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Ethnoscience exploration of sago processing as a science learning resource for elementary school

Indah Slamet Budiarti
Universitas Cenderawasih
INDONESIA

Kusdianto
Universitas Cenderawasih
INDONESIA

Megawati
Universitas Cenderawasih
INDONESIA

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Abstract

Background: The integration of local wisdom into science learning is crucial to promote contextual and meaningful education, particularly in primary schools. Despite its importance, the use of ethnoscience in primary school science curricula remains underexplored, leading to a disconnect between abstract scientific concepts and students' everyday experiences.
Aim: This study aims to explore the ethnoscience of sago processing in Sarmi Regency, Papua, and its application as a science learning resource for elementary schools.
Method: A qualitative descriptive method with a case study approach was employed, involving data collection through observations, interviews, and documentation with local community participants.
Results: The results reveal that traditional sago processing encompasses basic scientific principles, including simple machinery, energy transfer, friction, and sedimentation, which can be effectively contextualized in science lessons.
Conclusion: The integration of sago processing into the curriculum enhances students' comprehension of scientific concepts, fosters cultural appreciation, and encourages sustainability. These findings underscore the need to incorporate local wisdom into educational practices to develop student-centered, culturally relevant, and sustainability-oriented learning environments.

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INTRODUCTION

Integrating local wisdom into education plays a crucial role in bridging abstract concepts with students' daily experiences, especially in elementary schools. With the growing reliance on digital technologies in various aspects of life, public interest in technology-based games has significantly increased (Costantino et al., 2024; Elsherbiny & H. Al Maamari, 2021; Hausberg et al., 2019). However, long before these digital games emerged, traditional games and local knowledge rich in cultural values had already been part of Indonesian life (Ding & Li, 2023; X. Liu et al., 2024; Toyoda et al., 2022). Indonesia, an archipelago of immense cultural and geographical diversity, offers a wealth of local wisdom, with Papua being one of the regions renowned for its rich traditions and knowledge (Bourchier, 2019; Sekhar & Raina, 2021; Utami et al., 2018). Therefore, integrating local traditions, such as sago processing, into science education not only enhances students' understanding of scientific concepts but also fosters an appreciation for local culture.

Papua, located in the easternmost part of Indonesia, is home to numerous tribes, cultures, traditions, and beliefs (Akumbu, 2023; Fiharsono et al., 2024; Nggaruaka et al., 2023; Wahab et al., 2020). One of its regions, Sarmi Regency, consists of coastal, mountainous, and lowland areas. The name "Sarmi" is an acronym for the Sobei, Armati, Rumbuai, Manirem, and Isirawa tribes that inhabit the area. Among the many traditional practices in Sarmi, sago processing, or "menokok sago," stands out as a cultural tradition passed down through generations. This process involves several stages, from cutting down sago trees to extracting starch, and embodies both cultural heritage and fundamental scientific principles such as energy transfer, friction, and sedimentation. Therefore,

* **Corresponding author:**
Indah Slamet Budiarti, Universitas Cenderawasih, INDONESIA
indahslamet977@gmail.com

sago processing holds significant potential to be used as a contextual teaching tool in science education.

Science education in elementary schools is often seen as challenging for students due to its abstract nature and teaching approaches that are sometimes less engaging (Priliyanti et al., 2021; Wicaksono, 2020). Factors such as the use of unfamiliar scientific terms, teacher-centered methods, and monotonous teaching techniques frequently make it difficult for students to grasp scientific concepts (Yunarti, 2021). One potential solution is incorporating local wisdom into science lessons. Local wisdom reflects the interaction between humans and their natural surroundings and can help bridge students' experiences with scientific concepts (Thornton et al., 2021; Widiya et al., 2021). However, while scientific principles and concepts can be found in daily life, teachers rarely use local wisdom as a teaching approach, even though it has proven benefits in enhancing students' understanding and actively engaging them in the learning process (Varghese & Crawford, 2021). Integrating traditional practices such as sago processing into science education could be a significant step toward addressing these challenges while also contributing to cultural preservation. However, there is still limited research that explores this potential in depth, which this study seeks to address.

Previous studies have highlighted the importance of incorporating local wisdom into science education, but most of them have focused on general approaches and have not explored specific cultural practices, such as sago processing, which is rich in cultural and scientific value (Suprapto et al., 2021; Widiya et al., 2021). Although learning steps based on local wisdom, such as doing, observing, explaining, confirming, and applying, have been identified (Chen et al., 2020; Kanapathy et al., 2019), their direct connection to traditional practices like sago processing remains underexplored in the context of science education. Moreover, scientific concepts such as energy transfer, the use of simple machines, and sedimentation embedded in sago processing have not been systematically linked to the curriculum (Zidny et al., 2021; Zidny & Eilks, 2020, 2022). Existing studies also lack a detailed framework to guide teachers in integrating sago processing into elementary science lessons (Arjaya et al., 2024; Hawa et al., 2021; Lestari & Suyanto, 2024). Furthermore, while local wisdom is often recognized as a valuable teaching resource, few studies explicitly address its role in promoting cultural preservation and sustainability through education (Varghese & Crawford, 2021; Thornton et al., 2021). To address these gaps, this study aims to explore the ethnoscience of sago processing in Sarmi Regency, Papua, and its potential application in elementary science education. It seeks to identify the scientific concepts embedded in each stage of sago processing and develop a detailed framework to support cultural preservation, sustainability, and meaningful science learning.

