



Reconstruction of Local Knowledge in Science Learning: A Case Study of the Palm Sugar Making Process in Coastal Areas

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Abstract: Local context-based science learning is an effective approach to improve students relevance and understanding. This research aims to reconstruct local knowledge of coastal communities related to the process of making palm sugar as a source of science learning. The research method uses a descriptive-qualitative approach. Data were collected through in-depth interviews, field observations, and scientific literature reviews. Furthermore, the data were analyzed through triangulation to produce a scientific interpretation of the traditional practice. The results of the study indicate that the process of making palm sugar reflects the principles of sustainability, utilization of renewable energy, and natural preservation. In addition, the integration of science concepts with business and conservation aspects enriches the relevance of learning for students. It can be concluded that the reconstruction of local knowledge is able to support the preservation of local culture and ecosystems while increasing students understanding of applicable science. The contribution of this study to science is to create a sustainable learning approach, relevant to everyday life, and support the preservation of local wisdom in modern education. This integration provides new opportunities to improve scientific literacy in coastal areas by harmoniously connecting traditional knowledge and science.

Keywords: Science Reconstruction, Coastal Areas, Science Learning, Local Knowledge

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1. Introduction

Science education is an integral part of the academic process that plays a relevant role in the reconstruction of local knowledge. This readjustment of concepts is inseparable from natural sciences. The connection between both produces concrete knowledge based on theories, concepts, and principles. In addition, the application of local wisdom in learning influences the character of Indonesian students (Suarmika et al., 2021). Local wisdom refers to the knowledge and experiences of people in the particular area, perceived as a valuable resource in the learning process. The integration has been proven to have an impact on student learning achievement. The National Estuarine Research Reserve Coordinator Jacques Cousteau stated that science education is more interesting and relevant to the implementation of current environmental policy issues (McDonnell, 2018). Therefore, this research focuses on reconstructing local knowledge of coastal communities.

Indonesia is the fourth largest coastline in the world in the majority of the territories located in coastal areas (Azmanita & Fauzi, 2020). However, coastal communities in each region are characterized by different customs and jobs (Saleh & Harjito, 2020). For example, on Sembilan Kotabaru Island, the majority of the people feed on snails (Fajeriadi et al., 2019). In Pesisir Village, East Lombok, the people cultivate seagrass and mariculture (Syukur et al., 2021).

The majority of the people in Tanjung Iman II Village, Tanjung Kemuning subdistrict, Kaur district, Bengkulu province, have palm sugar making businesses. Furthermore, several countries, such as Malaysia, the Philippines, Thailand, India, and Sri Lanka, process sap into palm sugar with the production depending on local traditions and palm tree type (Ahmad & Suharto, 2020). Local knowledge in making palm sugar will be reconstructed to ensure the IPA concept is considered with the actual practice in coastal areas (Rizky & Hidayat, 2021).

The global context shows that the integration of local knowledge in science education not only enriches the learning experience but also promotes the preservation of cultural traditions (Ningsih & Yusuf, 2019). In the process of making palm sugar, the use of local resources supports sustainability goals and allows for contextually relevant learning (Widodo & Pratama, 2023). This is also in line with the community-based learning approach implemented in countries such as Thailand, the Philippines, and India, where traditional processes are integrated into the science curriculum to strengthen students' understanding of the relationship between science and everyday life (Rahmadani, 2021).

The integration of local knowledge in education enabled the students to develop an interest in the process of making palm sugar (Gunawan & Putri, 2021). In addition to the practical aspects, local knowledge also depicts cultural values and traditions. Sumarni et al. (2016), stated there are fifty original palm sugar production processes that can be reconstructed into science learning. The application of local knowledge in science learning also contributes to the sustainable preservation of the natural environment. This is expected to produce

contextual and meaningful learning for students through the reconstruction of local knowledge (Tanjung & Wibisono, 2021).

Scientific concepts are perceived as relevant by residents in coastal communities. Several research on the reconstruction of local knowledge includes 1) the five original methods of producing natural dyes used in making lurik (Sholihah et al., 2024) , 2) the process of making Sokka roof tiles by the people of Kedawung Village, Pejagoan District , Kebumen Regency, Central Java Province (Wirasti et al., 2022) , 3) the reconstruction of Pekalongan Batik Knowledge as Scientific Knowledge in Chemistry Education (Izza & Indyah, 2019) , and 4) the scientific reconstruction of local wisdom of natural batik dyes using an ethno-STEM method. Scientific knowledge in the field of chemistry concerning the process of fixation, extraction, solutions, alum compounds, anthocyanins, and pigments was also observed in the Batik process (Sudarmin et al., 2020) . Based on this research, the last five years have seen an increase in research on the reconstruction of local wisdom for science learning (Hemmerling et al., 2020) . However, this research is still limited to cultural aspects, and not much has highlighted the principles of sustainability or the integration of scientific concepts in the learning process. Therefore, this study fills the gap by identifying and reconstructing local knowledge about making palm sugar, which has the potential to provide novelty value in a local-based science learning approach. Therefore, this research aimed to reconstruct local knowledge of the process of making palm sugar in science learning. The urgency of this research is supported by data from coastal communities in Tanjung Iman II Village, where 80% of the population relies on traditional palm sugar production. This research is not only relevant for cultural preservation but also important for promoting contextual and meaningful education.

