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The Implementation of Realistic Mathematics Education (RME) to Support Indonesian 5th-Grade Students to Learn Multiplication and Division

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Abstract

This paper discusses the use of Realistic Mathematics Education (RME) as an alternative approach to enhance Indonesian 5th-grade students' ability in the topics of multiplication and division. The study presents the analysis of Indonesian 5th-grade students' difficulties in applying vertical multiplication and division, that is in reapplying the steps of the method. Furthermore, it describes a mathematics teaching learning practice to stimulate students in constructing their strategies, mathematical models, and number sense in solving mathematical problems that involve multiplication and division. In implementing RME, the steps taken to improve the learning process were: (1) analysing in detail the difficulties of students in vertical multiplication and division, (2) providing contexts of mathematical problems that can stimulate students to think mathematically, (3) holding a class mathematics congress, and (4) conducting a test to measure students' achievement. The implementation of RME has helped the 5th-grade students to improve their ability in multiplication and division. There were more students whose grades passed the minimum passing score. Moreover, there was an increase in the class average test score.

Keywords: RME, 5th-Grade students, multiplication, division, vertical method.

Introduction

Multiplication and division are two numeracy skills learned in primary school. These skills are developed once students have mastered the skills of addition and subtraction, which become initials to learn about multiplication and division. Slavin (2005) argues that multiplication is the sum in a quick way. Meanwhile, Karim et al. (1996) states that multiplication is a repeated sum. Conversely, division can be interpreted as a repeated reduction.

One of algorithms to do multiplication and division is by using vertical method. It is popular worldwide. However, there are some difficulties when children, including Indonesian primary students, applying the procedure. Several researches (Ahmad & Sivasubramaniam, 2010; Hasan, 2012; Rosyadi, 2016) indicate that primary students are dealing with hardship in using vertical multiplication and division because they are confused with the place value in the algorithm. In line with the relevance studies, the difficulty in doing vertical multiplication and division is also confronted by students in SD Bandut, Bantul, Yogyakarta.

The score of mathematics final assessment of grade 5 students in SD Bandut on the first semester were low. Only 2 out of 26 students were able to achieve the mathematics Minimum Passing Score, that is 70. It reflects that there are problems in learning mathematics. One of which was the difficulty in applying vertical multiplication and division to solve problems for calculating speed, water debit, and scale. On the other hand, the 5th-grade students are expected to be proficient in operating the vertical method to solve more complex mathematical problems.

Another problem is about students' perception of mathematics. The 5th-grade students in SD Bandut consider mathematics as a difficult and scary subject. The negative perception influences the development of students' learning (Yusmanita et al., 2018). To bring mathematics closer to students' life, we plan to use suitable mathematical activities that is based on Realistic Mathematics Education (RME) approach. Not only real or related to students' daily life, mathematical activities in RME can also be imagined by students (Van den Heuvel-Panhuizen & Drijvers, 2014).

Mathematical activities in this study focus on contexts. According to Fosnot and Dolk (2001), contexts play an important role to stimulate students to solve mathematical problems. The context of the mathematical activities is designed to enable students to construct their knowledge in mathematics. In addition, the learning context must be able to encourage students to come up with different strategies in solving mathematical problems.

By using contexts, we expect students are encouraged to build their mathematical concepts. Freudenthal (1991) mentioned that RME can encourage students to build their own knowledge by connecting students' prior knowledge related to their experience in the daily life to the mathematical problems. Moreover, mathematics is a human activity to reason about problems so that the solution makes sense.

According to the aforementioned background, we want to determine students' obstacles in applying vertical multiplication and division. Furthermore, we would like to explore the impact of implementing RME to students' ability in multiplication and division.

Methods

The participant of the study was 26 grade 5 students in SD Bandut which consist of 15 boys and 11 girls. There were four inclusive students who had slow learning barriers that require special attention. The study adapted action research as its methodology, which its purpose is to improve the quality of teaching learning practices (Gall et al., 2003). In addition, Creswell (2012) elaborates an action research as follows:

> Action research designs are systematic procedures used by teachers (or other individuals in an educational setting) to gather quantitative and qualitative data to address improvements in their educational setting, their teaching, and the learning of their students. In some action research designs, you seek to address and solve local, practical problems, such as a classroom-discipline issue for a teacher. In other studies, your objective might be to empower, transform, and emancipate individuals in educational settings. (p. 22)

The following are the steps applied in this study:

1. collecting data in the form of students' scores in the pre-test of multiplication and division;
2. analysing students' problems in applying vertical method for multiplication and division;
3. applying RME; and
4. conducting a test to measure the students' achievement.

Results and Discussion

Problems encountered

The following are the difficulties of the 5th-grade students of SD Bandut in operating vertical multiplication and division.

