Identification of indigenous science in the brick-making process through ethnoscience study

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Abstract. This study aims to find indigenous science in making bricks. In the brick-making process there are concepts of science used for generations obtained through local wisdom. This research method is descriptive qualitative by collecting data through interviews on brick-making home industries in Penggaron village of Semarang city and in Welahan village of Jepara. The result of the research indicates that the indigenous science is in the process of making bricks which includes materials composing, printing, drying, burning and brick quality testing. These findings can be integrated in the course of environmental physics.

1. Introduction

Natural sciences are some of the compulsory subjects taught in schools. They comprise physics, chemistry, and biology. Scientific contents are obtained from scientific methods such as observation, inquiry, conclusion, prediction, problem solving, classification, monitoring, interpretation, and adaptation [1]. This scientific mindset (culture) is adapted and adopted from the West, which is not necessarily in line with Indonesian culture [2]. Scientific contents from the West are universal in nature, yet they may not be suitable with the learning environment here. Indonesia is diverse in its ethnicity and culture. In fact each nation has its own culture or way in dealing with issues with their environment; including the way a nation create something from their immediate surroundings. One of this indigenous culture is in brick making.

Ethnoscience is the science that belongs to a certain nation or community, whereas the traditional technology that a community use to make things is known as ethnotechnology [3]. Brick making is an indigenous knowledge passed down through generations via internships. This knowledge is gained from local wisdom which is guided by attention, ethics, control, sharing, harmony, tolerance, holistic approach, and spirituality [1].

Brick is one type of artificial rock made of clay. It is used for all sorts of constructions. As time goes by, brick is getting less favorable due to many reasons. One of them is its small dimension and fragility. The other reasons include safety concerns related to earthquake, as buildings made of bricks have potential dangers. However, some people still believe that buildings constructed from bricks are much stronger than those made of the other types of rock. Brick making requires both skills and meticulousness in the process. Certain techniques are needed to make bricks. These techniques may vary in different regions.

On the other, the teaching of physics is sometimes hampered by the fact that students do not really know how to relate what they learn with their surroundings. As a result they cannot apply what they have learned in their everyday life in solving problems they may encounter, despite the fact that
physics is a subject very much related to everyday life [4]. Learning that is oriented on material mastery has been proven to be successful in short term, but it is a complete failure in helping students to solve long term problems. Learning will be even more worthy when students experience what they learn, instead of only knowing them [5].

Physics teaching materials are prepared in a somewhat linear way so far. That is providing concepts and principles, problem samples and solutions, and problems for further practice. Teaching materials are not yet related to real problems students know in their everyday life [6] like the energy crisis, the greenhouse effect, issues with lightning, fires due to short-circuiting, very high voltage power lines, and the likes. The books used for physics teaching should adopt contextual learning. Contextual learning relates learning materials with real life situations and encourages students to connect what they know with its applications is everyday life as they are members of both their family and community [7].

That disadvantageous physics learning characteristic is caused by many factors including learning that is oriented on result, instead of process. There needs to be a physics learning characteristic that directly relates students to real issues as to instil both concept and problem solving mastery in them. Learning that is focused on socio-scientific issues needs to be developed to encourage students to understand and apply their knowledge, attitude, and decision making skills in dealing with current issues in their community [8].

One of the ways to deal with issues affecting physics learning is by preparing teachers who are capable of comprehensive thinking. Prospective physics teachers should be able to apply their specialities and make use of physics to solve problems and adapt to any situations they are in. With those skills future teachers will be motivated to develop and apply physics education in their future classes. One way to do this now is training students to explore and identify current issues in their community. One course that represents this is Environmental Physics as it is an applied course. Upon finishing their class, students are expected to be able to relate physics with environmental issues. This research is aimed at finding the indigenous science in brick making that can then be integrated with the course of Environmental Physics.