2. Method

The research uses a descriptive-qualitative approach with a focus on the reconstruction of local knowledge. Primary data were collected through in-depth interviews with two main respondents who are traditional palm sugar craftsmen (R1, R2), as well as direct observation in Tanjung Iman II Village, Tanjung Kemuning District, Kaur Regency, Bengkulu Province. The instruments used include:

- a) Semi-structured interview guide to explore the palm sugar-making process.
- b) Field observation with visual documentation techniques to record the stages of the manufacturing process.
- c) Data triangulation to verify the validity of the information.

The rationality of this method is based on the relevance of local wisdom to scientific principles such as sustainability and renewable energy management (Wardhana et al., 2021) . The data collected were analyzed using a thematic approach, which allows the identification of main patterns and themes in local knowledge. The potential novelty of this method lies in the use of interview

instruments designed to connect local practices with scientific concepts, such as thermodynamics in the palm sap processing process.

Additionally, the results of the interpretation were discussed with science and local knowledge experts.

3. Result and Discussion

Data collected through observations and in-depth interviews with palm sugar makers, showed that knowledge possessed by coastal communities was passed down from ancestors and had not been influenced by Western culture.



Figure 1. Cooking Palm Nira/Water using firewood.



Figure 2. Adding safat fruit to sap to maintain the quality.



Figure 3. Pandan leaves for making palm sugar and adding natural fragrance.



Figure 4. Results of formed palm sugar.



Figure 5. Dried banana leaves used as a molding base for palm sugar preservative.



Figure 6. One of the respondents from the family of Mrs. Diharmawati

Table 1. Results of Reconstruction of Local Knowledge of Coastal Communities in the process of Making Palm Sugar

No	Question	Interview result	Reconstruction
1	Why do most coastal communities engage in palm sugar production?	R1: Because palm sugar business meets daily needs	Applying business and energy concepts in daily economic activities
2	Why is palm sugar produced using traditional methods?	R1, R2: Because of the desire to maintain ancestral heritage, traditional manufacturing methods are the most effective way to produce the best palm sugar.	Renewable energy
3	Why use pandan leaves to mold palm sugar?	R1, R2: Because it is difficult to get bamboo plants compared to pandan leaves in coastal areas.	Conservation and sustainability
4	What can be used to maintain the quality of sap to ensure it remains of good quality after harvest?	R1, R2: The addition of safat fruit is believed to maintain the quality of sap after harvest.	Preservation process with fruit properties
5	What is the function of dried banana leaves?	R1, R2: Dried banana leaves function as a preservative for palm sugar to prevent it from getting soft.	Preservation Mechanism

Based on Table 2, the results of the reconstructed local knowledge in the process of making palm sugar were further elaborated. First, coastal residents use palm sugar business to meet daily needs. This simply means the application of business and energy concepts to daily economic activities. Despite engaging in other occupations, such as palm oil farming, it is considered a monthly business. Knowledge passed down from ancestors is used to produce palm sugar daily through mechanical and thermal processes. Furthermore, physical effort played an important role in every stage, from sap collection to palm sugar packaging. Process reflected dependence on natural energy sources and the human ability to convert this energy into economically valuable products. The need to improve the quality of palm sugar products has enabled high added value through innovation (Fitriwati et al., 2021) . In addition, the production process was also influenced by raw material suppliers and producers with expertise and experience in processing palm sugar (Wardhana et al., 2021) .

Second, coastal communities intend to maintain ancestral heritage by preserving the traditional production process. This method is considered the most effective in producing the best palm sugar. Traditional methods include the use of locally available resources, such as firewood, which is a renewable energy source. The use of firewood in the process of making palm sugar reflects the integration of sustainability concepts and responsible natural resource management. Adequate energy is used to process sap into palm sugar without damaging the environment, with the ecosystem balance maintained through sustainable tree planting practices (Masitah & Suwianto, 2023) . Similar utensils were also used in various regions of South Sulawesi to process sap, including frying pans, straws, sieves, molding tools in the form of coconut shells, and wooden types such as bricks, including firewood (Syahidah et al., 2023) .

