2. Parabolic Motion

The application of parabolic motion is evident when a jumper leaps over a stone that is 2-2.5 meters high. If this condition is described in two dimensions, air resistance is neglected (Giancoli, 2014). Parabolic motion is a motion whose trajectory forms a parabola. This motion is a combination of uniform linear motion (horizontal axis) because there is no acceleration or deceleration, and uniformly accelerated linear motion (vertical axis) because it is influenced by gravitational acceleration (Saputra, 2018).


Figure 3: The Parabola Formed When Jumping Over a Stone

An analysis was conducted when the jumper moved freely in the air, influenced by gravity, so the jumper's acceleration was due to the Earth's gravity and directed downwards. The jumper's motion can be understood by analyzing the vertical (y) and horizontal (x) components of their motion, as seen in Figure 4. This is in line with Halliday et al. (2010) who stated that in projectile motion, the horizontal and vertical motions are independent of each other, meaning that one motion does not affect the other.



(Saputra, 2018)

Figure 4: Parabolic Analysis of the Jumper's Motion

Figure 4 illustrates the parabolic trajectory of a jumper leaping over a stone. The initial velocity and velocities at various points along the trajectory, along with their components (horizontal and vertical), are depicted based on the analysis of (Halliday et al., 2010). A key characteristic of this parabolic motion is the constant horizontal component of velocity and the changing vertical component due to the influence of gravity.

Dynamics

The dynamics in physics is a branch of science that studies the causes of an object's motion (Giancoli, 2010). This field delves deeper into what makes an object move, stop, or change direction. Subfields within dynamics include Newton's laws, force, momentum and impulse, work and energy, and many others. The forms of dynamics in *Fahombo* Stone Jumping include:

1. Newton's 1st Law

Newton's First Law is related to the law of inertia, which states that an object at rest tends to stay at rest and an object in motion tends to stay in motion with the same speed and in the same direction unless acted upon by an unbalanced force. This principle is evident in the Nias youth's stone jumping. During the landing phase, the jumper's body tends to continue its forward motion due to inertia. Therefore, the jumper must employ a proper landing technique to dampen the impact force and maintain balance. As seen in Figure 5 the jumper executes a landing technique that keeps their body balanced upon landing.

Figure 5: The Landing Moment

2. Newton's 2nd Law

Figure 6 demonstrates that before jumping over stone, jumpers must run first to gain acceleration. The change in velocity from the initial condition to an instantaneous velocity at a specific time (t) results in acceleration. One way to increase velocity is by applying force to the process. If the applied force is in the same direction as the object's movement, then the object will accelerate. When the applied force is opposite to the direction of the object, deceleration will occur.

Figure 6: The concept of Newton's 2nd Law in *Fahombo* Stone Jumping

The acceleration of an object is directly proportional to the net force acting on the object. This means that the greater the force applied, the greater the object's acceleration. However, the greater the mass of an object, the smaller the force will be.

3. Newton's 3rd Law

This law will explain the origin of the force that influences motion. Figure 7 shows that the jumper leaps over the main stone by using the smaller stone as a foothold.

Figure 7: Small Foothold Stone

The question is, how can the jumpers leap over a stone that is more than 2 meters high when explained in the concept of physics?

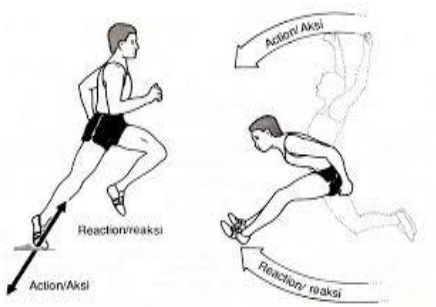


Figure 8: Action-Reaction Forces in Running and Jumping

The small stone utilized as a fulcrum in the *Fahombo* tradition enhances the propulsive force exerted by the jumper. This phenomenon can be explained by Newton's Third Law, which states that for every action, there is an equal and opposite reaction. Consequently, when the jumper's foot applies a force to the stone, the stone imparts an equivalent and opposing force onto the jumper's foot. This is in accordance with Newton's Third Law, which states: "When one object exerts a force on a second object, the second object exerts a force of equal magnitude and opposite direction on the first" (Giancoli, 2014).

4. Momentum and Impulse

As the jumper runs towards the stone to be jumped over, they possess a significant amount of momentum. It's important to remember that momentum is the product of an object's mass and velocity. Consequently, the greater the jumper's mass and speed, the greater their momentum. The role of momentum becomes apparent when the jumper is running towards the stone.


Figure 9: Momentum Occurs When the Jumper Is Running

Impulse is the change in momentum of an object resulting from a force acting on it over a specific time interval. In the *Fahombo* stone jumping, the impulse generated from the foot's push increases the athlete's upward momentum. A larger impulse leads to a greater change in momentum, enabling the athlete to jump higher. The role of impulse in this case is to provide the necessary upward force from the foot to successfully jump over the stone.

5. Work and Energy

The discussion of work and energy encompasses four inseparable components: work, energy, kinetic energy, and potential energy. In the context of *Fahombo* stone jumping, the entire process of jumping constitutes work. This is because a fundamental component of work is the displacement of an object due to a force. In this tradition, displacement occurs during both the running and jumping phases.

The concept of kinetic energy is applicable throughout the entire activity. This is because kinetic energy is influenced by mass and velocity. The faster the jumper runs, the greater their kinetic energy becomes during the jump.

Potential energy is at its maximum when the jumper reaches the peak of their jump, as a significant portion of the kinetic energy from the run has been converted into potential energy. This is because potential energy is influenced by height.

