The ability of mathematical representation through realistic mathematics learning based on ethnomathematics

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Abstract. Efforts to improve the mathematical representation, learning must begin from the real objects in daily life, which are culturally oriented related to horizontal mathematics in the form of ethnomathematics. The objective of this study was to determine the comparison of the ability of mathematical representation between students taught by realistic mathematical approach and conventional learning; determine the comparative ability of mathematical representation between students who are ethnomathematical and non-ethnomathematical oriented; determine the existence of interaction influence of learning approach and the orientation of mathematics material to the ability of mathematical representation. This research was a quasi-experimental study, which uses the pretest-posttest design of non-equivalent group design. The research instrument used was the test of mathematical representation ability. Data were analyzed using multivariate test of covariate analysis. The results showed that there were differences in the ability of mathematical representation between students who were taught by realistic mathematical approach and conventional learning after controlling students’ early ability; there is a difference in the ability of mathematical representation between students who are ethnomathematical and non-ethnomathematical oriented after controlling students’ early abilities; there is an interaction effect of the learning approach and the orientation of mathematical material on the ability of mathematical representation after controlling the student’s early ability.

1. Introduction
Mathematics is a compulsory subject in school. Mathematics is widely regarded as one of the most important subjects in the school curriculum [1]. The importance of mathematics is as a filter in determining the graduation of the final school exam. The need to acquire knowledge in mathematics throughout the world has become very clear [2]. This is because it is relevant to everyday life and in various disciplines. In addition, it can also be a determinant of the future career of students. In learning mathematics, we need good representation. However, students' mathematical representation ability was low [3-5]. To improve the understanding of mathematical representation, the teacher must determine what can be observed as a representation of student thinking internally [3] in the realistic mathematics learning [4], utilizing the student's cognitive structure effectively [5]. Therefore, mathematics learning is needed that is close to the mind and culture of students [5,6]. This is called ethnomathematics [7]. It subject lies on the borderline between the history of mathematics and cultural anthropology [8]. The learning of realistic mathematics was the most reasonable approach to improve students' mathematical
abilities [4,6,9]. Such learning requires contextual learning media [10]. Students were learn mathematics with the help of these media make it easy to do the representation and abstraction processes [3].

The mathematical learning provides the experience of students doing mathematical representations to understand facts, concepts, principles and operations [11]. Contextual learning media can effectively produce patterns that students can easily make statements as a conclusion [10]. In this case, ethnomathematics as the starting point of mathematics learning [12]. The base of learning is a realistic problem [13,14,15]. Students are easier to do vertical mathematical activities so that they can reach mathematical concepts and principles correctly [10]. Some studies show consistently that ethnomathematics makes it easy for students to learn mathematics. After the students’ initial ability of mathematical representation was controlled, the average mathematical representation ability of students taught in the classroom implementing the realistic mathematics learning approach was higher compared to those taught by implementing the conventional learning [11]. Also, the average ability of students’ mathematical understanding who learned the ethnomathematics-oriented materials was higher than students who were given non-ethnomathematics materials (their initial ability of mathematical representation was also controlled).

The results of research [16], show that students can develop the ability to solve problems through self-reflection on planning, monitoring and evaluating the implementation of thinking processes. Students can combine pieces of information about the parts of the custom house of Rejang Lebong so that in principle build space such as pyramids, prisms, beams, and cubes. The implication was that students can generate principles of geometry. From the analysis, it was established that majority of mathematics teachers are using ethnomathematics approach in teaching [1]. The study show that Trusmi Cirebon Batik contains mathematical elements, namely concepts of symmetrical geometry, transformation (reflection, translation, and rotation), and similarity [17]. The culture of the traditional Javanese house building, the roof of the house has a geometric shape of a flat building that is rectangular, trapezoidal, equilateral triangle, and a symmetrical wake [18]. The study of Budiarti, painting experts develop a whole set of geometric algorithms for the manufacture of monolinear and symmetrical designs [19]. Monolinear paintings and ornaments correspond to the same classes in the sense that although the underlying dimensional patterns differ, some paintings are drawn by applying the same geometric algorithm. Therefore, learning mathematics can begin with the game of dakon, the house of traditional Javanese and mosque domes contained mathematical concepts [18].

