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DEVELOPING STUDENT LEARNING MATERIALS ON THE MULTIPLICATION FRACTIONS FOR GRADE FIVE WITH REALISTIC MATHEMATICS EDUCATION

Hongki Julie
Sanata Dharma University
hongkijulie@yahoo.co.id

Abstract

Lortie-Forgues, Tian and Siegel (2015) suggests that students' understanding of the fractions was very important in the study of mathematics further and was also used in many professions, but according to Lortie-Forgues, Tian and Siegle (2015) and MA (1999), many students had great difficulty in understanding it. Furthermore, according to Ma (1999), the difficulty was not only the difficulties experienced by students in learning fractions, but also the difficulties experienced teachers to teach the concept of fraction.It was felt by teacher at one of the private elementary school in Yogyakarta, especially in teaching multiplication on fraction.The goals of this study were (1) to build a context that can be used to introduce the meaning of multiplication of two fractions and establish procedures multiply two fractions, (2) to describe the learning path by using the context, and (3) to describe the development of learning outcomes achieved by students. There were two contexts used by the researchers in this study that werebuyingthe ribbon and giving oranges. Lesson plans created by the researcher were for students of grade five. This type of research used by the researcher in this study was the design research developed by Gravemeijer and Cobb. According Gravemeijer and Cobb (in Akker, Gravemeijer, McKeney, and Nieveen, 2006) there were three phases in the research development, namely (1) the preparation of thedesign, (2) testing the design, and (3) the retrospective analysis.

Key Words:*the multiplication of fractions, realistic mathematics education (RME), and design research.*

INTRODUCTION

In 2013 and 2014, the researcher developed some context and sequence of learning that could be used to teach the fractional multiplication in gradefiveof the elementary school. From the experience of two years, the researcher wanted to develop other contexts that would be used to teach the multiplication of the fraction in gradefiveof the elementary school. In this year, the researcher had the opportunity to develop and provide contextsabout buyingthe ribbon, and giving oranges. The researcher also got the opportunity to pilot the lesson plan in one class on grade five in a private elementary school in Yogyakarta.

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1. According to Lamon (2001, in Ayunika, 2012), the development of understanding of the meaning of fractions in the teaching-learning process was a complex process because the concept of fraction had a number of interpretations, namely (1) fraction as a part of the

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1. According to Lamon (2001, in Ayunika, 2012), the development of understanding of the meaning of fractions in the teaching-learning process was a complex process because the concept of fraction had a number of interpretations, namely (1) fraction as a part of the

whole, (2) fraction as the result of a measurement, (3) fraction as an operator, (4) fraction as a quotient, and (5) fraction as a ratio.
2. According to Ross and Case (1999 in Shanty, 2011), on the process of learning fractions, teachers often emphasize on how to do the operation procedure than on the meaning of the operation.
3. StafylidoudanVosniadou (2004 in in Shanty, 2011) states that one of the reasons why the idea of mathematical fractions were systematically misinterpreted by students was an inconsistency with the principles of arithmetic used in operations involving natural numbers. For example in the operation of multiplication of natural numbers, if the two natural numbers multiplied, then the multiplicative result was a natural number greater than or equal to two natural numbers are multiplied. It was not always the case if the two fractions multiplied.
4. AccordingStreefland (1991), in many textbooks the instruction of fractions were characterized by:
   a. Towards the concept of fraction.
   b. There were not meaningful contexts both as sources and domains for the application of fractions.
   c. The isolated use of models and patterns, which never extends to serve the process of algorithmization or mathematization.
   d. There were not connections with mathematically domains, such as decimal fractions, ratios, scale, and percentages (Vergnaud, 1981).
   e. Towards the algorithms.

There werethreequestionsthatwillanswerin this paper, namely(1) what the contextsthat could be usedtointroducethe meaningof the multiplication of twofractions?, (2) how to usethese contexts to constructthe student's understandingabout the meaningof the multiplication twofractions, and (3) how the development of learning outcomes achieved by students?

