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Analyzing students’ errors on fractions in the number line

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Abstract. The objectives of this study are to know the type of student’s errors when they deal with fractions on the number line. This study used qualitative with a descriptive method, and involved 31 sixth grade students at one of the primary schools in Purwakarta, Indonesia. The results of this study are as follow, there are four types of student’s errors: unit confusion, tick mark interpretation error, partitioning and unpartitioning error, and estimation error. We recommend that teachers should: strengthen unit understanding to the students when studying fractions, make students understand about tick mark interpretation, remind student of the importance of partitioning and un-partitioning strategy and teaches effective estimation strategies.

1. Introduction
Number line representation is an importance model for teaching and learning fractions. Base on the Mathematics Standards 2016 for Elementary School Grade 3 [1], there is a basic competency 3.2 and 4.2: “Explain the whole number and simple fractions (such as $\frac{1}{2}$, $\frac{1}{3}$ and $\frac{1}{4}$ ) that presented on the number line and using simple whole number and fractions (such as $\frac{1}{2}$, $\frac{1}{3}$, and $\frac{1}{4}$ ) that presented on the number line; recognize that fractions can be used to represent parts of a whole, parts of a set, points on a number line, or distances on a number line”. Therefore, it is an important point for teachers to (a) acquire theoretical and practical skills and knowledge on teaching and learning fraction on the number line, (b) to understand how students think as they solve number line tasks, and (c) be aware of students’ misunderstanding about fractions on the number line. Based on the importance of this topic, the research problem is how the types of students’ errors when they deal with fractions on the number line.

In the area of fractions on the number line, some researchers explained the importance of number line representation for teaching and learning fraction. First, Riccomini [2] stated two instructional recommendations for better results in teaching fractions, using a number line and using multiple representations. Second, Wyberg et al [3] found that a piece of paper (paper folding) and number line can help students understand an important algorithm in the area of fraction multiplication. Third, Bright et al [4] found that there are two difficulties for students in the area of fractions on the number line: (1) un-partitioning number line; (2) associating symbols with representations, and may depend on an understanding of the un-partitioning process. The authors stated that two possible teaching techniques seem to arise from their research. First, multiple number line representations of a single fraction may be presented. Second, number lines with different subdivisions might be matched and
then labeled. Finally, another researcher, Hannula [5] stated that students’ understanding of fraction develops importantly from the fifth grade to the seventh grade. He also stated that part whole aspect is dominant in students’ thinking, and students have difficulties in perceiving a fraction as a number on a number line even on the seventh grade.

2. Methods
This research used the qualitative approach. The approach used in this research is more emphasis on interpretative study for data analysis. The data collection conducted through observation, interview, media/recording, document analysis and paper and pencil measure; for the data analysis, this research used grounded theory, with coding and constant comparison technique [6]. The respondents are students in the Public Elementary School X, Purwakarta, in the first semester of 2016/2017 school year. The majority of students in the schools are from average income family. The students’ curriculum is 2013 Curriculum text. The subjects of this study are 31 sixth grade students, students who represent the error on each topic is used as a research subject.

There are ten questions in the paper and pencil measure. Each question had four choices, with eight questions having the choice of “other” which allowed students to enter their own number for those questions. Also, students were asked to give an explanation of why they chose the answer.

3. Result and Discussion

3.1. Percent correct per each item
The following chart represents the percent correct per each item in the paper and pencil measure:

![Figure 1. The percent correct per each item](image)

For question number 1 and 2, no one can answer these questions correctly. In our opinion, this happens because students did not understand the concept of unit and partition.
Figure 2. Item number 1

For question number 1, if students understand the partitioning concept, the second tick mark is a half. Thus, the answer must be between \( \frac{1}{2} \) and \( \frac{3}{4} \).

Figure 3. Item number 2

For question number 2, if students understand the partitioning concept, the third tick mark is a half. Thus, the answer must be more than \( \frac{1}{2} \).

