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LEARNING TRAJECTORY OF GEOMETRY TRANSFORMATION BASED ON ETHNOMATEMATICS OF TRADITIONAL BALINESE HOUSES

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ABSTRACT

Various studies show that Indonesian students' mathematics literacy is very low. The low level of mathematics literacy is influenced by many factors including the fact that mathematics learning does not relate to culture. The term used to relate mathematics to culture is called Ethnomatematics. The purpose of this study is to determine the learning trajectory of geometrical transformation based on Ethnomatematics of Traditional Balinese Houses that can improve mathematical literacy. This type of research used is a design research type validation study consisting of 3 phases, namely: (1) preparation of experiments, (2) experiments, and (3) retrospective analysis. The study was conducted of Laboratory Undiksha Junior High School. The data of this study were collected by observation, interviews, and tests. Furthermore, the data were analyzed descriptively. The results showed that the learning trajectory of geometry transformation begins with the giving of problems, phenomena, patterns, pictures, which are related to Ethnomatematics of Traditional Balinese Houses. Furthermore, students conduct investigations individually or in pairs related to mathematical ideas that exist in Ethnomatematics. Through discussion, students construct mathematical knowledge. Another result is that students become more enthusiastic in learning, and students' abilities in solving mathematics literacy problems become better.

KEYWORDS: Learning Trajectory, Geometry Transformation , Ethnomatematics, Traditional Balinese Houses, Mathematical Literacy.

1. INTRODUCTION

Various studies show that mathematics literacy of Indonesian students is very low (OECD, 2013; Mahdiansyah and Rahmawati, 2014 ; OECD, 2016) . The research results of Suharta and Suarjana (2018) show that the Mathematical literacy of Undiksha prospective elementary school teacher is low. Low mathematics literacy influenced by many factor of which is mathematics which does not relate to the culture. Associating, mathematics with culture is called Ethnomatematics. The term Ethno describes all things that form the identity of cultural groups such as language, code, values, jargon, beliefs, food and clothing, and habits while mathematics has the meaning of counting, measuring, classifying, sorting , concluding, comparing , and modeling (D'Ambrosio, 1985 ; Balamurugan. 2015 ; Rosa & Orey, 2016).

According to Jenni L. Harding-DeKam (2007); François (2010), Ethnomatematics aims to draw cultural experience and use of mathematics so that it not only makes learning mathematics more meaningful, but also to give students insight that mathematical knowledge is interesting or inherent in social and cultural environments, and students better value the use of mathematics in life daily. Waziri Yusuf, Ibrahim Saidu, Aisha Halliru (2010) found that by using Ethnomatematics games on Hausa culture, mathematics can be learned more easily. Rosa & Orey (2011) found that the implementation of Ethnomatematics in the school mathematics curriculum helps students to develop their own cognitive, social and emotional abilities . A study conducted by Unodiaku, Stanislus Sochima (2013) found that the application of Ethnomatematics can improve student achievement in learning cylinder volumes. Similar studies show that application-based learning Etnomatematika can improve the performance of student learning (Iluno, C. and Taylor, 2013; Patrick Obere he walked, Okechukwu S. Abonyi, JO of Religious and Gabriel Okafor, 2016) .

The results of these studies have not been linked with mathematical literacy. Therefore it is very important to develop the learning trajectory of geometry transformation material based on Ethnomatematics of Traditional Balinese House in relation to increasing students' mathematical literacy.

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2. LITERATURE REVIEW

Ethnomatematics

According to D'Ambrosio (1985) ethnomatematic characteristics is as follows.

a. Practiced among cultural groups such as children, laborers, ethnic groups, professional classes etc.
b. That identity depends on interest, motivation, certain codes and jargon, which does not include academic mathematics.
c. The mathematics is not formal and was found to be used by engineers, builders etc.
d. The mathematics is broader in the sense that in addition to arithmetic also includes classifying, ordering, inferring, modeling etc.

The research results of Suharta , Sudiarta, Puja Astawa (201 7) are, Ethnomatematics has grown and developed in Traditional Balinese House Architecture . The use of measurements that are based on body size, ie *lengkat , nyari, rai* are very dominant in Balinese architecture. The concept of similarity and shift is widely used in the construction and ornamentation of Balinese carvings. Viewed from formal mathematics, the concepts of similarity and shift made by the Balinese Architecture are symmetry, reflection, and shifting .

