The thinking process of students in understanding the concept of graphs during ethnomathematics learning

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Abstract. Understanding of concepts was one of the goals of learning graph theory. The concept of graph can be achieved through learning ethnomathematics. The purpose of this study was to describe students' thinking processes in understanding the concept of graphs during ethnomathematics learning. This research was part of development research. This was the prototype stage. The subjects of this study were 26 students in the University of Bengkulu. The instrument of this study was the researchers themselves plus interview guides, anecdotes and observation sheets. Data collection was done during ethnomathematics learning. Data were analyzed qualitatively with the constant comparative technique. The results of this study were students begin learning with a culture of communication using mobile phones. Students think about the definition of graph by corresponding to a cellphone with a vertex. The edge of a graph was corresponded to the existence of a relationship between mobile phones. Students can define graph as a system that was built by a set of non-empty vertices, and a set of edges which were pairs of non-sequential vertices. The conclusion of this study was that students' thought processes in understanding the concept of graph through ethnomathematics approaches. It was a contextual problem about the culture of communication using mobile phones.

Keywords: Process thinking, understanding concepts, ethnomathematics.

1. Introduction
Graph theory was a compulsory course in mathematics education undergraduate programs. It was a material that was difficult for students to understand. It was shown that classically the level of student completeness only reaches less than 50% [1]. Understanding of concepts was one of the goals of learning graph theory. However, students learn graph theory and experience errors in writing a degree symbol from a vertex of 35%, there were 18% of students misunderstanding the concept of the degree of a vertex in a graph. In this study, there were 18% of students experiencing conceptual errors about the sides and vertices of a graph, 24% of students misunderstood the concept of degrees from a loop [2]. Therefore, we need to explore how students think in understanding the concept of graph. That was a way to determine the learning approach that was appropriate for a particular group of students. This was something important to know the thinking process of students in solving problems. The teacher knows the difficulties of students and to minimize the occurrence of the same mistakes in problem solving. Teachers can prepare appropriate learning strategies that were more in line with students' thinking processes [3].

The results of the study indicate that, in the process of teaching graph theory, if students were given a variety of instructional media that matches their daily habits, they can improve student performance.
in mathematical thinking [4]. It was giving instructions so that the lecturer provides a variety of learning techniques that match the students’ initial abilities. Therefore, mathematics learning (including graph theory) must be close to the mind and local culture. It was a contextual learning involving ethnomathematics. Ethnomathematics were mathematics practiced by cultural groups, such as urban and rural communities, groups of workers, professional classes, children in certain age groups, indigenous peoples, and many other groups identified by the same goals and traditions as this group [5].

Ethnomathematics learning has a positive impact on improving the ability of mathematical thinking processes. Such as compiling mathematics through local culture using local languages [6]. Also, the importance of developing a curriculum that integrates cultural values, as well as contributions from ethnomathematics curricula [7]. As far as the mathematics curriculum was concerned, it was certainly rational to integrate Ethnomathematics and mathematics curricula, using construction methods [8]. Ethnomathematics contribute to the process of teaching and learning mathematics [9]. Therefore, in teaching graph theory, the suitable starting point was the provision of contextual problems that were close to the mind [10] and student culture (ethnomathematics approach) [11].

This description provides support that the concept of graph can be achieved through learning ethnomathematics. Learning requires a unique process. This process was called the mathematical thinking process. The process of thinking of mathematics was a mental activity carried out by someone in problem solving, reasoning and compiling evidence. The process also requires mathematical communication, mathematical connections, and mathematical representations [12] [4]. The thinking process of students through mathematical reasoning was more difficult for those who were less proficient in mathematical arithmetic and it takes longer to develop [12].

In mathematics learning, there was no difference in thought processes between men and women with high mathematical abilities, but there were differences in thinking processes between men and women with moderate and low mathematical abilities. For students with moderate mathematical skills, men need a long time in making a problem-solving plan, while female students take a long time in understanding the problem [3]. Mathematics was very closely related to problem solving. In solving mathematical problems, there will be a thought process [13]. It was possible for students to think pseudo. Pseudo thinking was a thought process that produces an answer to a problem or construction to the concept of “it’s not true”. It was a model of thinking that might occur in students. The concept of construction does not represent true thinking [14]. Thus, we were interested in describing students’ thinking processes in understanding the concept of graphs during ethnomathematics learning.