2. Methods
The method employed in this research is descriptive qualitative. Data were collected from interviews with practitioners of brick making home industry in the villages of Penggaron Kidul, Semarang municipality, and Welahan, Jepara regency. The focus of this research is brick making as it can be categorized into both Physics and Natural Sciences. Interview instruments used has been validated by some expert judgments. Data resulted from qualitative research has also been validated with triangulation. Triangulation is the process of data validity examination using other parameters that serve as checking lists or comparison to research data. Triangulation is this research was by conducting interviews with multiple parties in order to gain proper understanding of some issues [9]. Qualitative data analysis made use of the Spradley model [10]. Data analyses were carried out continuously from the beginning to the end of the research. Data were taken intensively, categorized, arranged, and tested against hypotheses, and then afterwards interpreted, and discussed with some competent experts in indigenous knowledge. Findings from this indigenous knowledge in brick making were then compared to available scientific facts.

3. Results and discussion

3.1. Material mixing
Brick is mainly made of clay with some added materials. These added materials include husk ash, sand, husk, and saw dust. They are then blended by adding water whilst trampling on it until it becomes mud like mold. Scientifically, the clay used for brick making needs to be tested for its mineral content. However, clay generally contains kaolinite \((\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4)\) and \((\text{Ca,Na})(\text{Si,Al})_2\text{O}_8\).
The specific property of kaolinite is that it does not absorb water, nor does it expand upon contact with water [11].

Clay as raw material for brick making is taken from the surrounding areas. Respondents in Penggaron village get clay from the banks of Kalibabon river. Clay is taken when the river is dried and then it is processed with additional materials that are also taken from that river bank. Hence, bricks are only produced during the dry season and production has to be stopped during the rainy season as the river is inundated. On the contrary, in Welahan village, clay is taken from productive paddy fields during the rainy season. Back in the day, they only produce bricks during the dry season, but as the financial gain from this is interesting, the produce bricks all year long. The downside is that many farming lands are now laden with mud holes.

3.2. Molding

Bricks are made by molding soft clay on wood-mold by hands. Wooden brick-mold comes in many different sizes depending on the region. Respondents in Penggaron use molds of 21 cm x 9.5 cm x 4 cm dimension, while those in Welahan prefer the 23.5 cm x 11 cm x 4 cm dimension. Both sizes are still within the SNI.15-2094-2000 standard, as depicted in Table 1.

| Size   | Size 1 (mm) | Size 2 (mm) | Deviation Maximum (%) |
|--------|-------------|-------------|-----------------------|
| Length | 240         | 230         | 3                     |
| Width  | 115         | 110         | 4                     |
| Thickness | 52      | 50          | 5                     |

3.3. Drying

Once molded, bricks are then sun-dried to reduce their humidity. Again, respondents in Penggaron and Welahan set different timing for brick drying. In Penggaron, bricks are only dried for two days during the dry season, whereas in Welahan it takes four days in the same season. This is because added materials for clay making in both villages also differ. Bricks in Welahan are made with less additional materials and it contain more water, hence, it takes longer to dry them.

Drying is scientifically meant to reduce humidity, as the water content in bricks dry up. However, shrinkage from this drying process should not exceed 10%. Higher shrinkage percentage results in cracks at the end of the drying process [13].

3.4. Burning

Dried bricks are then burned with fires from wood and rice husk. It takes 4 – 7 days of burning depending on the weather and burning material. Burning with incinerating fire is indicated with glasses that melts if they are put in the fireplace. Burning is considered done when bricks have turned to red. Scientifically, burning very much depends on the material used. Different wood for the fire affects burning temperature. In turn, burning temperature affects resulting brick color. Standard temperature for brick burning is 500 – 1000 °C [14]. Comparisons of different brick colors based on burning temperature are given in Figure 1.