METHOD

Research Design

This study adopts a qualitative research design with a case study approach. This approach was selected to deeply explore the sago processing practices in Sarmi Regency, Papua, as a potential source for ethnoscience-based science learning. The research specifically focuses on identifying the scientific principles embedded in each stage of the sago processing process, aiming to integrate them into elementary school science education.

Participant

The participants in this study comprised ten individuals who were purposively selected based on their knowledge and experience with sago processing. The group included local community members, educators, and indigenous leaders who possessed deep understanding and expertise in this traditional practice. The inclusion of indigenous leaders was particularly important to ensure the authenticity and reliability of the data collected.

Population and the methods of sampling Instrumentation

The population of this study consists of residents of Wamariri Village, Apawer Hulu District, Sarmi Regency, Papua, who are actively engaged in sago processing activities. A purposive sampling method was employed to select participants based on specific criteria, including individuals with hands-on experience in sago processing, a clear understanding of the scientific principles involved, and the potential to contribute to the implementation of ethnoscience-based learning.

Instrument

The instruments used in this study were designed to facilitate an in-depth exploration of sago processing in Sarmi Regency, Papua, particularly in identifying scientific principles that could be integrated into elementary school science education. Three types of instruments were utilized: observation guides, semi-structured interview guides, and documentation tools.

The observation guides were developed to systematically record each stage of the sago processing process. Key aspects observed included the tools and materials used, the techniques applied, and the social interactions occurring during the activities. These guides enabled the researchers to identify critical elements of sago processing that reflect scientific concepts, such as the law of levers, kinetic energy, and sedimentation. The observation criteria are detailed in Table 1: Observation Guide, which outlines the primary aspects observed during the study.

The semi-structured interview guides were employed to gather deeper insights from the selected participants. These interviews were designed to provide a comprehensive explanation of each stage of the sago processing process, including material selection, implementation techniques, and the cultural values embedded within the practices. The interview questions were structured around key indicators to explore the relationship between traditional practices and their underlying scientific principles. A summary of the interview framework is presented in Table 2: Interview Guide, which contains a list of questions aligned with the research indicators.

Table 1. Observation Guide

Aspect Observed	Description
Implementation of sago processing	Observing the process of felling sago trees Observing the cleaning of sago trees Observing the peeling of sago trees Observing the process of pounding sago using Femea Observing the process of extracting sago starch Observing the technique of selecting sago trees Observing the process of felling sago trees Observing the process of squeezing sago pulp Observing the container used to collect sago starch

Table 2. Interview Guide

No	Indicator	Inteview Questions
1	Menokok sagu	What types of sago can be used for processing? Who is responsible for processing the sago? What tools are used to fell the sago trees? What tools are used for pounding the sago? How do you peel the sago tree? How long does the sago processing take? How much time is needed to complete the sago pounding process? How is the process carried out from pounding the sago to extracting the sago starch? What tools are used to create a container for collecting sago starch? What food products are made from sago starch?
2	Sago tree felling process	How do you determine the location/spot of the sago tree to be felled? What is the proper position for felling the sago tree? How do you determine where the sago tree will fall?

No	Indicator	Inteview Questions
3	Sago Tree Cleaning Process	Why must the sago tree be cleaned before it is peeled? Which part of the sago tree trunk should be peeled?
4	Sago Tree Peeling Process	How do you peel the sago tree?
5	Sago Pounding Using Femea	What materials are used to make the Femea? What size is needed to make the Femea? Who is responsible for making the Femea? How is the sago pounded using the Femea?
6	Sago Tree Selection Process	Is it necessary to cultivate a sago palm tree by planting it first before it is felled? How can you distinguish between a sago palm tree that is ready to be tapped and one that is not yet ready to be tapped? How do you choose and determine the best sago?
7	Sago Pulp Squeezing Process	What is the water condition needed to squeeze sago pulp? How do you squeeze sago pulp? How many times does sago pulp need to be squeezed to produce sago starch?
8	The process of producing sago starch	How do you determine if the water from squeezing sago pulp has produced sago starch? What materials are used to collect the water from squeezing sago pulp? How do you produce good quality sago starch?
9	The process of making a container to collect sago starch	What materials are used to make the container for collecting sago starch? Who makes the container to collect sago starch? How many times is the container for collecting sago starch used? Does the container for collecting sago starch need to be cleaned? What materials are used to clean the container for collecting sago starch? How do you make a container for collecting sago starch?

Procedures and Time Frame

This study was conducted over three months, from July to September 2024, in Wamariri Village, Apawer Hulu District, Sarmi Regency, Papua. The research procedure was systematically structured to ensure each stage was carried out comprehensively, covering preparation, data collection, analysis, and reporting.