Mathematics contains abstract objects. The theory sometimes it is not the same as real facts, so if we relate it to mathematics instruction in the classroom, we need concrete subjects in mathematics to make students interested and to make students understand what real problems mathematics can form [20]. Teaching materials developed describe ethnomathematical practices of tribes can be utilized in teaching secondary school mathematics [21]. This can guide our students in building their own experiences in making their feelings in class, because the representation of pure concepts is more real and offers rich applications in a cultural context.

The ethnomathematics has a role in teaching formal school mathematics where problem solving strategies that are relevant to context and limited provide the contextual meaning needed for many abstract mathematical concepts [22]. Based on this research means that the learning mathematics through a realistic approach based on ethnomathematics able to improve the ability of mathematical understanding. Students had improved mathematical representation abilities.

The role of ethnomathematics is to facilitate students in constructing mathematical concepts. This is part of mathematical literacy based on students’ knowledge of their socio-cultural environment [23]. Ethnomathematics indirectly influence nationalism [24]. It is providing a learning environment that creates good and pleasant motivation. Students have a great interest in following mathematics learning. Ethnomathematics was influence their mathematical abilities, especially math literacy skills [23]. The students exposed to ethnomathematics teaching approach were superior in achievement and retention than those exposed to conventional teaching method [2].

It is time for ethnomathematics to be integrated into each mathematics class [25]. Ethnomathematics is very compatible with constructivist theory which makes students build understanding and knowledge
through what they have learned and exposed beforehand. Therefore, learning a realistic mathematical approach as one approach that is in accordance with constructivist theory is feasible to be applied in mathematics learning [11].

The influence of contextual learning model on the ability of students to understand the concept of mathematics better than conventional learning model when controlled by cognitive conflict covariate [6]. According to Widada [26] the extended triad model has a positive effect on the ability of students' mathematical representation. The mean is better than conventional learning models when controlled by cognitive covariate styles. The ability to understand students’ concepts and problem solving through contextual learning models has experienced a very high increase [6].

Shirley stated that for the past two or three decades, various political, cultural and educational forces have brought ethnomathematics and multiculturality in general to a broad use [27]. Therefore, it is important to include ethnomathematical studies in teaching methodology and especially teacher education programs. The results of the study were, less developed countries have stopped stopping only to import 'superior' Western mathematical curricula, and have instead begun to apply local practices in education [28].

Ethnomathematics approaches can be taught by any math teacher. This can improve teacher performance and mathematics prospective teachers. Based on Katsap and Silverman, ethnomathematics in the education of mathematics teachers can influence the development of mathematics prospective teachers, so that prospective teachers incorporate the humanistic and social aspects of mathematics [29]. Ethnomathematics activities are apparently responsible for creating a classroom climate where appreciation and respect for different cultures and traditions emerge and develop.

According to Widada and Hearawaty, and based on the review discussed earlier, a realistic mathematics learning based on the ethnomathematics is needed as a starting point [11]. The realistic mathematics education produces various kinds of learning activities, instructional sequences, and local instructional theories [30]. The teacher applies realistic mathematics education in the classroom. This kind of teaching is very challenging for math teachers to improve students' mathematical abilities. The result of the research [31], a realistic mathematical approach can improve students’ logical thinking ability. It can be seen from students observed to be good enough in solving problems. Even though the resolution of the context problem is done it does formal model representation.

The study of Widada and Hearawati showed that the mathematics problem-based learning on ethnomathematics in Bengkulu could improve students’ ability to solve the problems, increase their cognitive process through a higher level of thinking, creative and critical thinking resulting in students being able to perform mathematical representation and communication correctly [11, 32]. Based on the previous description, this paper discusses the influence of realistic mathematics learning based on ethnomathematics on the ability of mathematical representation.

