Analysis toward learning obstacles of junior high school students on the topic of direct and inverse proportion

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Abstract. Direct and inverse proportion are the basic topics which need to be comprehended by students because they both will be used in discussing more advanced mathematics topics. However, many students still have obstacles in learning these topics. This study aims to identify and analyze students' learning obstacles on the topic of direct and inverse proportion. This study used qualitative research approach with phenomenological design and involved thirty 8th grade students. The data were collected using triangulation which employed test, interview, and document analysis. The results showed that students faced learning obstacles, which are inability to follow learning demands on the basic concept of ratio, multiplication concept in proportion, and direct proportion concept on algebraic equations (ontogenic obstacle), students are hampered by the presentation of direct and inverse proportion material is not considered well and not facilitate student-centered learning (didactical obstacle), and inability to use direct and inverse proportion concept in the context of graphs, algebraic equations, and non-routine questions (epistemological obstacle). These obstacles should be considered when developing a more optimal didactical design.

1. Introduction

Proportion is a concept in mathematics that is important to be understood by students because they might need this concept when they learn other mathematics topics. Proportion is a foundation of other mathematics topics, such as algebra, geometry, trigonometry, and others [1-6]. Regarding this matter, junior high school students need to be able to comprehend the concept of direct and inverse proportion.

However, it was found in some studies that many students still have difficulty in learning direct and inverse proportion. The results of previous studies showed that many students could not distinguish between direct proportion problems and inverse proportion problems, and they have difficulties on how to solve problem in different contexts [7-9]. These difficulties indicated that the learning activities was not optimal. The difficulties rose because students faced learning obstacles which teacher should address and overcome in order to ensure optimal learning activities for students [10-12].

There was a study about students’ difficulties in learning the concept of proportion which was conducted by Çalışıcı’s [13]. The difficulties in learning the concept of proportion might be the result of learning obstacles faced by the students [14]. However, the study which discussed learning obstacles faced by students in learning the concept of inverse proportion could not be found [7, 14] even though previous studies showed that students often encountered difficulties in learning the
concept of inverse proportion. Therefore, it is important to study students' learning obstacles which cause difficulties in learning the concept of direct and inverse proportion.

The learning obstacle is caused by many factors such as lacking relationship between teacher and student, teacher and knowledge, and student and knowledge [15]. If a relationship between these three (teacher, student, and knowledge) is failed to be built well, it will trigger learning obstacle. Brousseau [10] stated that based on the source, learning obstacle was classified into three types which are ontogenic obstacles (related to the development of student abilities), didactical obstacles (related to the presentation/teaching stages of the material) and epistemological obstacles (related to student relational understanding).

Therefore based on the problems discuss above this current study identified and analyzed the learning obstacle experienced by junior high school students in learning direct and inverse proportion. The results of the study is intended to make sure that the learning obstacles identified in this study will not occur in the future, and teacher might be able to minimize students’ learning obstacles.

2. Method
The study used qualitative research approach with a phenomenological research design, which is intended to obtain more in-depth data about the learning obstacle of junior high school students on the topic of direct and inverse proportion in natural conditions (without manipulation). The subject of the study is a class of 8th grade students in Lembang, West Bandung District, West Java, Indonesia. The class was chosen because the students had studied the topic of direct and inverse proportion.

The data collecting methods employed in this study were triangulation techniques which included giving diagnostic test to thirty students, interviewing six students who represented the rest of the students who made similar mistakes, and a mathematics teacher, and analyzing the textbooks used by students (document analysis). It was in accordance with the purpose of the study being carried out, namely choosing student answers which were the alleged learning obstacle. The main research instrument was the researcher itself and supported by a supporting instrument which was the diagnostic test instrument, consisting of six questions about concept of direct and inverse proportion that have been validated by mathematician and mathematics teacher.

The data obtained were then processed and analysed using qualitative data analysis techniques as follows: (1) identified student mistakes in the diagnostic tests; (2) invited some students who represented other students that had similar obstacles in understanding direct and inverse proportion material; (3) interviewed the invited-students; (4) conducted a documentation study of the textbooks used by students; (5) analyzed the results of diagnostic tests, the result of interviews and the documentation studies; (6) presented the data descriptively; (7) made the conclusion of the study.

