Connecting Indigenous Knowledge of Keris with Science Through an Ethnoscience E-module: A Case Study in Surakarta, Indonesia

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Abstract. Based on its history, Surakarta is one of the oldest cities in Indonesia which has various cultural heritage and indigenous knowledge. These can be integrated as ethnoscience-based science learning in schools. One of indigenous knowledge in Surakarta is Keris, a sharp weapon with a curved or straight blade. This paper attempts to explore students’ understanding in connecting indigenous knowledge with science through ethnoscience e-module in science learning. This covers students’ understanding about local indigenous knowledge and its scientific explanation. This mixed case study contains a combination of quantitative and qualitative approaches. Quantitative data is obtained based on the questionnaire results of 125 students from 5 schools in Surakarta using purposive sampling, while qualitative data is in the form of in-depth interviews of 5 students. The questionnaire results show significant impacts in increasing students’ understanding about local indigenous knowledge and its connection with scientific explanation. The amount of students understanding about the meaning of dhapur and pamor increased from only 2.4% to 68.8% and from 1.6% to 71.2% for understanding the meaning of the addition of meteorite metal in Keris. Then, the in-depth interview indicates that students are happy and have interest in learning with ethnoscience. This paper also contributes to cultural preservation by providing indigenous knowledge as well as scientific understanding by linking science with local culture.

Keywords: e-module, ethnoscience, indigenous knowledge, keris, Surakarta

Introduction

Indigenous knowledge refers to the understandings, skills and philosophies of Indigenous peoples, developed through long and multigenerational histories of interactions with the natural world and adapting to highly variable and changing ecological and social conditions including colonisation and globalisation (Adger et al., 2014; UNESCO, 2017). Indigenous peoples themselves have long recognised the importance of their knowledge systems for managing change (Ford et al 2020). This knowledge is integral to cultural complexes, which also encompass language, systems of classification, resource use practices, social interactions, values, ritual and spirituality. These distinctive ways of knowing are important facets of the world’s cultural diversity (UNESCO 2017). Indigenous knowledge offers rich and authentic contexts for science learning and provides chances to
reflect views on nature and science in contemporary science education for contributing to
the development of more balanced and holistic worldviews, intercultural understanding,
and sustainability (Zidny, et al., 2020).

Indigenous knowledge has valuable resources for integrating the concept of
ethnoscience. Ethnoscience can be defined as a system of knowledge about nature that is
owned by a particular indigenous or traditional culture and covers both ecological aspects
and the mutual relationships between humans and nature (Zidny, et al., 2020). Ethnoscience reconstructs the indigenous knowledge which seems to be mythical
knowledge, superstition and perception into scientific knowledge by describing it based on
experience, verification and data reduction to complete concepts into science (Ogawa,
1986; Tan & Kim, 2012; Sudarmin, 2014). Ethnoscience is a high potential alternative
approach to enhance students’ learning process and result. Ethnoscience can improve
the creative and innovative character of students (Sudarmin, et al., 2020) and make the
understanding of science to be more meaningful and contextual (Khusniati, et al.,
2023). Ethnoscience is efficacious in improving attitudes towards science that can help
students further develop interest in science and technology (Fasasi, 2017).

Indonesia is rich in various religions, tribes, cultures, and traditions (Fajrin et al.,
2021). Several studies about ethnoscience have been conducted by many researchers in
Indonesia. They explore indigenous knowledge as ethnoscience learning. Sumatra island
has Pacu Jalur which is a local term from the Malays in Rantau Kuantan Riau referring to a
rowing competition for a long boat made of a wooden tree. It is related to kinematics,
Newton’s second law, and Bernoulli’s principle (Zulirfan, et al., 2023). Then Kalimantan
island has the essential oil composition of insulin leaves (Tithonia diversifolia) which is used
as a medicinal plant by the Banjar people to treat glycemia (Fauzi’ah & Hajati, 2020). Java
island has 53 of the ethnoscience studies with the composition 31 in Central Java, 18 in
East Java, and 4 in West Java (Kasi, et al., 2021).