1. **Preparation Stage (July 2024, Weeks 1–2)**
   During this phase, the researcher developed research instruments, including observation guides, semi-structured interview protocols, and documentation tools. These instruments were validated through expert reviews to ensure alignment with the study's objectives. Permissions were obtained from local authorities and schools, and socialization sessions were held with community leaders, educators, and participants to explain the research's goals, benefits, and procedures.
2. **Data Collection Stage (July 2024, Week 3 – August 2024, Week 3):**
   Data were collected using three methods:
   - **Observations:** Focused on recording the stages of sago processing (logging, peeling, beating, starch extraction) along with the tools, materials, and techniques involved.
   - **Semi-structured Interviews:** Conducted with ten purposively selected participants to explore local knowledge, traditional practices, and underlying scientific principles.
   - **Documentation:** Photos and videos were taken to visually complement the data from observations and interviews.

3. **Analysis Stage (August 2024, Week 4 – September 2024, Week 2)**
   Collected data were organized and categorized systematically to facilitate thematic analysis. Triangulation was employed to ensure data consistency and accuracy.
4. **Reporting and Conclusion Stage (September 2024, Weeks 3–4)**
   The research findings were compiled into a detailed report, which included descriptions of sago processing stages, scientific principles involved, and their potential integration into science learning. Recommendations for ethnoscience-based teaching were also provided.

Analysis Plan

The data analysis was conducted using a qualitative approach with thematic analysis techniques to identify patterns, themes, and relationships within the data. This process provided a comprehensive understanding of how sago processing practices could be integrated into ethnoscience-based science learning.

1. **Data Organization**
   Raw data from observations, interviews, and documentation were classified by type and source. Observation records were organized according to sago processing stages, such as logging, peeling, beating, and starch extraction. Interview transcripts were categorized based on research indicators like tools used, traditional techniques, and cultural values. Visual documentation, such as photos and videos, supplemented textual data for a more vivid depiction.
2. **Data Coding**
   Relevant data segments were assigned initial codes, such as "scientific principles," "traditional tools," "processing techniques," and "cultural values." These codes were grouped into broader categories, including "integration of scientific principles in local culture" and "science learning potential." The coding process was supported by qualitative data analysis software for accuracy and efficiency.
3. **Pattern and Theme Identification**
   Emerging patterns included connections between traditional tools and scientific principles, such as the law of levers, kinetic energy, inclined planes, and sedimentation. Key themes identified were "ethnoscience in science education," "environmental sustainability," and "cultural preservation."
4. **Data Validation**
   Triangulation was conducted by comparing data from observations, interviews, and documentation to ensure consistency. Discrepancies were addressed through follow-up discussions with participants. Multiple analysis techniques were also employed to confirm the reliability of the findings.
5. **Data Interpretation**
   Patterns and themes were interpreted in relation to relevant literature. For example, the principle of slope in sago starch filtration was explained using $F = W \sin\theta$, while sedimentation was analyzed with $v_s = \frac{2(\rho_p - \rho_f)gr^2}{9_\eta}$. These interpretations highlighted the application of scientific principles in traditional practices.
6. **Conclusion**
   The validated findings were used to draw conclusions, emphasizing the stages of sago processing that align with scientific principles and their integration into elementary science learning. The findings were presented through descriptive narratives, tables, and visual illustrations to ensure clarity and accessibility.

RESULTS AND DISCUSSION

Results

The findings of this study reveal that the sago processing practices in Sarmi Regency, Papua, involve multiple stages rich in both scientific and cultural significance. Each stage demonstrates the integration of scientific principles with traditional knowledge, offering valuable insights for ethnoscience-based science learning.

The initial stage involves felling sago trees using a modified traditional stone axe. This process applies the principle of a first-class lever, where the force exerted on the axe generates kinetic energy to cut the tree trunk. The use of this simple machine showcases a practical example of how physics concepts operate in daily life. Once the trunk is cut, it is split into two halves using a traditional tool known as "pangkur." This tool, now enhanced with metal tips for durability, applies the principle of compression to break the fibers of the trunk into smaller fragments.

The next stage focuses on separating sago starch from the fibers through a filtration process. This is done by channeling water on an inclined plane made of large sago leaves, which serve as gutters to direct the flow of water and debris. This stage demonstrates the principle of gravitational force, making it easier to separate the starch from the fibers. The final separation occurs through sedimentation, where a mixture of water and starch is filtered using woven coconut fronds. The heavier starch settles at the bottom, while lighter fibers remain on top. This step provides a clear example of how density and viscosity influence material separation.

Interviews with local communities revealed that sago processing is a collaborative activity involving nuclear families or small indigenous groups. Tasks are divided based on roles and capabilities, with men typically felling trees, women sifting starch, and children assisting in drying the starch. This division of labor highlights the harmonization of local knowledge, cultural values, and environmental sustainability. For example, the use of natural tools such as coconut leaves and fronds reflects the community's efforts to minimize environmental impact while maintaining efficiency.

The analysis of findings also highlights the potential of integrating sago processing into elementary science education. This process provides a tangible context for teaching scientific concepts such as energy transfer, force, and sedimentation. By linking these concepts to everyday cultural activities, students gain a deeper understanding of how science relates to their lives. For instance, the principle of levers can be demonstrated through simple classroom experiments that mimic the use of a stone axe, while sedimentation can be illustrated through hands-on activities involving mixtures of water and solids.