Third, coastal communities used pandan leaves to make palm sugar. In other regions, the people use bamboo or coconut shells. It is difficult to find bamboo plants in coastal areas compared to pandan leaves. In certain areas, *pandanus tectorius* is used in the craft industry because it has strong fibers (Nurmeilisa et al., 2024) . *Pandanus tectorius* is also used in modern packaging, which offers better comfort and a neater appearance (Natadjaja & Yuwono, 2016) . However, conservation and sustainability need to be considered when using modern packaging, such as plastic. The use of local plants such as pandan to meet certain needs in coastal areas helps preserve natural ecosystems, reduces pressure on rarer resources, namely bamboo, and protects the environment from plastic waste (Suhendra et al., 2020) . The use of these resources can be maintained in the long

term without damaging the environment. Pandan leaves (*pandanus tectorius*) obtained from the leaves are natural ingredients with strong fiber properties (Astari et al., 2024; Nuryati et al., 2020). The selection of plants that suit local habitats is an important step in sustainable practices (Utami & Hermanto, 2020).

Fourth, Safat fruit plays an important role as a natural preservative in the palm sap processing process, especially in maintaining the quality of the palm sap so that it remains fresh and free from decay. The presence of active ingredients in safat fruit helps prevent fermentation that can damage the palm sap and extend its shelf life. This preservation process occurs through several mutually supportive mechanisms. First, the organic acid contained in safat fruit can lower the pH of the palm sap (Harahap & Yani, 2023). This decrease in pH creates an environment that does not support the growth of microorganisms, such as bacteria and fungi, which can usually cause decay or fermentation. In lower pH conditions, microorganisms cannot reproduce properly, so the decay process can be inhibited (Suryani & Lestari, 2021). Second, saffat fruit contains antimicrobial compounds that function to inhibit or even kill microorganisms that can damage the quality of the palm sap (Melati & Surya, 2022). These antimicrobial compounds act directly on pathogens or microbes in the palm sap, reducing the number of microorganisms that can cause fermentation or decay. Thus, safat fruit functions as an effective protective agent to maintain the cleanliness and stability of the quality of the palm sap (Budiarti & Syamsuddin, 2019). Third, saffron fruit is also rich in antioxidant compounds that play an important role in preventing oxidation. Oxidation is a chemical process that can damage the natural components in the sap, such as sugar and vitamins, thereby reducing its freshness. The antioxidants in the sapote fruit protect the components of the sap from the oxidation process so that the sap stays fresh longer and is not easily damaged (Hardiyanto & Wibowo, 2021). Overall, the use of safat fruit as a preservative in sap is not only effective in extending the shelf life of the sap but also prevents spoilage caused by microorganisms and oxidation. This natural preservation process makes safat fruit an environmentally friendly and efficient solution in the sap processing industry (Ahmad & Suharto, 2020).

The natural preservatives used by palm sugar entrepreneurs in South Sulawesi to inhibit the fermentation of the sap are tappajeng roots and garcinia leaves (Syahidah et al., 2023). The active compounds in this material work by inhibiting the growth of microorganisms and extending the shelf life of the sap. Tappajeng roots contain tannins, while garcinia leaves contain hydroxycitric acid, which is effective in preventing fermentation. Fifth, the use of dry banana leaves serves as a preservative to prevent palm sugar from softening. The leaves maintain a low humidity, thereby preventing the sugar from absorbing water from the

environment (Iskandar & Rahman, 2020) . The combination of antimicrobial properties, moisture-absorbing ability, physical barrier, aromatic compounds, thermal insulation properties, and pH influence makes dried banana leaves an effective preservative (Lestari & Rahmat, 2022) . This is an example of the application of traditional technology to achieve natural food conservation objectives (Septiani & Rahman, 2023) . These leaves were used in 1) processing fiber-reinforced thermoplastic cassava starch composites (Jumaidin et al., 2021) , 2) while the semi-dried ones were used for biogas production (Jena et al., 2017) , 3) the completely dried leaves were used for pyramidal microwave absorber design (Farhany et al., 2012) , including 4) improved wastewater treatment, and a bacteriophage cocktail (El-DougDoug et al., 2020) .

The process of making palm sugar in coastal areas not only reflects local wisdom that has been passed down from generation to generation, but also reflects the principle of sustainability that is integrated into the daily lives of the community (Rizky & Hidayat, 2021) . The use of local resources such as firewood and pandan leaves shows the relevance of the concept of renewable energy, where firewood is used as a renewable energy source, while pandan leaves function as an additional ingredient in the palm sugar-making process (Zulkifli & Harsono , 2023) . This underlines the importance of sustainability in palm sugar production that not only relies on existing natural resources but also supports environmentally friendly energy management. Hemmerling et al, (2020) emphasize that the use of renewable energy in traditional practices, such as those used in the manufacture of palm sugar, can be a model for reducing dependence on fossil fuels while preserving the environment and local economy.