Figure 10: Potential Energy at the Highest Point of the Jump

Conclusion

Based on the research and discussion above, it can be concluded that there are two main physics concepts in the stone jumping tradition: kinematics and dynamics. In kinematics, the concepts of linear and projectile motion are present. In dynamics, the study explores the forces acting on objects, momentum, impulse, work and energy.

Acknowledgments

The authors extend their sincere gratitude to the advisors for their valuable contributions to the completion of this article. They also wish to thank the Agency for the Assessment and Application of Technology (BPPT) and the Education Fund Management Institution (LPDP) of the Republic of Indonesia for providing financial support for the international conference and article preparation.

References

Ali, M., & Aprilia, T. (2024). Evaluation of physics education based on ethnoscience, culture, and local wisdom in Indonesia. IJAMC: International Journal of Applied Mathematics and Computing, 1(2).

Amalissholeh, N., Sutrio, S., Rokhmat, J., & Gunada, I. W. (2023). Analisis Kesulitan Belajar Peserta Didik pada Pembelajaran Fisika di SMAN 1 Kediri. Empiricism Journal, 4(2), 356–364. https://doi.org/10.36312/ej.v4i2.1387

Elvianasti, M., Lufri, L., Zainul, R., Festiyed, F., Diliarosta, S., Zidny, R., & Damaiana, M. A. (2023). Exploring Indigenous Knowledge of Traditional Martial Art "Silat Beksi" to Identify Contents and Contexts for Science Learning in Biology Education. Pegem Journal of Education and Instruction, 13(02). https://doi.org/10.47750/pegegog.13.02.40

Gea, S. R., & Sazali, H. (2023). Hombo Batu sebagai Media Penguatan Moderasi Beragama di Kepulauan Nias. Journal of Education Research, 4(2).

Giancoli, D. C. (2014). Fisika: Prinsip dan Aplikasi (Terjemahan Irzam Hardiansyah). Erangga.

Halliday, D., Resnick, R., & Walker, J. (2010). Fisika Dasar (Terjemahan). Erlangga.

Kemdikbud. (2023). Lompat Batu, Tradisi Budaya dari Tanah Nias. https://ditsmp.kemdikbud.go.id/ragam-informasi/article/lompat-batu-tradisi-budaya-dari-tanah-nias

Mardana, I. G., Sudiana, I. K., & Kardiawan, I. K. H. (2022). Analysis of Physics Concepts in Games Traditional Tajog. Proceedings of the 2nd International Conference on Physical Education, Sport, and Health (ICoPESH 2022), 47–52. https://doi.org/10.2991/978-2-494069-79-4_7

Mavhunga, F., & Kibirige, I. (2018). Tapping the Tacit Knowledge of Playfield Swings to Learn Physics: A Case Study of Childhood Reflections by Pre-service Teachers. African Journal of Research in Mathematics, Science and Technology Education, 22(2), 221–230. https://doi.org/10.1080/18117295.2018.1479620

Moleong, L. J. (2018). Metodologi Penelitian Kualitatif (38th ed.). PT Remaja Rosdakarya.

Sampe Daun, N., Helmi, & Haris, A. (2020). Diagnosis Kesulitan Belajar Fisika Peserta Didik di SMA Negeri 1 Bontomarannu. Prosiding Seminar Nasional Fisika PPs UNM, 2, 37–40.

Saputra, M. R. D. (2018). Pengembangan Media Pembelajaran (Hombo Batu) Berbantuan Android untuk Meningkatkan Kemampuan Representasi Diagram dan Berpikir Kritis pada Pembelajaran Fisika SMA [Tesis]. Universitas Negeri Yogyakarta.

Saputra, M. R. D., & Kuswanto, H. (2018). Development of Physics Mobile (Android) Learning Themed Indonesian Culture Hombo Batu on the Topic of Newton's Law and Parabolic Motion for Class X SMA/MA. Journal of Physics: Conference Series, 1097, 012023. https://doi.org/10.1088/1742-6596/1097/1/012023

Siregar, A. Z., & Syamsuddin. (2015). Tradisi Hombo Batu di Pulau Nias: Satu Media Pendidikan Karakter Berbasis Kearifan Lokal. SIPATAHOENAN: South-East Asian Journal for Youth, Sports & Health Education, 1(2), 2019–2218. www.mindamas-journals.com/index.php/sipatahoenan

Taurusi, T., Septi, S. E., & Osma, U. S. (2024). Discovery Learning Model to Improve Creative Thinking Skills and Ability to Understand Concepts in Ohm's Law Material: Meta Analysis. EduFisika: Jurnal Pendidikan Fisika, 9(1), 104–116. https://doi.org/10.59052/edufisika.v9i1.32640

Wati, M., Rizka Putri, M., Misbah, M., Hartini, S., & Mahtari, S. (2020). The development of physics modules based on madihin culture to train kayuh baimbai character. Journal of Physics: Conference Series, 1422(1), 012008. https://doi.org/10.1088/1742-6596/1422/1/012008

Winarti, W. T., Yuliani, H., Rohmadi, M., & Septiana, N. (2021). Pembelajaran Fisika Menggunakan Model Discovery Learning Berbasis Edutainment. Jurnal Ilmiah Pendidikan Fisika, 5(1), 47. https://doi.org/10.20527/jipf.v5i1.2789

Yuenyong, J., & Yuenyong, C. (2012). Connecting Between Culture of Learning in Thai Contexts and Developing Students' Science Learning in the Formal Setting. Procedia - Social and Behavioral Sciences, 46, 5371–5378. https://doi.org/10.1016/j.sbspro.2012.06.441

Contact emails: ikapratiwi.2022@student.uny.ac.id
ikapratiwi91295@gmail.com