These results underscore the importance of integrating ethnoscience into the curriculum to create meaningful and sustainable learning experiences. The blending of scientific principles with cultural practices fosters not only cognitive understanding but also appreciation for local heritage and environmental stewardship. By leveraging traditional knowledge like sago processing, educators can bridge the gap between abstract scientific theories and practical, real-world applications, making science education more engaging and relevant for students.

Discussion

This study reveals that the sago processing process in Sarmi Regency, Papua, can be used as an effective science learning tool by integrating scientific concepts in each stage of its activities (Darmanto, 2022, 2024; Jackson et al., 2020). This process reflects the basic principles of physics, such as levers, kinetic energy, and sedimentation, all of which have relevance in ethnoscience-based science learning (do Val Siqueira et al., 2021; Movahedi et al., 2020; L. Wang et al., 2024; Yuan et al., 2024). The importance of incorporating local knowledge in science education to increase the relevance of learning and support cultural sustainability.

At the felling stage of sago trees, the use of traditional stone axes involves the application of the principle of first-class lever, where the fulcrum is between the applied force and the load of the sago trunk (Koirala, 2023; Zidny et al., 2020). The basic mechanics equation for a lever can be explained as follows:

$$F_{effort} \times d_{effort} = F_{load} \times d_{load} \quad (1)$$

In this context, people intuitively utilize the length of the axe arm to minimize the required force. This principle provides students with the opportunity to understand how the laws of mechanics work in real-life situations, which can increase their engagement and understanding of the subject matter (Jagaba et al., 2024; Lee et al., 2024; S. Liu et al., 2023; H. Wang et al., 2024). The process of splitting sago stems also involves the use of kinetic energy, which is calculated through the following equation:

$$KE = \frac{1}{2} m \cdot v^2 \quad (2)$$

Where, M is the mass of the axe, and V is the speed of the swing. This kinetic energy is used to break down the core of the sago stem into small flakes using traditional tools such as "pangkur" (Balkissoon et al., 2023; Kalla-Bertholdt et al., 2023; Lenhart et al., 2020; Equestrian, 2021). This principle allows students to understand the concept of kinetic energy in the context of local culture, the importance of a contextual approach in science learning (Hussain et al., 2020; Pendi et al., 2023; Pendi & Hussain, 2024; Yan et al., 2022).

The next stage, namely the separation of starch from sago stem fibers using sago leaf gutters, applies the principle of inclined plane. The use of a slope helps to reduce the force required to move water and sago flakes along the gutter, which corresponds to the equation:

$$F = W \sin \theta \quad (3)$$

where F is the required force, W is the weight of the object, and θ is the angle of inclination. This understanding can help students understand how slopes facilitate daily work, so that they can appreciate the relationship between scientific concepts and practical applications (Wei et al., 2024; Zhang et al., 2023; Zhou et al., 2021). The final process, namely sedimentation, uses the principle of density difference to separate the sago starch from water and fibers. This principle can be explained through the sedimentation equation:

$$v_s = \frac{2(\rho_p - \rho_f) g r^2}{9_\eta} \quad (4)$$

where V is the speed of precipitation, ρp and ρf are the density of starch and fluid particles, g is the acceleration of gravity, r is the radius of the particles, and η is the viscosity of the liquid. By studying this process, students can understand how the principles of physics are used to separate materials in a simple but effective way.

The findings also highlight the potential of ethnosciences to improve students' science literacy, especially in terms of the relationship between science, culture, and the environment. The integration of local knowledge in learning can increase sustainability awareness and build closer relationships between students and their local communities (Gelhardt et al., 2021; Meng et al., 2019; Shi et al., 2024). This is very relevant in the context of the sustainability of education in culturally rich areas such as Papua.

Furthermore, this integration of ethnosciences also contributes to the preservation of local culture. Traditional activities such as sago processing are not only a source of learning, but also a means to maintain the cultural identity of the community (Jin et al., 2021; Leksono et al., 2023).. In this case, science is not only a tool to understand the natural world, but also a means to respect and preserve local traditions.

Overall, this study emphasizes the importance of locally-based education in improving the quality of learning. The integration of the sago process in science learning not only improves students' understanding of scientific concepts, but also encourages them to appreciate cultural values and sustainability (Irfandi et al., 2023; Matindike & Ramdhany, 2024; Movahedi et al., 2020). This approach is in line with global efforts to promote culturally relevant, scientifically in-depth, and sustainability-oriented education, as stated in the SDGs education goals.

Implications

This research contributes both theoretically and practically to the field of ethnoscience-based learning. Theoretically, it reinforces the ethnoscience approach by integrating traditional knowledge with scientific concepts, particularly in science education. By examining sago processing as a learning resource, this study broadens the understanding of how local wisdom can act as a bridge between abstract scientific theories and the real-world relevance of students' daily lives. These findings align with and enrich existing literature on contextual and meaningful learning.

Practically, this study offers concrete guidance for educators on incorporating traditional activities, such as sago processing, into science lessons. It enables students to grasp scientific principles such as the law of levers, kinetic energy, sedimentation, and the application of simple tools through culturally familiar activities. Moreover, this approach contributes to cultural preservation and fosters students' environmental awareness, aligning with the goals of sustainable education outlined in the SDGs, particularly SDG 4. The findings empower teachers to design learning experiences that are not only relevant but also tailored to the cultural context of their students.