2. Method
Development research was a long-term project for us. We were a research team in the mathematics education graduate program at the University of Bengkulu. That was the research listed in our research master plan. Therefore, this study was part of the development research. This was the prototype stage. The subjects of this study were 26 students in the University of Bengkulu. We chose the subject through snowball techniques. The instrument of this study was the researchers themselves plus interview guides, anecdotes and observation sheets. There were five students interviewed in depth. That was selected based on the results of the paper and pencil. This interview was conducted to explore students’ thought processes in achieving graph concepts. To get accurate data, audio-visual was recorded. Anecdotes and observation sheets were filled out by members of the research team. It was to ensure that ethnomathematics learning was carried out correctly. We implement the ethnomathematics learning approach, as many as four meetings. To get accurate and complete data we document it with audio-visual. Data retrieval was done during learning with the ethnomathematics approach. Data were analyzed qualitatively and the constant comparative technique.

3. Results and discussion
During the process of learning graph theory, we applied the ethnomathematics approach. Students come in direct contact with local customs and culture. To understand graph theory, students begin with
the basic concept. That was the definition of graph. Graph G was a system built by a non-empty set V that contains vertices, and the set E which contains edges so that each edge was a non-sequential pair of vertices in V [15]. We will use mobile phones as a starting-point for graph concept learning.

Mobile phone was a communication tool that has been entrenched in the community. Likewise for all students. Therefore, we utilize the starting-point of learning as a contextual problem based on student culture. It was an ethnomathematics. Mobile phones have become an important aspect of everyday human life. It was a tool that has changed the way people live, communicate, interact, and connect with others. Mobile phones also change the way people access and use information and media. Since cellphones were rapidly spreading in communities throughout the world, it was important to explore how cellphones affect the way people communicate and interact with others, access information, and use media, and their daily lifestyles [15]. The widespread use of cellular phones and cellular communication devices has increased their acceptance of their use in almost all social situations. Incoming calls were no longer seen as a disruption to the main activity that occurs, but instead were treated as communication that was equally important. Proximity was not important in terms of social interaction. Cellular technology has changed our culture and identified the ways in which we now view socially acceptable communication [16]. Therefore, in learning graph definitions, the use of mobile phones as ethnomathematics was appropriate and reasonable.

When starting graph concept learning, give a sheet of student activities whose contents were contextual issues about mobile phone communication devices. Through the mobile phone they create the meaning of graph. Students' thinking processes vary. Data about it can be presented in Figure 1.

![Figure 1. Percentage of student thinking processes](image)

Based on Figure 1, the percentage of students in the class was reviewed based on the type of thinking process. It was a result of assessment after ethnomathematics learning takes place. There were 67% of students who were able to solve problems, 76% of students were able to communicate mathematically, 83% were able to think mathematical connections, and 78% were able to make mathematical representations. This shows that the thinking process ability of students was already in a good level. However, only 15% of students were able to prove theorems through formal and deductive reasoning. That was a percentage that has not been encouraging. The process of thinking of mathematics and vertical matematization processes still need to be improved.

On this occasion, students were traced to the thought process. First of all students who cannot formally prove theorems. The results of the analysis show that they have difficulty linking formal objects in graph theory. It was the difficulty of making reasoning about definitions, axioms and previous theorems. In fact, that was the main requirement for arranging arguments deductively. Note the results of our interview (= Q) with a student (= Fn).

Q: Try to explain the proof that you compiled about the statement: "the number of points with an odd degree on a graph was even"
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Fn: ... I take the example of a simple graph with one point ... the number of points that have an odd degree does not exist ... means zero ... that's even ...

Q: Just that?

Fn: ... there was a lot of proof ... suppose two points from simple graph ... suppose the graph was connected ... means that each of them has a degree of 1 ... then there were 2 points of odd degree ... that was even ...

Q: Why do you only prove with examples like that?

Fn: ... actually I can really show a lot ... and all my examples prove that truth ...

The footage shows that Fn, does not have the ability to think about proving theorems. The reason was just to give an example. He does not have deductive reasoning. Also without understanding valid proof techniques. The logic was misleading. That was a low level thinking ability. He proved to only give a few examples. It was an affirmative proof, and not having an understanding of the evidence was general. Students feel very confident that the thought process produces an answer to a problem or construction to a concept, but the thought process was wrong [14].

