The cognitive process of students in understanding the parallels axiom through ethnomathematics learning

D Herawaty, D Khrisnawati, W Widada, P Mundana and A F D Anggoro
Universitas Bengkulu, Jl. W. R. Supratman, Kandang Limun, Muara Bangka Hulu, Bengkulu 38371
E-mail: dherawaty@unib.ac.id

Abstract. The thinking process of students in understanding the parallels axiom through ethnomathematics learning was abstract activities of remembering, analyzing, understanding, judging, reasoning, imagining and speaking that was needed in learning geometry. This was the cognitive process of students based on culture. Lobachevsky's axiom of parallelism was difficult to understand through low thinking. Ethnomathematics was one solution. The purpose of this study was to describe the cognitive process of students in understanding parallels through ethnomathematics learning. This research was the initial stage of development research. We conducted in-depth interviews with 8 high school students in Bengkulu, Indonesia. The research instrument was the researcher himself who was guided by an interview guide on understanding the Lobachevsky Axiom of Parallel Lines. Interviews were conducted during geometry through the ethnomathematics learning approach. Data were analyzed qualitatively through fixed comparison techniques. The results of this study were that students can encapsulate two or more traits in the Lobachevsky Parallel Lines axiom through ethnomathematics in the form of bubu. (Bubu was a traditional fishing gear in the village community in Bengkulu). The next cognitive process was that students can build an object about infinite lines that were parallel to certain line. The encapsulation activity produces a correct understanding based on the properties of woven mats. The conclusion of this study was that through the ethnomathematics approach students can achieve trans level cognitive processes.

1. Introduction
Geometry was one of the difficult subjects for students. There were a number of problems in teaching geometry in elementary schools in Indonesia. For example, the approach used to teach geometry topics was very theoretical, and many abstract concepts and formulas were introduced without regard to many aspects such as logic, reasoning, and understanding [1]. Geometry was a mathematical system with deductive reasoning. It was based on the set of all points. Starting from several axioms and undefined terms, the theorem was obtained and so on, it becomes a deductive structure. In learning it requires a good cognitive process [2]. The thinking process of students in understanding the parallels axiom through ethnomathematics learning was abstract activities of remembering, analyzing, understanding, judging, reasoning, imagining and speaking that was needed in learning geometry. This was the cognitive process of students based on culture. Lobachevsky's axiom of parallelism was difficult to understand through low thinking. Ethnomathematics was one solution [3].

Ethnomathematics activities, which connect mathematics and culture, were very beneficial for students. Students can learn about various people using mathematics in their culture. These activities create opportunities for teachers to integrate mathematics with other disciplines such as social studies,
language, and art, which produce opportunities previously mentioned for students [4]. The philosophical basis for ethnomathematics was to ensure that there was an explanation of the way mathematics was composed, understood, and communicated that was consistent with sociological and anthropological descriptions of how mathematics was disseminated and used. Also, each account must explain how one mathematical culture becomes dominant, and, apparently, was highly developed compared to other mathematical cultures [5]. Mathematics expresses a broad view of mathematics that includes arithmetic; classifying, ordering, modeling, and practicing mathematics were products of culture (ethnomathematics) [6]. Therefore, mathematics as a process and the results of student activities. That can be either discovery or rediscovery. It was an interaction between student-learning-student-teacher devices.

Student-centered mathematics learning, utilizing cultural-based contextual problems. In problem-based learning, students were asked to solve various types of problems was important [7][8]. These problems must include critical concepts and skills that were potentially. It involves students in making mathematical understandings. The process of interaction in learning, allows them to build understanding by reflecting and communicating mathematically. This requires problems that can encourage them to develop cognitive processes properly. It needs our knowledge of good problems. Although it does not have to be a realistic problem, because the criteria for a problem called realistic was that the possibility of the problem was experienced by students as something real and interesting personally. This often occurs in problems that arise from situations where students work with direct material, which implies that realistic problems do not always originate from the daily lives of students [9].

Ethnomathematics does not only discuss the issue of historic places, it was not only a tool for multicultural classrooms. Ethnomathematics along with perspectives that consider mathematics as a subject that relates to context and culture, helps provide a meaningful framework for creative mathematics classes [10]. To help identify ecocultural mathematics about space and geometry, four principles were defined and discussed about the structure of language, lines and reference points, size of space and worldview and interpretation of space as a place [11]. Therefore, outdoor learning with the ethnomathematics approach was right for students. It was to improve the ability to understand the mathematics [12]. The assisted group views mathematics as a human activity that was deeply rooted in culture and, thus, can be greatly enriched by intellectual diversity in curriculum and pedagogy.