Despite the abundance of studies related to ethnoscience, only a few studies have
discussed indigenous knowledge of Surakarta as ethnoscience learning. Whereas,
Surakarta is considered the cradle of Javanese culture (Purwani, 2014, 2017), with two
existing Javanese royal courts residing in the city: i) the royal court of Surakarta and ii)
the minor court of Mangkunegaran. The past domination by the royal court and the minor
court over the people of Surakarta had made it possible for the courts to have a role in
history, and to hang on to cultural and physical remnants (Purwani et al., 2022). This led
Surakarta as one of the oldest cities in Indonesia which has various cultural heritage and
indigenous knowledge. The city has rich cultural diversity in the form of historical buildings,
culinary delights, cultural products, cultural arts, and traditional rituals (Fadilah & Abidin
2021). Today, Surakarta City is one of the major cities in Indonesia, with an area of 44.03
km² and a population of 522,728 in 2022, and has 5 subdistricts (Safira et al., 2023).

Keris is one of the most popular indigenous knowledge and cultural objects in
Surakarta. Keris is a distinctive, asymmetrical dagger from the Indonesian island of Java
(UNESCO, 2005). The presence of the Nusantara Keris Museum which was inaugurated in
August 2017 and a bridge with a keris-shaped design in the city center certainly confirm
that Keris is the icon of the city. Although keris is a famous cultural object, no study
discusses it for ethnoscience. Hence, Keris should be explored for ethnoscience learning,
especially for students in Surakarta. This paper attempts to explore students’
understanding in connecting indigenous knowledge of keris as cultural heritage of
Surakarta with science through ethnoscience e-module in science learning. This will
contribute to students’ understanding of science and culture at once.
Methods

This paper utilizes a case study which contains a combination of qualitative and quantitative approaches. Case study method enables a researcher to closely examine the data within a specific context (Zainal, 2007). Then, the qualitative and quantitative results should complement each other to create a meaningful whole according to the object and purpose of the investigation (Starman, 2013).

Quantitative data is obtained based on the questionnaire results of 125 students from 5 schools in Surakarta. The technique used in sampling is a non-probability sampling technique, purposive sampling technique. Purposive sampling is a technique for determining samples with certain considerations or criteria that have been formulated in advance by researchers (Campbell et al., 2019). The criterion in this research sample is the representation of the zone in Surakarta due to the implementation of zoning. The determination of the sample size is based on the number of students in one class at each school. Table 1 presents the sample number of subjects.

Table 1. Research sample

<table>
<thead>
<tr>
<th>No</th>
<th>School</th>
<th>Zone</th>
<th>Number of Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SMP Negeri 1 Surakarta</td>
<td>Banjarsari</td>
<td>25</td>
</tr>
<tr>
<td>2</td>
<td>SMP Negeri 2 Surakarta</td>
<td>Laweyan</td>
<td>25</td>
</tr>
<tr>
<td>3</td>
<td>SMP Negeri 6 Surakarta</td>
<td>Pasar Kliwon</td>
<td>25</td>
</tr>
<tr>
<td>4</td>
<td>SMP Negeri 8 Surakarta</td>
<td>Jebres</td>
<td>25</td>
</tr>
<tr>
<td>5</td>
<td>SMP Negeri 19 Surakarta</td>
<td>Serengan</td>
<td>25</td>
</tr>
</tbody>
</table>

The questionnaire is an online open and close-ended questionnaire that asks students’ knowledge and understanding about Keris in the context of ethnoscience. It is given in the beginning and in the end of the learning process using ethnoscience e-module. Student’s ability to connect indigenous science and scientific explanation is measured if students can answer both questions in indigenous knowledge aspect and scientific aspect as shown in Table 2.

Table 2. Determining students’ ability in connecting indigenous and scientific knowledge

<table>
<thead>
<tr>
<th>Question</th>
<th>Indigenous Aspect</th>
<th>Scientific Aspect</th>
<th>Connecting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can students answer question by following aspects?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

Then, qualitative data is in the form of in-depth interviews of 5 students. In-depth interviews, conducted at the end of the learning process, served as an important source of information for identifying students’ understanding and challenges experienced during the activity. This result is analyzed and described to support information obtained from the questionnaire results.

Results and Discussion

Ethnoscience of Keris

Keris is a famous cultural object especially in Surakarta, as shown in Figure 1a, ab and 1c. Keris is defined as a sharp weapon with a curved or straight blade, usually equipped with a scabbard and lucky. The keris is one of Indonesia’s cultural heritages that has been recognized worldwide (UNESCO, 2005). Meanwhile, Jarwadhasa, the word for keris in
Javanese is kekeran aris. Kekeran means fence, barrier, warning, and control. Aris means calm, careful and subtle. Keris means that in human relations, someone must be able to guard each other or fence, warn and control themselves wisely, not to show themselves off (Sutrisna, 2009). According to Garjito & Vita (2020), the aesthetic value of a keris includes three things, namely dhapur, pamor, and tangguh. In Javanese terms, dhapur is a model or shape of a keris that gives it uniqueness and makes it different from other keris, pamor is a pattern or motif found on the blade which is formed from a combination of metal and forging-folding techniques, and tangguh is an interpretation related to the origin and estimated age of a keris.