3. Results and Discussion
The study found that students experienced three types of learning obstacles in the concept of direct and inverse proportion classified by Brousseau [10], which will be discussed as follows.

3.1. Ontogenic Obstacle
Students faced ontogenic obstacle in solving the diagnostic test questions on the number 1, 3, 5, and 6. Figure 1 shows a problem that asked students to compare the ratio of female students from each team. In this figure, it can be seen that a student chose wrong option because the students misunderstood the key technicalities in the basic concept of ratios. The student only paid attention to the quantity of female students without considering the quantity of all students in the team. Thus the student assumed that there was no team having more female students than the other.

While analyzing the textbook used by students, an explanation of the ratio was found, but it is not explained comprehensively and it looks confusing for the students. For example, in the textbook it is written "Out of 150 students, 100 students choose online media and 50 students choose print media. Therefore $\frac{1}{3}$ of the students of Sukamaju junior high school who took the survey chose print media to
read the news”. After student 1 was asked about the $\frac{1}{3}$ value, the student did not know how the $\frac{1}{3}$ was obtained. The textbook should have explained that $\frac{1}{3}$ students were obtained from $\frac{50}{150}$ students. Judging from that experience, it can be concluded that the student was not able to follow the learning demands on the concept of ratio.

**Figure 1.** Answer of student 1 in problem number 1.

Figure 2 shows the student’s 2 answer for problem number three in the diagnostic test. In this number, students were asked to determine the graph that corresponded to the problem in the questions. When being interviewed, the student recognized that the question was about a direct proportion. Student 2 argued if train 2 actual size was higher than train 1 actual size, the train 2 model size would be higher than train 1 model size. However, student 2 experienced a misunderstanding in the concept of direct proportion. Student 2 connected the concept of proportion with the addition situation. The student assumed when the train 1 actual size is 3 meters, and the train 1 model size is 10 meters, the difference between the real and model size was seven (the student reduce 3 from 10 even though their unit of measurement was different). Therefore, the student immediately assumed the model height of train 2 is 10.9 meters. The student got the number by adding seven to train 2 actual size. Here, it can be seen that the student was not able to follow the learning demands of multiplication concept in proportion.

**Figure 2.** Answer of student 2 in problem number 3.

Figure 3 shows problem number five from diagnostic test and the answer from student 3. Here, the students were asked to use the concept of direct proportion to solve algebraic equations. It can be seen that student 3 made a mistake in determining the value of p and q. The student only relied on the logic about the sum pattern of a number that he found out without connecting the concept of direct proportion in a multiplication situation. After being confirmed through the interview, it turned out that the student was confused about the meaning of the table in the problem. The student explained that he
found the pattern of numbers in the row (a) was +3 and in the row (b) was +4. Then, the students discovered that q and p were 12 and 4. However, he thought that the patterns +3 and +4 are the values of q and p respectively. Moreover, student 3 added brackets while trying to solve 3p+q equations even though it was clear that there was no brackets in the problem. The student added the brackets so that the answer obtained was on the list of options. This shows that students were not yet confident in their own abilities and only rely on logic without paying attention to algebraic arithmetic operations and proportion concepts.

Figure 3. Answer of student 3 in problem number 5.

Figure 4 shows similar mistake that another student made because the student misunderstood the concept of proportion with the addition pattern. For instance, as experienced by student 4 in answering question number 6, student 4 also connected the addition pattern in solving the problem of inverse proportion.

Learning obstacles presented above was ontogenic obstacles. According to Suryadi [12], ontogenic obstacle is a learning obstacle that occurs due to a gap in learning demands with the capacity or level of students' cognitive abilities, so that students are not able to participate in learning activity optimally. Based on the ontogenic obstacle found, students were not ready to take part in learning because their
cognitive abilities were not yet able to adapt to the basic concept of ratios, the concept of multiplication in comparison, and the concept of direct proportion in the context of algebraic equations. The process of learning should be done by paying attention to the cognitive abilities of students. Piaget's theory states that learning should focus on students' cognitive development based on biological development or age [16-18].