THEORETICAL FRAMEWORK

The philosophy of RME was mathematics as a human activity, which means that the learning process of mathematics first of all should not be connected with mathematics as a deductive system that was well organized and formal, but it should be connected with mathematics as a human activity (Freudenthal, 1971, 1973, in Gravemeijer, 1994). If the mathematics which was learned by the student was connected with a formal deductive system, then the student would view that mathematics was resulted by the human thinking; it was an abstract and was not related to real-life. So, they will think that they could not find mathematics and using mathematics in their life. Learning mathematics should be able to make the students thought that there was mathematics in human activities, and it was be used by them in real life.

There were four main principles in the RME (Gravemeijer, 1991 and 1994, Treffers, 1991, and Julie, 2014), namely:
1. Guided reinvention;
2. The progressive mathematizing;
3. Didactical phenomenology;
4. Self-developed models.

RESEARCH METHODOLOGY

The approach used to develop the students' learning materials and the teacher giude in this research activity was RME. This type of research that was used by the researcher in this study

was the design research with three cycles. Things that were presented in this paper what was done by the researcher and what comes out of the third cycle. The data analysis was conducted by video data and the student's work. The steps undertaken by the researcher followed the phases in the development research were developed by Gravemeijer and Cobb.

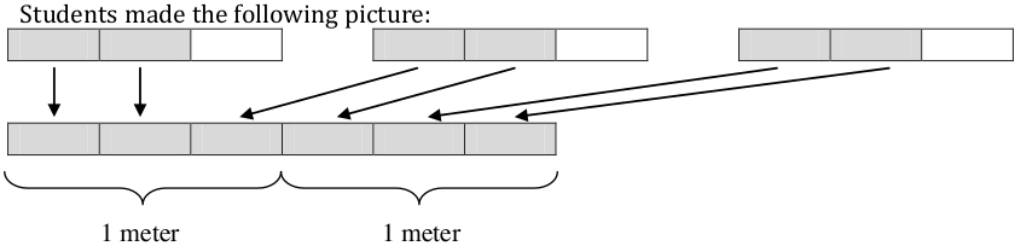
RESULTS

The research results presented in this paper were limited by the researcher on the third cycle. The aims of the design that was made by the researcher were that students could know about the meaning of multiplication of two fractions and the fractional multiplictation procedure. Before students experienced learning process designed by the researcher, students have learned about fractions in grade four, namely (1) the meaning of fractions, (2) the ordering of fractions, (3) the simplfying of fractions, and (4) the additing and subtracting of fractions. The problemsweregiven to studentsinspiredbythe problems that existin the book thatwritten by Fosnot, andDolk (2002) and the teacher' idea who taught the students in grade five.

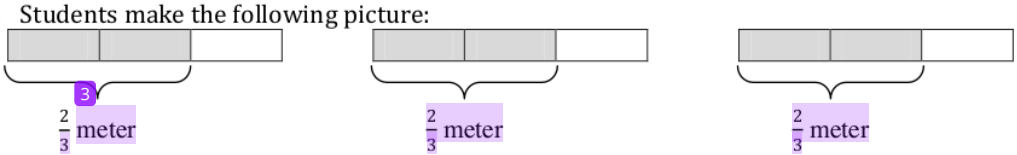
Here was presented problems that were given to students, a possible answer to such problems, learning path, and the student' answers:

1. **The problem was given to students:**
   Kiki needed 3 pieces of ribbon for the gift decoration.
   The length of each ribbon was needed Kiki is $\frac{2}{3}$ meter.
   To fulfillthe needs of a ribbon, Kiki would purchase the ribbon.
   How many meters of ribbon were to be purchased by Kiki?

