HYPOTHETICAL LEARNING TRAJECTORY BASED ON ETHNOMATHEMATICS

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ABSTRACT

Ethnomathematics is the study of the relationship between mathematics and culture. The culture in question is related to the habits of human behavior in their environment. It is intended that through ethnomathematics, students can better understand mathematical concepts and their culture so as to create meaningful learning. It is important for teachers to develop a mathematics learning model that is meaningful to students from the aspects of content and process. One of the efforts that can be made is to design an ethnomathematics-based Hypothetical Learning Trajectory (HLT) in mathematics learning. The method used in writing this article is literature review. Based on supporting theories, it can be concluded that HLT is a learning design that includes student learning activities based on initial understanding abilities and student characteristics to achieve higher understanding abilities. HLT consists of three components, namely learning objectives, learning activities and learning process hypothesis. HLT in material form is in the form of context and content related to culture-based environment. Developing ethnomathematics-based HLT means using cultural values contextually by considering learning obstacles, material linkages, learning stages that are in accordance with students' thinking abilities, methods used by students and the carrying capacity of learning.

Keywords : Hypothetical Learning Trajectory, Ethnomathematics

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LATAR BELAKANG

Math is one of the subjects that has an important part in our daily lives. Math is used as a standard for intelligence and placement tests. Math is present in test rooms to determine the level of a person's ability. This causes math to always be related to solving problems that are limited in time and involve calculations. Mathematics is one of the compulsory subjects in school because it can equip students to have the ability to think logically, critically, systematically, analytically, and creatively. The importance of mathematics can be seen from its objectives, according to the National Council of Teachers of Mathematics (NCTM) that the purpose of learning mathematics is so that students: (1) learn to appreciate mathematics; (2) be confident in their ability to do mathematics; (3) become mathematical problem solvers; (4) learn to communicate mathematically; (5) learn to reason mathematically. From the objectives of learning mathematics put forward by NCTM, it can be understood that students in learning process to become aware of the experiences they have gained in their lives.

But the fact is that there are still many students who tend to think of math as a boring and scary lesson because it is full of numbers and formulas. This should be corrected so that a learning process is needed that needs to pay attention to students regarding how students think about mathematics itself which later students can connect between one material and another. In accordance with what is stated by Ausuble that meaningful learning is a learning process that actively connects new material with students' pre-existing knowledge.

One of the realizations of creative and meaningful learning is implemented through culture-based learning. Education and culture are something that cannot be avoided in everyday life, because culture is a whole and comprehensive unity, applies in a society and education is a fundamental need for every individual in society. Ethnomathematics is mathematics in a culture. The culture in question is the habits of human behavior in their environment, such as the behavior of urban or rural community groups, work groups, professional classes, students in age groups, indigenous peoples, and certain other groups (Abrasodo, 1989). By applying ethnomathematics, it is hoped that it can improve students' ability to learn mathematics to a maximum. This is because during the learning process students are given problems or problems related to their daily culture (Sarwoedi, et.al., 2018).

The main goal of ethnomathematics is to understand how different cultures develop, use and understand mathematical concepts in their own contexts. Ethnomathematics is a way used to learn mathematics by involving local activities or culture so that it makes it easier for someone to understand (Sarwoedi, et al., 2018). Ethnomathematics recognizes that ways of thinking about and using mathematics can vary greatly across cultures. This can involve different ways of counting, measuring, or understanding concepts such as time, space, quantity, and patterns. The study of ethnomathematics can also help reveal the diverse understandings of mathematics that exist in different cultures and show that mathematical concepts are not always universal, but are formed within their respective cultural contexts.

Some concepts in ethnomathematics involve:

1. Measurement System: How traditional societies traditionally measure time,

distance, volume or weight using specialized tools or methods.

2. Traditional Geometry: The study of geometric forms and concepts that arise in specific cultures, such as geometric decoration in art, traditional architecture, or patterns in weaving.

3. Number Systems: How number systems are used and realized in various cultures. The number systems used in different societies may vary.

4. Traditional Calculations: The ways in which people in a culture perform calculations, be it for everyday purposes, rites, or economic activities.