Figure 4. Item number 3

For question number 3, 58% of the students can answer this question correctly. In our opinion, more than half of students can answer this question correctly because the problem is equivalent to their thinking about counting the tick marks. Firstly, students can add two tick marks on the number line, and then count those tick marks. This question does not need students to understand the unit, they just count the tick mark and get the solution.
For question number 4 and 8, only 13% of students can solve these problems. It is less than a quarter of the total students. In our opinion, if the students do not understand the unit concept then they will not get the correct answer to these problems.
Question number 5 and 10 is the highest result in this test, 71% of students can answer this question correctly. In our opinion, many students can answer this question correctly because the problem is equivalent to their thinking about counting the tick marks. These questions do not need students to understand the unit, they just count the tick mark and get the solution.

For question number 6, 42% of students can answer this question correctly. In our opinion, students who understand the concept of partitioning will correctly answer this question.

For question number 7, only 23% of students can answer this question correctly. In our opinion, students who understand the concept of a unit will correctly answer this question.
For question number 9, only 3% of students can answer this question correctly. If students can interpret the tick mark correctly, the dot is $\frac{6}{10}$. Thus, the answer must be $\frac{3}{5}$.

3.2. Analysis of students’ errors
In this section, we will focus on analyzing four types of students’ errors, that are unit confusion, tick mark interpretation error, partitioning and un partitioning, and estimation error.

3.2.1 Unit Confusion. Unit understanding is very important in studying fractions on a number line; because it is the basis for understanding the value of fractions. In our result, students had difficulty in understanding unit size. For example, see the answer of one student:

The student gave answer $\frac{7}{8}$, assuming that the unit size is 1, he did not realize that the number on the right is 2. Thus, student misunderstands what the unit or he did not consider what the unit on the number line test. From this result, teachers should strengthen unit understanding to the students when studying fractions on the number line. This result is in line with NCTM [7] recommendation that the concept of a unit is fundamental to the interpretation of rational number.

3.2.2 Tick Mark Interpretation. The most common error on the question number six was the tick mark error in which students counted all the tick marks on the number line and then reasoned that the dot was between the 2 and the 3 tick marks, therefore the answer must be $\frac{2}{3}$. Here is the answer of one student:
Here, the student gave answer $\frac{2}{3}$, by calculating the tick mark from the left, he did not realize that $\frac{2}{3}$ is more than $\frac{3}{4}$ (number on the right). Thus, the student makes tick mark interpretation error.

3.2.3 Partitioning and un-partitioning. The student can make, named and renamed fraction by partitioning. By partitioning, the student can create their own fraction diagrams and representation on a number line. The strategies are halving or the third. In the picture below, the student ignores equal partitions. If the student made a halving partitioning strategy, the dot must be more than $\frac{3}{4}$.

Unfortunately, the student gave answer $\frac{3}{4}$, by calculating the tick mark from the left, he did not realize that there is an equal partition. Thus, the student ignores equal partitions. In line with this result, Siemon [8] stated that the key to formalize fraction concept is the partition.

3.2.4 Estimation Error. By estimating, the student can grasp the gist of the fraction. For the general answer, estimations are helpful. In the picture below, the student can estimate that $B$ is $\frac{1}{6}$; because the first tick mark is $\frac{1}{5}$.
Figure 15. Example of estimation error.

The student gave no answer, he did not realize that there was a letter B before \( \frac{1}{5} \), which can be estimated as \( \frac{1}{6} \).

4. Conclusion
Based on the result and discussion, we can conclude that there are four types of student’s error when they deal with fractions on the number line. The first error is unit confusion, the second error is tick mark interpretation, the third error is partitioning and un partitioning, and the fourth error is estimation error.

All these errors are a manifestation of the students’ way of thinking when studying fractions on the number line. Based on the results, we recommend that teachers should: (1) strengthen unit understanding to the students when studying fractions; (2) make students understand about tick mark interpretation; (3) Remind student of the importance of partitioning and un partitioning strategy; and (4) teaches effective estimation strategies.

5. References
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