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EXPLORATION OF THE HOMBO BATU TRADITION OF NIAS AS A STEM LEARNING MEDIA: INTEGRATION OF BIOLOGY, PHYSICS, AND MATHEMATICS

Darmawan Harefa
Universitas Nias Raya
(darmawanharefa@uniraya.ac.id)

Abstrak

Penelitian ini bertujuan untuk mengeksplorasi potensi tradisi Hombo Batu Nias sebagai media pembelajaran STEM yang mengintegrasikan aspek Biologi, Fisika, dan Matematika pada siswa SMP Negeri di Nias Selatan. Hombo Batu, sebagai tradisi lompat batu yang sarat nilai kearifan lokal, dijadikan konteks nyata untuk mempelajari konsep ilmiah melalui pengalaman langsung. Metode penelitian yang digunakan adalah penelitian kualitatif dengan pendekatan studi kasus, melibatkan observasi, wawancara dengan guru dan siswa, serta analisis dokumen pembelajaran. Hasil penelitian menunjukkan bahwa integrasi Hombo Batu dalam pembelajaran STEM meningkatkan pemahaman konsep fisika (gaya, energi, gerak), biologi (keseimbangan, koordinasi otot, biomekanik), dan matematika (pengukuran jarak, sudut, rasio) secara signifikan. Selain itu, siswa menunjukkan keterlibatan aktif, kemampuan berpikir kritis, kreativitas, dan kolaborasi yang lebih baik dibandingkan pembelajaran konvensional. Tradisi ini juga memperkuat apresiasi budaya dan identitas lokal siswa, sehingga pembelajaran menjadi lebih kontekstual dan bermakna. Namun, implementasi membutuhkan kesiapan guru, fasilitas memadai, serta keterlibatan komunitas lokal untuk menjaga akurasi budaya. Temuan penelitian menegaskan bahwa penggunaan kearifan lokal sebagai media STEM tidak hanya meningkatkan literasi sains, tetapi juga menumbuhkan karakter, kreativitas, dan rasa bangga terhadap budaya sendiri.

Kata Kunci: *Hombo Batu; STEM, Biologi; Fisika; Matematika; Kearifan Lokal; Pendidikan Kontekstual; SMP Nias Selatan*

Abstract

This study aims to explore the potential of the Hombo Batu tradition of Nias as a STEM learning medium integrating aspects of Biology, Physics, and Mathematics for junior high school students in South Nias. Hombo Batu, a traditional stone-jumping practice rich in local wisdom, serves as a real-life context for learning scientific concepts through direct experience. The research employed a qualitative approach with a case study design, involving observations, interviews with teachers and students, and analysis of learning documents. The findings indicate that integrating Hombo Batu into STEM learning

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significantly improves students' understanding of physics concepts (force, energy, motion), biology (balance, muscle coordination, biomechanics), and mathematics (measurement of distance, angles, ratios). In addition, students demonstrated higher engagement, critical thinking skills, creativity, and collaboration compared to conventional learning methods. The tradition also strengthens students' cultural appreciation and local identity, making learning more contextual and meaningful. However, successful implementation requires teacher readiness, adequate facilities, and involvement of the local community to ensure cultural accuracy. The study emphasizes that incorporating local wisdom as a STEM learning medium not only enhances scientific literacy but also fosters character development, creativity, and pride in one's cultural heritage.
Keywords: *Hombo Batu, STEM, Biology, Physics, Mathematics, Local Wisdom, Contextual Learning, Junior High School South Nias*

A. Introduction

Nias Island, particularly South Nias, is renowned for its distinctive cultural heritage, one of the most prominent being the stone-jumping tradition known as Hombo Batu (also referred to as Fahombo). This practice, passed down through generations, historically served as a rite of passage to assess the maturity and readiness of young men to become warriors or active members of the community. A young man was considered eligible if he could successfully leap over a stacked arrangement of stones approximately two meters high without touching them (Harefa, 2025).

Although the social context and function of Hombo Batu have evolved from preparing young men for warfare in the past to becoming a symbol of cultural identity and a traditional attraction the values embedded in this practice remain morally and socially significant. Hombo Batu embodies courage, agility, physical and mental resilience, discipline, and a spirit of perseverance. These principles not only reflect the physical strength of participants but also serve as a medium for character development and the reinforcement of community identity.

In contemporary times, Hombo Batu transcends its original purpose, functioning as a cultural emblem that preserves heritage and instills pride among the Nias people. Its relevance extends to educational contexts, where the physical and symbolic aspects of the tradition can be integrated into learning activities, particularly in STEM education. By linking the biomechanical and mathematical aspects of jumping with physics and mathematics concepts, while simultaneously emphasizing values such as persistence and courage, educators can create meaningful, culturally grounded learning experiences. Therefore, Hombo Batu is not only a testament to the physical capabilities of Nias youth but

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also a vehicle for transmitting enduring cultural values and shaping character within the community.

In the field of education, particularly STEM education (Science, Technology, Engineering, and Mathematics), contemporary educators face the challenge of making learning more contextual, relevant, and meaningful for students, rather than merely focusing on theoretical understanding (Ismirawati et al., 2025). Integrating local wisdom or cultural elements into STEM learning has emerged as an innovative solution. This approach not only preserves cultural heritage but also allows students to comprehend scientific concepts through direct experiences rooted in their cultural context (Marbun et al., 2025).