In general, students have a process of thinking about mathematical connections, mathematical communication, being able to make mathematical representations, and problem solving abilities. First of all the students connect graph concepts to the culture of communicating using a mobile phone. They carried out an analysis of the definition of graph G. G was a system that requires two interconnected sets. That was the first set cannot be empty, and the second set can be empty. The first set contains dots. The second set contains sides. This concept will be enough if each side of the second set was a pair that was not sequential from the points on the first set. This inspires us to correspond with the cellphones of the students. While the sides of our second set were analogous to the connection between mobile phones. If two phones can connect, that means it's one side. If the mobile phone was a dual card, it can contact itself and it corresponds to a loop. Their thinking process can be seen in Figure 2.

![Figure 2](image)

**Figure 2.** Seven mobile phones, each cell phone was associated with a point

Students give a good process of thinking. Seven cell phones were asked to connect to each other. Every sim card number in the mobile phone was used to connect. That was that two sim cards were connected by a communication link. But dual card cell phones can contact themselves. Also, there was a possibility that two different cell phones can do two or more connections. Each connection was associated with one edge. The thought process produces representation as shown in Figure 3.
Based on Figure 3, the thinking process of students was increasing by trying to provide answers to the challenges of compiling the meaning of graph. It was starting to formulate definitions formally. Each cell phone was associated with a point. Also, every connection between two sim cards was corresponded to one edge, as well as if the two sim cards were in the same cell phone, then one side was called a loop. This was represented by students in Figure 4.

**Figure 3.** Every two cell phones that can connect signals were associated with a line, also between sim cards

**Figure 4.** $G$ was a display of a Graph
Students then continue the cognitive process by trying to compile the necessary and sufficient requirements for a graph definition. They start using Figure 4. That was an example of a graph display. Students state that G was a graph consisting of two sets. The first set was a set of vertices (say V), and the second set has members of edges (called E). They said that understanding was not enough. The sufficiency was that each edge on set E was a non-sequential pair of points in V. While guided by a lecturer, students write the definition as follows. G = (V, E), V = {v1, v2, v3, v4, v5, v6, v7, v8}, E = {e1, e2, e3, e4, e5, e6, e7, e8}. A graph G consists of a set of vertices V that non empty and a set of edges E, where an edge was an unordered pair of vertices. This was the end of the problem solving process. They were able to achieve it.

It turns out that ethnomathematics learning has a very good influence on students’ mathematical thinking processes, especially in connection, communication, and mathematical representation. Also, improve the thinking process in problem solving. In this case educators become their role models and learning guides. The results of other studies showed a personal connection between a Tribal Elder and a teacher in the class. Also, on the further development of the mathematics teacher theory as a Tribal Elder in the class and can later be imitated by others [17]. Teachers and the community at D’Ambrosio stated that mathematics and culture were interconnected. If the teacher acknowledges the existence of a relationship, they often involve students in multicultural activities as a curiosity. Teachers must know how the culture relates to children and their learning. An important component of current mathematics education must reaffirm, and in some cases, restore the dignity of the culture of children [18]. Also, other studies state that students’ metacognitive processes increase after taking ethnomathematics [19]. Mathematical understanding of students learned the ethnomathematics oriented materials was higher than those learned non-ethnomathematics oriented materials [20]. After participating in ethnomathematics learning, students were able to link between actions, processes, objects, and other schemes. It can be used to solve mathematical problems and related problems [21].

Thus, the thinking process of students through learning with a culture of communication using mobile phones, shows a good stage. It was the process of thinking about the connection of mathematics, mathematical communication, mathematical representation, and problem solving. Students think about the definition of graph by corresponding to a cellphone with a vertex, the edge of a graph corresponds to the existence of a relationship between mobile phones. Students can define graph as a system that was built by a set of non-empty vertices, and a set of edges which were pairs of non-sequential edges. The conclusion of this study was that students’ thinking process in understanding the concept of graph begins with the culture of communication using mobile phones.

4. Conclusion
The thinking process of students during and after learning graph theory through ethnomathematics approaches was mathematical connection, problem solving, communication and mathematical representation. That was the dominant thought process for them. To make a definition of the concept of graph, they use a culture of communication through cell phones. Students were able to show the process of thinking correctly. Also, they produce well define. That was empirical evidence that ethnomathematics based on mobile phone were learning approaches that were suitable to achieve a concept about graph.

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