2. Methods
The research was an assessment of the realistic mathematics learning model based on ethnomathematics in Bengkulu Selatan. We implemented them in the classroom. In the implementation, we employed a $2 \times 2$ factorial experimental design. The learning approach included realistic and expository mathematics, while the approach of mathematics materials included ethnomathematics and conventional. The population of the study was all students in one of senior high school in Bengkulu Selatan, with a sample of 64 students. The sample was selected by the intact group technique. The realistic mathematics learning approach based on ethnomathematics in Bengkulu Selatan was implemented in the experiment class, and the conventional approach was implemented in the control class. Data collection was carried out using the instrument of mathematics understanding ability. It was used to measure students' cognitive level of mathematics understanding. Data were analyzed using multivariate test of covariate analysis (MANCOVA).
3. Results and discussions
Based on the score of mathematical representation ability in the realistic mathematics learning experiment with ethnomathematics in Senior High School Bengkulu Selatan, the analysis of covariance was conducted with the controlling the students' initial ability of mathematical representation, the results are presented in Table 1.

| Source       | Type III Sum of Squares | Df | Mean Square | F     | Sig. |
|--------------|-------------------------|----|-------------|-------|------|
| Corrected Model | 11894.379               | 4  | 2973.595    | 221.641 | 0.000 |
| Intercept    | 400.422                 | 1  | 400.422     | 29.846 | 0.000 |
| A            | 224.389                 | 1  | 224.389     | 16.725 | 0.000 |
| B            | 297.043                 | 1  | 297.043     | 22.141 | 0.000 |
| A * B        | 269.770                 | 1  | 269.770     | 20.108 | 0.000 |
| X            | 3243.441                | 1  | 3243.441    | 241.755 | 0.000 |

Table 1 shows that Fo (A) = 16.725, df = (1, 59) and p-value = 0.00<0.05, Ho was rejected. It means that there was a significant difference in mathematics representation ability between students taught by realistic and conventional mathematics learning approach. Table 1 also displays that Fo (B) = 22.141, df (1, 59) and p-value = 0.00<0.05, Ho was rejected. This means there was a significant difference in mathematics representation ability between students who were given the ethnomathematics-oriented the non-ethnomathematics learning materials. Besides, Table 1 also presents Fo (AB) = 20.108, df (1, 59) and p-value = 0.00<0.05, Ho was rejected indicating that there was an interaction effect of the learning approach and mathematics materials orientation to the ability of mathematics representation ability. It is also shown that Fo (X) = 241.755, df (1, 59) and p-value = 0.00<0.05, Ho was rejected meaning that there was the linear covariate effect of student's initial ability of mathematical representation and mathematics understanding ability. As for the corrected model, Fo = 221.641 with df (4, 59) and p-value = 0.00<0.05 Ho was rejected. Thus, the students' initial ability of mathematical representation, learning approach and mathematics material orientation together influence the mathematics understanding ability.

| Parameter | B    | Std. Error | t    | Sig. |
|-----------|------|------------|------|------|
| Intercept | -70.410 | 7.638      | -9.219 | 0.000 |
| A1        | 3.349 | 1.464      | 2.287 | 0.026 |

Based on Table 2, t = 2.287 and p-value = 0.003<0.05 means Ho was rejected. This means that the average ability of students’ mathematical comprehension to be taught with realistic mathematics learning approaches was higher than students who were taught using conventional learning approach.

| Parameter | B    | Std. Error | t    | Sig. |
|-----------|------|------------|------|------|
| Intercept | -72.622 | 7.009      | -10.361 | 0.000 |
| B1        | 5.077 | 1.320      | 3.847 | 0.000 |