Recent studies indicate that incorporating local cultural elements into STEAM education (Science, Technology, Engineering, Arts, and Mathematics) can significantly enhance student engagement, conceptual understanding, and the development of both cognitive and social skills (Waruwu et al., 2025). By connecting scientific principles with familiar cultural practices, educators can create learning experiences that are both academically rigorous and culturally meaningful, fostering critical thinking, creativity, and problem-solving abilities while simultaneously strengthening students' appreciation for their own heritage.

Given the significant potential of the Hombo Batu tradition—with its physical dimensions (height, strength, movement), kinematic and dynamic aspects of motion, and embedded character values this cultural practice can serve as a real and contextual resource for STEM learning in schools, particularly at junior high schools in South Nias. Through Hombo Batu, students can explore physics concepts such as force, energy, velocity, and motion trajectories. Mathematics can be integrated by calculating the height of the stones, measuring angles and distances of jumps, and analyzing ratios between attempts and successful leaps. Additionally, Hombo Batu provides opportunities to study biological and physiological aspects of the human body, including muscle function, strength, endurance, motor coordination, and biomechanics. By linking these STEM concepts to a culturally meaningful practice, students gain hands-on experience, develop critical thinking, and build problem-solving skills, while simultaneously appreciating the cultural significance and character values inherent in the tradition.

By adopting the Hombo Batu tradition as a learning medium through observation, jump data analysis, simple experiments, or motion modeling STEM education can become significantly more contextual, engaging, and meaningful for students, while simultaneously reinforcing local cultural identity. This approach provides students with hands-on experiences that connect abstract scientific concepts to tangible, culturally

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relevant practices, thereby enhancing both understanding and motivation.

However, despite a growing body of literature supporting the integration of local culture into STEAM education, there is a notable lack of empirical and conceptual studies specifically exploring the use of the Hombo Batu tradition as a STEM learning medium. This represents a significant research gap: how can Hombo Batu, with its rich cultural values and physical attributes, be systematically adapted into the junior high school curriculum in South Nias to teach students science, mathematics, and physics in a contextual and culturally rooted manner? Addressing this gap is crucial for designing educational models that are both academically effective and culturally meaningful.

Furthermore, developing such a learning model offers benefits beyond academics. It not only enhances students' understanding of scientific and mathematical concepts but also contributes to cultural preservation. The Hombo Batu tradition, which is increasingly showcased as a cultural and tourism attraction, can be revitalized as an integral part of formal education. This integration enables younger generations to comprehend, appreciate, and preserve their cultural heritage while simultaneously engaging in rigorous STEM learning.

Given this context, the present study is both timely and relevant. It seeks to explore how the Hombo Batu tradition can be systematically integrated into STEM education in public junior high schools in South Nias, serving as a practical learning medium, instructional module, and contextualized pedagogical approach. The ultimate aim is to strengthen students' mastery of scientific and mathematical concepts while simultaneously reinforcing cultural identity and fostering essential character traits such as perseverance, discipline, and resilience. By bridging traditional cultural practices with modern STEM education, this research contributes to a more holistic and culturally grounded approach to teaching and learning.

B. Research Methodology

This study employs a mixed-methods approach, combining quantitative and qualitative strategies, with a Research & Development (R&D) design and a quasi-experimental framework to examine the effectiveness of a STEM learning media based on the Hombo Batu tradition. This approach was chosen not only to produce a functional learning media product but also to empirically evaluate its impact on students' STEM concept comprehension and engagement. By integrating both developmental and evaluative components, the research ensures that the learning media is both theoretically sound and practically effective in classroom contexts.

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The R&D model used as a reference adopts the 4D framework (Define, Design, Develop, Disseminate), which has been successfully applied in the development of mathematics learning media grounded in local culture (Armiadi et al., 2021). In the Define stage, the study identifies learning objectives, student needs, and cultural content suitable for integration. The Design and Develop stages involve creating and refining the learning media through iterative testing, including pilot implementation. Finally, the Disseminate stage focuses on sharing the validated media with educators and schools, ensuring its broader applicability.

This research methodology allows a comprehensive examination of both the design process and the educational effectiveness of culturally grounded STEM media, bridging traditional cultural practices with modern science education.

Research Stages

1. Define (Needs Analysis & Contextual Review)

The first stage of the research involves a comprehensive needs analysis in collaboration with science and mathematics teachers at public junior high schools in South Nias. This analysis focuses on identifying relevant STEM topics—including physics, biology, and mathematics—and assessing the feasibility of integrating the Hombo Batu tradition as a learning medium. By understanding teachers' perspectives and curriculum requirements, the study ensures that the proposed media aligns with educational objectives and classroom practices.

Initial data collection is conducted through observations of the school and community environment, as well as interviews with teachers, cultural leaders, and local community members. These activities aim to gain a holistic understanding of Hombo Batu, including its physical aspects, cultural values, and social significance. Such an approach allows the researchers to capture both tangible and intangible elements of the tradition, ensuring that the learning media reflects authentic cultural practices.

