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Reconstruction Indigenous Science into Scientific Science in Roof Tile Production as Chemistry Material Learning

Hestin Wirasti(1), Sri Haryani(2), Nanik Wijayati(3), Woro Sumarni(4), Sudarmin Sudarmin(5)

(1) Universitas Negeri Semarang
(2) Universitas Negeri Semarang
(3) Universitas Negeri Semarang
(4) Universitas Negeri Semarang
(5) Universitas Negeri Semarang

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Abstract

This study aims to explore and reconstruct community knowledge into scientific knowledge about the process of making Sokka roof tiles carried out by the people of Kedawung Village, Pejagoan District, Kebumen Regency, Central Java Province. The research method used is a qualitative method with an ethnoscience phenomenological approach. The research instruments used were observation sheets and interviews. The stages of the research were observation, verification, reconstruction, formulation, and conceptualization and documentation. Descriptive data analysis was also carried out for the data on the transformation of indigenous people's science and local wisdom into scientific science. The analysis results show that the owners and craftsmen have good techniques and methods and innovative ideas to produce quality roof tiles. The results showed that the chemical concepts in making Sokka Kebumen roof tiles were the nomenclature of compounds, hydrocarbons, reaction rates, and colloids. The expected output of this research is as a contextual learning resource for science teachers in schools to grow the students' scientific literacy.

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INTRODUCTION

Technology development has led to the advancement of Science and Technology in various fields, one of which is education. Teachers or prospective teachers must be able to arm the students through learning to preserve existing culture or local wisdom. Science learning needs to be made a continuous effort between scientific knowledge (science) and original science or local wisdom that exists in the community. The scope of scientific knowledge includes chemistry, biology, physics, agriculture, ecology, and medicine. Learning science that is not integrated with culture or local wisdom will have an impact on the diluting of eastern culture, which is the cultural heritage of their ancestors. Scientific knowledge that develops in the community or original science contains concepts, principles, or scientific knowledge that have not been formalized (Duit, 2007). Exploration of local wisdom or indigenous science from the community and turning it into scientific science needs to be done to be integrated into learning. Learning with a local wisdom approach significantly impacts student learning outcomes (Fadli & Irwanto, 2020). Learning by analogizing culture or local wisdom also makes it easier for students to understand and master the learning process (Sutrisno et al., 2020). Local wisdom originating from certain areas can be used as a learning context to balance the learning demands of the 21st-century era.

21st-century education requires students and teachers to have four skills, (1) critical thinking and problem-solving skills, (2) communication skills, (3) creativity and innovation skills, and (4) collaboration skills (Kemendikbud, 2020). One of the main needs of students in the 21st century is scientific literacy skills (Deming et al., 2012). Therefore, some countries make scientific literacy the main goal in education (Sumarni et al., 2017). In line with 21st-century skills, scientific literacy is needed in the life and development of an era full of complexity (Pelch & McConnell, 2017) and to solve challenges that exist in real environments (Purnami et al., 2021) and predict natural phenomena (Kaya & Elster, 2019). Scientific literacy skills are needed to understand scientific issues, the risks and benefits of science, and the characteristics of science, including its relationship to culture (Fasasi, 2017). Scientific literacy is knowledge and understanding of scientific concepts and processes and how a person can make decisions and participate in social life, culture, and economic growth (Anjarsari, 2014).

The average score of Indonesian scientific literacy in 2000 was 393, in 2003 it got a score of 395, in 2006 it got a score of 393, in 2009 it got a score of 383, in 2012 it got a score of 382, in 2015 it got a score of 403, and in 2018 it got a score of 396. Based on the data on the average score of scientific literacy, from 2003 to 2012 it decreased successively, in 2015 it rose quite high, but in 2018 the average score of Indonesian scientific literacy declined again. The low scientific literacy of students is due to misconceptions, students' reading skills, selection of textbooks, and non-contextual learning (Fuadi et al., 2020). Scientific literacy needs to be developed continuously, one of which is through educational instruments (Heryani et al., 2020). Measurement of scientific literacy may not be based on issues contained in the context of the school curriculum but rather on issues in the context of local life or historical contexts, which are usually used to assess students' understanding of the processes and practices involved in advancing scientific knowledge (Abidin, 2017). Local wisdom that contains environmental problems and local cultural issues can be used as a source of scientific literacy learning (Perkasa, 2018).