Mathematical literacy

According to the OECD (2013) mathematical literacy is an individual's capacity to formulate, employ, and interpret mathematics in a variety of contexts. It includes mathematical reasoning and using mathematical concepts, procedures, facts, and tools to describe, explain, and predict phenomena. It assists individuals to recognize the role that mathematics plays in the world and to make the well-founded judgments and decisions needed by constructive, engaged and reflective citizens. In accordance with this, mathematical literacy is related to: (1) a person's ability to formulate, use and interpret mathematics in various contexts, (2) use mathematical reasoning, concepts, procedures, facts, and assistive devices to describe, explain and predict phenomena, and (3) provides benefits about the role of mathematics in the real world.

In accordance with the OECD (2010; 2013) which states that the construction of mathematical literacy developed consists of content, context, and competence. The content consists of change and relationship, space and shape, quantity, and uncertainty and data. In this research the content is geometry transformation. The context consists of situations / personal context (personal), occupation (occupational), social / general (societal), and scientific (scientific). According to Stacey (2010) emphasizes the importance of context in learning, because students are prepared to welcome future challenges. According to the OECD (2013) competencies in PISA are called competency clusters, which consist of level 1 (knowledge), level 2 (applying routine procedures in familiar contexts), level 3 (applying multistep procedures in various contexts), and level 4 (reasoning and reflection).

Learning trajectory

The implementation of realistic mathematics is very relevant to the demands of the 2013 curriculum (Suharta, 2013). Planning mathematics learning in the context of integrated thematic learning related to planning other subjects. Hypothesis implementation of learning is called the Hypothetical Learning Trajectory (HLT) which is continuously being improved. Hypothetical Learning Trajectory consists of 3 (three) components, namely the objectives, planned learning activities , and the hypothesis learning process. Objectives that refer to basic competencies and indicators will give direction to what should be done by the teacher and students, the planned learning activities are a series of activities carried out by the teacher and students, while the hypothesis learning process is the hypothesis response of students during learning and guidance conducted by the teacher. The result of developing a HLT is called learning trajectory.

The framework for developing the learning path of geometry transformation using Indonesian Realistic Mathematics Education (IRME). IRME was adapted from Realistic Mathematics Education (RME). The RME philosophy refers to Freudenthal's view that mathematics as a human activity. The implication of this view is that mathematics must be close to student life and students need to be given the opportunity to rediscover mathematics. Real life problems are used as a starting point for learning and students are given the opportunity to solve problems in informal ways. Through problem solving, class interaction, and reflection it is expected that

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informal ways by students develop towards formal mathematics. In general, the characteristics of IRME are using realistic problems , active students , guided meetings , democratic classroom settings , and teacher roles as facilitators and inspirators (Suharta, 2016).

3. RESEARCH METHODS

This research was conducted at IX grade students of of Laboratory Undiksha Junior High School. Type of research is design research type of validation studies. According to Plomp (2013) research design type validation studies have focused on designing the trajectory of learning with the aim to develop and validate theories about learning, as well as how to design an appropriate learning environment.

This study is planned to last for one year, ie 2019 with procedures are research in accordance with the phases design research. Detailed activities in each phase are shown in the following table.

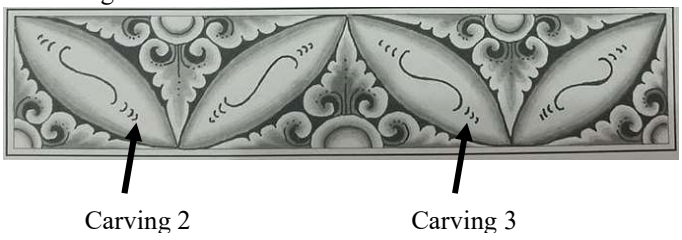
Table 1: Activity of each Phase Design Research Validation Study Type

Phases	Activity
Experiment preparation	1. Review Core Competencies (CC) and Basic Competencies (BC) for Junior High Schools and learning according to the 2013 Curriculum 2. Describe CC and BC that are relevant to the Ethnomatematics of Traditional Balinese Houses 3. Conducting field studies (class observations) and interviews with teachers related to student circumstances, learning resources, student and teacher problems. 4. Describe the Indonesian Realistic Mathematics Education which is used as a development theory framework. 5. Compiling HLT of geometry transformation
Experiment	Conduct first and second field trials. The results of the trial are used as HLT improvement materials.
Retrospective Analysis	Data obtained during and at the end of the trial were analyzed qualitatively and compared with the alleged mental activity in HLT. Furthermore, revisions and improvements are made as well as formulating learning trajectory which develops mathematical literacy and determines how learning based on ethnomatematics of Traditional Balinese Houses is carried out.