Figure 1a. Keris; 1b. Nusantara Keris Museum; 1c. Keris-bridge in Surakarta

Keris as a cultural product is a human work that has many meanings for its people. According to Siswanto (2012), the creation of a keris is a manifestation of two wishes, namely the party who ordered the keris and the creative will of the master's initiative accompanied by a prayer full of devotion. The embodiment of pamor and dhapur on the keris blade is a monument to the will of the keris buyer and the master which will emit a certain suggestive power. In the manufacturing process, keris has many meanings, including the choice of material. There are two types of basic metal used in making keris, namely iron and steel. However, apart from these two metals, some keris are made with the addition of meteorite metal. According to Junus (2012), the union of the meteorite metal material on the keris is believed to represent the powerful power of the keris because the meteor object from space which is called Bapa Akasa is combined with metal material from the earth (iron sand) which in Javanese is called Ibu Pertw. The use of meteorite metal was done intentionally as part of the spiritual process of the masters when creating the keris. This spiritual process also accentuates human beliefs based on the philosophy of ‘manunggaling kawula Gusti’. Until now, belief in the power of the keris due to its union with the meteor strengthened the existence of the keris.

These indigenous knowledge of Keris have been believed for hundreds of years by society. As the ethnoscience reconstructs them to scientific explanation, the process of verification and data analysis has been recapitulated in Table 3. The data obtained from literature review relating the explanation of the aspects discussed, the choice of material and the addition of meteorite metals.

<table>
<thead>
<tr>
<th>Table 3. Indigenous knowledge and scientific knowledge of Keris</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aspect</td>
</tr>
<tr>
<td>Choice of materials</td>
</tr>
</tbody>
</table>
on the keris blade will emit a certain suggestive power. The feature, the layers of soft iron create a beautiful configuration and that is what is then called 'pamor'.

| Addition of meteorite metals | The union of the meteorite metal material on the keris is believed to represent the powerful power of the keris because the meteor object from space which is called *Bapa Akasa* is combined with metal material from the earth which in Javanese is called *Ibu Pertiwi*. | Meteorite metal is known to have a high titanium content, in addition to nickel, cobalt, silver, tin, chromium, antimony and other metals. These metallic elements have many advantages over other metals. |

From a scientific perspective, there are weaknesses in each metal that makes keris. Steel that is hard, sharp, but brittle (easily broken), must be sandwiched between other flexible metals (such as a layer of soft iron) to cover the weaknesses of the hard, easily broken steel (Afifah, 2021). Because the layered arrangement of the keris has another feature, the layers of soft iron create a beautiful configuration and that is what is then called 'pamor'. The word 'pamor' comes from the Javanese word 'amor' or 'diwor' which means mixed' or 'put together'. So the prestige comes from the experiment of mixing various types of metal to produce weapons that are superior in terms of materials. Then, scientifically, meteorite metal is known to have a high titanium content, in addition with nickel, cobalt, silver, tin, chromium, antimony and other metals (Cannon et al., 2023). These metallic elements have many advantages over other metals.

**Ethnoscience E-Module Development**

E-module is an electronic form of module. A module is a unit of learning activities that is planned and designed to facilitate students in the process of completing objectives by arranging material according to students' abilities in order to maximize their abilities (Simarmata et al., 2017). So, electronic modules are a computer-based learning resource and contain various materials. Electronic modules are designed systematically and interestingly to achieve competencies that match the curriculum (Laili et al., 2019; Samiasih et al., 2017).

Ethnoscience e-module is developed based on google site by integrating ethnoscience to e-module. It contains the discussion of keris connected with material of elements, compounds, and mixtures. It also provides instructions for use, learning objectives, apperception, pretest and posttest. Figure 2 shows the cover of the ethnoscience e-module.
The science material related to ethnoscience chosen is elements, compounds and mixtures. This topic discusses the properties and examples of grouping materials in everyday life (Hasanah et al., 2021). Based on the Science Book for Middle School Class VIII (8th grade) published by the Ministry of Research, Technology and Higher Education in 2021, the subject of elements, compounds and mixtures is the 5th chapter taught at the beginning of the semester.