5. Mathematical Symbolism: The use of mathematical symbols in the art, mythology, or folklore of a culture.

Of course there are many more ethnomathematics that have been studied so far and of course these studies have illustrated to many people that mathematics is not a rigid science, but can blend in various aspects of human life. In addition to the many ethnomathematics that have been studied, there must be ethnomathematics that have not been or are being studied. One of the ethnomathematics that is interesting to study is ethnomathematics learning oriented to learning trajectory (Suardipa, et.al., 2021).

This is in line with the opinion expressed by (Rakhmawati, M., 2016) that ethnomathematics is defined as special ways used by a certain cultural group or society in mathematical activities. Where the mathematical activity in question is an activity in which there is an abstracting process from real experiences in everyday life into mathematics or vice versa, including grouping activities, counting, measuring, designing buildings or tools, making patterns, counting, determining location, playing, explaining and so on.

Ethnomathematics has generated a wide range of interesting research and studies, including research on traditional counting systems, mathematics in the daily lives of tribal people, and how mathematical concepts are used in various cultural traditions. It has also contributed to critical thinking about the mathematics curriculum in schools and how mathematical concepts can be taught in a more contextualized and meaningful way for students from diverse cultural backgrounds. Ethnomathematics has an important impact in mathematics education, as it allows teachers and learners to better understand the diversity in mathematical understanding and respect the mathematical knowledge that exists in different cultures. It can also help teach mathematics in a way that is more relevant and contextualized for students who come from diverse cultural backgrounds.

Ethnomathematics can be used as an alternative method for a teacher to make it easier for students to understand mathematics. With ethnomathematics, students are expected to further explore their metacognitive abilities, critical thinking and problem solving skills (Sarwoedi, et al., 2018). Learning trajectory or Hypothetical Learning Trajectroy (HLT) includes three components in the form of learning objectives, learning activities, and hypothetical learning processes (predictions about how learners' thinking and understanding will develop in the context of learning activities (Simon, 2014).

Hypothetical learning trajectory (HLT), which contains a series of instructional tasks in order to make students understand the concept of mathematics learning, is one of the important aspects that must be owned by teachers in teaching students to learn meaningfully (Hendrik, et.al., 2020). Hypothetical learning trajectory is needed by

teachers to design learning that will match the thinking patterns of students in the classroom according to student characteristics (Rezky, 2019).

Therefore, it is important for teachers to know the learning trajectory and hypothetical learning trajectory because it is expected that teachers will be able to develop learning models at school. This is so that teachers can pay attention to the characteristics of students based on existing theories and the initial abilities of each learner so that all the needs of students can be fulfilled and also the potential of students will be more developed through the appropriate learning design.

Developing ethnomathematics in the nuances of learning trajectory means embedding and utilizing cultural values contextually in mathematics learning with learning stages that are in accordance with the development of students' thinking processes, methods that students use, or the level of thinking that students show. Thus, it is expected that students can more easily understand culturally charged mathematical concepts. Therefore, this paper will discuss the development of ethnomathematics oriented learning trajectory.

METODE PENELITIAN

This research is a literature study. Literature study is one way to answer research problems by tracing reference sources related to research topics. Literature study is a method used to collect library data, read references, record information needed in a study and process research materials (Blegur, 2021). The first thing to do in this research is to look for reference sources related to the research topic. Each reference source obtained aims to help answer how the Hypothetical Learning Trajectory is related

to Ethnomathematics, especially in learning mathematics in junior high school. The data obtained in this study are secondary data based on the results of previous researchers relevant to this study. After obtaining the data, it was analyzed using the descriptive analysis method. Descriptive analysis method is one of the research methods by collecting data in accordance with the truth, then data processing, analysis is carried out to be able to provide answers to how the Hypothetical Learning Trajectory is related to Ethnomathematics.