Limitations and Suggestions for Future Research

While this research provides valuable contributions, it is not without limitations. Methodologically, the qualitative approach with descriptive data restricts the generalizability of the findings to other regions. Additionally, the study involved a relatively small sample size of ten respondents, which may not fully capture the perspectives of the entire community in Sarmi, Papua. Future research could address this by including a larger and more diverse group of participants to achieve more representative results. Another limitation lies in the potential challenges of applying these findings in regions without a sago processing culture. Adapting this ethnoscience-based approach to other forms of local wisdom in different regions presents a significant challenge that needs to be addressed to broaden its applicability. Furthermore, the study does not extensively address the infrastructure and teacher training required to implement this approach in everyday educational practices. The readiness of teachers and schools remains a critical factor for the successful integration of these findings into educational settings.

Future research can address these limitations by expanding the scope to other regions and exploring diverse forms of local wisdom. Employing a quantitative or mixed-methods approach could provide a more comprehensive understanding of the direct impact of ethnoscience-based learning on student outcomes. Additionally, future studies could investigate ways to adapt these methods to regions with different cultural practices, ensuring their flexibility and broader applicability. In teaching practice, educators can develop learning modules that incorporate local wisdom, such as sago processing, to contextualize scientific concepts. These modules should include clear, step-by-step guidelines to assist teachers in effectively implementing scientific principles within the framework of local culture. Furthermore, teacher training programs are essential to enhance educators' skills and confidence in integrating ethnoscience into their teaching practices, enabling them to deliver more engaging and meaningful learning experiences for students. At the policy level, local governments and educational institutions can play a pivotal role in promoting the integration of local wisdom into national education curricula. Supportive policies that encourage ethnoscience research and its application in schools can amplify the positive impact of this approach. Additionally, collaboration between local communities and educational institutions can strengthen cultural preservation efforts by documenting and utilizing local wisdom as a valuable educational resource.

CONCLUSION

This study highlights the potential of sago processing as an ethnoscience resource for elementary school science education. By integrating local knowledge into the curriculum, students can connect abstract scientific principles, such as simple machines, gravitational force, and sedimentation, with real-world applications. This approach enhances the relevance and engagement of science learning while fostering critical thinking, problem-solving skills, and cultural awareness. The findings reveal that ethnoscience-based learning not only improves students' comprehension of scientific concepts but also preserves local traditions and promotes sustainable resource use. These results underline the importance of incorporating cultural heritage into teaching practices to create a holistic and culturally relevant educational experience. From a practical standpoint, this study provides a framework for educators to develop learning modules that integrate local wisdom, accompanied by clear guidelines to support implementation. Teacher training is essential to ensure the successful application of this approach in diverse classroom settings. For future research, it is recommended to expand the scope to other regions and explore different forms of local wisdom to evaluate the adaptability and scalability of this method. Additionally, employing mixed methods could help measure the direct impact of ethnoscience-based learning on students' academic and personal development.

AUTHOR CONTRIBUTIONS STATEMENT

Indah Slamet Budiarti: Conceptualization, Investigation, Writing - original draft;
Kusdianto: Conceptualization, Supervision, Writing - review & editing;
Megawati: Methodology, Investigation, Writing - review & editing

REFERENCES

Akumbu, R. V. (2023). Conceptualizing Theoretical Frameworks for Post-colonial Education for Kisii K–12, Kenya. *International Conference on Quantitative Ethnography*, 244–260. https://doi.org/10.1007/978-3-031-47014-1_17

Arjaya, I. B. A., Suastra, I. W., Redhana, I. W., & Sudiatmika, A. A. I. A. R. (2024). Global trends in local wisdom integration in education: A comprehensive bibliometric mapping analysis from 2020 to 2024. *International Journal of Learning, Teaching and Educational Research*, *23*(7), 120–140. https://doi.org/10.26803/ijlter.23.7.7

Balkissoon, S., Andrew, J., & Sithole, B. (2023). Dissolving wood pulp production: a review. *Biomass Conversion and Biorefinery*, *13*(18), 16607–16642. https://doi.org/10.1007/s13399-022-02442-z

Bourchier, D. M. (2019). Two decades of ideological contestation in Indonesia: From democratic cosmopolitanism to religious nationalism. *Journal of Contemporary Asia*, *49*(5), 713–733. https://doi.org/10.1080/00472336.2019.1590620

Chen, M., Jeronen, E., & Wang, A. (2020). What lies behind teaching and learning green chemistry to promote sustainability education? A literature review. *International Journal of Environmental Research and Public Health*, *17*(21), 7876. https://doi.org/10.3390/ijerph17217876

Costantino, C., Calleo, A., Benedetti, A. C., Bartolomei, C., & Predari, G. (2024). Fostering Resilient and Sustainable Rural Development through Nature-Based Tourism, Digital Technologies, and Built Heritage Preservation: The Experience of San Giovanni Lipioni, Italy. *Sustainability*, *16*(13), 5588. https://doi.org/10.3390/su16135588

Darmanto. (2022). Good to Produce: Food, gardening, and valued persons in contemporary Mentawai society, Indonesia. *Indonesia and the Malay World*, *50*(148), 289–312. https://doi.org/10.1080/13639811.2022.2089479

Darmanto, D. (2024). Eating, sharing, and mutuality of being among the mentawai on Siberut Island, Indonesia. *Food, Culture & Society*, 1–27. https://doi.org/10.1080/15528014.2024.2359773

Ding, K., & Li, H. (2023). Digital addiction intervention for children and adolescents: a scoping review.