Data about the state of students, learning resources, and problems experienced by students and teachers were collected through classroom observations and interviews with teachers using observation sheets and interview instruments. Data about mathematical literacy was collected by tests and interviews with test instruments and interview sheets. The data of this research are in the form of qualitative and quantitative . Quantitative data about mathematics literacy was analyzed using descriptive statistics.

Examples of Mathematics Literacy problems, Geometry Transformation Materials, General Contexts, and Level 2 Competence

Carving on the side is one example of the application of the concept of rotation. At what angle does the second engraving turn into the third engraving? Prove it with pictures! Take points A and B freely right at each end of the carving!



Picture 1. Carving of Traditional Balinese Houses

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4. RESEARCH RESULTS AND DISCUSSION

The IX grades students of Laboratory Undiksha Junior High School consist of 3 classes, with mastery learning of grade IX-1, IX-2, and IX-3 respectively 4%, 20%, and 21%. Based on these results, in general students' abilities are low. The situation of these students, emphasized by the teacher that students tend to be passive in learning in class, and have a low enthusiasm for learning. Based on the study of mathematics realistics , frame work development of HLT is . students are given problems, phenomena, patterns, pictures, which are related to Ethnomatematics of Traditional Balinese Houses . In this case it is also possible if students create or demonstrate Ethnomatematics models . Ethnomatematics is used as a source of learning mathematics. Furthermore, students conduct investigations individually or in pairs related to mathematical ideas that exist in Ethnomatematics . These ideas are strengthened through discussion or class interaction. With the guidance of the teacher, through the process of negotiating meaning students are given the opportunity to construct mathematical knowledge. Following is an example of HLT of reflection.

Table 1: Example Hypothesis Learning Trajectory of Reflection

Learning objectives	Determine the shadow of an object (point) after being reflected / mirrored.
Learning Activity	1. The teacher shows daily activities that use the concept of reflection as shown below.  Picture 2: Mirror **Then** lure students to be more interested in learning the concept of reflection by displaying traditional Balinese buildings such as *Gapura*.  Picture 3: *Gapura* 2. The teacher asks students to find out why the *Gapura* uses the concept of reflection through the activities that exist in the student activity sheet (SAS). 3. The teacher gives an SAS containing 2 activities and several questions in each group. First, the teacher asks students to

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	understand the problems in activity 1 contained in the SAS, which are related to the formulation of reflections on certain lines. 4. After students formulate the results of reflections on each line (activity 1) carried out at meeting 1 , then students are directed to work on activity 2 namely the application of the concept of reflection into daily life using culture that is carving / ornamentation in traditional Balinese buildings namely archway building. 5. The teacher asks students to draw a *Gapura* in the Cartesian coordinate plane by following the steps in the SAS. 6. The teacher guides a group of students who find it difficult to complete activity 2. 7. After students are able to apply the concept of reflection to everyday life then students are directed to answer other questions in the SAS based on activities that have been carried out such as the notion of reflection and the nature of reflection by using the reflex concept that has been found based on activity 1 and 2. 8. After the student group carries out the teacher's direction, then the teacher asks students to draw a flat figure and then apply the concept of reflection. 9. The teacher asks students to reflect more than 1 time the flat shape that has been made. 10. The teacher randomly appoints group representatives to present the results of the discussion in front of the class, then students from other groups are given the opportunity to respond if there are differences of opinion and ask the presenter group. 11. The teacher reaffirms and explains the concept of reflection that has been found by students based on the presentations that have been done so that no concept errors occur. 12. The teacher provides opportunities for students to ask questions related to the concept of reflection that is still poorly understood. 13. Students together with the teacher discuss the results of the presentation and correct them if there are still errors. 14. The teacher gives the opportunity to students to conclude the learning activities that have been carried out. 15. The teacher gives an evaluation test in the form of a quiz to see the extent of understanding students have had regarding the concept of reflection. 16. The teacher closes the learning with closing greetings.
The learning process hypothesis	1. Students will look at examples of problems in everyday life regarding geometrical transformation, namely reflection. 2. Students pay attention to the examples given by the teacher. It is possible that some students thought of other examples, some students thought "why did Balinese traditional building carvings / ornaments use the concept of reflection". 3. Students pay attention to activity 1 on the SAS by filling in a few tables and following the steps requested until the students find the pattern of each reflection formula. Through this activity 1, students use their initial knowledge by using the concept of Cartesian coordinates, laying points on the plane of Cartesian

