Ethnomathematics in Balinese culture as a learning material for logic and reasoning geometry

N P A A Wijayanti¹, Sunardi², I M Tirta³, P M Margaretha⁴, Y Y Wijaya⁵
Mathematics Department of Faculty of Teacher Training and Education Jember University Jln. Kalimantan 37, Jember 68121-Indonesia

*wijayantiayuastuti05@gmail.com

Abstract. Indonesia's involvement in international tests, one of which PISA (Program for International Student Assessment), shows that Indonesia learners are less capable of using mathematical concepts to solve problems associated with real life. This is because these students tend to be taught practical formulas that will be used to answer questions in the exam. This research aimed at describing ethnomathematics in some Balinese cultural elements; ceniga, the yard size based on asta kosala-kosali, and also the pattern of Legong dancer position. Those three cultural elements were used because it is appropriate with plane figure geometry material for seventh grade students and further it is hoped to create ethnomathematics-based geometry problems. This research was a descriptive qualitative. The data were collected by conducting Balinese culture based geometry test to know the seventh grade students’ logic and mathematics reasoning ability that had been chosen as the subject of the research based on the performance rubrics. The results of research show that there are significant mathematical abilities of students to logic and reasoning in solving geometry-based culture of Bali.

1. Introduction
Mathematics is one of many school subjects learned by students from the early education until the higher one. Mathematics is a universal knowledge underlies the development of technology and human thinking power. Existing mathematics curricula have come under increasing inspection for their consideration of culture all over the globe. Suggestions for comprehensive reforms originate in part from research-based knowledge of how students construct their own knowledge based on their cultural background and how the contents of mathematics can be organized for effectual teaching and meaningful student learning. Unconsciously, people have applied some mathematics concepts in their daily life, for example, Balinese societies’ customs. The relationship between mathematics and daily life has been claimed by some education experts who said that one’s mathematics is influenced by their background culture because what they do is based on what they see and feel naturally [23]. Mathematics that related strongly to culture mathematics model called as ethnomatematics. In Indonesia, it has been known as ethnomathematics [17].

Mathematical learning can come from a real-life context [10]. Mathematical concepts can replace the real world. Various mathematical concepts can be extracted through traditional Javanese games [20], early bregada of Yogyakarta palace [14], art of Rebana [15], Sundanese society activity [1], Baduy community activity [2], Batak ornament house [7], Indramayu batik artwork [20], traditional house of Ogan Komering Ulu South Sumatra [19], and so on. Problems related to daily life of people need to be used as reference material in developing mathematics learning. [18].
Figure 1. Describes the relationship between cultural values, mathematical modeling, and mathematics

Describes the relationship between cultural values, mathematical modeling, and mathematics in the following Venn diagrams. Based on the diagram it is seen that ethnomathematics emerged as a slice of mathematics, and mathematical modeling. Thus, ethnomathematics emerges from the process of community life which is directly related to mathematics. The innovation in mathematics learning with ethnomathematics approach is felt proper and more meaningful for the students as the solution [11]. This innovation is expected to contribute to the efforts to conserve Balinese culture. Much linkage is evident between everyday cultural practices of geometric significance and the abstract concepts found in school mathematics [12]. To realize that mathematics learning, a learning media that can be applied in their daily life is needed. The learning media which relate to Balinese culture and contain geometry element of a plane figure in mathematics is ceniga, the yard calculation in asta kosali, and the pattern of legong dancer position [13]. The aims of this research were to describe ethnomathematics in Balinese culture as mathematics learning material and to arrange research product in the form of questions in geometry test to measure students’ logic and reasoning ability.

2. Method
2.1. Research Design
This study was descriptive research using a qualitative approach. Qualitative research method is a research method to analyze the natural object condition [21]. The data analysis was inductive and the study result emphasized more in the meaning than the generalization. The research using qualitative approach emphasized the analysis of inductive thinking process relating to the dynamics of relationship among the observed phenomena, and constantly employing the scientific logic. The purpose of the qualitative approach is to improve the sensitivity concept to problems encountered, explain the reality related to the grounded theory and develop an understanding of one or more phenomena [9].