HASIL DAN PEMBAHASAN

In its implementation, mathematics learning according to the 2013 Curriculum has learning objectives to be achieved, namely so that students can: 1) understand mathematical concepts; 2) use patterns as conjectures in problem solving, and be able to make generalizations based on existing phenomena or data; 3) use reasoning on properties, perform mathematical manipulation both in simplification, and analyze existing components in problem solving in the context of mathematics and outside of mathematics; 4) communicate ideas, reasoning and be able to compile mathematical evidence using complete sentences, symbols, tables, diagrams or other media to clarify situations or problems; 5) have an attitude of appreciating the usefulness of mathematics in life; 6) have attitudes and behaviors that are in accordance with the values in mathematics and its learning; 7) perform motor activities that use mathematical knowledge; 8) use simple props and technological results to perform mathematical activities (Kemendikbud, 2014). From this explanation, it can be concluded that mathematics learning for junior high school students is emphasized on structuring

reasoning, problem solving, attitude formation, and skills in the application of mathematics.

In Jean Piaget's theory of children's cognitive development, that junior high school students have entered the stage of formal operations. In this case, students are able to think logically and systematically about symbols related to concrete objects. Mathematics learning in junior high school is grouped into four scopes of material, namely numbers, algebra, geometry and measurement, as well as statistics and opportunities. Although already in the formal operation stage, in terms of numbers and algebra, students experience learning difficulties, especially when working on non-routine contextual problems. In terms of geometry, students have difficulty in visualizing the shape of the flat or spatial shapes they learn. Similarly, in terms of statistics and opportunities, students have difficulty in the process of drawing conclusions from a data analysis. Therefore, it is necessary to design learning in a structured and systematic way by considering students' initial abilities so as to create meaningful learning.

Based on Ausubel's theory, meaningful learning is the process of linking new information to relevant concepts in one's cognitive structure. The cognitive structure in question includes facts, concepts, materials and generalizations that students have learned and that are still remembered by students. The main factors that influence meaningful learning according to Ausubel are the existing cognitive structure, stability and clarity of knowledge in a particular field of study and at a certain time. Meaningful learning occurs when a person learns by associating new phenomena into their knowledge structure. In the learning process

a person constructs what he has learned and associates new experiences, phenomena, and facts into their knowledge structure (Rezky, 2019). The prerequisites for learning to be meaningful according to Ausubel are: (1) students have meaningful strategies; (2) learning tasks given to students must be in accordance with the knowledge already owned by students; and (3) learning tasks given must be in accordance with the stage of intellectual development of students (Rahma, 2013).

Efforts are made so that learning can associate new phenomena into the knowledge structure by designing learning designs in the hypothetical learning trajectory (HLT). HLT is a learning design in the form of conjectures on student learning activities based on initial understanding and student characteristics to achieve higher understanding. In mathematics learning, hypothetical learning trajectories are designed by considering students' learning obstacles, students' prior knowledge, and learning materials, so that learning activities that will be hypothesized for students to achieve learning objectives are built based on these things. It is necessary to link the material with the daily life experienced by students as well as local culture so that learning is meaningful. HLT starts with discovering students' learning difficulties (learning obstacles) through assessment, then using the information from the assessment to develop a didactic design that can help students achieve the learning objectives. This didactic design is outlined in the lesson plan (Hendrik, et.al., 2020).

Hypothetical learning trajectory (HLT) in mathematics learning is a description of the expected development of students' understanding and ability in a mathematical topic over time. It is an approach used by teachers and instructors to plan effective

mathematics instruction. Hypothetical learning trajectory is a concept used in mathematics learning to plan how students can develop their mathematical understanding from basic concepts to more complex concepts. It is a way to plan math instruction by understanding the progression of student thinking from lower to higher levels of understanding.

Simon in his research report Reconstructing Mathematics Pedagogy from a Constructivist Perspective introduced the term Hypothetical Learning Trajectory (HLT). In his research, Simon described his concern with the way teachers teach and his hope to inform students how to think about mathematical concepts, as well as creating a new experience or problem designed to help students' understanding process. This means that HLT consists of three components, namely, learning objectives for meaningful learning, learning activities that contain a set of tasks to achieve these objectives, and hypotheses about how students learn and how students think. The three components are interrelated, namely the form of learning activities will depend on the learning objectives to be achieved, which the possibility of achievement can be reviewed from the hypothesis of student responses to these activities (Putrawangsa, 2017).