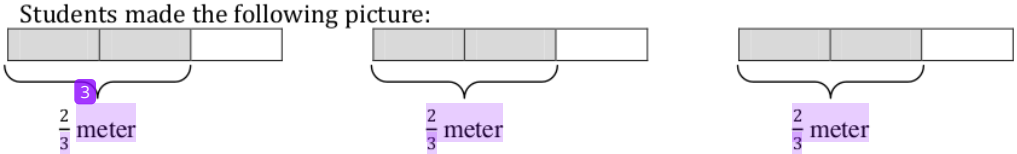
   Possible answers for the problem:
   a. Students made the following picture:



   Thus, the length of the ribbon that needed to be purchased by Kiki was 2 meters.
   b. Students make the following picture:



   Students then made the following calculations: $\frac{2}{3}+\frac{2}{3}+\frac{2}{3}=\frac{2+2+2}{3}=\frac{6}{3}=2.$
   Thus, the length of the ribbon that needed to be purchased by Kiki was 2 meters.
   c. Students made the following picture:



   Students then made the following calculations: $\frac{2}{3}+\frac{2}{3}+\frac{2}{3}=3\times\frac{2}{3}=\frac{3\times2}{3}=\frac{6}{3}=2.$
   Thus, the length of the ribbon that needed to be purchased by Kiki was 2 meters.

d. Students made the following calculations: $\frac{2}{3}+\frac{2}{3}+\frac{2}{3}=\frac{2+2+2}{3}=\frac{6}{3}=2.$
e. Students made the following calculations: $\frac{2}{3}+\frac{2}{3}+\frac{2}{3}=3\times\frac{2}{3}=\frac{3\times2}{3}=\frac{6}{3}=2$
f. Students made the following calculations: $3\times\frac{2}{3}=\frac{3\times2}{3}=\frac{6}{3}=2.$

The path of the teaching and learning process:

a. Students formed discussion groups consisting of 2-3 students.
b. Students were required to discuss how to solve the problem of Kiki and wrote the results of their discussions on the poster paper.
c. When students did group discussion, a teacherobserved how students solved the problem. If a student was having problems, the teacher could help students. Help teachers can be accomplished by (1) asking the students to describe the threepiecesof ribbon that will be purchased by Kiki, (2) provided guiding questions, for example: how to add fractions same denominator ?, how to write $\frac{2}{3}+\frac{2}{3}+\frac{2}{3}$in the form of multiplication?, etc..
d. After all the groups complete the discussion, ask two or three groups who have different strategies to present the results of group discussions.
e. Make a class discussion. Bring the discussions that the students came to the conclusion that in order to obtain the result of multiplying an integer by a fraction could be done by multiplying integers with the fractional numerator, and then divided by the fractional denominator.

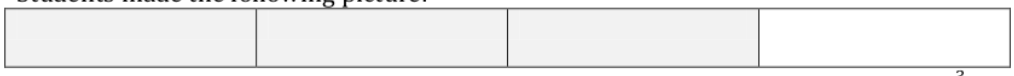
Answer made by students: from 6 possible answers, there were only 5 emerging, namely the possibility of b, c, d, e, and f.

2. **The problem was given to students:**

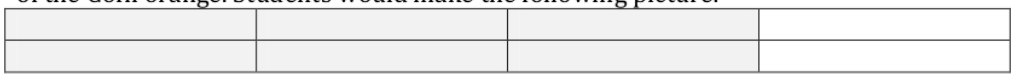
Gofil had$\frac{3}{4}$ kg of oranges.
Gofil gave half part of oranges owned to Berto.
How many kg of oranges would be given by Gofil to Berto?

Possible answers for the problem:

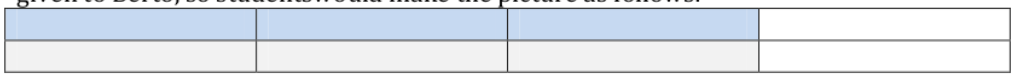
a. Students made the following picture:



The gray shaded area was the heavy ofthe orangethat owned by Gofil, ie$\frac{3}{4}$kg. Then, students shorethe Gofil' orange into two equal parts. Students would get half part of the Gofil'orange. Students would make the following picture:

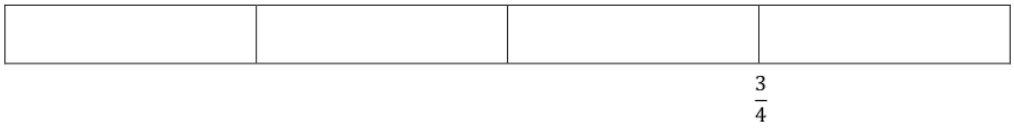


Then, students shaded with different colour to show the half part of the Gofil's orange given to Berto, so studentswould make the picture as follows:



1) The blue shade indicatedthe area of the Gofil'orange given to Berto, that is equal to $\frac{3}{8}$kg. Because there were 3 blue shade parts of 8 parts of a whole.
2) The blue shade indicatedthe area of the Gofil'orange given to Berto, that is equal to$\frac{1}{2}$part of$\frac{3}{4}=\frac{3}{8}$kg.Because there were 3 blue shade parts of 8 parts of a whole.

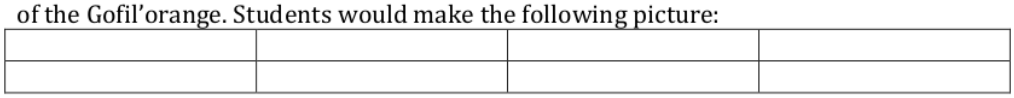
b. Students made the following picture:



$\frac{3}{4}$

Students annotate the boundary area thatshowed$\frac{3}{4}$, so the weight of the Gofil' orange was represented by the left area of the boundary.

Then, students shore the Gofil' orange into two equal parts. Students would get half part of the Gofil'orange. Students would make the following picture:

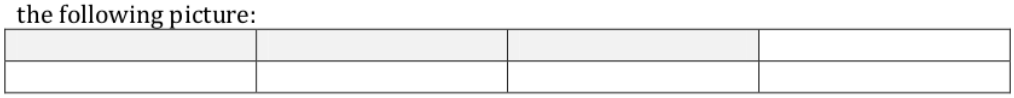


$\frac{1}{2}$

$\frac{3}{4}$

Students annotate the boundary area thatshowed$\frac{1}{2}$ part of $\frac{3}{4}$ kg, sohalf of the Gofil 'orange weight was represented by the upper area of the boundary.

Then, students shaded to indicate the area of Gofil'orange given to Berto, as shown in the following picture:



$\frac{1}{2}$

$\frac{3}{4}$

1) The gray shade indicatedthe areas of Gofil'orange given to Berto, that is equal to $\frac{3}{8}$kg. Because there were three blue shade parts of eight parts of a whole.
2) The gray shade indicatedthe areas of Gofil'orange given to Berto, that is equal to $\frac{1}{2}$part of$\frac{3}{4} = \frac{3}{8}$kg. Because there were 3 blue shade parts of 8 parts of a whole.

The path of the teaching and learning process:

a. Students formed discussion groups consisting of 2-3 students.
b. Students were required to discuss how to solve the Gofil problem and wrote the results of their discussions on poster paper.
c. When students did group discussion, a teacher observed how students solve the problem. If a student was having trouble, the teacher could help the student. Help teachers could be accomplished by (1) asking the students to make a picture that describedthe Gofil'orange. After that, the teacher asked the students to describe half part of the Gofil'orange. Then the teacher asked to students, how many kg of oranges given Gofil to Berto?; (2) providing the guided questions and orders, for example: how many kg Gofil'orange?; please, try to drawthe Gofil'orange heavy, how many part of the Gofil'orange given to Berto?;please, try to draw the Gofil'orange given to Berto; how many kg of orange given by Gofil to Berto?, etc.
d. After all the groups completed the discussion, the teacher asked one or two groups who had different strategies to present the results of group discussions.
e. The teacher explains to the students that $\frac{1}{2}$ part of $\frac{3}{4}$ could be written as $\frac{1}{2} \times \frac{3}{4}$. Thus, we would obtained $\frac{1}{2}$ part of $\frac{3}{4} = \frac{1}{2} \times \frac{3}{4} = \frac{3}{8}$.
f. Bring the discussions that the students came to the conclusion that in order to obtain the result of multiplying two fractions could be done by multiplying both the numerator of the fraction and the denominator of the two fractions. In this case, we would obtain$\frac{1}{2} \times \frac{3}{4} = \frac{1 \times 3}{2 \times 4} = \frac{3}{8}$.