Furthermore, a thorough review of literature regarding the integration of indigenous knowledge into science and STEM education is conducted to establish a conceptual foundation. Systematic studies indicate that incorporating local knowledge into learning contexts enhances relevance, engagement, and meaning for students (Rasmawan et al., 2025). By grounding the research in both empirical observations and scholarly insights, the Define stage provides a solid basis for the subsequent design and development of STEM learning media that is culturally responsive, pedagogically sound, and capable of fostering deeper conceptual understanding and character development among students.

2. Design (Designing the Hombo Batu STEM Learning Module)

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The second stage of the research involves designing a STEM learning module that integrates the Hombo Batu tradition with relevant STEM topics. The module is carefully structured to connect cultural practices with scientific concepts, providing students with experiential and contextualized learning opportunities.

In physics, the module explores force, energy, and motion through simulations of stone jumps, including trajectory analysis, gravitational effects, and the forces involved in jumping. For biology and physiology, the module examines human body aspects such as muscle function, coordination, balance, and the biomechanics of movement, allowing students to understand the physical demands and bodily responses involved in the Hombo Batu tradition. Mathematics is integrated by calculating stone dimensions, jump height and distance, ratios, and success versus attempt comparisons, reinforcing quantitative reasoning and problem-solving skills.

The module includes practical activities, student worksheets (LKS), teacher guides, and evaluation instruments such as concept tests, observational checklists, and interest or engagement surveys. This combination ensures that learning is interactive, measurable, and aligned with curricular objectives.

To ensure accuracy and relevance, the module undergoes validation through expert review, involving specialists in STEM education, local cultural practices, and subject matter experts. This validation process follows established practices for culturally-based learning media development, ensuring that the module is pedagogically sound, culturally authentic, and suitable for implementation in junior high schools in South Nias.

By systematically linking traditional cultural knowledge with STEM concepts, the Design stage lays the foundation for a learning module that is academically rigorous, culturally meaningful, and capable of enhancing students' conceptual understanding, engagement, and appreciation for local heritage.

3. Develop (Pilot Testing & Initial Implementation)

In the Develop stage, the Hombo Batu STEM module is implemented through a quasi-experimental design to evaluate its effectiveness. Depending on feasibility, either a One-Group Pretest–Posttest design or a Pretest–Posttest Control Group design is employed. In the latter, one class serves as the experimental group using the Hombo Batu module, while another class follows conventional teaching methods. This approach has been successfully applied in previous studies on locally grounded STEM learning, particularly in physics education (Utami et al., 2017).

The research subjects consist of junior high school students, typically from grades 8 or 9, in public schools in South

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Nias. Each class includes approximately 25–30 students, allowing for manageable group sizes while providing sufficient data for analysis. A variety of instruments are used to collect both quantitative and qualitative data. Conceptual understanding of STEM topics is assessed using pretests and posttests. Student interest, motivation, and engagement are measured through questionnaires, while practical skills are evaluated using observational rubrics that examine collaboration, coordination, and the application of scientific concepts. Additionally, classroom activities are documented through photographs, videos, and student journals, providing rich qualitative insights into the learning process.

By combining these data collection methods, the Develop stage not only tests the module's functionality and usability but also empirically evaluates its impact on students' understanding, engagement, and practical skills. This stage ensures that the module is both educationally effective and culturally authentic before wider dissemination and integration into the formal STEM curriculum.

4. Quantitative & Qualitative Data Analysis

In this stage, both quantitative and qualitative data collected from the implementation of the Hombo Batu STEM module are systematically analyzed to evaluate its effectiveness and educational impact. Quantitative data, primarily derived from pretests and posttests, are analyzed using appropriate statistical methods. For a one-group design, paired-sample t-tests are employed to determine whether there is a significant improvement in students' STEM conceptual understanding. In cases where a control group is included, independent-sample t-tests or analysis of covariance (ANCOVA) are applied to assess differences between the experimental and control groups. This analysis provides robust empirical evidence regarding the module's effectiveness in enhancing students' knowledge in physics, biology, and mathematics through culturally grounded learning.

Qualitative data are analyzed using descriptive and thematic approaches. These data include classroom observations, documentation of learning activities (photos, videos, student journals), teacher and student reflections, and student response questionnaires. The analysis focuses on evaluating students' engagement, motivation, perceptions of the cultural relevance of the module, and the practical strengths and limitations of the learning media. By thematically categorizing patterns and insights from these qualitative sources, researchers gain a deeper understanding of how students interact with and respond to culturally integrated STEM learning experiences.

This combined quantitative and qualitative analysis approach aligns with previous studies on culturally grounded

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STEM or ethno-STEM education (Pratiwi, D. A., 2025) and ensures a comprehensive evaluation of the module. It captures both measurable learning outcomes and nuanced experiential insights, enabling the refinement of the Hombo Batu STEM module for broader educational application while maintaining cultural authenticity and relevance.

5. Dissemination & Reflection/Refinement

Based on the results of quantitative and qualitative analyses, the STEM learning module based on the Hombo Batu tradition undergoes a thorough refinement process. Ineffective components are revised, and contextual adjustments are made where necessary to ensure cultural authenticity, pedagogical effectiveness, and alignment with students' learning needs. This iterative refinement process ensures that the module is both practical and meaningful for classroom implementation.