In addition, Rezky (2019) stated that through HLT, teachers' assumptions about how students learn are created, so that it is not only the material that is taken into consideration but also whether or not students understand during the learning process. Thus, HLT becomes one of the learning guidelines that help teachers to apply the right model, teaching material strategy and assessment according to the stages of student thinking. Atsnan (2016) states that learning trajectory is a series of activities that children go through in solving a problem or understanding a concept. Learning trajectory provides a plan or pattern that will be used as a reference for making learning designs in each learning process that will be carried out. The use of learning trajectory is expected to be able to develop mathematical thinking competence for students and no concept understanding errors occur.

It is important to remember that each student can develop at different rates, so teachers need to be flexible in their teaching and provide appropriate support for each student. State that a learning trajectory can never claim to be the single best way to move all students towards understanding. Therefore, a learning trajectory is considered a hypothesis even though it has been validated by thousands of students empirically. The learning trajectory can also differ from country to country or curriculum to curriculum, but it gives a general idea of how math learning can progress from primary to higher levels. In mathematics learning, hypothetical learning trajectory is one of the means to facilitate the achievement of expected mathematics learning objectives in students (Hendrik, et.al., 2023).

The integration of ethnomathematics in learning is carried out in a learning trajectory-oriented learning process. Learning Trajectory is a science that studies how students learn and how students think which is applied in Teaching Trajectory on how teachers organize the teaching and learning process. Innovative teachers build Learning Trajectory by learning how students think and learn through various references on learning and teaching theories to create learning tools based on Learning Trajectory and facilitate student learning (Teaching Trajectory) by linking the

material before, PBM material, and material after learning (Suardipa, et.al., 2021).

Hypothetical learning trajectories based on ethnomathematics show how the teacher's efforts and hard work to present mathematical concepts in ethnomathematics into learning activities, so that these concepts can be directly related to students' culture and with their daily experiences. Where learning is carried out following a natural level pattern, namely learning mathematical skills and ideas in a student's way. The role of the teacher is how to provide facilities, space and time opportunities to students with various innovative methods in accordance with the stage of student development, so that students can build their own knowledge. Based on the principle of learning trajectory, learning always links between previous learning, ongoing learning and future learning. This will create a pattern of students' natural levels, apply learning principles, and activities that are arranged in it, so that a meaningful learning environment for mathematics has been built.

Learning trajectory is a learning path or route that provides a description of the prerequisite knowledge that students already have (as a starting point) and each step from one point to the next, describing the thinking process that students use, the methods that students use, or the levels of thinking that students show. Learning trajectory and teaching trajectory consist of material, formal, normative and spiritual forms. Learning trajectory in material form is in the form of context and content where the context can be in the form of artifacts (physically), culture-based environment (for example ethnomathematic, which is culture-based mathematics), and up to other learning tools.

Research results (Hendrik, et.al., 2020) show that to design HLT in mathematics learning, educators need to consider students' learning obstacles, the hierarchy of materials, and the carrying capacity of learning. So that the learning activities that will be hypothesized are built based on the these things. It is recommended that future researchers can apply the existing HLT, as well as develop HLT on existing materials. HLT, as well as developing HLT on materials that have not been tested by examine more deeply about HLT and what influences it, so that they can conduct research with different reviews.

The results of research (Suardipa, et.al., 2021) state that developing ethnomathematics in the nuances of learning trajectory means embedding and utilizing cultural values contextually in mathematics learning with stages of learning stages that are in accordance with the development of students' thinking processes, methods that students use, or levels of thinking that students show. Thus, it is expected that students can more easily understand the concepts of culturally charged mathematics. Similarly, the results of research (Sarwoedi, et.al., 2018) stated that several indicators of students' understanding abilities stated that there was an ethnomathematics effect on students' mathematical understanding abilities, namely in terms of Identifying, Translating, interpreting the meaning of symbols, Understanding and applying mathematical ideas, Making an exploration (estimate). As well as increasing the acquisition of student learning outcomes. From this explanation, it can be stated that ethnomathematics learning can be implemented in a learning trajectory where learning is adjusted to the level of students' thinking. This can be used as an alternative in choosing a learning strategy. Where

students apply contextual learning while recognizing existing cultures with a pleasant atmosphere and students do not feel burdened because their level of thinking is appropriate.