Mathematical education, we argue, must reflect the diversity of classroom cultures, and an increasingly interconnected world. Mathematics educators must continue to adopt ethnomathematics into their lesson plans [13]. The ethnomathematics was brings to class mathematical and cultural connections through the practice of craftsmen. It was to be noted here, not self-recognizing hidden mathematics in their work, but only labeling their expertise as cultural knowledge. Informal knowledge of craftsmen was introduced in the classroom, developing dialogue with students' formal geometric knowledge, which was expanded and elaborated in a context. The use of new technology helps shape the teaching of multimodal mathematics in the classroom [10]. In ethnomathematics learning, according to Massarwe, Verner, & Bshouty [14], students practicing with compasses, Parallel Lines and geometric transformations help deepen their understanding of geometry and direct them to find geometric solutions rather than trigonometry. The students develop ornament construction skills and proof of their properties through geometric transformations. The students also get the skills and motivation to teach geometry in a cultural context. Dealing with ornaments gives them the opportunity to enjoy the beauty of geometry. Students showed that because of the discourse in class they became more familiar with their own culture, other cultures and cross-cultural similarities. Research results of Widada et al. [15], students who were given ethnomathematics oriented material, the ability to understand mathematics from those who learned by applying realistic mathematics learning approaches was higher than students who used conventional learning approaches after controlling students' initial abilities. However, for material learning students oriented to non-ethnomathematics, the mathematical understanding ability in the class uses a realistic mathematical learning approach lower than their counterparts after students' initial abilities were controlled.
Therefore, we were interested in discussing the cognitive process of understanding parallels axiom through ethnomathematics learning. We use fish culture in Bengkulu, Indonesia. Bengkulu was one of the provinces that has the longest coastline in Sumatra. Therefore, Bengkulu produces hundreds of thousands of tons of fish every year. It was born a tradition and culture of catching fish together by using "bubu"[16]. Bubu was a tube-shaped traditional fishing rod made of bamboo. The tradition of catching fish with bubu was still commonly found in the Bengkulu area. Usually the bubu was installed when late in the evening, to be taken back in the morning. This tradition then gave birth to a creation dance from Bengkulu called "Bubu Dance".

2. Methods
This study was the initial stage of development research, namely the needs assessment phase. The subject of this study was selected from high school students in Bengkulu, Indonesia. The selection was done by snowball technique. We conducted in-depth interviews with 8 students.

The research instrument was the researcher himself who was guided by an interview guide about the understanding of the Lobachevsky Axiom of Parallel Lines. It was material that was not covered by the high school curriculum, but this was an enrichment for them. Interviews were conducted during geometry learning through the ethnomathematics approach. Learning geometry was carried out through the ethnomathematics approach by utilizing fishing culture. Traditional culture of catching fish using "bubu". It was recorded using audio-visual. Data analysis was carried out during and after the interview. Data were analyzed qualitatively through fixed comparison techniques.

3. Results and Discussion
Based on interview data based on the task of the Lobachevsky Parallel Lines axiom. Interviews were conducted on eight selected high school students. We analyzed descriptively qualitatively, and continued with constant comparison analysis. However, we provide interview footage as an analysis argument.

During geometry learning about the Lobachevsky axiom, students were faced with real problems related to the culture of fishing using bubu. Students use activity sheets to trigger their cognitive processes in understanding and achieving a principle of line Parallel Lines. The expected ignition was the axiom of Lobachevsky's Parallel Lines. The following was a sequence of cognitive processes of high school students in understanding the axiom. Look at Figure 1.

![Bubu Image](image_url)

**Figure 1. Bubu**

Based on Figure 1, students then draw lines drawn from the lines on the tray. The lines were sketched on the working paper as stated in Figure 2.
The cognitive process of the research subject states that based on Figure 2, the subject states that the lines $g_1$ and $g_2$ were two lines through point P outside the line $g$ and parallel to it. This can be concluded from the following interview footage (Q: Interviewer, GS: Research subject).

Q: What can be revealed from the assignment you were working on?
GS.01: ... Well ... I start by choosing point P outside the line $g$, which was at the bottom of Bubu. I can make the line $g_1$ line $g_2$ through the point P and parallel to the line $g$.