Sustainability in traditional production is also reflected in the use of natural preservatives in the palm sugar-making process, such as safat fruit. The addition of fruit properties not only functions as a natural preservative but also illustrates the practical application of the antimicrobial compounds contained in it. These antimicrobial compounds effectively inhibit the growth of microorganisms that can cause decay, thereby maintaining the quality of the sap and palm sugar. As explained by Sudarmin et al. (2020), the application of antimicrobial compounds contained in natural ingredients such as saf at fruit supports the sustainability of traditional products, allowing these products to remain of high quality without having to rely on synthetic preservatives that can damage the environment and health. Therefore, this method is not only useful in the context of maintaining product quality but is also in line with the principles of sustainability that are part of local culture.

The description of scientific concepts is inseparable from local knowledge of people in coastal areas. The composition of palm sugar includes complex carbohydrates, vitamin B, minerals such as iron, calcium, and magnesium, and phenolic compounds that have antioxidant activity. Palm sugar is known by various names, such as "brown sugar" in Indonesia, "jaggery" in India, "coconut sugar" in Malaysia, and "palm sugar" in English (Fadli et al., 2023) . This diversity of names reflects the global acceptance of palm-based products. Science learning, which is presented in an integrated manner, makes it easier for students to learn scientific concepts and apply the knowledge daily. Furthermore, meaningful learning improves student learning outcomes. Motivation is important for those in the northern coastal region of Java Island in obtaining learning achievement (Sarwi et al., 2023) . Meanwhile, various learning methods were used to integrate local knowledge with natural science concepts, namely 1) Science, Environment, Technology, and Society (SETS) thematic learning integrated with local wisdom enabled the reconstruction and improvement of disaster management knowledge (Atmojo et al. , 2018) . 2) distance learning system using open source Moodle e-learning has a positive influence on students' ability to improve scientific literacy based on coastal wisdom (Shofatun et al., 2021) , and 3) increased local knowledge through participatory modeling in coastal Louisiana (Hemmerling et al., 2020) .

The integration of local knowledge with scientific concepts enables students to realize the relevance of science in daily activities and increase learning motivation. It also leads to the appreciation of local knowledge existing in the communities (Rahayu & Santoso, 2020) . In addition, this is important in maintaining ongoing conversations regarding local wisdom as a form of respect for the aspirations and independence of marginalized communities through the construction of valid knowledge (Canagarajah, 2002) .

In the context of education, the integration of local knowledge, such as the process of making palm sugar, into science learning has a positive impact on students' understanding (Widodo & Hartono, 2021) . Especially in coastal areas, this local knowledge can be the basis for introducing relevant and applicable scientific concepts so that students can relate the theories learned to their daily lives. Izza & Indyah (2019) emphasize the importance of contextual learning, which not only teaches theory but also relates it to local social and cultural realities (Putra & Ningsih, 2021) . This increases student engagement in the learning process and helps them to better understand and appreciate the relationship between science and their lives around the coast. Through this approach, students not only learn science theoretically but also develop critical thinking skills that are useful in facing environmental challenges in their area.

The thematic method used in data analysis can make a significant contribution to improving students' scientific literacy, especially in understanding the process of making palm sugar practically (Azmanita & Fauzi, 2020) . By using a thematic approach, students can see the relationship between scientific concepts, such as renewable energy, microbiology, and chemistry, which are used in making palm sugar. Wardhana et al. (2021) explained that the thematic method allows the integration of various disciplines in one learning topic, strengthening students' understanding of the relationship between theory and practice. This not only improves students' understanding of science but also opens up opportunities for them to develop more holistic scientific literacy, where they can connect scientific concepts with their applications in real life. Thus, the thematic method not only improves scientific knowledge but also strengthens students' skills in dealing with environmental and social issues that are relevant to their lives (Sudarmin et al., 2020) .

4. Conclusion

The reconstruction of local knowledge of coastal communities in the process of making palm sugar shows the importance of using local resources for preserving traditions while supporting ecosystem sustainability. This process reflects the integration of cultural values with scientific concepts, including renewable energy, conservation, and preservation mechanisms using natural materials such as safat fruit and dried banana leaves. This study also confirms that science education based on local wisdom can increase the relevance of science in everyday life. Thus, the results of this study are expected to be the basis for further development in education that respects local wisdom and community-based innovation. This approach not only has a positive impact on cultural preservation but also paves the way for better collaboration between traditional knowledge and modern science.

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