International Journal of Environmental Research and Public Health, *20*(6), 4777. https://doi.org/10.3390/ijerph20064777
do Val Siqueira, L., Arias, C. I. L. F., Maniglia, B. C., & Tadini, C. C. (2021). Starch-based biodegradable plastics: Methods of production, challenges and future perspectives. *Current Opinion in Food Science*, *38*, 122–130. https://doi.org/10.1016/j.cofs.2020.10.020
Elsherbiny, M. M. K., & H. Al Maamari, R. H. (2021). Game-based learning through mobile phone apps: effectively enhancing learning for social work students. *Social Work Education*, *40*(3), 315–332. https://doi.org/10.1080/02615479.2020.1737665
Fiharsono, A., Carey, M., Hyde, M., Beazley, H., & Yektiningtyas-Modouw, W. (2024). Culturally based learning needs of Korowai students in a lowland-remote area of Indonesian Papua: school physical environment and building design. *The Australian Educational Researcher*, *51*(2), 611–629. https://doi.org/10.1007/s13384-023-00615-x
Gelhardt, L., Dittmer, U., & Welker, A. (2021). Relationship of particle density and organic content in sieve fractions of road-deposited sediments from varying traffic sites based on a novel data set. *Science of the Total Environment*, *794*, 148812. https://doi.org/10.1016/j.scitotenv.2021.148812
Hausberg, J. P., Liere-Netheler, K., Packmohr, S., Pakura, S., & Vogelsang, K. (2019). Research streams on digital transformation from a holistic business perspective: a systematic literature review and citation network analysis. *Journal of Business Economics*, *89*, 931–963. https://doi.org/10.1007/s11573-019-00956-z
Hawa, N. N., Zakaria, S. Z. S., Razman, M. R., & Majid, N. A. (2021). Geography education for promoting sustainability in Indonesia. *Sustainability*, *13*(8), 4340. https://doi.org/10.3390/su13084340
Hussain, H., Yan, W.-J., Ngaini, Z., Julaihi, N., Tommy, R., & Bhawani, S. A. (2020). Differential metabolites markers from trunking and stressed non-trunking sago palm (Metroxylon sagu Rottb.). *Current Chemical Biology*, *14*(4), 262–278. https://doi.org/10.2174/2212796814999200930120925
Irfandi, I., Sudarma, T. F., Festiyed, F., Yohandri, Y., Diliarosta, S., Surahman, D., & Siregar, A. M. (2023). E-learning and physics teaching materials based on malay ethnoscience on the east coast. *Jurnal Pendidikan IPA Indonesia*, *12*(3), 366–376. https://doi.org/10.15294/jpii.v12i3.45442
Jackson, G., McNamara, K. E., & Witt, B. (2020). "System of hunger": Understanding causal disaster vulnerability of indigenous food systems. *Journal of Rural Studies*, *73*, 163–175. https://doi.org/10.1016/j.jrurstud.2019.10.042
Jagaba, A. H., Lawal, D. U., Abdulazeez, I., Lawal, I. M., Mu'azu, N. D., Birniwa, A. H., Usman, A. K., Hagar, H. S., Yaro, N. S. A., & Noor, A. (2024). Advancements and prospects in the utilization of metal ions and polymers for enhancing aerobic granulation during industrial effluent treatment and resource recovery. *Journal of Water Process Engineering*, *66*, 105972. https://doi.org/10.1016/j.jwpe.2024.105972
Jin, T., Liu, T., Lam, E., & Moores, A. (2021). Chitin and chitosan on the nanoscale. *Nanoscale Horizons*, *6*(7), 505–542. https://doi.org/10.1039/D0NH00696C
Kalla-Bertholdt, A.-M., Baier, A. K., & Rauh, C. (2023). Potential of modification of techno-functional properties and structural characteristics of citrus, apple, oat, and pea dietary fiber by high-intensity ultrasound. *Foods*, *12*(19), 3663. https://doi.org/10.3390/foods12193663
Kanapathy, S., Lee, K. E., Sivapalan, S., Mokhtar, M., Syed Zakaria, S. Z., & Mohd Zahidi, A. (2019). Sustainable development concept in the chemistry curriculum: An exploration of foundation students' perspective. *International Journal of Sustainability in Higher Education*, *20*(1), 2–22. https://doi.org/10.1108/IJSHE-04-2018-0069
Koirala, K. P. (2023). Ethno science practice as Indigenous wisdom: challenges to braiding with Western-based school science curriculum. *Diaspora, Indigenous, and Minority Education*, *17*(4), 270–282. https://doi.org/10.1080/15595692.2022.2138321
Lee, E., Min, K. J., Lee, A. H., & Park, K. Y. (2024). Effect of cations on aerobic granulation for sidestream treatment. *Heliyon*, *10*(17). https://doi.org/10.1016/j.heliyon.2024.e37216
Leksono, S. M., Kurniasih, S., Marianingsih, P., Nuryana, S., Camara, J. S., El Islami, R. A. Z., & Cahya, N. (2023). From Farm to Classroom: Tubers as Key Resources in Developing Biology Learning Media Rooted in Banten's Local Culture. *Jurnal Pendidikan IPA Indonesia*, *12*(4).