Q: Why was line $g_1$ the line $g_2$ parallel to line $g$?
GS.02: ... yes line $g_1$ line $g_2$ was parallel to $g$ because the two lines never intersect with line $g$.

Q: was only the line $g_1$ line $g_2$ parallel to $g$?
GS.03: ... of course I can find another line through P and parallel to $g$, and I'm sure there were a lot of these lines.

Q: Can you determine the number of lines you mean?
GS: So much ... means that infinite lines were parallel to $g$.

Based on the footage of the interview with the GS Subject, he was able to take actions based on the lines on the bullet. He interiorizes the process of moving sketches of lines into paperwork (See Figure 2). Then, the subject was able to encapsulate these processes to become an object of line Parallel Lines (GS.02). Also, students can conclude that there were many lines parallel to $g$. He was able to build up the statements stored in his information processing system in the form of schemes. The statement was "there were infinite lines that were parallel to $g$". He was states that the background of the statement was point P outside the line $g$, lines whose infinity was the line through point P. It was a mature scheme that has GS. This result was supporting Widada, et. al. for another focus. He stated that students were able to organize activities and make algorithms that form concepts/principles correctly. Functional students can also carry out abstraction processes using rules in the mathematical system [17][18]. It was a structured collection of mental activities carried out by the subject to describe how mathematical concepts/principles can be developed in his mind [19]. It was meaningful that students can summarize two or more traits in the Lobachevsky Parallel Lines axiom through ethnomathematics in the form of traps. Bubu was a traditional fishing gear in rural communities in Bengkulu, Indonesia. The next cognitive process was that students can construct objects about infinite lines that were parallel to certain lines. Encapsulation activity results in a correct understanding based on the nature of the woven mat. It was that through the ethnomathematics approach students can achieve trans level cognitive processes.

These results also support Herawaty, et. al. [20] that students solve mathematical problems through mathematical processes based on ethnomathematics. The students were aware that ethnomathematics was the starting point of horizontal mathematical activity. Just like traditional homes, culture was a real problem to achieve certain concepts. Student metacognition was used to validate the truth of the statement made.
Another study states that the character of students at the abstract level was able to use all the statements given to solve the ethnomathematics problem. Students can explain the relationship of statements given with arguments in solving problems. He was able to explain the usefulness of each statement used to solve the problem, as a result of a proven statement. Also, students can explain statements that were arranged as a result of existing statements using good arguments [21].

Another subject (= TR) in this study was to state something similar to GS. TR completes the task starting by selecting point P on the small tray (see Figure 3). The subject states that through point P there were two lines parallel to line g. Say the lines were h and k.

![Figure 3. Small Bubu](image)

The following was a sample interview with TR, as follows.

Q: What can you explain about the Parallel Lines of these lines?
TR01: ... Yes ... There were two lines that I can draw (see Figure 4). Parallel lines were actually still many more ...
Q: What do you mean by that?
TR02: ... actually I can still find the 3rd line ... 4th and so on ... And it turns out to be infinite.
Q: What was your conclusion?
TR03: ... through point P which was not located at line g, there were no lines that were parallel to g.

![Figure 4. Point P outside the line g, and lines h and k through point P](image)

Based on interview footage with TR, it means that students can coordinate the action-process of objects from the properties of parallel lines. He was able to produce a mature scheme of the axiom of Lobachevsky's Parallel Lines. He can apply the scheme to deduce the existence of lines parallel to a certain line. The lines were infinite in number.

This conclusion means that TR was at the Trans Level [17]. Students can coordinate other objects and processes, so the scheme was formed about series convergence and infinite lines. The subject was able to thematize so that forming a mature scheme was characteristic of the trans level [22]. Trans
students were able to build thematic relationships between actions, processes, objects, and other schemes. This scheme can be used to solve mathematical and related problems [23]. These students turned out to experience an increase in level after attending learning with the ethnomathematics approach. That was in accordance with other studies, such as Herawaty, et.al. [24], the groups of students given ethnomathematics-oriented material, the ability to understand mathematical concepts from students taught with realistic mathematical learning approaches was higher than those taught with direct instruction. Thus, we believe that the cognitive process of students after following the ethnomathematics approach has increased the level of the scheme.

4. Conclusion
Based on the results, the conclusion was that there was an improvement in the cognitive process of students after following geometry learning with the ethnomathematics approach. These students were able to build the traits of parallel lines that they don't normally find in regular learning. They reach a fairly good cognitive level.