KESIMPULAN

Hypothetical learning trajectory (HLT) provides teachers with an understanding of the importance of considering students' prior knowledge as well as differences in students' abilities in developing learning designs. HLT can also be used as a guideline for teachers in dividing the learning stages by creating a section of learning objectives to achieve the main learning objectives. HLT can be one of the alternative strategies or scaffolding to help students overcome difficulties in understanding the concepts learned. HLT is a learning design that includes student learning activities based on initial understanding ability and student characteristics to achieve higher understanding ability. HLT consists of three components, namely learning objectives, learning activities and hypothesized learning process. HLT in material form is in the form of context and content related to culture-based environment. Developing ethnomathematics-based HLT means using cultural values contextually by considering learning obstacles, material linkages, learning stages that are in accordance with students' thinking abilities, methods used by students and the carrying capacity of learning.

DAFTAR PUSTAKA

Ambrosio, U. D.'. (n.d.). *Ethnomathematics and its Place in the History and Pedagogy of Mathematics*.

Blegur, J., Tlonaen, Z. A., Lumba, A. J. F., & Leko, J. J. (2021). *The Importance of Self-Esteem to Students Learning Responsibilities and Group Learning Commitment of Physical Education Students*. In *Journal of Education, Teaching, and Learning* (Vol. 6).

D'Ambrosio, U. 2006. Preface. Prosiding, International Congress of Mathematics Education Copenhagen. Pisa: University of Pisa.

Fajaruddin Atsnan, M. (2016). *Keterlaksanaan Learning Trajectory pada Pembelajaran Matematika. LENTERA Jurnal Ilmiah Kependidikan*. *11*(1), 57–63.

Ferrini-Mundy, J. (n.d.). Principles and Standards for School Mathematics: A Guide for Mathematicians. In *NOTICES OF THE AMS* (Vol. 47, Issue 8). http://www.nctm.org/

Hardiani, N., & Putrawangsa, S. (2019). *Etnomatematika: Tradisi Pengukuran Masyarakat Suku Sasak dan Potensi Pengintegrasiannya dalam Pembelajaran Matematika. AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, *8*(1). https://doi.org/10.24127/ajpm.v8i1.1814

Ivana Hendrik, A., Ekowati, C. K., & Samo, D. D. (2020). *Kajian Hypothetical Learning Trajectories dalam Pembelajaran Matematika di Tingkat SMP*. In *Jurnal Matematika dan Pendidikan Matematika* (Vol. 1, Issue 1).

Lisna Handayani, N. (n.d.). *Pembelajaran Learning Trajectory Berbasis Ethnomathematics*.

Okta Marinka, D., Febriani, P., & nyoman Wirne, I. (2018). Efektifitas Etnomatematika dalam Meningkatkan Kemampuan Pemahaman Matematika Siswa. In *Jurnal Pendidikan Matematika Raflesia* (Vol. 03, Issue 02).

https://ejournal.unib.ac.id/index.php/jpmr

Prodi Matematika STAIN Palopo, D. (2013). *Belajar Bermakna Ausubel*. Oleh: Nur Rahmah. In *Belajar Bermakna Ausubel Al-Khwarizmi: Vol. I*.

Rakhmawati, R., Raden, M. I., & Lampung, I. (2016). Aktivitas Matematika Berbasis Budaya pada Masyarakat Lampung. In *Jurnal Pendidikan Matematika* (Vol. 7, Issue 2).

Rezky, R., Negeri, S., Buton Selatan, S., & Penulis, K. (2019). *Hypothetical Learning Trajectory (HLT) dalam Perspektif Psikologi Belajar Matematika*. *18*(1), 762–769. http://jurnal.iain-bone.ac.id/index.php/ekspose

Simon, M. (2014). Hypothetical Learning Trajectories in Mathematics Education. In S. Lerman (Ed.), *Encyclopedia of Mathematics Education* (pp. 272-275). Springer Netherlands