Answer made by students:the four possible answers appear in the results of the student discussion.

3. **The problem was given to students:**Find the widest part of A!

A	

...

Possible answers for the problem:

a. Students completed the picture and fill in the empty spots in order to obtain the following picture:

$\frac{1}{3}$ A	
$\frac{1}{2}$	

b. Students calculated, the widest part of A = $\frac{1}{3}$ part of $\frac{1}{2} = \frac{1}{6}$.
Becausethere wasone gray shade part of six parts of a whole.

c. Students calculated, the widest part of A = $\frac{1}{3}$ part of $\frac{1}{2} = \frac{1}{3} \times \frac{1}{2} = \frac{1 \times 1}{3 \times 2} = \frac{1}{6}$.

d. Students calculated, the widest part of A = $\frac{1}{3} \times \frac{1}{2} = \frac{1 \times 1}{3 \times 2} = \frac{1}{6}$.

The path of the teaching and learning process:

a. Students were required to solve the problem of seeking the widest part A individually.

b. When students solved the area problem, the teacherobserved how students solve the problem. If a student was having trouble, the teacher couldhelp students. Help teachers could be accomplished by (1) asking questions so that students completed the picture that were in the problem such the students could get the picture which would like in the posibility student' answer, (2) asking students to fill spots still vacant in the picture. If students had difficulty filling in the blanks, then the teacher could help students by providing guided questions, for example: pay attention to the process of sharing large rectangle using the lines of the vertical, how many parts were formed by the division of a rectangle using the vertical line.

c. Two or three students who have different answers asked by the teacher to present the results of its work.

d. Make a class discussion. Remind students about the results of previous class discussions could be concluded that multiplying two fractions could be done by multiplying both the numerator of the two fractions and the denominator of the two fractions. Navigate the discussion so that students could conclude that the widest part A was $\frac{1}{3}$ part of $\frac{1}{2} = \frac{1}{3} \times \frac{1}{2} = \frac{1 \times 1}{3 \times 2} = \frac{1}{6}$.

e. Directed students so that they could conclude again that to obtain the result of multiplying two fractions could be done by multiplying both the numerator of the two fractions and multiplying the denominator of the two fractions.

Answer made by students:the three possible answers appear in the results of student work.

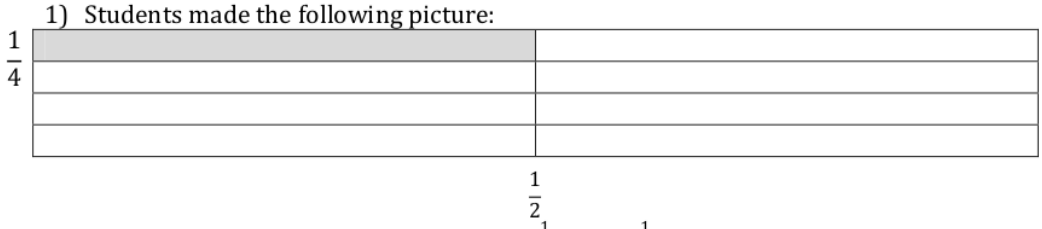
4. **The problem was given to students:**

Use the follow rectangle to illustrate the statement $\frac{1}{4}$ part of $\frac{1}{2}$ and calculate the results.