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coordinates , quadrants on Cartesian coordinates and drawing lines of equations that have been studied previously.

4. Students draw the Cartesian coordinate plane on the SAS on the page provided, then follow the steps requested on the SAS.
5. Students describe the *Gapura* in quadrant 1 as the *Gapura* of the initial object to be reflected, using points at each corner of the *Gapura* image at the head of the *Gapura*, and the legs of the *Gapura* so that it takes 3 points in drawing the requested *Gapura*. Then reflect the day of reflection from the initial object.
6. Some possibilities that students will do are:
    - Put the point first then connect it to the picture in the form of a simple *Gapura*.
    - Draw a *Gapura* first in a simple form, by not passing the dots that have been determined.
    - There are several groups of students who are still confused about what steps to take at the beginning.
    - Some groups of students who are already familiar with the concept of reflection and formulas found in the activities of one, then they can easily describe the result of reflection from the initial object is to reflect on the points that have been made later described it back by connecting h a sil reflection from the point was made.
    - Some groups that do not really understand the formulation of reflection to calculate the distance of the initial object with the shadow must be the same then describe the object shadow.
7. In answering other questions on SAS , students use concepts that have been found in previous activities regarding the understanding and nature of reflection.
8. Students describe two-dimensional objects (flat shape). Some possibilities for students:
    - Between one group of students with other groups describe different flat shapes.
    - The group of students who have been able to understand easily draw a flat figure using a particular point and draw a shadow of a flat figure that has been made with the concept of reflection that has been understood.
    - Students are still discussing what shape they will build.
    - Some students who are still not familiar with previous activities, will find it difficult to answer other questions on SAS.
9. Students reflect twice a point.
10. Some groups of students conclude with their own words based on the activities that have been carried out.
11. Some groups of students read textbooks or other mathematics books to see the meaning of reflection.
12. For some groups of students who are still experiencing difficulties in working on SAS, asking and asking for guidance and direction from the group representative will present the results of the discussion in front of the class.
13. Each group is likely to have a different strategy or way of doing every activity in the SAS, so it is possible for differences of opinion between one group to another.

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	14. Students discuss the results of the presentation together, and then conclude what has been learned starting from activities 1, 2 and other questions. 15. Students pay attention to the teacher's explanation related to the concept of reflection to find out the mistakes made by the group and ask the teacher about things that are not understood. 16. Students together with the teacher conclude the results of learning that have been implemented.

The experimental phase was carried out for class IX-3 and IX-2 students. The results of the posttest are as many as 16 out of 25 people who mastery learning or there were 64% of students who mastery learning. In addition, students seemed more enthusiastic in learning.

5. CONCLUSION

Development of learning trajectory based on Ethnomatematics of Traditional Balinese House can motivate students to learn, students appear more motivated to learn. By using the general context of carving Traditional Balinese Houses students can better understand the concept of geometry transformation. This has implications for students to be better able to use their understanding to solve mathematical literacy problems.

The learning trajectory of geometry transformation begins with the giving of problems, phenomena, patterns, pictures, which are related to the Ethnomatematics of Traditional Balinese Houses. Furthermore, students conduct investigations individually or in pairs related to mathematical ideas that exist in Ethnomatematics. Through discussion students are encouraged to construct mathematical knowledge.

