Teacher’s belief of mathematical literacy based on local culture: Case study of junior high school mathematics teacher

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Abstract. This study was conducted to explain the teacher’s belief of school mathematics subjects in relation to their concepts of mathematical literacy based on local culture. The participants were three mathematics teachers at Junior High School in Java, Indonesia. They were chosen because they met the criteria, namely having at least five years teaching experience, having the awareness to conduct ethnomathematics studies, and teaching mathematics at school using local cultures minimum in one academic year. Research data were collected through interviews, observations during the teaching and learning process, and lesson plans. The data were then analysed using the interactive models of Miles and Huberman. The results of the study showed that mathematics was believed as a tool for solving problems in everyday life, which was related to human and cultural dimensions. The concept of teaching mathematical literacy based on local culture, as according to teacher perceptions, had not placed local culture as an evaluation tool for the development of mathematical literacy. This was because mathematical literacy was not yet believed to be a social construction developed based on mathematical ideas and practices in local culture.

1. Introduction

The awareness of using mathematics in the socio-cultural environment outside of school encourages the emergence of the concept of mathematical literacy as a cultural identity. The cultural context influences students’ mathematical learning abilities, so that teachers need to know the initial knowledge of mathematics that students already have [1]. Mathematics education that connects mathematics with student culture will empower students and teachers socially, to contribute to real life [2].

The issues regarding culture are not explicitly mentioned in Indonesian school mathematics curriculum. Therefore, it depends on the teacher’s ability to understand, transfer, and implement cultural-based mathematics education in line with the curriculum. Despite many educational reforms, a large number of teachers still consider mathematics conventionally, not in progressive terms, namely as a discipline with a priori rules and procedures, which must be found mechanically, not constructed [3]. The teacher cannot immediately change their way of teaching, if the teacher’s belief of mathematics education is still conventional [3-6]. Therefore, teachers need to understand that mathematics is a knowledge that is related to norms and values of various cultures [7]. Teachers also
need to care how substantive knowledge of mathematics which students understand and how students’ cultural knowledge may be developed through mathematics education [8].

The mathematical literacy education requires concepts that originate from the teacher’s practical experience as cultural agents at schools [6]. The main goal of developing teacher professionalism is to lay the basis for teaching mathematics on students’ cultural backgrounds using mathematics in everyday life and cultural activities [2]. Therefore, research on teacher’s belief of mathematical literacy based on local culture is needed.

The practice of mathematics teachers in the classroom are influenced by belief and knowledge about mathematics education. Cultural value differences related to education such as human nature, the nature of mathematics, learning and teaching mathematics, have implications for student attitudes, teacher attitudes, teaching styles, and teacher competencies [6]. Teachers’ belief of the nature of mathematics can be described into three categories, namely: 1) Instrumentalist which sees mathematics as a collection of facts, skills and rules used to achieve some external goals, 2) Platonist which sees mathematics as a building static science which already exists and is waiting to be discovered, and 3) Problem solving which sees mathematics as a result of human discovery that is dynamic and creative, as a process rather than a product [9].

Thought about what is mathematics is inseparable from the view of how to acquire knowledge in mathematics. There are two mathematical epistemological views, namely absolutist and fallibilist [10]. Absolutist argues that mathematics is an exact science, which has absolute truth, so the way to obtain this knowledge is to learn symbols. Unlike language and art, mathematics is seen as not related to human and cultural dimensions because mathematics is developed based on coherence as a system of values and consensus [11]. The truth criterion, in mathematics, is consistent with existing theorems, postulates, or axioms. The principle of formal logic, and pure mathematics, uses the rational knowledge paradigm, where knowledge is obtained through mere mind reason without observation [12].

In the view of fallibilist, mathematics is an open science towards correction and revision which means that errors can still be found. Although mathematical proof must be deductive, the creative process in this direction is not always the case; mathematicians also use other methods such as observation, measurement, intuition, imagination, induction, and even trial and error methods [13]. Mathematical truths can be achieved through agreement or consensus. Based on the point of view of Fallibilist, mathematics in its essence is a social construct [10]. Mathematical ideas cannot be born without human interaction with nature and the environment, and human and human interaction.

Mathematical literacy is also the ability to function mathematics in life, for mathematics related to other fields of life or related to multidimensional spectrum [14]. There are three categories that are interconnected and influence mathematical literacy, namely contextual powers, changes in theory and emerging new perspectives such as ethnomathematics, and practical and pedagogical innovations [15]. In mathematical literacy based on local culture, innovation is influenced by the ethnomathematics perspective and the meaning of the context of mathematical problems for students.

Mathematics in local culture is not seen as a structure of science, but as a social activity. School mathematics, which is purposed to develop student learning instruments, is emphasized as an activity [16]. Thus, the link between mathematics in local culture and school mathematics lies in the nature of mathematics as a social activity. School mathematics activities are designed based on mathematical activities in local culture, which are appropriate for students. Students’ mathematical literacy skills are expected to develop through these activities.

