Identification of the indigenous science concepts in the batik-manufacturing process to develop STEM integrated ethnoscience learning

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Abstract. The aim of the study was to identify the scientific concept in the batik manufacturing processes as learning resources for developing science teaching learning grounded in STEM-approaches and ethnoscience. The research method was one of qualitative ethnographic studies. Data were collected by observation, interviews, and documentation studies at Pekalongan Municipality and Regency. The results showed that in the process of batik-manufacturing by indigenous people in Pekalongan, the concept of science was successfully identified and related to science teaching learning for junior high schools. Furthermore, these scientific concepts were integrated into science learning using the Science, Technology, Engineering and Mathematics (STEM) approach.

1. Introduction
Science learning generally refers to western science [1]. Science learning in Indonesia often contains the content and context of western science. On the other hand, Indonesia is rich in culture and natural resources. It is time for science learning in Indonesia grounded in the culture of the local community, called indigenous science/society science. Analysis of the science education curriculum reveals that the curriculum has a concern for local cultural characteristics so that it can be used as a potential to develop education in the regions. In other words learning can be viewed from the cultural and scientific context based on a multicultural perspective [2]. Therefore, it is interesting to develop further science learning from a multicultural perspective (integrated ethnoscience).

Pekalongan, Central Java is known for its batik culture. Pekalongan indigenous people have been doing batik activities for generations. Batik has never been studied by an educational institution, even people can make batik and apply science concepts in their process of batik. Many science concepts are identified in the batik manufacturing process, such as elements, compounds, mixtures, acid-bases, solubility and others. Indigenous science concepts can be reconstructed into scientific knowledge as science learning resources in the classroom. Science learning can be viewed from multicultural perspectives. Reconstruction of indigenous science from Pekalongan society into the form of scientific knowledge is needed as a basis for integrating ethnoscience into science learning. This process of reconstruction and inculturation of indigenous science into scientific knowledge in the process of batik.
manufacturing has not been yet done much, so that in this study it is necessary to do reconstruction and inculturation of indigenous science in the process of batik-making into scientific science.

Analysis of various scientific publications showed that 21st century learning requires innovative learning. One of the innovative learning currently being developed in various countries is Science, Technology, Engineering, and Mathematics (STEM) education [3]. STEM is integrated learning that can support the success of 21st century skills achievement. STEM education help improve creativity and problem solving [3,4]. STEM education influences academic success, creative thinking skills, scientific attitude, process skills [5-7]. Thus, STEM education needs to be developed and implemented to achieve the success of 21st century skills achievement.

2. Methods
This study used a qualitative approach through ethnoscience research. This research was focused on identification of concepts of science of society in the process of batik manufacturing. It was conducted at the District of Pekalongan and Pekalongan Municipality, Central Java. The data collection technique was implemented by observation, interview, and documentation study. The focus questions at the time of observation and interviews were included: definition of batik, knowledge of batik, preparation stages in batik, designing batik process with stamp-batik, colouring process with natural dyes, fixation (colour sharpening), colouring process with synthetic dyes, and the process of removing batik wax (pelorodan).

The steps of reconstructions of indigenous knowledge into scientific knowledge are presented in the Table 1.

| No  | Steps                                | Activities                                                                 |
|-----|--------------------------------------|---------------------------------------------------------------------------|
| 1   | Observation and Exploration          | Conducting observations and interviews with batik workers to reveal their knowledge about "ethnoscience in the batik-manufacturing processes" |
|     |                                      | Exploring scientific terms, technology, engineering, creative ideas, and mathematics in the process of batik-making which is an indigenous science |
| 2   | Reduction and verification           | Reducing indigenous science in the batik-manufacturing processes that can be reconstructed into scientific knowledge |
|     |                                      | Verifying indigenous science that can be reconstructed into scientific knowledge |
| 3   | Validation and Conceptualization     | Conducting validation to the references, relevant data sources, and the experts |
|     |                                      | The finding of scientific knowledge as a science concepts as a result of the reconstruction of indigenous science related to the batik-manufacturing processes |

Furthermore, the reconstructed science concepts provide information in integrating ethnoscience in STEM-approach science learning.

3. Results and Discussion
The code of the respondent is stated by Table 2.

| No  | Respondent Code | Batik Worker                  |
|-----|----------------|-------------------------------|
| 1   | B1, B2, B3      | *Pembatik tulis*: someone who works as a written batik maker. It is female. |
2. C1, C2, C3 Pembatik cap: someone who works as stamp batik maker. It is male.

3. N1, N2, N3 Batik worker using natural dyes.

4. G1, G2, G3 Tukang Ngerek: Batik worker that take a part in colouring.

5. L1, L2, L3 Tukang Nglorod, Batik workers that take a part in removing waxes

Based on observations and interviews with batik workers, information was obtained as follow:

### 3.1. The definition of batik

Currently batik workers were already in the 4th generation. The batik workers (B1, B2, B3) cannot explain the meaning of batik. The definition of batik as stated by [8] Batik is one of the results of Indonesian culture that has become an economic commodity and has been recognized worldwide through UNESCO as a non-materials cultural heritage on October 2, 2009 [8].

### 3.2. The batik knowledge

Figure 1 show activities interview the batik workers. When asked about where to get knowledge about batik. They answered that the batik knowledge possessed by batik workers was obtained from generation to generation from earlier batik workers. This is as expressed in the previous ethnoscience study that the knowledge obtained by the community originated from generation to generation or ancestral heritage [9,10].

Figure 1. Interview with batik worker (Ibu Muripah and Ibu Atikah).