https://doi.org/10.15294/jpii.v12i4.48278

Lenhart, V., Quodbach, J., & Kleinebudde, P. (2020). Mechanistic understanding regarding the functionality of microcrystalline cellulose and powdered cellulose as pelletization aids in wet-extrusion/spheronization. *Cellulose*, *27*, 2189–2210. https://doi.org/10.1007/s10570-019-02895-y

Lestari, N., & Suyanto, S. (2024). A systematic literature review about local wisdom and sustainability: Contribution and recommendation to science education. *Eurasia Journal of Mathematics, Science and Technology Education*, *20*(2), em2394. https://doi.org/10.29333/ejmste/14152

Lin, M.-H., Chen, H.-C., & Liu, K.-S. (2017). A study of the effects of digital learning on learning motivation and learning outcome. *Eurasia Journal of Mathematics, Science and Technology Education*, *13*(7), 3553–3564. https://doi.org/10.12973/eurasia.2017.00744a

Liu, S., Zhou, M., Daigger, G. T., Huang, J., & Song, G. (2023). Granule formation mechanism, key influencing factors, and resource recycling in aerobic granular sludge (AGS) wastewater treatment: A review. *Journal of Environmental Management*, *338*, 117771. https://doi.org/10.1016/j.jenvman.2023.117771

Liu, X., Bai, L., Leng, X., Yao, Y., Yang, Y., Li, D., & Yin, H. (2024). Coopetition, exploration and exploitation capabilities, and growth performance in digital healthcare ventures. *Frontiers in Public Health*, *12*, 1369885. https://doi.org/10.3389/fpubh.2024.1369885

Matindike, F., & Ramdhany, V. (2024). Incorporating indigenous knowledge perspectives in integrated STEM education: a systematic review. *Research in Science & Technological Education*, 1–21. https://doi.org/10.1080/02635143.2024.2413675

Meng, D., Wu, J., Chen, K., Li, H., Jin, W., Shu, S., & Zhang, J. (2019). Effects of extracellular polymeric substances and microbial community on the anti-scouribility of sewer sediment. *Science of the Total Environment*, *687*, 494–504. https://doi.org/10.1016/j.scitotenv.2019.05.387

Movahedi, M., Asefnejad, A., Rafienia, M., & Khorasani, M. T. (2020). Potential of novel electrospun core-shell structured polyurethane/starch (hyaluronic acid) nanofibers for skin tissue engineering: In vitro and in vivo evaluation. *International Journal of Biological Macromolecules*, *146*, 627–637. https://doi.org/10.1016/j.ijbiomac.2019.11.233

Nggaruaka, T., Priyatni, E. T., Suwignyo, H., & Siswanto, W. (2023). Ethno-Pedagogical Expressions in the Ndambu Culture of the Kimaima Community, Papua. *The Qualitative Report*, *28*(1), 121–142. https://doi.org/10.46743/2160-3715/2023.5771

Pendi, F. H., & Hussain, H. (2024). Transcriptome dataset of Metroxylon sagu palms from multiple sago plantations in Sarawak. *BMC Research Notes*, *17*(1), 251. https://doi.org/10.1186/s13104-024-06924-3

Pendi, F. H., Yan, W.-J., Hussain, H., Roslan, H. A., & Julaihi, N. (2023). Advances in Sago Palm Research: a Comprehensive Review of recent findings. *Sains Malaysiana*, *52*(11), 3045–3059. https://doi.org/10.17576/jsm-2023-5211-03

Priliyanti, A., Muderawan, I. W., & Maryam, S. (2021). Analisis kesulitan belajar siswa dalam mempelajari kimia kelas XI. *Jurnal Pendidikan Kimia Undiksha*, *5*(1), 11–18. https://doi.org/10.23887/jjpk.v5i1.32402

Sekhar, C., & Raina, R. (2021). Towards more sustainable future: assessment of sustainability literacy among the future managers in India. *Environment, Development and Sustainability*, *23*(11), 15830–15856. https://doi.org/10.1007/s10668-021-01316-0

Shi, X., Zhang, J., Wang, Q., Wang, K., Han, J., Hui, Y., Jin, X., & Jin, P. (2024). A new perspective of sediment layering scour and migration under the coupled effects of particle distribution and bio-viscosity–cavitation erosion. *Science of The Total Environment*, *952*, 175929. https://doi.org/10.1016/j.scitotenv.2024.175929

Suprapto, N., Prahani, B. K., & Cheng, T. H. (2021). Indonesian curriculum reform in policy and local wisdom: Perspectives from science education. *Jurnal Pendidikan IPA Indonesia*, *10*(1), 69–80. https://doi.org/10.15294/jpii.v10i1.28438

Thornton, S., Graham, M., & Burgh, G. (2021). Place-based philosophical education: Reconstructing 'place', reconstructing ethics. *Childhood & Philosophy*, *17*. https://doi.org/10.12957/childphilo.2021.54696