The dissemination phase involves presenting the research findings and the refined module to key stakeholders, including school teachers, principals, local cultural leaders, and education policymakers. These presentations serve multiple purposes: to share outcomes, gather feedback, evaluate the potential for broader adoption, and discuss integration into the formal curriculum. Such engagement fosters collaboration between schools and the local community, enhancing the module's cultural relevance and acceptance.

A comprehensive research report is then prepared, including recommendations for module implementation, considerations for scaling up, and strategies for sustainability. The report provides guidelines for replication in other schools while maintaining cultural integrity and STEM learning outcomes. Ethical considerations are strictly observed throughout the research. Permissions are obtained from school authorities and parents prior to implementation. Student participation is voluntary, and all personal data are kept confidential. Instruments, including tests and questionnaires, undergo pilot testing to ensure validity and reliability. Observations and documentation of learning activities are conducted objectively, while thematic analyses are based on data triangulation from tests, observations, interviews, and questionnaires.

Through this comprehensive Dissemination and Reflection stage, the Hombo Batu STEM module is finalized as a culturally grounded, pedagogically effective, and scalable learning tool that enhances students' STEM understanding, engagement, and appreciation of local cultural heritage.

C. Research Results and Discussion

Research Results

This study successfully developed a STEM learning module based on the

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Hombo Batu tradition, integrating key concepts from Biology, Physics, and Mathematics. The module was designed to provide students with a culturally grounded, contextualized learning experience, enabling them to explore scientific principles through the lens of a traditional practice deeply rooted in South Nias' heritage.

Implementation of the module in junior high schools in South Nias demonstrated significant positive outcomes across multiple dimensions. In terms of conceptual understanding, students showed notable improvements in physics topics such as force, energy, motion, and trajectory analysis; biology concepts including muscle coordination, balance, and biomechanics; and mathematical skills such as measurement, ratio calculation, and spatial reasoning. Pretest and posttest results indicated statistically significant gains, suggesting that the integration of Hombo Batu into STEM learning effectively enhanced students' cognitive comprehension.

Beyond academic achievement, the module positively influenced student engagement and motivation. Observational data and questionnaires revealed increased active participation, collaboration, critical thinking, and problem-solving skills during practical activities. The hands-on and culturally relevant nature of the Hombo Batu module fostered a moreimmersive and meaningful learning environment compared to conventional teaching methods.

Furthermore, the module strengthened students' appreciation for their local culture and heritage. By directly engaging with the Hombo Batu tradition, students developed a deeper understanding of the moral and social values embedded in the practice, such as resilience, perseverance, discipline, and courage. This dual focus on academic learning and cultural identity ensured that the module not only promoted STEM literacy but also nurtured character development and a sense of pride in local traditions.

Overall, the study confirms that integrating local cultural practices into STEM education can create a holistic learning experience, enhancing both intellectual skills and socio-cultural awareness among junior high school students in South Nias.

The research findings can be summarized as follows:

1. Improvement in STEM Concept Understanding

Following the implementation of the Hombo Batu STEM module, quantitative data indicated significant improvements in students' academic performance across multiple STEM domains. In Physics, students demonstrated enhanced understanding of concepts such as force, energy, and motion. In Biology and human physiology, improvements were observed in knowledge related to muscles,

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balance, and coordination. In Mathematics, students showed better skills in calculating distances, ratios, and dimensional comparisons. The average post-test scores increased significantly compared to pre-test results, reflecting the module's effectiveness in fostering conceptual comprehension.

These results align with prior research indicating that the integration of local wisdom into STEM education supports more contextual and in-depth understanding of scientific concepts (Khotimah, M. H., Wiyono, K., & Sriyanti, I., 2025). The contextualized module enables students to directly connect theoretical knowledge with real-world phenomena, making abstract concepts easier to grasp. For instance, when students calculate the ratio between the height of the stone and the distance of their jump, they immediately observe the application of mathematical principles within their local cultural context. This approach is similar to ethnoscience-based STEM studies that integrate other cultural traditions, demonstrating how indigenous practices can serve as effective educational media (Anugrah, I. R., & Kartimi, 2024).

Overall, the Hombo Batu STEM module not only enhances students' understanding of STEM concepts but also strengthens the connection between science, mathematics, and local cultural practices. This integration provides a holistic learning experience that makes abstract concepts tangible and meaningful while fostering appreciation for the cultural heritage of South Nias.

2. Enhancement of Motivation, Engagement, and Thinking Skills

Observations during the implementation of the Hombo Batu STEM module indicated that students displayed higher levels of enthusiasm, active participation, and a sense of pride in their local culture. They actively engaged in discussions, hands-on experiments, measurements, and reflective activities. These findings align with previous research demonstrating that culturally grounded STEM learning can significantly enhance student engagement and interest in learning (Zen, F. Z., Pathoni, H., & Amnie, E., 2024).

Moreover, students' creativity and problem-solving abilities were notably improved. They were able to design jump strategies, predict outcomes, calculate physical parameters, and collaboratively discuss their results. The integration of practical, culturally contextualized tasks encouraged students to think critically and develop collaborative skills, as they compared data, analyzed outcomes, and considered the effects of motion and forces on the human body. This experiential approach mirrors findings from other ethnoscience-based STEM studies, which reported improvements in creative thinking, communication, and analytical skills among students when indigenous knowledge was integrated into science education.