Possible answers for the problem:

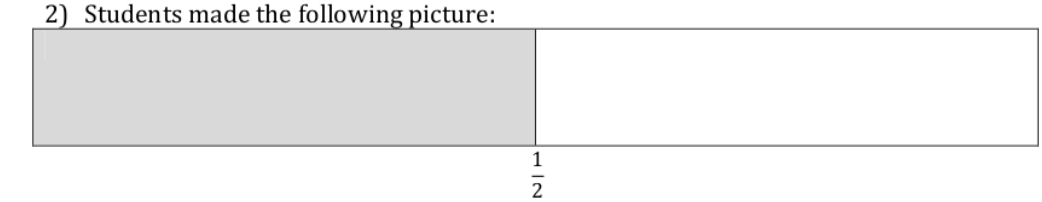
a. The possible answers were made by the student to describe $\frac{1}{4}$ part of $\frac{1}{2}$

1) Students made the following picture:



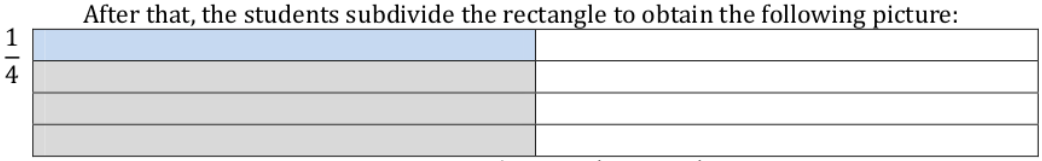
Students stated that the shaded area was $\frac{1}{4}$ part of $\frac{1}{2}$.

2) Students made the following picture:



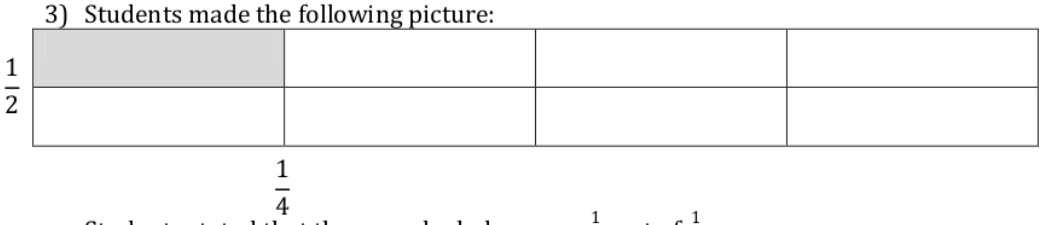
Students stated that the gray area shaded was $\frac{1}{2}$.

After that, the students subdivide the rectangle to obtain the following picture:



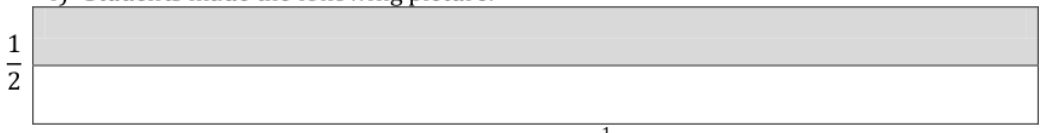
Students stated that the blue shaded area was $\frac{1}{4}$ part of $\frac{1}{2}$.

3) Students made the following picture:



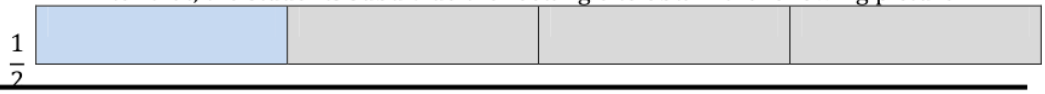
Students stated that the gray shaded area was $\frac{1}{4}$ part of $\frac{1}{2}$.

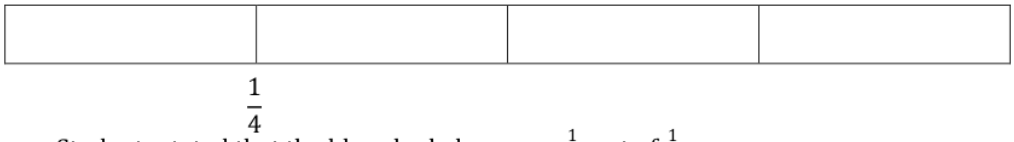
4) Students made the following picture:



Students stated that the gray shaded area was $\frac{1}{2}$.