The identification of science concept from indigenous science of batik-manufacturing can be seen in the Table 3.

| No | Research Questions and Indigenous Science | Scientific Knowledge |
|----|-------------------------------------------|----------------------|
| 1  | What material is batik made of? B1, B2, B3: Primissima, Cotton, Silk, Viscose, Dobi, Gedhog (Belacu). | Cotton is a fiber that is cellulosic. Reactive dyes, direct dyes, vat dyes and sulphur dyes are the most regularly ones used for cotton. With groups of cotton fiber hydroxyl, a covalent bond is formed by reactive dyes. Cationic dyes and Acid dyes' affinity to the cotton fabric is not good and merely surface deposition comes about because of ionic attraction. Silk is a natural fiber and has protein. The texture of silk is smooth, soft, but not slippery. The glittering image that is the attraction of silk comes from a triangular prism-like structure in the fiber that makes silk fabrics deflect light from different angles.[11]. Gedhog (Belacu) is mori fabrics that have not been bleached. A Primissima mori fabric contains 94% of cellulose. Cellulose fibers have very hygroscopic properties [12]. It means that the choice of fabrics is depend on the affinity to the dyes. Science concept that related to the indigenous science is the nature of material (Junior High School). |
| 2  | How many kinds of batik wax? B1: There are several types of batik wax. The wax for written batik is better (fine wax and stronger). The manufacturing process is different. Batik waxes are a mixture of cat’s eyes (resin), gondorukem (pine tree sap), BBM (parafin), Palembang wax. The wax used | Kinds of batik waxes are: (1) the batik tulis (written) wax, (2) the batik cap (stamp) wax, (3) the wax that is used to nomboek (blocking a large area). Batik wax is a mixture of paraffin, microcrystallin, beeswax, gondorukem, and animal fat. Pure paraffin is transparent white, odorless, has a chemical formula C_{20}H_{42}. Melting point 50-57°C (135-145°F). Beeswax is a natural purification of bees, the color is rather dark, and smells good. Granules. Beeswax is added to the wax mixture to smooth the paraffin so that it can... |
What is the process of colouring with synthetic dyes?

**G1:** Dyed in dye solution, that is base + kostik sisik. 1 gayang (bucket) of batik dye is used for 1 fabric, then dyeing in garem (salt solution) + air keras (sulphuric acid) for color sharpening. Before the second dye, the fabrics are washed first, and then given another color so that the dye that binds with garem is not release again.

**G2:** To make soft colors, before being dyed the fabrics are dipped first so the color is easily absorbed. Dip it into the solution 3 times. Then dipping into the air keras (sulphuric acid) for “locking color or mejah”. 1 gayang color solution for 1 fabric.

**G3:** To make an old color, we have to color it twice. Dyes for coloring: base + kostik sisik, AS + cowstics garem (salt solution) + nitrile. Gurem (salt solution) mixed with air keras.

What is the pelorodan (removing batik wax) process?

**L1:** Dip it in hot water with soda ash mixture. After the wax is released, the wax is removed and immediately washed for twice.

**L2, L3:** First dip it in hot water which is given a soda stick to the fabric and not easily crack. It has melting point of 130°F. Microcrystalline (microwax) is a synthetic form of beeswax. It functions like beeswax, it has a melting point at 160-170°F. Gondorukem comes from pine plant sap (Pinus merkassii). Animal fat is obtained from beef. It has a low melting point, making it easy to melt. Used as a mixture in manufacturing batik wax so that batik wax is easily removed again (dilorer).
ash mixture (so the wax is easily released). Next step is dipped in hot water without soda ash (for cleaning). After the wax is released, the batik is lifted and immediately washed (dyed). Inserted tinoval cleaning for 0.5-1 hours to make it white. Tinoval in the form of powder brewed with water and then put in the tub. The batik is dyed, lifted, then drying. been attracted presented to shading, in light of the fact that the top of the texture is still covered in a slight layer (wax not totally blurred) [20].

Science Concept

- Heat

The results of the science concept reconstructed from indigenous science to scientific knowledge can be integrated to the science subject in Junior High School. Students can better understand science content that comes from local wisdom sources. The exploration of local culture is important for understanding the local knowledge that is integrated into the school. Cross-culture approach is used when science in school can combine western science (modern science) with traditional science (indigenous science) [18, 19]. Furthermore in a study revealed that the teachers stated that out-of-school learning environments affect positively on students’ cognitive and affective development [20]. The concept of science then linked to competence standards in science learning. It is related to basic competence as stated in the Table 4.

Table 4. Basic Competence Related to Science Concept Reconstructed from Indigenous Science to Scientific Knowledge.

| No | Basic Competence | Science Concept |
|----|------------------|-----------------|
| 1  | 3.3. Explain the concept of a mixture of single substances (elements, compounds (physical and chemical properties, physical and chemical changes in everyday life) 4.3. Presents the results of investigations or works about the nature of solutions, changes in physics and chemical changes, or separation of mixtures | Element, Compound, and Mixtures, Physical and Chemical Properties, Substance Changes, Mixture Separation, Acid and Base |
| 2  | 3.4. analyze the concepts of temperature, expansion, heat, heat transfer and its application in daily life including mechanisms to maintain the stability of human and animal body temperature. 4.4. conduct experiments to investigate the effect of heat on the temperature and shape of objects and heat transfer. | Heat, Heat Transfer (Conductor, Insulator) |
| 3  | 3.8. analyze the occurrence of environmental pollution and its impact on the ecosystem 4.8. writing about the idea of resolving pollution problems in the environment based on observations | WaterPollutions |

4. Conclusion
From the study, it was found that there was scientific knowledge reconstructed from indigenous science in the batik-manufacturing processes. Science concept resulted from that reconstruction can be integrated into science learning using STEM approach.

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