The production of Sokka Kebumen roof tile is one of the local wisdom found in Kebumen. Soka roof tile is a characteristic or icon of Kebumen Regency. The process of making sokka roof tiles through several stages passed down from ancestors to produce quality roof tiles. The roof tile production process starts from raw materials, manufacturing methods, and other aspects involving the scientific process, namely chemistry. The original science of sokka roof tile production contains local wisdom values embraced by the community but have never been integrated into the learning process. If the knowledge that lives in society and has not undergone formalization is reconstructed

into scientific knowledge, it can be used in the learning process as an alternative learning resource (Sudarmin & Asyhar, 2012).

Based on the description of the background above, this research aims to explore and reconstruct the community's original knowledge or science into scientific knowledge about the Sokka roof tile production process carried out by the people of Kedawung Village, Pejagoan District, Kebumen Regency, Central Java Province. This research is focused on qualitative analysis through phenomenological. The process of exploration and reconstruction of indigenous knowledge or science of the community in the production process of sokka tile has not been widely carried out, so in this research, it is necessary to explore and reconstruct indigenous knowledge or science of the community into scientific knowledge. The results of this exploration and reconstruction can be used as a contextual learning resource for science teachers in schools so that they can grow students' scientific literacy. The material learning chemistry based on local wisdom for making sokka tiles in Kebumen has not been developed yet and hoped that integrating elements of certain local wisdom into science learning can encourage students to develop their regional potential.

METHODS

The research method used is a qualitative method with an ethnoscience phenomenological approach (Sudarmin et al., 2017). Phenomenological studies are studies of knowledge systems organized from community culture and local wisdom related to phenomena and events related to nature and local wisdom (Sudarmin et al., 2017). The data used in this study are primary data and secondary data. Primary data was obtained through observation, interviews, discussions, and direct observations in the field. Observations were made in Sokka Hamlet, Kedawung Village, Pejagoan District, Kebumen Regency. Interviews were conducted twice, the first interview was with Sokka roof tile producers, namely Mr. Khafid and Mr. Ahmad, and the second interview was with roof tile workers, namely Yu Jariah, *Kang* Selamet, and *Yu* Santi. Secondary data is obtained by literature study through books, journals, or other relevant reference sources. The research steps were observation, verification, reconstruction, formulation, conceptualization, and documentation (Sudarmin, 2014). The research step begins with conducting observations and interviews with several sources and providing information about the history of Sokka Kebumen roof tiles, raw materials for sokka roof tiles, and techniques for making sokka roof tiles. The next research step is verification, reconstruction, formulation, and conceptualization to acquire scientific knowledge as a source of learning for the student. Descriptive data analysis was also carried out for data on the transformation of indigenous people's science and local wisdom into scientific science, besides that data analysis was also carried out using the Ethno-STEM approach to find out the community's creative ideas in the production of sokka roof tiles to produce quality roof tiles.

RESULTS AND DISCUSSION

This section presents the results of research and discussion as a whole. There is no separating the results and discussion in the form of new chapters/sub-chapters. The results presented in this section are final results. Data analysis processes such as statistical calculations and testing processes hypothesis do not need to be presented. The results of the study can be supplemented with tables, pictures, and graphs to clarify the presentation. Tables and graphs must be narrated and commented on before presented.