After that, the students subdivide the rectangle to obtain the following picture:





$\frac{1}{4}$

Students stated that the blue shaded areawas $\frac{1}{4}$ part of $\frac{1}{2}$.

b. Then, to calculate the amount of $\frac{1}{4}$ part of $\frac{1}{2}$,the possibility undertaken by students were as follows:
   1) Studensts answered$\frac{1}{4}$ part of $\frac{1}{2} = \frac{1}{8}$. Because there wasone gray shade parts of 8 parts of a whole.
   2) Students calculated that$\frac{1}{4}$ part of $\frac{1}{2} = \frac{1}{4} \times \frac{1}{2} = \frac{1 \times 1}{4 \times 2} = \frac{1}{8}$.
   3) Students calculated that$\frac{1}{4} \times \frac{1}{2} = \frac{1 \times 1}{4 \times 2} = \frac{1}{8}$.

The path of the teaching and learning process:

a. Students were required to solve the problem of describing and calculating $\frac{1}{4}$ part of $\frac{1}{2}$ individually.
b. When students solvedthis problem, the teacher went around observing how students solve the problem. If a student was having trouble, the teacher could help students. If students had difficulty todescribe $\frac{1}{4}$ part of $\frac{1}{2}$, then the teacher could do so (1) asking the students describe $\frac{1}{2}$on the rectangle that was available; (2) after that, students were asked to write or shading which part of the rectangle which stated $\frac{1}{2}$; and (3) the students were asked to describe the fourth part of the shaded area. If students have difficulty to calculate$\frac{1}{4}$ part of $\frac{1}{2}$, then the teacher could help students by providing guided questions, for example: (1) pay attention to the first division process, how many parts were formed by the division process; (2) pay attention to the second division process, how many parts were formed by the division process; and (3) consider the result of two of divisionprocess, how many parts were formed by the first and second division process.
c. Two or three students who have different answers asked by the teacher to present the results of its work.
d. Make a class discussion. Remind students about the results of previous class discussions could be concluded that to obtain the result of multiplying two fractions could be done by multiplying both the numerator of the two fractions and multiplying the denominator of the two fractions. Navigate the discussion so that students could conclude that $\frac{1}{4}$ part of $\frac{1}{2}$ was$\frac{1}{4} \times \frac{1}{2} = \frac{1 \times 1}{4 \times 2} = \frac{1}{8}$.
e. Directed students so that they could conclude again that to obtain the result of multiplying two fractions could be done by multiplying both the numerator of the two fractions and multiplying the denominator of the two fractions.

Answer made by students:the four possible answers about drawing$\frac{1}{4}$ part of $\frac{1}{2}$andthe three possible answer about calculating $\frac{1}{4}$ part of $\frac{1}{2}$appear in the results of student work.

5. **The problem was given to students:**calculate the follow multiplication $5 \times \frac{3}{7}$.

Possible answers for the problem:

a. $5 \times \frac{3}{7} = \frac{3}{7} + \frac{3}{7} + \frac{3}{7} + \frac{3}{7} + \frac{3}{7} = \frac{3+3+3+3+3}{7} = \frac{15}{7} = 2\frac{1}{7}$.
b. $5 \times \frac{3}{7} = \frac{5 \times 3}{7} = \frac{15}{7} = 2\frac{1}{7}$.