The development of mathematical knowledge occurs through an interactive process, which involves object/reference context, mathematical sign/symbol, and mathematics concept in the epistemological triangle [17]. Using this epistemological triangle, local culture can be used as object/reference context in the real world. Sign/symbol in mathematics shows the role of mathematics as language. The concept, in mathematics is projected more broadly as mathematical literacy.
Figure 1. Conceptual framework of mathematical literacy based on local culture

The interaction between local culture, mathematics as a language, and mathematical literacy, involves mathematization. The interaction between mathematical literacy and local culture is the core of mathematical literacy as a cultural identity. Mathematical literacy must appear to function in daily life as a required performance model to develop the culture of society. Local culture plays a role as an evaluation tool for mathematical literacy, which is developed to see the relevance of the condition of society in the present and in the future.

2. Research Methods
The case study was conducted in three junior high schools in Java, Indonesia. Participants as key informant were three Junior High School mathematics teachers. They were selected using the following criteria: having at least five years teaching experience, having taught mathematics using local culture minimum of one academic year and having self-awareness conducting ethnomathematics in learning. Self-awareness is important because it is closely related to the teacher’s belief about culture-based mathematics education.

The first case, Er (pseudo name) had nine years’ experience of teaching mathematics. She had used local culture as an example of the usefulness of mathematics in everyday life since 2015. She used cloth craft called batik as an example of congruence, and various traditional foods as examples of three-dimensional shape in daily life. She was encouraged to teach mathematics using local culture after a seminar on ethnomathematics. The second case, Wa (pseudo name) had 21 years’ experience of teaching mathematics. Driven by the desire to preserve Javanese culture, she had used local culture, traditional food, Prambanan temple, batik, and palace buildings in Yogyakarta called Keraton Ngayogyakarta Hadiningrat since 2014. The third case, Ar (pseudo name) had nine years of mathematics teaching experience. She taught in private schools, which apply methods based on local culture, and she wanted to maintain those characteristics in mathematics learning. She had used local culture, such as traditional vehicle wheels called Andong, batik, traditional musical instruments, traditional food, and Prambanan Temple.

The instruments used to obtain research data were interview guidelines, teaching and learning observation guidelines, and learning plans. In-depth interviews were needed to understand the teacher’s belief about mathematics. Information that would be explored through interviews includes teachers’ belief about the nature of mathematics, which was then associated with culture, mathematical literacy, and ethnomathematics. The data were analyzed by interactive models [18]. Cross-case synthesis was used as an analysis technique. At the beginning, data from individual cases were displayed in a table, according to the theme to display the profile of each case effectively. Then, profiles were observed and compared to find out there were no differences. Each case was presented as a chosen example, to achieve a better understanding of the issue under study.

3. Results and Discussion
3.1. Teachers’ Belief About School Mathematics in Relation to Culture
Teachers’ belief about school mathematics can be seen in Table 1. below.
### Table 1. Teacher’s Belief of School Mathematics

| Theme                        | Belief                      | Er  | Wa  | Ar  |
|------------------------------|-----------------------------|-----|-----|-----|
| Belief of mathematics        | Instrumentalist             | ✓   | ✓   | ✓   |
|                              | Mathematics as a collection of facts, skills and rules |     |     |     |
|                              | Platonist                   |     |     |     |
|                              | Mathematics is a static building of existing science |     |     |     |
|                              | Mathematics is a building of pure and structured science | ✓   | ✓   | ✓   |
|                              | Problem Solving             |     |     |     |
|                              | Mathematics as a result of human discovery | ✓   | ✓   | ✓   |
|                              | Mathematics is dynamic and creative | ✓   | ✓   | ✓   |
|                              | Mathematics as a process not a product |     |     |     |
| Epistemology of Mathematics  | Absolutist                  |     |     |     |
|                              | Learn symbols               |     | ✓   | ✓   |
|                              | The truth criteria are consistent with existing theorems, postulates, or axioms | ✓   | ✓   | ✓   |
|                              | Knowledge is obtained through mere mind without observation |     | ✓   | ✓   |
|                              | Fallibilist                 |     |     |     |
|                              | Learning through social interaction | ✓   | ✓   | ✓   |
|                              | Mathematical truth can be achieved through consensus | ✓   |     | ✓   |
|                              | Knowledge is obtained through observation, measurement, intuition, imagination, induction, or trial method | ✓   | ✓   | ✓   |

(✓) = yes

The three teachers perceive how important logic is in learning mathematics. In responding on what is mathematics, Er answered that mathematics is a science which includes logic, numbers, and geometry, which are useful in everyday life. Wa answered that mathematics is a science that teaches logical, analytical, honest and ordered ways of thinking. Ar answered that mathematics is not only a set of formulas, but requires logic to think, to understand and use. They belief that the truth of mathematics is universal and can be ascertained through proof, so they still hold strongly the theory of coherence as a benchmark of mathematical truth. The symbols used in mathematics are also universal, therefore it is important for students to learn and master the symbols in mathematics. However, they believe that mathematics is not a static building of science but an applied science. In mathematics teaching, the three teachers exemplify the usefulness of mathematics in everyday life and in the world of work to motivate students.