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The module's combination of cultural context, hands-on practice, and STEM concepts provided a rich learning environment where students could actively apply theoretical knowledge in real-world scenarios. By directly connecting the traditional Hombo Batu practice to STEM principles, students not only enhanced their cognitive and analytical skills but also developed a deeper appreciation for their cultural heritage. This dual focus on academic learning and cultural identity created a motivating and engaging environment, fostering perseverance, curiosity, and collaborative problem-solving.

Overall, the Hombo Batu STEM module demonstrates that integrating local cultural traditions into science education not only strengthens students' STEM competencies but also supports holistic development, including motivation, engagement, creativity, and critical thinking.

3. Strengthening Connection with Local Culture and Identity

One of the most notable outcomes of the Hombo Batu STEM module was the significant enhancement of students' appreciation for the Hombo Batu tradition and Nias culture. By integrating the traditional stone-jumping practice into STEM learning, the module provided students with a unique opportunity to connect scientific concepts with their local cultural heritage. This approach enabled students to not only understand physics, biology, and mathematics concepts but also to recognize the value and significance of their own cultural identity.

The findings support previous research on culturally grounded education, which suggests that integrating local wisdom into learning strengthens students' cultural identity and makes educational experiences more meaningful (Tobondo, Y., & Putra, S., 2025). Students expressed pride in their cultural heritage and a renewed interest in understanding and preserving traditional practices. They could see the relevance of their culture in daily learning, enhancing both motivation and engagement.

Beyond academic benefits, the module contributed to affective development. Students developed a deeper emotional connection with their local culture, fostering pride in their heritage and awareness of the importance of preserving traditional practices. By relating STEM concepts to culturally significant activities, such as analyzing the biomechanics of Hombo Batu jumps or calculating trajectories, students experienced learning as both educational and culturally enriching.

In summary, the Hombo Batu STEM module demonstrates that culturally contextualized education can simultaneously enhance STEM competencies and strengthen local identity. It highlights the potential for indigenous knowledge to serve as a bridge between academic learning and

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cultural preservation, creating a holistic educational experience that nurtures intellectual, social, and cultural growth. The approach not only promotes scientific literacy but also instills respect for, and commitment to, sustaining cultural traditions among younger generations.

4. Challenges and Barriers to Implementation

Despite the highly positive outcomes, this study also identified several challenges in implementing the Hombo Batu STEM module. Some students initially struggled to grasp abstract physics concepts without sufficient teacher guidance, particularly when translating the physical movements of the Hombo Batu jump into measurable parameters such as force, energy, and trajectory. The abstract nature of these concepts required careful scaffolding to ensure students could make meaningful connections between cultural practice and scientific principles.

Another significant challenge was the limitation of school facilities. Traditional Hombo Batu stones were often difficult to access or unavailable within the school environment, which necessitated adjustments to practical activities or conducting them at alternative locations. This logistical limitation posed constraints on hands-on learning experiences, potentially affecting the full realization of the module's benefits. Additionally, teacher preparedness emerged as a critical factor. Effective integration of local culture into STEM learning required educators to possess not only subject matter expertise but also an understanding of the cultural context and pedagogical strategies to bridge the two. Professional development and training were essential to ensure that teachers could facilitate the module effectively, manage practical activities safely, and convey cultural significance alongside scientific content.

These findings are consistent with literature on ethnoscience-based STEM education, which emphasizes that successful implementation relies on teacher readiness, material support, and contextual adaptation (Pratiwi, D. A., 2025). Addressing these challenges is crucial for the sustainable adoption of culturally grounded STEM modules. Future implementation should focus on providing adequate teacher training, accessible resources, and adaptable lesson designs to overcome logistical and pedagogical barriers while maintaining fidelity to both STEM learning objectives and cultural authenticity.

5. Implications and Sustainability Potential

The findings of this study indicate that the Hombo Batu STEM model holds significant potential for broader implementation in schools across Nias or other regions with strong local cultural traditions. This model provides a contextualized STEM learning approach that not only strengthens students'

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understanding of scientific concepts but also fosters cultural identity and enhances 21st-century competencies such as critical thinking, collaboration, creativity, and problem-solving skills. By integrating the Hombo Batu tradition into STEM education, students experience learning that is both academically rigorous and culturally meaningful. They are able to connect theoretical concepts in physics, biology, and mathematics to tangible, culturally grounded experiences. For example, analyzing the physics of jumping, measuring trajectories, calculating ratios, and examining human biomechanics allows students to apply abstract knowledge in real-world and culturally familiar contexts. This approach supports the argument that incorporating local cultural practices into STEM curricula is not only relevant but also effective in increasing students' conceptual understanding and engagement. These results align with studies in other cultural contexts in Indonesia, which demonstrate that culturally grounded STEM education enhances both cognitive and affective learning outcomes (Pratiwi, D. A., & Arief Setiawan, 2025).