The path of the teaching and learning process:

a. Students were required to calculate $5 \times \frac{3}{7}$.

b. When students did group discussion, a teacher went around observing how students solve the problem. If a student was having trouble, the teacher could help students. The teacher aid process could be done as follows: (1) ask the students to describe or write down what it means $5 \times \frac{3}{7}$., and (2) if the student had not been able to interpret what was the meaning of $5 \times \frac{3}{7}$, then the teacher asked what that means 2 x 3.

c. One or two students who have different answers asked by the teacher to present the results of its work.

d. Make a class discussion. If the student answers that appear only in the first possibility, the teacher could remind about the class discussion results on the previouse meeting, i.e. students conclude that in order to obtain the result of multiplying an integer by a fraction could be done by multiplying integers such as the numerator fractional and divided by the denominator fractional. Navigate the discussion so that students can conclude that $5 \times \frac{3}{7} = \frac{5\times3}{7} = \frac{15}{7} = 2\frac{1}{7}$.

e. Directed students so that they could conclude again that to obtain the result of multiplying an integer by a fraction could be done by multiplying integers with the fractional numerator and divided by the denominator fractional.

Answer made by students:the two possible answers appear in the results of student work.

6. **The problem was given to students:**calculate the follow multiplication $\frac{5}{6} \times \frac{12}{15}$

Possible answers for the problem:

a. $\frac{5}{6} \times \frac{12}{15} = \frac{5\times12}{6\times15} = \frac{60:30}{90:30} = \frac{2}{3}$.

b. $\frac{5}{6} \times \frac{12}{15} = \frac{5}{6} \times \frac{4}{5} = \frac{5\times4}{6\times5} = \frac{20:10}{30:10} = \frac{2}{3}$.

The path of the teaching and learning process:

a. Students were required to calculate $\frac{5}{6} \times \frac{12}{15}$individually.

b. When students solvedthis problem, the teacher went around observing how students solve the problem. If a student was having trouble, the teacher could help students. If the student was difficult to calculate the fractional multiplication, then ask the student to describe what was the meaning of $\frac{5}{6} \times \frac{12}{15}$. If students had difficulty describing $\frac{5}{6} \times \frac{12}{15}$ thatwas interpreted as$\frac{5}{6}$ part of $\frac{12}{15}$, then the teacher could do so (1) asking the students describe $\frac{12}{15}$by using a rectangle; (2) after that, students were asked to write or shadewhich part of the rectangular section that stated$\frac{12}{15}$; and (3) the students were asked to describe the $\frac{5}{6}$part of the shaded area. If students have difficulty calculating $\frac{5}{6}$ part of $\frac{12}{15}$, then the teacher could help students by providing guided questions, for example: (1) pay attention to the first division process of the rectangle, how many parts were formed by the division process; (2) pay attention to the second division process of the rectangle, how many parts were formed by the division process; and (3) consider the result of the first and second division process, how many parts were formed by the division process.

c. Two or three students who had different answers asked by the teacher to present the results of its work.

d. Make a class discussion. Directed students so that they could conclude again that to obtain the result of multiplying two fractions could be done by multiplying both the numerator fractional of the two fractions and multiplying the denominator fractional of the two fractions.

Answer made by students:the two possible answers appear in the results of student work.

CONCLUSIONS

The student learning materials has been tried out on students in the 5th grade at a private elementary school in Yogyakarta. The results of the trial were as follows:

1. Kiki problem could lead students to the conclusion that to obtain the result of multiplying an integer by a fraction could be done by multiplying integers with the fractional numerator and divided by the denominator fractional.
2. Gofil' orange problem could lead students to get the conclusion that to obtain the result of multiplying two fractions could be done by multiplying both the numerator fractional of the two fractions and multiplying the denominator fractional of the two fractions.
3. The problem about calculating$5 \times \frac{3}{7}$ could bestrengthen students' understanding about the meaning and the procedur of multiplication between an integer and a fraction.
4. Problem (a) seek the widest part, (b) describe and calculate the results of the $\frac{1}{4}$part of $\frac{1}{2}$, and (c) calculating $\frac{5}{6} \times \frac{12}{15}$could strengthen students' understanding about the meaning and the procedure of multiplication of two fractions.
5. The context ofthe Kiki' ribbon and the Gofil'orange could help students to construct about (a) the meaning and the procedure of multiplication of an integer and a fraction, and (b) the meaning and the procedure of multiplication of two fractions.

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