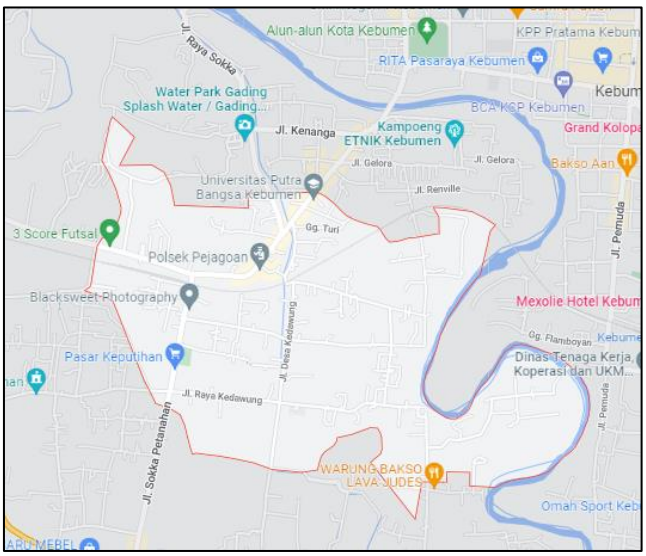

Figure 1. Map of Kedawung Village, Kebumen Regency

The establishment of the sokka roof tile was motivated by the PES epidemic that hit Indonesian people. Because most people still use roofs made of coconut leaves or called *bleketepe*. The house's roof became a nest of insects, snakes, and rats. Many Indonesian people fell ill and died. This is the background for the Netherlands to conduct research to find good alternative roofs. The results of Dutch research show that the soil in Kedawung Village contains kaolin and iron, the soil is clayey, and the color is not red. The first sokka roof tile factory was a tile factory owned by Mr. Ahmad, which is now SMP Negeri 1 Pejagoan.

The interviews with informants revealed that the knowledge possessed to produce roof tiles is passed down from generation to generation. Figure 2 is an observation activity that aims to collect data.

Figure 2. (a) Research sites, (b) *Nandon* step, (c) *Geblek* step, (d) *Cetak* step, (e) *Meme* or *Jereng* step, (f)*Obong* step

The results of the exploration and science reconstruction are presented in Table 1.

Table 1. Results of Reconstruction and Community Science Exploration

<table>
<tr><th>Question</th><th>Community Knowledge</th><th>Scientific Knowledge</th></tr>
<tr><td>What kind of soil is used to make roof tiles? Have you ever tried using soil from outside Kedawung or Kebumen?</td><td>Soil that is sticky so it does not disperse.
Never. from the past, even from my parents, it was used to use the soil from here.</td><td>Clay because it has strong characteristics and is not easy to crack (Mufarrohah et al., 2020).
Clay contains the following compounds (Bambali, 2021).
<table><tr><th>Chemical Formula</th><th>Compound Name</th></tr><tr><td>SiO_2</td><td>Silicon Dioxide</td></tr><tr><td>Al_2O_3</td><td>Aluminum Oxide</td></tr><tr><td>Fe_2O_3</td><td>Iron(III) Oxide</td></tr><tr><td>MnO</td><td>Manganese(II) Oxide</td></tr></table></td></tr>
<tr><td>Was the soil taken from Kedawung only, or other areas as well? What are the excesses of Kedawung Village soil compared to others?</td><td>Kedawung Village soil is suitable, neat, and not red. Sticky to hold.</td><td>Kedawung Village soil is better used as raw material for making roof tiles because it has good plasticity. When it is burned, it does not experience many cracks, so it is not easily broken. Based on XRD analysis, Kedawung clay has a high content of kaolin (13%), montmorillonite (29%), sized quartz (53%), and albite (5%). The presence of kaolin content makes Kedawung clay not easy to expand because kaolin has a small value of CEC (Cation Exchange Capacity) (ANSORI, 2010).</td></tr>
<tr><td>What are the supporting materials for making roof tiles?</td><td>The supporting materials are sand and water. Mixed in the early process of making roof tiles, later molded and called Kweh.</td><td>The process of mixing clay with water and sand aims to make the dough smooth and close the soil pores so that after grinding and homogeneous, the resulting pores become homogeneous.</td></tr>
<tr><td>What tools are used to produce Sokka roof tiles?</td><td>Hoes, molen machines/cement-mixer, corkscrew/extruder machines, hand press machines, wet tile cutters, trays, drying racks, furnaces</td><td></td></tr>
<tr><td>How is the process of making Sokka roof tiles?</td><td>The first process is called nandon. Usually, take the soil from the fields, but it has to be the inside of the ground because the top has a lot of leftover rice or secondary crops, so it does not get dirty</td><td>The top layer of the soil is the ground flower which is not used as a roof tile-making material. This is because the content of humus and nutrients are very good for plants. Soil extraction is done by removing the ground flowers, and the soil taken is at the bottom of the ground flower, approximately 25 cm deep from the soil surface.</td></tr>
<tr><td></td><td>The second process is refining the dough consisting of clay and sea sand to be processed into kweh. Once mixing can be done 2-3 times by the</td><td>Mixing clay, water, and sand aims to make the raw material dough more homogeneous and the pores perfectly distributed. The more milling, the more homogeneous the dough so that the kweh is smoother. The finer the kweh, the better</td></tr>
</table>