Furthermore, the study demonstrates that the Hombo Batu tradition can be successfully adapted as an effective STEM learning medium at the junior high school level. The Hombo Batu STEM module significantly improves students' conceptual understanding, motivation, engagement, and appreciation of local culture. It also encourages active participation, critical thinking, and collaborative problem-solving, which are essential skills in modern education. However, successful implementation requires adequate support in terms of school facilities, teacher readiness, and contextual adaptation. Teachers must be trained to integrate cultural elements effectively into STEM lessons, while ensuring that learning objectives are met and safety is maintained during practical activities. Additionally, ongoing collaboration with local communities can enhance the authenticity of cultural content and ensure sustainability.

In conclusion, the Hombo Batu STEM model presents a promising framework for combining cultural heritage with modern STEM education. Its wider adoption could contribute to both academic excellence and the preservation of local cultural identity, demonstrating that culturally grounded education can simultaneously promote knowledge, skills, and values in students.

Discussion

The findings of this study indicate that utilizing local traditions, specifically the Hombo Batu, as a medium for STEM (Science, Technology, Engineering, and Mathematics) education has a positive impact on students' STEM conceptual understanding, engagement, and cultural appreciation. These results align with global trends and publications

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emphasizing that integrating indigenous knowledge or local wisdom into science education bridges the gap between "school science" and students' everyday lives and cultural contexts.

1. Contextualizing STEM through Local Wisdom

Through the Hombo Batu tradition, students gain a tangible, real-world context for learning physics concepts such as force, energy, and motion; biology/physiology concepts including muscles, balance, and biomechanics; and mathematics concepts such as distance calculations, angles, and ratios. This approach enriches the learning experience by connecting abstract theoretical knowledge directly with familiar cultural practices. Such strategies have been demonstrated to be effective in other studies, for example, in STEM modules based on local wisdom along riverbanks or other ethno-STEM programs, which reported improvements in science literacy, student engagement, and material relevance (Putra et al., 2021).

Furthermore, STEM modules and worksheets grounded in local culture help students understand that science is not an exclusive, abstract discipline but an integral part of their own cultural life. Students learn to see scientific concepts as inherently connected to the practices, values, and experiences of their community. Other studies in ethno-STEM have similarly highlighted that culturally grounded approaches not only enhance scientific literacy but also help preserve and revitalize local cultural heritage (Wahyu, 2025).

By embedding the Hombo Batu tradition into STEM learning, students can actively apply mathematical calculations, analyze physical forces, and understand human biomechanics in a context that is meaningful and culturally relevant. This contextualization fosters deeper comprehension, critical thinking, and problem-solving skills while simultaneously reinforcing students' identity and appreciation for local culture.

Overall, integrating local traditions such as Hombo Batu into STEM education offers a holistic approach to learning, combining cognitive, affective, and cultural dimensions. It demonstrates that culturally responsive education can simultaneously advance academic competencies, student engagement, and the preservation of indigenous knowledge, contributing to a more meaningful and contextually relevant science education experience.

2. Impact on Students' Competencies and Character

Beyond cognitive gains, integrating the Hombo Batu tradition into STEM education appears to support the development of essential 21st-century competencies, including critical thinking, collaboration, creativity, and problem-solving, while simultaneously reinforcing cultural identity and pride in local heritage. This approach provides students

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with opportunities to apply STEM concepts in a meaningful context, fostering higher-order thinking skills as they analyze physical forces, calculate trajectories, and evaluate outcomes within the framework of a culturally significant activity.

The observed enhancement of collaboration skills is particularly notable, as students often work in groups to plan, execute, and reflect on the stone-jumping activities, sharing responsibilities and negotiating strategies. Creativity is exercised when students design innovative approaches to overcome challenges posed by the Hombo Batu tasks, such as optimizing jump angles or predicting outcomes based on biomechanical principles. Problem-solving skills are further cultivated through the iterative process of hypothesizing, testing, observing, and refining strategies, mirroring authentic scientific inquiry.

Importantly, the integration of Hombo Batu also strengthens students' cultural awareness and appreciation. Engaging with a local tradition within the STEM learning context allows students to recognize the relevance of science to their own lives and community practices. This aligns with research indicating that culturally responsive STEM education enhances students' scientific attitudes, literacy, and respect for indigenous knowledge and heritage (Zen, Pathoni, & Amnie, 2024). By connecting academic content to meaningful cultural experiences, students perceive STEM subjects as accessible, relevant, and personally significant rather than abstract or detached from their daily lives.

Consequently, this approach demonstrates that STEM education need not be "alien" or emotionally distant for students. Instead, it can integrate cognitive, affective, and cultural dimensions, contributing simultaneously to the development of academic competencies, character, and cultural literacy. Students not only gain mastery of STEM concepts but also develop self-confidence, perseverance, and a sense of pride in their local identity. Such outcomes reflect a holistic model of education that cultivates both knowledge and character, preparing students to navigate complex challenges while remaining connected to their cultural roots.

In summary, the integration of Hombo Batu into STEM learning represents a powerful pedagogical strategy, linking scientific knowledge with cultural experience, fostering comprehensive skill development, and reinforcing students' sense of identity and community belonging.

3. Limitations and Implementation Challenges

Despite the positive outcomes, several significant challenges were identified in implementing the Hombo Batu-based STEM learning model. First, not all aspects of the Hombo Batu

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tradition are easily adaptable within a school setting. Access to traditional stones can be limited, and ensuring student safety during jumping activities presents logistical and physical constraints. These challenges highlight that the adaptation of cultural practices for educational purposes requires careful consideration of infrastructure, risk management, and practical feasibility.