Toyoda, R., Russo-Abegão, F., & Glassey, J. (2022). VR-based health and safety training in various highrisk engineering industries: a literature review. *International Journal of Educational Technology in Higher Education*, *19*(1), 42. https://doi.org/10.1186/s41239-022-00349-3

Utami, R. E., Nugroho, A. A., Dwijayanti, I., & Sukarno, A. (2018). Pengembangan E-Modul Berbasis Etnomatematika Untuk Meningkatkan Kemampuan Pemecahan Masalah. *JNPM (Jurnal Nasional Pendidikan Matematika)*, *2*(2), 268. https://doi.org/10.33603/jnpm.v2i2.1458

Varghese, J., & Crawford, S. S. (2021). A cultural framework for Indigenous, Local, and Science knowledge systems in ecology and natural resource management. *Ecological Monographs*, *91*(1), e01431. https://doi.org/10.1002/ecm.1431

Wahab, N. A., Goh[1], P. S.-C., Ong[1], E.-T., Ibrahim, M. H., & Affandi, H. M. (2020). *Construction of the forest school framework based on indigenous knowledge in Malaysia*.

Wang, H., Hua, Y., Xu, H., Liu, H., Yang, D., & Dai, X. (2024). Illuminating the role of powder carrier materials in shaping sludge aggregation in wastewater treatment: Insights from extended operation performance to microbial response mechanism. *Bioresource Technology*, *410*, 131268. https://doi.org/10.1016/j.biortech.2024.131268

Wang, L., Jin, H., Qiu, J., Luo, Y., & He, J. (2024). Preparation of a moisture-permeable glazed tile to prevent indoor floor condensation. *Journal of Building Engineering*, 109858. https://doi.org/10.1016/j.jobe.2024.109858

Wei, H., Xie, Y., Zhou, C., Tao, Y., Zhou, J., & Liu, C. (2024). Analysis and calculation of scour critical velocity of suspended particles in a storm sewer. *Water Environment Research*, *96*(9), e11135. https://doi.org/10.1002/wer.11135

Wicaksono, A. G. (2020). Jumanto, & Irmade, O.(2020). Pengembangan media komik komsa materi rangka pada pembelajaran IPA di sekolah dasar. *Jurnal Pendidikan Dasar Dan Pembelajaran*, *10*(2), 215–226. https://doi.org/10.25273/pe.v10i2.6384

Widiya, M., Lokaria, E., & Sepriyaningsih, S. (2021). Pengembangan Modul Pembelajaran IPA Berbasis Kearifan Lokal Kelas Tinggi di Sekolah Dasar. *Jurnal Basicedu*, *5*(5), 3314–3320. https://doi.org/10.31004/basicedu.v5i5.1281

Yan, W.-J., Hussain, H., Chung, H. H., Julaihi, N., & Tommy, R. (2022). Transcriptome dataset of sago palm in peat soil. *Data in Brief*, *41*, 107908. https://doi.org/10.1016/j.dib.2022.107908

Yuan, M., Jin, T., Wu, J., Li, L., Chen, G., Chen, J., Wang, Y., & Sun, J. (2024). IAA-miR164a-NAC100L1 module mediates symbiotic incompatibility of cucumber/pumpkin grafted seedlings through regulating callose deposition. *Horticulture Research*, *11*(2), uhad287. https://doi.org/10.1093/hr/uhad287

Yunarti, N. (2021). Analisa kesulitan dalam pembelajaran IPA pada siswa SMP negeri 1 Rambang. *Jurnal Educatio FKIP UNMA*, *7*(4), 1745–1749. https://doi.org/10.31949/educatio.v7i4.1570

Zhang, Y., Zhang, J., Zhu, D. Z., & Qian, Y. (2023). Experimental study on pollution release and sediment scouring of sewage sediment in a drainage pipe considering incubation time. *Environmental Science and Pollution Research*, *30*(19), 54945–54960. https://doi.org/10.1007/s11356-023-26294-w

Zhou, Y., Yao, X., Gu, Y., Qian, D., Tang, Y., Zhang, Y., Zhu, D. Z., & Zhang, T. (2021). Biological effects on incipient motion behavior of sediments with different organic matter content. *Journal of Soils and Sediments*, *21*, 627–640. https://doi.org/10.1007/s11368-020-02807-9

Zidny, R., & Eilks, I. (2020). Integrating perspectives from indigenous knowledge and Western science in secondary and higher chemistry learning to contribute to sustainability education. *Sustainable Chemistry and Pharmacy*, *16*, 100229. https://doi.org/10.1016/j.scp.2020.100229

Zidny, R., & Eilks, I. (2022). Learning about Pesticide Use Adapted from Ethnoscience as a Contribution to Green and Sustainable Chemistry Education. *Education Sciences*, *12*(4). https://doi.org/10.3390/educsci12040227

Zidny, R., Sjöström, J., & Eilks, I. (2020). A multi-perspective reflection on how indigenous knowledge and related ideas can improve science education for sustainability. *Science & Education*, *29*(1), 145–185. https://doi.org/10.1007/s11191-019-00100-x

Zidny, R., Solfarina, S., Aisyah, R. S. S., & Eilks, I. (2021). Exploring indigenous science to identify contents and contexts for science learning in order to promote education for sustainable development. *Education Sciences*, *11*(3), 114. https://doi.org/10.3390/educsci11030114