Regarding the steps to be taken in this study or the components which should be applied to achieve the result in accordance with the research purpose, this research required a research design as a stage taken to get the data to be analyzed until achieved a conclusion in accordance with the research purpose. In brief, the research design was presented as follows.
2.2. The Participants
The subjects research is the intended subjects to be analyzed. The research employed one class of the seventh grade students in SMP Negeri 1 Negara. The participants were employed because geometry material especially two-dimensional figure based on 2013 curriculum with 2017 revision being used in the second semester of seventh grade. The participants were used to find out the achievement of logic and reasoning mathematics abilities on seventh grade students in SMP Negeri 1 Negara in solving Balinese culture based geometry test. After all students in the class were tested, the answers sheets were assessed based on the assessment guidelines and then two representative students who had high logic and reasoning skill in completing the test, two representative students who had moderate skill and two students of low skill were selected. Afterward, the researcher utilized the interview using the validated interview rubric.

2.3. Instruments
The research subject were geometry explain the assessment aspect of student logic and reasoning abilities. Geometry questions test in this research focused on geometry learning material based on standard competency in the seventh grade. This research developed questions test that was modified and developed further using local culture namely Balinese because Balinese culture was using its local culture to raise the ancestral heritages including the facilities and infrastructures of prayer Hindu people in Bali, the standard in asta kosala kosali Bali, and the rules of Balinese dance. Applying open-ended questions were regarded as the most effective way to improve students’ logic and reasoning abilities. In this study, the assessments focused on the assessment of logic and reasoning with high thinking ability.

2.4. Data Collection and Data Analysis
The data were collected using geometry questions test based on Balinese Culture to analyzed students’ logic and reasoning mathematics abilities on the selected seventh grade students as the participants by applying performance rubrics that had been made. The rubric assessment based on the instruments of Assessment (performance task, performance rubrics, scoring guide) about the geometry test based on Balinese culture and interview guidelines. Performance task contained the problems of mathematics thinking tasks namely geometry. Performance rubrics included the completion indicators of each defined steps. After the tests were carried out, the interviews were utilized on the students to obtain a more in-depth analysis.
Data analysis is a search or tracing of patterns. Qualitative data analysis is systematic test toward something to determine the parts, interrelationships between the studies, and the relationship to the whole [9]. In this stage, the results of students’ answers were analyzed based on Performance Task and the interviews. The analysis was the main purpose of the study, it aimed at describing the thinking and reasoning abilities of the seventh grade students based on the assessment and level achieved by the students in solving Balinese culture based geometry task. After describing the students’ answers and making interviews were utilized, the conclusion of the logic and reasoning students’ abilities level was drawn on every participant whether their mathematics abilities were high, moderate, or low skill. The following diagram was presented to show the data analysis.

![Data Analysis Process](image)

**Figure 3.** Data Analysis Process (modified by Susanto, 2010: 97)

3. Results And Discussion
One area of science that is needed to develop knowledge is mathematics. Mathematics is a human activity that is related to a pattern, problem-solving, logical thinking and etc, aimed to understand the world [8]. These things have been found in people daily activities especially in Indonesian culture. Culture is a system of ideas and concepts from the form of culture as a series of human actions and activities that interact with each other [22]. The activities often link with culture form where mathematics concepts found in some culture groups. Based on the result of data collection, this research focused on the findings of Balinese culture elements that can be taken into geometry problem to be used as teaching material of logic and reasoning geometry in students’ plane figure subject matter.

3.1 Ethnomathics behind Ceniga
Lemak or what so-called *ceniga* in Bali is a symbol of our footsteps to climb life in a vortex of time to faithfulness in this universe as mentioned lemak as a symbol of footsteps to the faithfulness created in various religious ornaments equipped with gunungan, cili-cilian, moon, star, sun, and etc [6]. *Ceniga* often made of *busung* (*janur*) and *semat*. Balinese women might not know the definition of the rectangular and triangle, they also do not know how to describe it. However, Balinese women know how to create triangle and rectangular by using traditional tool; *busung*, *semat* and knife.
Figure 4. The application of Plane Figure in Ceniga

Geometry material in this research can be used as the learning material in plane figure surface area lesson for seventh grade students in 2013 curriculum that has been mentioned in the revised mathematics syllabus 2017. Ethnomathematics plane figure surface area especially rectangular can be used as a learning material for the application of surface area in daily life as presented in figure 5.

Figure 5. Plane Figure Surface Area Question Application

3.2 Ethnomathematics Behind Sikut (Calculation) Bali House Yard
In Bali, house yard size cannot be counted randomly. The yard must be confined to avoid dominancy to the settlement landscape and also can give safety and comfort for the owner. In the translation of Lontar Dharmaning HataKosala no 361, it mentioned some names of the yard size for housing plot [16]. The following are some yard size unit followed by its name based on the lontar:

1. Gajah yard has 15 depa lengths with 14 depa width. Gajah yard is believed to have a good influence for its inhabitant.
2. Dwaja yard has 14 depa length and 13 depa width and has a good influence.
3. Singa yard has 13 depa length and 12 depa width.
4. Wreksa yard has 12 depa length and 11 depa width.
5. Lembu alit yard has 8 depa length and 7 depa width.
6. Lembu singa yard has 9 depa length and 8 depa width.