In relation to culture, they belief that mathematics is no longer free from human subjectivity. Mathematics in nature is the result of human discovery through a creative process, so that it develops from the culture of society. In Er’s case, she found doubts about absolute mathematical truths, with a case of different points of view, regarding the vertex of a cone. She perceives that the truth of mathematics can be relative, when it involves different human perspectives.

Er and Ar belief that how to obtain mathematical knowledge can be through various ways, such as observation, measurement, intuition, or imagination. The epistemological view of these two teachers tends to the fallibilist view. Meanwhile, Wa tends to the absolutist view, because students are guided to learn symbols, and put a local culture as a stepping stone towards mathematics content. The findings are similar to what was sugested by Siswono et al [20] that teachers did not show high consistency in belief of mathematics.
3.2. Teacher’s Belief about Mathematical Literacy Based on Local Culture

The three teachers use local culture in mathematics teaching precisely based on mathematical point of view as science. Local culture will be used in teaching, if it is in accordance with the junior high school mathematics curriculum. This means that the orientation of the use of local culture is in the interest of teaching material, which has been arranged hierarchically and structured by curriculum developers. However, the teacher themselves believes that not all mathematical topics in the curriculum are needed in the daily lives of students.

The three teachers identify mathematics in a culture that is physically tangible such as historical buildings, conventional transportation equipment, conventional musical instruments, and conventional food. They then use it to study geometry topics in the school mathematics curriculum. On the topic of algebra, cultural artifacts are played as symbols of tourist attractions where buying and selling activities take place or as trading commodities. In learning, the artifact was used as an example of application of mathematics in everyday life. In line with Andika et al [19], using artifact can motivate students because mathematics learning involves an object that is already well known to students.

The teacher’s conception of mathematical literacy based on local culture can be seen in table 2 below.

| Table 2. Teacher’s Conception of Mathematical Literacy based on Local Culture |
|-----------------------------------------------|--------|--------|--------|
| Theme                                          | Conception                      | Er     | Wa     | Ar     |
| Local Culture                                  | Local culture as starting point of learning | -      | √      | √      |
|                                               | Formulation from local culture to mathematics problem using symbol, such as mathematical modeling | √      | √      | √      |
|                                               | Developing indigenous mathematical ideas and practices | -      | -      | -      |
|                                               | Evaluating formal mathematics by using local mathematics | -      | -      | -      |
| Mathematics as language                        | Employing mathematics to solve problems with cultural contexts | √      | √      | √      |
|                                               | Interpreting mathematical solution into daily situation | √      | √      | √      |
| Mathematica                                    | Solving problem using reflective thinking | √      | √      | √      |
| Literacy                                       | Enabling mathematical knowledge and skills in daily activities | √      | √      | √      |

Local culture is seen as a mathematical object and the context of mathematical problems. However, the point of view for studying local culture is using formal mathematics with universal symbolic language and logical logic. The teachers have not explored from the point of view of the local culture itself, about how mathematical ideas and practices possessed by people with unique cultures.

Cultural products in the form of physical objects are the most concrete compared to cultural forms as ideas, values and patterns of activity. In fact, the forms of culture influence each other. Local culture has not been explored as an actual form of mathematics in society, which can be developed into higher mathematical literacy. It means that not enough effort to bridge informal to formal mathematical knowledge. Informal skill have direct effect on the development of formal mathematical skill as sugested by Purpura [21]. This is because the teacher themselves does not know the ideas and practices of the indigenous mathematicians.

The use of artifacts, as mathematical objects, can be processed in order to achieve mathematical knowledge to be creative, because it not only uses rational learning of symbols, but also uses observation. However, when viewed from an ethnomathematics perspective, the process is still inadequate, because observations are focused on achieving formal mathematical knowledge through mathematical means, and paying less attention to cultural content. Ideas, values and practices of mathematics which are indigenous is very important for students to develop mathematical literacy, which at the same time builds their cultural identity.
4. Conclusion
The teacher have belief that mathematics is a tool to solve problems in everyday life, which is tied to human and cultural dimensions. The concept of mathematical literacy based on local culture from the perspective of an instrumentalist teacher, has not placed local culture as an evaluation tool to develop mathematical literacy. This is because mathematics is not completely seen as a social construction developed based on mathematical ideas and practices in local culture.

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