3.2. Didactical Obstacle
Didactical obstacle experienced by students are found when students have difficulty in solving diagnostic test questions on the number 1, 3, and 6. From the problems discussed in figure 1, it was observed that students experienced learning obstacle on the concept of ratio because the textbook was not clear in presenting the concept of ratio. In addition, the problems presented in figure 2 shows that even though comprehending the meaning of direct proportion, the student still had difficulty in making mathematical modeling. The claimed can be proved by looking at the answer of the student's interview who said that the student forgot the formula explained by the teacher. It shows that there was a mismatch of the learning process with students’ need. Students was not facilitated to understand the concepts actively and independently, and they only remembered the procedures exemplified by the teacher.

Figure 5 shows that students were asked to solve non-routine problems about the inverse proportion material, and there are answers from student 5. It can be seen that student 5 misunderstood the meaning of the questions. After being interviewed, the student admitted to remember and follow the explanation that the teacher has delivered. However, this question asked how many students had to be added where the problems given by the teacher asked the number of students in total. This occurrence means that the learning did not facilitate students to understand the concept actively and independently even though learning should be a student-centered. According to Bruner's discovery learning theory, learning process will be meaningful if it is carried out in a way that students actively make discoveries by themselves because the knowledge obtained from their own findings will last a long time [19].

The learning obstacle previously discussed is a didactical obstacle. According to Suryadi [12] didactical obstacle is a learning obstacle that occurs due to a mismatch between the stages of presenting the material in the learning process and the stages of students’ needs. It means that students have not been able to participate in learning activities optimally because the stages of the material presented in the textbooks and the material delivered by the have not been according to student needs. Therefore, in making didactical design, a teacher is required to review the content of the material by positioning himself as a student so that the stages of presenting the material are in accordance with the students’ needs.
3.3. Epistemological Obstacle

Epistemological obstacle experienced by students were found when students had difficulty in solving diagnostic test questions on the number 3, 4, 5, and 6. Figure 6 shows problem 4 from the diagnostic test and the answer from student 6. In this number, students were asked to determine the graph that described the problem of inverse proportion material. The explanation given by student 6 actually shows that he was able to draw graphs, but when used in the concept of inverse proportion, student 6 experienced a misunderstanding in determining the (x,y). Likewise in Figure 2, Figure 3 and Figure 5, students were not able to use the concept of direct and inverse proportion in other context or concepts, such as drawing graphs, algebraic equations, and non-routine questions. When being interviewed, the student showed that he understood the concept of direct and inverse proportion, marked by the student’s ability to notice the changes between quantities, but the student faced difficulty when the problems were linked to other concepts or were presented in non-routine problems.

![Figure 6. Answer of student 6 in problem number 4.](image)

Learning obstacle above is an epistemological obstacle as Suryadi [12] states that epistemological obstacle is a learning obstacle that occurs due to the limited understanding of students who only understand a concept in certain contexts. It means that students have not been able to participate in learning activities optimally because of the limitations of students’ relational understanding. Students have the knowledge of a concept, but can only apply it well in certain contexts, and cannot operate the concept if it is presented in other contexts. Skemp [20] states that relational understanding is a complex and interconnected knowledge structure used in solving mathematical problems. Therefore, didactical design must facilitate diverse contexts based on the relationship between concepts.

4. Conclusion

According to the results of the study, it can be stated that the sample students experienced learning obstacles in direct and inverse proportion, namely (a) ontogenic obstacle: students are hampered by their inability to follow the learning demands on the basic concept of ratio, multiplicative concept in proportion, and direct proportion concept on algebraic equations; (b) didactical obstacle: students are hampered by the presentation of ratio material is incomplete, the presentation of proportion material at mathematical modeling stage is not considered well, and the presentation of proportion material does not facilitate student-centered learning; (c) epistemological obstacle: students are hampered by their inability to use direct and inverse proportion concept in the context of graphs, algebraic equations, and non-routine questions. This study might be used as a reference for developing a more optimal didactical design. It is hoped that there will be further research regarding the development of didactical design in direct and inverse proportion that might minimize student learning obstacles.

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