These various sizes related strongly to mathematics in which the size uses comparison principle to decide the length and the width of the yard. Uniquely, the depa size used is different based on hand lump and those sizes can be doubled according to the needs of the owner and the available yard. Therefore, this ethnomathematics is appropriate to be applied in mathematics especially in daily life application.
3.3 Ethnomathematic behind Balinese Legong Dancer Position

*Legong* dance is a Balinese traditional dance that is one of many classic dances from Kraton dance and only performed surround the keraton at the time of Balinese kingdom. We could see that legong dance both the dance and the clothes wearing by the dancer has relation with mathematics. The relationship related to the concept of plane figure in mathematics. Mathematics expresses a wide overview of mathematics that includes arithmetic, classification, marketing, mathematics modeling is a culture product. The result of the aspect analysis and activity in Legong dance were as follows.

There are various mathematics aspects in *legong* dance; geometry aspect and counting activity. Ethnomathematics in *legong* dance can be beneficial as the source for mathematic learning, increasing students knowledge about mathematics existence in cultures around them, so that they can practice their logic and reasoning ability and it can facilitate students to elaborate concepts that have been learned with the real situation. The application example in a test for students was as follows.

**Fig. 6** The Question of The Application of Length and Width Ratio

**Fig. 7** The relationship between Geometry and *Legong* dance
Ethnomathematics has grown and developed in life practice. Ethnomathematics is relevant with formal mathematics that has been taught in the classroom. In order to make a meaningful mathematics teaching and learning, ethnomathematics can be used as the alternative of teaching and learning starting point. Although many educators [3], [4], [5], argue that the cultural perspective endorses the centrality of people in education and helps to demonstrate that mathematical knowledge is constructed, interpreted and shaped by people as owners of that culture, this current study evidences the disparity of people within a culture with regard to the knowledge they have to own as a member of a particular community. In conducting a tryout test of ethnomathematics to the several seventh grade students of SMP Negeri 1 Negara, there was a different tendency between the high, average and low achiever students in logic and reasoning ability. The high achiever students tend to analyze problem well so that they could write what they know and what is asked completely in details. Furthermore, the students could also analyze argument well and write all their reason for each solving steps. In drawing conclusion, they tend to answered correctly.

The average achiever students tend to analyze problem well. They could write what they know and what is asked completely. However, they were less good in analyzing argument. The students tend to write most of their solving reasons and drawing conclusion correctly.

The low achiever students tend to analyze problem less good than others. There was a student who written what is they know less complete. The students were also less good in analyzing argument because they could only write a few reasons from their problem solving steps. In drawing conclusion, the students had two tendencies, there are some students answered correctly and some others who did not so. The failure in drawing conclusion was caused by failure in solving steps of the problem. After the research and the results obtained, as for the ability of logic and reasoning students who have high, medium and low math skills can be drawn is as follows.

**Table 1. The Tendency of Students’ Logic and Reasoning Abilities in Solving Geometry Tasks Based on Balinese Culture**

| Mathematics Abilities | Logic and Reasoning Abilities Indicators |
|------------------------|-----------------------------------------|
| High                   | The students tend to write down the known and questioned informations in full. | The students tend to write down all the reasons for every step of the solutions. | The students tend to be able to draw the conclusion of a problem correctly. |
| Moderate               | The students tend to write down the known and questioned informations in full. | The students tend to be able to write down a small part of the reason for every step of the solutions. | The students tend to be less precise in drawing a conclusion |
| Low                    | The students tend to write down the known and questioned informations in full. | The students tend to be able to write down a small part of the reason for every step of the solutions. | The students tend to be less precise in drawing a conclusion |

**Fig.8** The application of question for Triangle Surface area
4. Conclusion

The result of this research showed that there was ethnomathematics in various culture aspects such as ceniaga, yard measurement, and Balinese dancer position. The learning material obtained from this research was in the form of questions related to the plane figure that focused on the application of surface are wide based on 2013 curriculum by using revised syllabus 2017. Whereas, the tryout of a small scale based on the analysis above, there were some tendencies between the high, average and low achiever students in logic and reasoning ability.

Therefore, it can be concluded that the higher the level of students mathematics ability, the higher the students logic and reasoning ability of Balinese culture based geometry problem. Mathematics ability and logic and reasoning ability have an equal relationship. Therefore, ethnomathematics is suggested to be the alternative for teaching and learning to elicit students to increase their geometry logic and reasoning.