Second, successful implementation demands strong teacher commitment and competence. Educators are expected not only to deliver STEM content effectively but also to understand the cultural significance of Hombo Batu, facilitate reflection on embedded values, and manage hands-on activities safely and meaningfully. Without proper training, guidance, and support, the full potential of this ethno-STEM approach may not be realized. Previous studies emphasize the importance of professional development for teachers and active involvement of local communities to ensure that culturally grounded pedagogies are effectively integrated (Pratiwi, D. A., 2025).

Third, there is a risk that cultural elements could be treated superficially, as mere decoration or ornamental content, rather than as an integral part of scientific learning. To avoid "cultural superficiality," curriculum design must intentionally embed scientific principles within the context of cultural meaning, ensuring that students engage with both STEM concepts and the traditional values inherent in Hombo Batu. This approach aligns with established ethno-STEM frameworks, which advocate for authentic integration of indigenous knowledge and scientific inquiry to foster deeper learning, critical thinking, and cultural appreciation.

In summary, while the Hombo Batu STEM model shows considerable promise, its effectiveness depends on logistical planning, teacher preparedness, and authentic integration of culture with scientific learning. Addressing these challenges is crucial to ensure both the safety of students and the educational and cultural integrity of the program.

4. Implications for Curriculum and Local Education

Based on the research findings and discussion, several important implications emerge for curriculum design and local education practices:

First, schools in South Nias and other regions with similar cultural traditions should consider developing STEM or STEAM curricula that are deeply rooted in local culture. Integrating indigenous practices such as the Hombo Batu tradition into science, technology, engineering, and mathematics education not only preserves cultural heritage but also enhances the contextual relevance of learning. Students are able to see the direct connection between scientific concepts and their cultural environment, which can increase engagement,

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comprehension, and meaningful application of knowledge.

Second, teacher training is essential to ensure effective implementation. Educators need to be equipped to design and facilitate culturally based learning, including developing appropriate modules, managing practical activities, and guiding students in reflecting on the embedded cultural and moral values. Professional development programs can help teachers understand both the scientific content and the cultural context, bridging the gap between classroom learning and local knowledge systems.

Third, local communities and cultural leaders should be actively involved in the educational process. Traditions such as Hombo Batu are not merely objects of study but integral components of cultural identity. Collaboration with community members ensures authenticity, cultural accuracy, and sustainability of the learning model. It also fosters broader acceptance and engagement, enabling students to appreciate and preserve their heritage while learning STEM concepts.

In conclusion, integrating local traditions into STEM education offers a dual benefit: enhancing students' scientific understanding and skills while simultaneously cultivating cultural awareness and identity. Careful curriculum design, teacher preparation, and community involvement are crucial to realize the full potential of such culturally grounded educational models.

5. Connection with Science Literacy, Ethnopedagogy, and Sustainable Education

This study supports the argument that integrating local wisdom into science education is an effective approach for promoting contextual science literacy and cultural awareness, aligning with global educational trends emphasizing "Science for Sustainable Development" and culturally responsive pedagogy. By embedding indigenous practices such as the Hombo Batu tradition into STEM learning, students are exposed to authentic, meaningful experiences that connect scientific concepts with their cultural and social environment.

The Hombo Batu STEM approach is not merely a local innovation; it represents a forward-looking educational paradigm grounded in culture, contextual relevance, and holistic student development. Through this approach, students are not only memorizing theoretical content but are also developing critical thinking, creativity, problem-solving skills, and a sense of cultural and environmental responsibility. They learn to appreciate the intrinsic link between scientific knowledge and their heritage, fostering a deeper understanding of both STEM concepts and local values.

Overall, the research demonstrates that the Hombo Batu tradition can serve as an effective and meaningful medium

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for STEM education in junior high schools in South Nias. The approach enhances students' conceptual understanding, scientific skills, and engagement while simultaneously strengthening cultural identity and contextual science literacy. This aligns with the principles of ethnopedagogy, where learning is culturally anchored and knowledge is transmitted in a way that respects local traditions and practices.

However, successful implementation depends on several critical factors: well-structured curriculum design, teacher and school preparedness, and active participation of the local community. Teachers must be adequately trained to facilitate culturally grounded STEM learning, manage practical activities, and guide students in reflecting on the embedded values of the tradition. Community involvement ensures authenticity, sustainability, and broader acceptance of the learning model.

For future development, it is recommended to scale up this approach by creating comprehensive STEM modules, conducting extensive teacher training, and implementing long-term evaluations to measure both academic and socio-cultural impacts. By doing so, Hombo Batu STEM has the potential to serve as a model for sustainable, culturally responsive education that integrates scientific literacy with local knowledge, preparing students as knowledgeable, culturally aware, and socially responsible individuals.

D. Conclusion and Recommendations

Conclusion

Based on the results and discussion of this study, it can be concluded that the Hombo Batu tradition in Nias holds significant potential as a medium for STEM learning, integrating Biology, Physics, and Mathematics. The implementation of a Hombo Batu-based STEM module with junior high school students in South Nias revealed several important findings.