1. Inaccuracy in multiplication

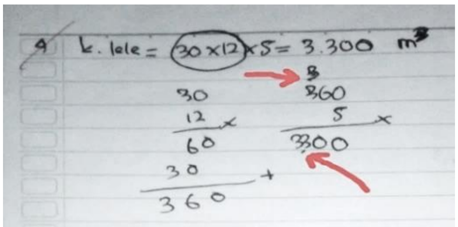

Figure 1. Example of an inaccuracy.

Figure 1 shows a student's solution for a question given: "Mr. Rian made a catfish pond with the size of 12 m length, 5 m width, and 30 m height. What is the pool volume?" Solving the problem above involves multiplication of three numbers: 30, 12, and 5. The student did 30×12. The result was accurate, 360. However, the multiplication did not require a carrying step. The next multiplication was 360×5. At this stage, the student seemed to have difficulty with the multiplication of 5×3 plus the carried number, 3. The result should be 18 but it became 33. Thus, final result was inaccurate.

2. Incorrect in arranging the results of multiplication

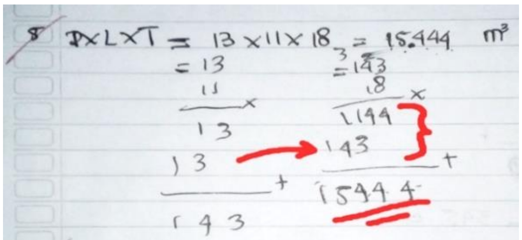

Figure 2. Answer lines arrangement.

The question of the solution illustrated in Figure 2 is "A cuboid water reservoir is 13 meters length, 11 meters width, and 18 meters height. What is the volume?" The problem was solved by multiplying 13, 11, and 18. For 13×11, the student did not experience difficulties in finding the accurate result, 143. The next step was to multiply 143 by 18. Here, the student found difficulty in arranging the results of multiplication of 143×8 and 143×1. The results of the multiplications are 1,144 and 143. In writing the result, the student should have only shifted 143 to larger number place. Regarding the multiplication of 143×1, the number value of 1 is tens place. Therefore, there must be only one 0 put behind 143. However, the student put 00 which made the addition of the two answer lines inaccurate.

3. Students do not understand under what condition they need to carry the number

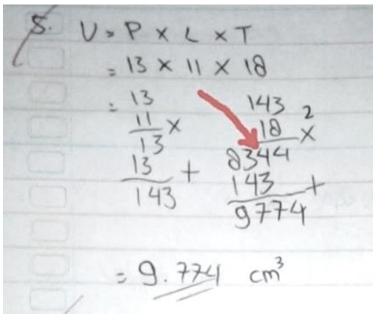

Figure 3. The carrying step.

In the multiplication shown in Figure 3, the student solved 13 × 11 × 18 with inaccurate results. The reason was the mistake in doing the second multiplication, 143 × 18. The multiplication began by multiplying 8 to 3 with a result of 24. The student wrote digit 4 and carried 2. Next, the student multiplied 8 by 4 with the result of 32. The student added 32 with 2 as the carried number and the result was 34. Student should have written 4 and carried 3 because there was another multiplication, 8 × 1. However, the student wrote 34, which became error in result because it was too big.

4. Students forget to do one step multiplication

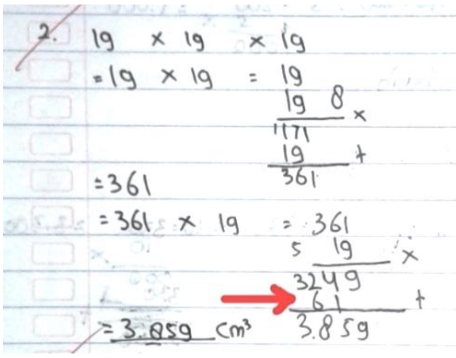

Figure 4. The steps of the student.

At the completion of the problem shown in Figure 4, the student had no difficulty in the concept of carrying in multiplication. However, the results of the multiplication became inaccurate because the student made a mistake in the second multiplication of 361 × 19. It was notable because the result was correct. A problem arose when multiplying 361 by 1. The result should have been 361, but it was written 61.

5. Students have difficulty in operating vertical division with 0 remainder

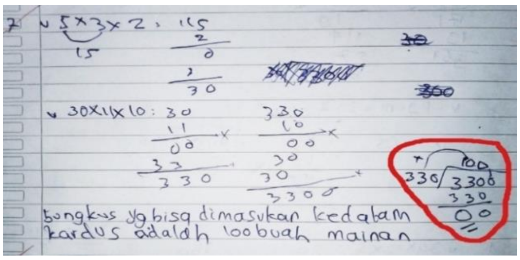

Figure 5. Remainder of 0.