3.5. Quality check

The bricks produced in Welahan, as reported by respondents, do not shrink much, are hard enough, and do not have any cracks. That is how they check for check quality. Meanwhile, respondents in Penggaron said that they check brick quality by beating the brick and check for the ‘ting’ sound. Knowledge for this brick quality checking is based on trial and error, from their experience and is also adjusted according to market demand.
Figure 1. Red Brick Color Variation After Burning at Different Temperatures, from 500°C (left) to 1000°C (right)

Scientifically, brick quality can be determined in many ways. One of them is using pressure test. Compressive strength of bricks can be determined from the pressure formula \( P = \frac{F}{A} \), where \( P \) = brick compressive strength (N/m²), \( F \) = compressive force (N) and \( A \) = compressive area (m²) [15]. Measurement of brick compressive strength can also be conducted technically using equation \( C = \frac{P}{A} \), where \( C \) = brick compressive strength (kg/cm²), \( P \) = maximum load (kg) and \( A \) = object area (cm²) [16].

Results of brick quality testing for both villages show different levels of quality as shown in Table 2. Q1 Penggaron brick, when measured for its compressive strength is better than that of Welahan brick, but physically, in terms of softness and color, Welahan bricks are better than those of Penggaron. These differences in both quality and appearance are due to the different additional materials and burning time employed.

Table 2. Results of Pressure Test for Brick Quality

| Brick Quality | Penggaron | Welahan |
|---------------|-----------|---------|
| Q1            | 11.13     | 8.87    |
| Q2            | 6.3       | 5.6     |
| Q3            | 2.9       | 3.07    |

The main material for brick making is clay. Indigenous knowledge of brick making with clay and its additional materials are passed down through generations. Without having to learn science, people living in Kalibobon river area can know and understand soil properties. If school science and indigenous science are examined more appreciatively and interactively, it is expected to result in attitudes and actions that are more harmonious to nature, instead of being exploitative and even destructive against nature [17]. This harmonious attitudes and actions to nature is what is known as local wisdom.

There is local wisdom to process clay to make bricks. Even though clay is widely available and easily obtainable, local people do not exploit it to gain as much a profit as they can. Brick makers in Penggaron Kidul village only take clay from the banks of Kalibobon river in the dry season. People around Kalibobon river already understand the principle of land and water conservation in Kalibobon river. Watershed management is oriented toward land and water conservation with an emphasis on welfare improvement for the local people [18]. This measure is aimed at maintaining the balance and function of soil components and vegetation as required. If business, industry, and resource management are capable of integrating indigenous science and school science, it well help ensure sustainable development.

Measurement for height and width in brick molding is an example of integration of indigenous and scientific knowledge. This is possible as people are accustomed to make measurement using traditional ways, whilst knowing the scientific methods. In practice, local people make brick measurements using span of the hand (jengkal), span of ulna (hasta), and fathom (depa), but when they are asked about brick dimension, they answer it in centimeters. This indicates that indigenous
knowledge on brick measurement is well understood, despite the fact that they also master modern units of measurements and how to use them.

Indigenous knowledge on brick making includes picking out the proper clay, molding, drying, burning, and quality determination, which are related to the main aspects discussed in the course of Environmental Physics. The integration of indigenous knowledge into the course of Environmental Physics is expected to help students the principles of both local and western cultures [19]. Knowledge and education appear beneficial to all people and intrinsic to the progress and development of modern technological society [20].

Examining the process of brick making allows students to understand local wisdom and culture whilst learning how to integrate scientific concepts into everyday life issues. Discussion on soil properties can be integrated with studying the laws of thermodynamics of soil. Measurements for brick molding can be integrated into the discussion of units and measurements. The process of drying bricks under the sun can be integrated into the discussion of solar energy and substance inertia. Burning of bricks can be integrated into the discussion of energy in everyday life, especially on heat conduction, convection, and radiation. The same thing also goes for brick quality checking in terms of color and strength, which can be integrated into the discussion on the concepts of colors and stress and also strain.

4. Conclusion
The process of brick making involves picking out the main material, molding, sun-drying, burning, and quality checking. Understanding the process of brick making is similar to examining water, soil, and air in the course of Environmental Physics. Hence, it can be concluded that brick making process can be integrated into the course of Environmental Physics.

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