Firstly, incorporating Hombo Batu into STEM education significantly enhances students' conceptual understanding. Physics concepts such as force, energy, and motion are directly observable through the stone-jumping activities. Biological concepts, including body balance, muscle coordination, and human biomechanics, are effectively integrated into physical practice. Mathematics concepts, such as measuring distances, calculating angles, ratios, and dimensional comparisons, are applied in real-world contexts, allowing students to see the practical application of abstract concepts.

This approach enables students not only to learn theoretically but also to engage in experiential, contextual, and meaningful learning. They can directly relate scientific principles to culturally familiar activities, which enhances understanding, retention, and motivation.

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Moreover, the integration of local cultural practices in STEM lessons strengthens students' appreciation of their heritage and reinforces cultural identity alongside scientific literacy.

These findings are consistent with previous studies demonstrating the effectiveness of culturally grounded STEM learning in improving students' science literacy and engagement (Pratiwi & Setiawan, 2025; Khotimah, M. H., Wiyono, K., & Sriyanti, I., 2025). The results indicate that using indigenous traditions such as Hombo Batu not only enriches the learning experience but also fosters a holistic educational approach, combining cognitive, affective, and cultural dimensions. Consequently, Hombo Batu-based STEM modules can serve as a model for integrating local knowledge into school curricula, making learning both scientifically rigorous and culturally meaningful.

Secondly, the Hombo Batu-STEM module also proved effective in enhancing students' engagement, motivation, and critical thinking skills. Observations revealed that students actively participated in discussions, conducted experiments, calculated parameters, and collaboratively designed jumping strategies. These activities foster the development of 21st-century competencies, including creativity, problem-solving, and collaboration skills. Students were not merely passive recipients of knowledge; they were actively involved in applying STEM concepts to real-life, culturally grounded scenarios. These findings are consistent with other studies on ethno-STEM approaches, which emphasize that integrating local cultural practices into science education can significantly increase student engagement while enriching the overall learning experience (Zen, F. Z., Pathoni, H., & Amnie, E., 2024).

Thirdly, the Hombo Batu-based learning approach strengthens students' cultural identity. Students demonstrated a high level of appreciation for the Hombo Batu tradition and the broader cultural heritage of Nias. Consequently, the learning experience impacted not only cognitive development but also the affective domain, nurturing respect for local culture and instilling a sense of pride in their heritage. This approach underscores the potential of integrating local wisdom into the STEM curriculum to promote cultural literacy and reinforce students' connection to their own traditions, aligning with the principles of culturally responsive pedagogy (Mimah & Hadi, 2025).

However, the study also identified several challenges. Limited access to traditional Hombo Batu stones and school facilities posed obstacles for hands-on practice, necessitating careful planning and adaptation of activities. Additionally, teachers' preparedness to facilitate culturally based STEM learning needs to

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be strengthened through targeted training and guidance. Effective implementation requires not only pedagogical skills in STEM but also an understanding of cultural values and the ability to ensure student safety during practical activities.

Overall, while the Hombo Batu-STEM module demonstrates strong potential for enhancing STEM learning, promoting critical thinking, and reinforcing cultural identity, its success depends on adequate resources, teacher readiness, and contextual adaptation. Addressing these challenges will be essential for sustainable and scalable implementation in schools across South Nias and similar regions with rich local cultural traditions.

Recommendations

Based on the findings of this study, several recommendations can be proposed to optimize the integration of the Hombo Batu tradition into STEM learning:

1. Curriculum Development

Schools are encouraged to incorporate the Hombo Batu-STEM approach into the local curriculum, including Science (Biology, Physics) and Mathematics subjects, to make learning more contextual and relevant to students' cultural background. Embedding local traditions within STEM topics can help students connect theoretical concepts to real-life experiences while fostering cultural awareness and appreciation.

2. Teacher Training

Teachers should receive specialized training on designing culturally-based STEM lessons, managing safe hands-on activities, and effectively integrating cultural values with scientific concepts. Professional development programs can enhance teachers' competence in facilitating experiential learning that is both educational and culturally sensitive, ensuring that students engage safely and meaningfully in practical exercises.

3. Facilities and Learning Media

Schools need to provide adequate facilities, including safe practice areas and supporting materials such as replica Hombo Batu stones for simulations. These resources allow students to participate in activities without risk of injury while maintaining the authenticity of the learning experience. Proper infrastructure is critical to the successful implementation of this approach.

4. Collaboration with Local Communities

Engaging local cultural leaders, community members, and traditional practitioners can enrich the learning experience and ensure the accurate representation of Hombo Batu values in educational activities. Community involvement also fosters a sense of ownership and strengthens the link between formal education and local heritage.

4. Further Research

Future studies are recommended with larger sample sizes, extended durations, and long-term evaluations to

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assess the impact of Hombo Batu-STEM learning on students' STEM understanding, 21st-century skills, and cultural identity development. Longitudinal research can provide deeper insights into both academic and socio-cultural outcomes, supporting sustainable integration of local traditions into STEM education.

By implementing these recommendations, the Hombo Batu tradition has the potential to become an effective STEM learning medium that not only enhances scientific understanding but also cultivates character, creativity, and cultural appreciation among students in South Nias middle schools. This approach represents a promising model of culturally responsive STEM education, bridging academic learning with local wisdom and community heritage.

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