Table 3 presents t = 3.847 and p-value = 0.000<0.05 meaning Ho was rejected. This means that the average ability of students' mathematics understanding learned using the ethnomathematics-oriented material was higher than those given non-ethnomathematics oriented material.
**Table 4. Parameter estimates (3).**

| Parameter | B      | Std. Error | t      | Sig.  |
|-----------|--------|------------|--------|-------|
| Intercept | -40.334| 7.640      | -5.279 | 0.000 |
| X         | 1.761  | .113       | 15.548 | 0.000 |
| A1B1      | 11.209 | 1.499      | 7.478  | 0.000 |

Based on the results shown in Table 4, it is identified that $t = 7.478$ and $p$-value $= 0.000<0.05$, meaning $Ho$ was rejected. It indicates that there was an interaction effect between the learning approach factor and mathematics materials orientation to the mathematics representation ability.

**Table 5. Estimates parameters (4).**

| Parameter | B      | Std. Error | t      | Sig.  |
|-----------|--------|------------|--------|-------|
| Intercept | -40.334| 7.640      | -5.279 | 0.000 |
| X         | 1.761  | .113       | 15.548 | 0.000 |
| A1B1      | 11.910 | 1.413      | 8.427  | 0.000 |
| A1B2      | -5.001 | 2.199      | -2.274 | 0.021 |

Table 5 describe the results of t-test (column A1B1) showing $t = 8.427$ and $p$-value $= 0.000<0.05$ indicating that $Ho$ was rejected. Thus, mathematics representation ability of students who were taught with a realistic mathematics learning approach was higher than those taught by the conventional learning approach (both groups of students were given ethnomathematics-oriented materials). Furthermore, the t-test result on column A1B2 shows that $t = -2.274$ and $p$-value $= 0.011<0.05$ meaning $Ho$ was rejected. Therefore, the mathematics representation ability of students learned using realistic mathematics learning approach was lower compared to the students learned by the conventional learning approach (both groups of students were given mathematics materials of non-ethnomathematics).

The results of this study support the results of previous studies. The students exposed to ethnomathematics teaching approach (ETA) were superior in achievement and retention than those exposed to conventional teaching method [2]. ETA has proved to be a viable option in promoting meaningful learning in Locus. According to Jama, the implementation of ethnomathematics was an attempt to document some of the original social practices and procedures used by people in this region to manage their "everyday math problems" [33]. This is like a local culture, which can be used to produce mathematical arguments in the class, explained. Thus, ethnomathematics can be included in the mathematics syllabus, and mathematics learning resources. Studies from Rosa and Orey, it presents the mathematical concepts of the school curriculum in ways in which these concepts are related to the cultural and daily experiences of students, thereby enhancing their ability to describe meaningful connections and deepen their understanding of mathematics [34].

In this study, ethnomathematics-based realistic mathematics approaches can replace conventional approaches. Like opinion Rosa and Orey, that the ethnomathematical approach to mathematics curriculum is intended to make school mathematics more relevant and meaningful to students and to promote the overall quality of their education [34]. The implementation of an ethnomathematical perspective in the school mathematics curriculum helps develop students' intellectual, social, emotional, and political learning by using their own unique cultural references to instill their knowledge, skills, and attitudes.

**4. Conclusion**

Based on the results of statistical analysis with covariate is the initial ability of mathematical representation, it can be concluded that: the average mathematical representation ability of students
taught in the classroom applies a higher realistic mathematics learning approach compared to those taught by applying conventional learning. Also, the average ability of understanding mathematics students who study ethnomathematics-oriented material is higher than students who were given non-ethnomathematics material. The results also indicate that for the students studied using the realistic mathematics learning approach, the mathematics representation ability of students given the ethnomathematics-oriented materials was higher than the students learning with the non-ethnomathematics materials. Finally, when students were taught using a conventional learning approach, the mathematics understanding of students obtained the ethnomathematics-oriented materials was lower compared to the students with non-ethnomathematics materials.

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