	cement mixer, the roof tile is later strong and good.	the quality of the roof tile.
	The next process is *meme* or *jereng* for 2-4 days on a special shelf so that when molded, it would not be soggy. If it is soggy, it will break easily.	This process is carried out in order to remove the water content due to the homogenization process between water, sand, and clay. During the drying process, the raw materials need to be inverted. This process aims to make the elasticity of the raw materials.
	The next process is *geblek*. *Geblek* is done so that it is thin, so it is easy to mold. Then smeared with oil so the soil does not stick to the mold.	This process aims to smooth the surface of the roof tile raw material by beating it with a special bat until it is flat/thin. The top and bottom surfaces are smeared with oil. The oil used is used cooking oil or diesel oil. The use of used cooking oil reduces the use of diesel oil. Besides that, the price is lower than diesel oil. The purpose of basting with diesel or cooking oil is to make the roof tile, when pressed on the top surface becomes smooth and not sticky.
	The next process is molded, aerated, and burned. *Obong* or burning is carried out in the *tobong* until the fire is white. The wood used is big in order to make it durable. Usually, they use old *sengon* logs.	*Tobong* is a closed room that is used specifically for burning roof tiles. *Tobong* is designed closed because it has a higher level of fuel efficiency (Sutrisno, 2003). Sengon wood log contains holocellulose and alpha cellulose. The log part of sengon wood is the part that contains the highest holocellulose and alpha cellulose (Putra et al., 2018). The cellulose content is 41.88% (Trisanti et al., 2018), hemicellulose 14.55%, and lignin 24.78% (Hairul Bahri et al., 2020).
When is the sokka roof tile declared ripe?	If the fire is white, it means it is ripe.	The roof tile is already ripe when it reaches a temperature of ± 25000C. At 2700 K, the flame will be white (Durmus, 2021).
Have you ever innovated in making roof tiles?	I have never done innovation, only in the tools, in the past, my parents used more traditional tools, and now I use hydraulic tools for the molding process. As for the composition, and the steps of making roof tile, my wife and I use the method passed down from generation to generation from my parents, my parents also got their knowledge from my grandparents.	

The Sokka roof tile production process was also analyzed using the ETNO-STEM approach. The analysis results using the ethno-stem approach are presented in Table 2.

Table 2. Analysis of Sokka Roof Tile Production Using Ethno-Stem Approach

Aspect	Results Analysis
Science	The raw material used in the production of sokka roof tile is clay which is not red. Clay has strong characteristics and is not easy to crack (Mufarrohah et al., 2020). Clay contains compounds SiO_2, Al_2O_3, Fe_2O_3, MnO, MgO, CaO, Na_2O, K_2O, TiO_2, P_2O_5, As_2O_3, BaO, CuO, NiO, PbO, SO_3, SrO, ZnO, ZrO_2, Rb_2O, Cr_2O_3 (Bambali, 2021). The soil used is Kedawung Village soil because it contains kaolin clay so it is not easy to grow, because kaolin has a small value of CEC (Cation Exchange Capacity). (Ansori, 2010)
Technology	The tools used to produce Sokka Kebumen roof tiles are traditional tools such as hoes, cement mixer machines, corkscrew/extruder machines, hand presses, wet tile cutters (wire), wooden trays, bamboo drying racks, and furnace.
Engineering	The molding process uses a hydraulic tool that must be pressed using a certain pressure to obtain a quality roof tile. The burning process must be carried out in the *tobong*, and before being laid out in the *tobong*, the *tobong* must be heated first.
Mathematics	Calculation of the composition of raw materials must be clear, 30% water, and 100% soil. Calculation of this composition will affect the quality of the roof tile.

Based on the information above, the process of making roof tiles can be related to the process of science, especially chemistry which is linked to the Basic Competence (KD) of Chemistry. The relationship between the process of making roof tiles and chemicals is presented in Table 3.