Acknowledgment

The authors would like to acknowledgment the support of the support of the teacher and education faculty. This work was supported by Junior High School 1 Negara.

References

[1] Abdullah, A. S. 2017 Ethnomathematics in perspective of sundanese culture. Journal on Mathematics Education Vol 8, pp 1-16
[2] Arisetayawan, A., Suryadi, D., Herman, T., Rahmat, C., & No, J. D. S. 2014 Study of Ethnomathematics: A lesson from the Baduy Culture International Journal of Education and Research Vol 2(10), pp 681-688
[3] Bishop, A. 1991 Mathematics education in its cultural context. In M. Harris (Ed.), Schools mathematics and work (New York: Academic.)
[4] Bishop, A. 1992 Cultural issues in the intended, implemented and attained curriculum In G. Leder (Ed.) Assessment and learning of mathematics pp. 169–189
[5] Bishop, A. 1993 Influences from society. In A, Bishop, K, Hart, S, Lerman, and T, Nunes, (Eds.). Significant Influence on Children Learning of Mathematics (pp. 3–26) (Paris, France: UNESCO)
[6] Darmayasa, J. B. 2016 Ethnomathematicss as one of the Mathematic Learning Pedagogical Foundation in Bali Mathematical and Mathematic Education National Seminar 2016 , Vol 4, pp. 701-710
[7] Ditasona, C. 2018 Ethnomathematics Exploration of the Toba Community: Elements of Geometry Transformation Contained in Gorga (Ornament on Bataks House). In IOP Conference Series: Materials Science and Engineering Vol. 335 IOP Publishing
[8] G. Glorin 1980 Connecting mathematics practices in and out of Schools Journal of Ethnomathematics Canada Vol. 2
[9] Gunawan, Imam. 2013. Metode Penelitian Kualitatif: Teori & Praktik. Jakarta: Bumi Aksara.
[10] Johnson, Elenie B. 2002 contextual teaching and learning. Thousand Oak, California: Sage Publication Company
[11] M. Rosa and D. C. Orey, 2011 Ethnomathematicss: the cultural aspects of mathematicss, Revista Latinoamericana de Etnomatemática, pp. 32-54
[12] Matang, R. 2002 The role of ethnomathematics in mathematics education in Papua New Guinea: Implications for mathematics curriculum Journal of Educational Studies Vol. 24(1), 27–37.
[13] Moses, R. & Cobb, C. 2001 Radical equations: Civil rights from Mississippi to the algebra project. Boston, MA: Beacon.
[14] Pratikno, H. 2018 Ethnomathematics at Soldier of Yogyakarta’s Palace. In Prosiding Seminar Nasional Pendidikan Matematika Etnomatnesia.
[15] Putri, L. I. 2017) Explore of “Rebana” Art Ethnomathematics as Source of Primary School Mathematics Learning. Jurnal Pendas,Vol. 4(1)
[16] Pulasari 2008. Cakepan Asta Kosali lan Asta Bhum. Surabaya Paramita
[17] Risdiyanti, I., Prahma, R. C. I. 2018 Ethnomathematics: Explore in Java Traditional Game. *Journal of Medives* Vol. 2(1) pp 1-11

[18] Rosa, M., Orey, D. C. 2011. Ethnomathematics: the cultural aspects of mathematics. *Revista Latinoamericana de Etnomatemática* Vol. 4(2) pp 32-54

[19] Sari, E. F. P., Somakim, S., & Hartono, Y. 2018 Ethnomathematics at “Ogan Komering Ulu Sumatera Selatan” Custom Home Culture. *Journal of Medives* Vol. 2(1) , pp 137-144

[20] Sudirman, S., Rosyadi, R., and Lestari, W. D. 2017 Using Ethnomathematics at “Batik Indramayu” Artworks in Trandormation Geometry Learning. *Journal of Mathematics Education* Vol. 2(1)

[21] Sugiyono. 2010. *Understanding of Kualitatid Research*. Bandung: CV. Alfabeta.

[22] Tonjaya, I. N. 1982 *Trajectory ASTA KOSALI*. Denpasar: RIA

[23] Zusmelia. 2016. Matematika dalam Perspektif Indegenous People dan Indegeneous Knowledge (Kasus pada Masyarakat Matrilineal Minangkabau Sebuah Tinjauan Sosiologis). *Seminar Nasional Matematika dan Pendidikan Matematika* (pp. 1-12). Padang: STKIP PGRI Sumatera Barat