**Impacts of the Ethnoscience E-module.**

Table 4 shows the result of the questionnaire to 125 students from 5 schools in Surakarta. The pre test results indicate most students know about keris and the buildings in Surakarta that relate to Keris as the city icon. In general, students cognized the tangible aspects of the Keris. The results show that 120 students (96% of the total participants) knew keris, 75.2% students knew Nusantara Keris Museum, and 81.6% knew the bridge in Surakarta with a keris-shaped design. After using ethnoscience e-module, all of them knew about this tangible knowledge about keris.

**Table 4. Questionnaires results about tangible aspects of Keris**

<table>
<thead>
<tr>
<th>Questions</th>
<th>Before (%)</th>
<th>After (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you know Keris?</td>
<td>Yes 96</td>
<td>No 4</td>
</tr>
<tr>
<td>Do you know Nusantara Keris Museum?</td>
<td>Yes 75.2</td>
<td>No 24.8</td>
</tr>
<tr>
<td>Do you know bridge in Solo with a keris-shaped design?</td>
<td>Yes 81.6</td>
<td>No 18.4</td>
</tr>
</tbody>
</table>

On the contrary, only a few students were able to explain the meaning of *dhapur* and *pamor* in javanese culture and science aspect as well as the meaning of the addition of
meteorite metal in making keris. Student’s ability to connect indigenous science and scientific explanation is measured if students can answer both of questions in indigenous knowledge and science aspect. The result shows that most of them are not able to connect indigenous knowledge of keris with scientific explanation as presented in Table 5. Only 2.4% students can connect the indigenous knowledge of dhapur and pamor with its scientific explanation, while 1.6% students can connect the meaning of the addition of meteorite metal.

Table 5. Students’ understanding about ethnoscience aspects of Keris

<table>
<thead>
<tr>
<th>Questions</th>
<th>Before (%)</th>
<th>Connecting (%)</th>
<th>After (%)</th>
<th>Connecting (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understanding about the meaning of dhapur and pamor in javanese culture</td>
<td>4.8</td>
<td>95.2</td>
<td>77.6</td>
<td>22.4</td>
</tr>
<tr>
<td>Understanding about the meaning of dhapur and pamor in science aspect</td>
<td>3.2</td>
<td>96.8</td>
<td>74.4</td>
<td>25.6</td>
</tr>
<tr>
<td>Understanding about the meaning of the addition of meteorite metal in javanese culture</td>
<td>7.2</td>
<td>92.8</td>
<td>82.4</td>
<td>17.6</td>
</tr>
<tr>
<td>Understanding about the meaning of the addition of meteorite metal in science aspect</td>
<td>1.6</td>
<td>98.4</td>
<td>76</td>
<td>24</td>
</tr>
</tbody>
</table>

After learning using ethnoscience e-module, the results denote a significant increase in students’ understanding of the keris, including indigenous knowledge and scientific aspects of the keris. The understanding of the meaning of dhapur and pamor in javanese culture and science aspect as well as the meaning of the addition of meteorite metal in making keris increase from 4.8% to 77.6%, from 3.2% to 74.4%, from 7.2% to 82.4%, and from 1.6% to 76%, respectively. By this understanding, the amount of students that are able to connect indigenous knowledge of keris with scientific explanation also witness a drastic increase to 68.8% in meaning of dhapur and pamor as well as 71.2% in meaning of the addition of meteorite metal.

After the post test, 5 students were selected to conduct interviews. This interview was carried out to emphasize subjective experiences and the meanings they have for an individual. These results can be seen in Table 6. The results obtained are able to confirm that students are happy and enthusiastic about ethnoscience. Although they struggle with unknown words like dhapur, pamor, and tangguh (javanese words), they can deal with these obstacles. They also have an interest to explore more cultural topics in Surakarta and turn it into ethnoscience learning. Last but not least, they recognized that Surakarta has more cultural topics that relate with science learning like batik, gamelan, and wayang.