Table 3. The Relationship between the Process of Making Roof Tiles and Chemical Materials

Chemical Materials Related to Roof Tile Making	Basic competencies
Colloid (clay, smoke)	3.14 Classify the various types of colloid systems and explain the uses of colloids in life based on their characteristics 4.14 Making food or other products that are colloidal or involve colloidal principles
Thermochemistry (Burning Process)	3. 4 Explain the concept of the enthalpy change for a reaction at constant pressure in thermochemical equations 4.4 Summarizing the results of the thermochemical experimental data analysis at constant pressure
Reaction rate (The heating process)	3.6 Explain the factors that affect the rate of a reaction using collision theory 4.6 Presenting information search results on ways to organize and store materials to prevent uncontrollable physical and chemical changes
Carbon chemistry	3.3 Identify the complete and incomplete combustion of hydrocarbons and the nature of the combustion products (CO_2, CO, carbon particulates) 4.3 Develop ideas on how to overcome the impact of burning carbon compounds on the environment and health
Compound nomenclature	Clay content.

Table 3. shows that chemistry is closely related to everyday life so that it can be integrated into learning. The process of making tiles can be integrated with chemicals. The first chemical

material that can be associated with the manufacture of roof tiles is colloidal material where the smoke produced by burning roof tiles in a chimney is an example of a colloidal dispersion system between solids in gas, because the dispersed phase is a solid, while the dispersion medium is a gas. In addition, *kweh* or clay is used as raw material for making roof tiles. The second chemical that can be related to the process of making roof tiles is thermochemistry, where the process of burning roof tiles in a tile is an exothermic reaction. The third chemical related to the process of making tiles is the reaction rate, where temperature and surface area affect the rate of tile ripening. The fourth chemical material related to the process of making tile is hydrocarbons, where the burning of wood is an oxidation reaction that produces CO_2 and H_2O. The fifth chemical material related to the process of making roof tiles is the nomenclature of compounds where the raw materials for making roof tiles have certain characteristics and chemical content. The chemical content contained in clay or *kweh* is very much, and to find out the names, students must learn compound management.

Problems in everyday life, both local and personal, can be integrated into science learning. Learning that relates to these issues can encourage students to think critically. In addition, it can encourage students to explain scientific concepts obtained with scientific facts (Rahayu et al., 2022). Local wisdom-based learning has a better effect than conventional learning in improving student learning outcomes. This is because students are taught about local wisdom and understand more about the environment around them (Rahma Febriani et al., 2020). Stimulus based on local wisdom can be used in the learning process to measure scientific literacy and analytical thinking skills (Parmin & Fibriana, 2019).

Exploration of local culture is important to understand local wisdom that is integrated into schools (Izzah et al., 2020). Inserting local wisdom in learning means participating in preserving cultural sustainability. Teachers and schools must be able to support efforts to preserve local culture in the modern era like now. This is to balance the presence of foreign cultures that enter so that local culture is not lost. Integrating local wisdom in science learning can be done by inserting it into learning as a stimulus or integrated into learning resources such as modules, student worksheets, or teaching materials.

The insertion of local wisdom into science books is a form of cultural preservation because it participates in perpetuating cultural science (Parmin et al., 2019). Learning needs to be supported by the availability of teaching materials that follow the criteria of 21st-century teaching materials, which include dimensions of scientific literacy such as content, procedures, and scientific behavior in real-life environments (Naezak et al., 2021). Learning using teaching materials based on local wisdom provides great benefits such as increasing interest in learning, changing behavior, and making students understand and love local wisdom (Anggramayeni et al., 2018). Learning by utilizing local wisdom-based science modules also received a positive response from teachers and students during learning (Fitriani et al., 2019).

CONCLUSION

Based on observations and interviews, it can be concluded that people use the knowledge passed down from their ancestors. Knowledge in producing roof tiles from ancestors can be reconstructed into scientific knowledge. From this scientific knowledge, it can be integrated into the learning context or used as a learning resource. Learning contexts that contain culture or local wisdom can make learning more meaningful and improve scientific literacy. The analysis results show that the owners and craftsmen have good techniques and methods and innovative ideas to produce quality roof tiles. Suggestions for further researchers are to develop learning resources that contain local wisdom to make learning more meaningful and improve scientific literacy.

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