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REFERENCES

[1] Balamurugan, M. (2015). Ethnomathematics; An Approach For Learning Mathematics From Multicultural Perspectives. International Journal of Modern Research And Reviews . Vol. 3, No.6 , pp 716-720
[2] D'Ambrosio, Ubiratan . (1985). Ethnomathematics & its Place in the History & Pedagogy of Mathematics . For the Learning of Mathematics . Vol. 5 , No.2, pp. 44-48
[3] François, Karen.(2010). The role of Ethnomathematics Within Mathematics Education. Proceedings of CERME 6 , January 28th-February 1st 2009, Lyon France
[4] OECD. (2010). PISA 2012 Mathematics Framework . Paris: OECD Publishing
[5] OECD .(2013). PISA 2012 Assessment and Analytical Framework: Mathematics, Reading, Science, Problem Solving and Financial Literacy. Paris: OECD Publishing.
[6] OECD.(2016). Program for International Student Assessment (PISA) Results from PISA 2015
[7] Iluno, C. And Taylor, JI (2013). Ethnomathematics: The Key to Optimizing Learning and Teaching of Mathematics. IOSR Journal of Research & Method in Education (IOSR-JRME). Vol . 3, No.1 . pp. 53-57
[8] Jenni L. Harding-DeKam.(2007). Foundations in Ethnomathematics for Prospective Elementary Teachers. The Journal of Mathematics and Culture . V ol.2 .No.1 . pp 1-19
[9] Mahdiansyah and Rahmawati. (2014). Secondary Education Student Mathematics Literacy : Analysis Using International Test Designs with an Indonesian Context . Research and Development Agency, Ministry of Education and Culture . Jakarta: Ministry of Education and Culture
[10] Mohammed Waziri Yusuf, Ibrahim Saidu, Aisha Halliru.(2010) . Ethnomathematics (A Mathematical Game in Hausa Culture). International Journal of Mathematical Science Education . Vol. 3, No. 1, pp. 36 - 42

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

[11] Patrick Obere Abiam, Okechukwu S. Abonyi, JO Ugama and Gabriel Okafor. (2016). Effects of Ethnomathematics-based Instructional Approach on Primary School Pupils' Achievement in Geometry. Journal of Scientific Research & Reports . Vol.9, No.2, pp. 1-15
[12] Plomp, Tjeerd. (2013). Educational Design Research: an Introduction. In Tjeerd Plomp and Nienke Nieveen (Ed). An Introduction to Educational Design Research (pp. 10-51) Netherlands: Netzodruk, Enschede an
[13] Rosa, M & Orey, D, C.(2011). . Ethnomathematics: the cultural aspects of mathematics. Revista
[14] Latinoamericana de Etnomatemática , Vo. 4 , No.2, pp . 32-54
[15] Rosa, M & Orey, D, C. (2016). Humanizing Mathematics through Ethnomodelling . Journal of Humanistic Mathematics. Vol. 6, No.2, pp. 1-23
[16] Stacey, K. (2010). Mathematical and Scientific Literacy Around The World. Journal of Science and Mathematics Education in Southeast Asia, Vol. 33, No.1, pp . 1-16 .
[17] Suharta.(2013). Curriculum 2013: Rethinking Mathematics Learning . Paper Presented
[18] in the Mathematics Teachers Workshop at JB School Denpasar, October 31
[19] 2013
[20] Suharta. (2016). Indonesian Realistic Mathematics Education (PMRI). presented at the PMRI Workshop for Elementary Teachers on October 27, 2016
[21] Suharta, Sudiarta,& Puja Astawa. (2017). Ethnomathematics of Balinese Traditional Houses . International Research Journal of Engineering, IT & Scientific Research (IRJEIS) . Vol. 3 No. 4, pages: 42 ~ 50
[22] Suharta & Suarjana .(2018). A Case Study on Mathematical Literacy of
[23] Prospective Elementary School Teachers. International Journal of Instruction , 11 (2), 413-424.
[24] Unodi, Stanislus Sochima.(2013). Effect of Ethno-Mathematics Teaching Materials on Students' Achievement in Mathematics in Enugu State. Journal of Education and Practice Vol.4, No.23, pp . 70-77
[25] Waziri Yusuf M, Ibrahim Saidu, and Aisha Halliru.(2010). Ethnomathematics (A Mathematical Game in Hausa Culture). International Journal of Mathematical Science Education . Vol. 3 , No.1, pp. 36 – 42.