References
[1] Fauzan A, Slettenhaar D, and Plomp T 2002 Traditional Mathematics Education vs Realistic Mathematics Education: Hoping for changes Proc. 3rd Int. Math. Educ. Soc. Conf. Copenhagen Cent. Res. Learn. Math. 1–4
[2] Anderson L W and Krathwohl D R et al 2001 A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom’s Taxonomy of Educational Objectives (Boston: Allyn & Bacon)
[3] Ambrosio U D 2001 What was ethnomathematics, and how can it help children in schools? National Council of Teachers of Mathematics Feb.
[4] Snipes V and Moses P 2001 Linking Mathematics and Culture to Teach Geometry Concepts,” LATM J. 1 1–17
[5] Barton B 1998 Ethnomathematics and philosophy A Presentation to The First International Conference on Ethno-mathematics, University of Granada, Spain, September 2–5
[6] Balamurugan M 2015 Etnomathematics: An Approach For Learning Mathematics From Multikultural Perspective Int. J. Mod. Res. Rev. 3 716–20
[7] W Widada 2004 Pendekatan Pembelajaran Matematika Berbasis Masalah (Surabayas: Unipa Press)
[8] Widada W 2015 Proses pencapaian konsep matematika dengan memanfaatkan media pembelajaran kontekstual J. Penelit. Pendidik. Mat. dan Sains 22 31–44
[9] Wubbels T, Korthagen F and Broekman H 1997 Preparing teachers for realistic mathematics education Educ. Stud. Math. 32 1–28
[10] Stathopoulou P, Kotarinou C and Appelbaum P 2015 Ethnomathematical research and drama in education techniques: developing a dialogue in a Geometry class of 10th grade students Rev. Latinoam. Etnomatemática 8 105–35
[11] Owens K 2014 Diversifying our perspectives on mathematics about space and geometry: an ecocultural approach Int. J. Sci. Math. Educ. [1] Fauzan A, Slettenhaar D, and Plomp T 2002 Traditional Mathematics Education vs Realistic Mathematics Education: Hoping for changes Proc. 3rd Int. Math. Educ. Soc. Conf. Copenhagen Cent. Res. Learn. Math. 1–4
[12] Anderson L W and Krathwohl D R et al 2001 A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom’s Taxonomy of Educational Objectives (Boston: Allyn & Bacon)
[13] Ambrosio U D 2001 What was ethnomathematics, and how can it help children in schools? National Council of Teachers of Mathematics Feb.
[14] Snipes V and Moses P 2001 Linking Mathematics and Culture to Teach Geometry Concepts,” LATM J. 1 1–17
[15] Barton B 1998 Ethnomathematics and philosophy A Presentation to The First International Conference on Ethno-mathematics, University of Granada, Spain, September 2–5
[16] Balamurugan M 2015 Etnomathematics: An Approach For Learning Mathematics From Multikultural Perspective Int. J. Mod. Res. Rev. 3 716–20
[17] W Widada 2004 Pendekatan Pembelajaran Matematika Berbasis Masalah (Surabays: Unipa Press)
[18] Widada W 2015 Proses pencapaian konsep matematika dengan memanfaatkan media pembelajaran kontekstual J. Penelit. Pendidik. Mat. dan Sains 22 31–44
[19] Wubbels T, Korthagen F and Broekman H 1997 Preparing teachers for realistic mathematics education Educ. Stud. Math. 32 1–28
[20] Stathopoulou P, Kotarinou C and Appelbaum P 2015 Ethnomathematical research and drama in education techniques: developing a dialogue in a Geometry class of 10th grade students Rev. Latinoam. Etnomatemática 8 105–35
[21] Owens K 2014 Diversifying our perspectives on mathematics about space and geometry: an ecocultural approach Int. J. Sci. Math. Educ. 12 941–74
[22] Widada W, et al 2019 Ethnomathematics and outdoor learning to improve problem solving ability Adv. Soc. Sci. Educ. Humanit. Res. 295 13–6
[23] Brandt A and Chernoff E 2015 The Importance of ethnomathematics in the math class Ohio J. Sch. Math. 71 31–37
[24] Massarwe K, Verner I and Bshouty D 2012 Ethnomathematics and multicultural education: Analysis and construction of geometric ornaments J. Math. Cult. 4 344–60
[25] Widada W, Herawaty D, and Lubis A N M T 2018 Realistic mathematics learning based on the ethnomathematics in Bengkulu to improve students’ cognitive level J. Phys. Conf. Ser. 1088 012028