Table 6. Interview results

<table>
<thead>
<tr>
<th>No</th>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>What do you think about learning with ethnoscience especially</td>
<td>Students are happy and enthusiastic about ethnoscience. This ethnoscience brings two things in one way, science and culture. Ethnoscience makes learning science contextual and introduces culture, especially keris where most people only...</td>
</tr>
<tr>
<td></td>
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<tr>
<td>---</td>
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<td></td>
</tr>
<tr>
<td><strong>Do you have any obstacles in learning with ethnoscience e-module?</strong></td>
<td>Almost all students struggle with unknown words like <em>dhapur, pamor, and tangguh</em> (javanese words). However, after use the e-module carefully, these words are explained which can add their understanding.</td>
<td></td>
</tr>
<tr>
<td><strong>Do you want to learn more ethnoscience?</strong></td>
<td>Students are willing to learn ethnoscience again with other cultural topics. Almost all of them recognized that Surakarta has more cultural topics that can relate with science learning like batik, gamelan, and wayang.</td>
<td></td>
</tr>
</tbody>
</table>

The result indicates that students’ ability in connecting indigenous knowledge of keris to scientific explanation was low before using ethnoscience e-modul. Students only knew the tangible aspects like “I know keris” or “I know that this city has Keris Museum” or “I know that this city has a bridge with a keris-shaped design”. But, they didn’t understand about the ethnoscience of keris. This result is in line with the research done by Zulirfan, et al. (2022) that identifying the extent to which *Pacu Jalur* tradition had an impact on students’ ethnoscience literacy. Students in who live around the Kuantan River area in Riau, where the community adheres to the *Pacu Jalur* tradition, have not been able to provide a good scientific explanation about the *Pacu Jalur*, although every year they witness, and even get involved in the preparation and competition of the *Pacu Jalur* (Zulirfan et al, 2022). Ilham et al. (2023) also exhibit the same result, students’ critical thinking ability in ethnoscience-based biology learning with ecosystem subjects were in a very low category.

After using ethnoscience e-modul, students’ understanding about ethnoscience of keris witnessed a drastic increase. They were able to connect indigenous knowledge and scientific explanation. This result indicates that ethnoscience e-modul can help students in connecting indigenous knowledge of keris with its scientific explanation. Some researches denote the same result. Idul and Fajardo (2023) report that ethnoscience-based instruction can be utilized by schools to indigenous learners to improve their science critical thinking skills. Beside that, ethnoscience integrated science teaching materials based on guided inquiry are feasible and effective to be applied and implemented in learning to improve students' scientific literacy (Wati et al, 2021). Yasir et al (2022) also conclude that the application of ethnoscience-based mind mapping videos using indigenous knowledge have an impact on science learning innovations in junior high schools in teaching science material in the context of culture and local wisdom and developing scientific literacy skills of students.

Students are happy and enthusiastic in learning ethnoscience. This ethnoscience brings two things in one way, science and culture. Susilawati et al. (2018) stated that the application of physics learning device on ethnoscience based heat material in Kabupaten tegal obtains the high criteria. Then, the results of the research by Risdianto et al (2019) concluded that students are happy with the model of direct instruction based on ethnoscience. Hikmawati and Suastra (2021) showed that student responses are said to be positive towards local wisdom-based lectures in terms of 4 aspects, namely happy, new, enthusiastic, and interested. Then, students also are willing to learn ethnoscience again with other cultural topics. Almost all of them recognized that Surakarta has more cultural topics that can relate with science learning like batik, gamelan, and wayang.

On the other hand, students still have obstacles in learning with this ethnoscience e-module. Almost all students struggle with unknown words like *dhapur, pamor, and tangguh* (javanese words). The study by Nurmasari et al (2017) supported this finding that there
are lots barriers on learning Javanese language for students such as language habits in family, school, and neighbourhood, Javanese language complexity, lack of competent Javanese language teachers, limited hours of Javanese language lessons, and lack of media and learning resources that can support on learning Javanese language. However, after using the e-module carefully, these words are explained which can add to their understanding. This indicates that ethnoscience e-module can also help students to understand some local language words. Therefore, it can also be used to preserve local culture. This is supported by Akmal et al. (2021) that the purpose of applying ethnoscience in learning is to introduce and understand the environment and local culture, have a positive impact with the existence of skills and expertise that support local culture, have an attitude that is by noble values, can shape the character of a nation, and preserve and maintain culture.

Conclusion

This study concludes that ethnoscience e-module has significant impacts in increasing students’ understanding about indigenous knowledge of keris and its connection with scientific explanation. It also indicates that students are happy and have interest in learning with ethnoscience. The limitation of this research is the cultural topic chosen which is only keris. In further research, this ethnoscience e-module can be developed with other cultural topics in Surakarta like batik, gamelan, and wayang. This paper contributes to cultural preservation by providing indigenous knowledge as well as scientific understanding by linking culture with science. This also helps Surakarta become a strong cultural city by educating the younger generation to understand local cultures.

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