Figure 5 shows the student's solution to the question: "Cuboid toy packages with the length of 5 cm, the width of 3 cm, and the height of 2 cm will be put into a big cuboid with 30 cm length, 11 cm width, and 10 cm height. Count how many packages of toys can get into the big cuboid?" In solving the problem, the student calculated the big and small cuboid volumes through multiplication. The results of these multiplications were accurate: 3,300 cm^3 and 330 cm^3.

The next step was to divide 3,300 by 330 to find out how many toy packages could fit into the big cuboid. Multiplication with these numbers is easy if the student knew that $3{,}300 : 330$ is equal to 330×10. On the other hand, the student used the vertical division by initially dividing 330 by 330 with 1 as the result. The student subtracted 330 with 330, and the result is 0. The problem arose when there was 0 left over to divide. After bringing a copy down, the remainder became 00. The student copied the remainder 00 behind 1, so that the final result was 100.

6. Students' steps were inaccurate in division

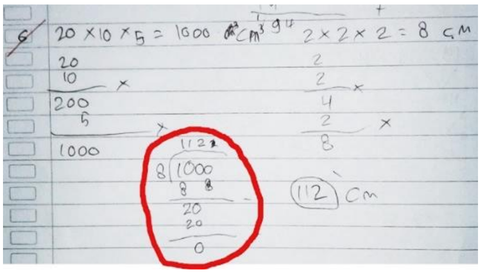

Figure 6. The student's accuracy in division.

As seen in Figure 6, the student divided 1,000 by 8 with vertical division. The division began with dividing 10 by 8 and resulted with 1 and a remainder of 2. The result 1 was written above, while 2 as the remainder was written below. Then, digit 0 from 1,000 was copied and brought down to change 2 to 20. Next, the student divided 20 by 8. At this stage, an error occurred. He wrote 12 as the result without any remainder. Therefore, according to the student, 1,000 by 8 was 112. This result was inaccurate considering 112×8 is not 1,000.

By knowing the facts above, it can be concluded that the vertical multiplication and division is a difficult arithmetic operation for the 5th-grade students in SD Bandut. The method had been studied for approximately three years. However, many students had not been able to apply the methods properly. The students' difficulties in multiplication were carrying numbers, arranging the answer lines of the multiplication, predicting the result of the division, and working with 0 as a remainder. Thus, the teacher the 5th-grade students in SD Bandut should look for more efficient ways to help students carry out multiplication and division operations.

The Implementation of RME to Help Students in Multiplication and Division

Considering the findings about students' difficulties in applying vertical operations, RME offers solutions. The following are the steps for implementing RME to overcome the multiplication and division difficulties.

a. Using a context for mathematical problems
   Here are contexts given to students:
   1. The context of counting fruits

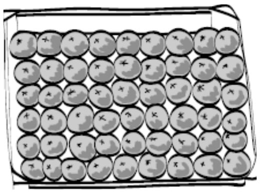

Figure 7. Using the fruit context (Fosnot & Dolk, 2001).

For the 5th-grade students, the context shown in Figure 7 enables them to use multiplication for the rows and the columns to find out the result. In reality, many 5th-grade students in SD Bandut did not memorize the result of 6×9. Many students tried to count one by one. The context was chosen because it is impossible for students to solve the multiplication by using vertical method. To work with the vertical multiplication, two digits are needed for at least one of the given numbers. The fruit context is rich to emerge different strategies. This will lead students to count efficiently. Using the context, students were involved in the discussion of counting the fruits in the picture below:

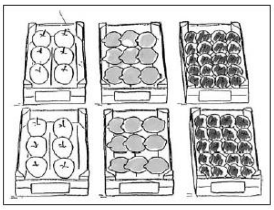

Figure 8. Context of fruit grouping (Fosnot & Dolk, 2001).

The context of the calculation in Figure 8 is intended to stimulate students to do different kinds of grouping. The grouping strategy helps them to calculate a larger number. Therefore, in order to solve 6×9, students are expected to group numbers that make them easy to calculate.

   2. The context of counting cakes

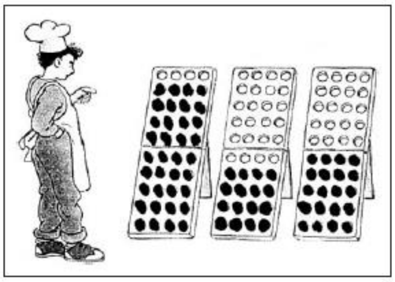

Figure 9. The cake context (Fosnot & Dolk, 2001).

Students were given an additional context about counting cakes as presented in Figure 9. The cakes were placed in two parts: the top and bottom. Each section had the same capacity of 20 cakes. The students were provided with three cakes placed in three separate containers. The first, the second, and the third container contained 36 cakes, 16 cakes, and 20 cakes respectively. Students were expected to be able to find out that 36 is a grouping of 20 plus 16 through the context. Another possibility was that students would be able to find out that 36 is the result of $40 - 4$. This context shows that the use of vertical multiplication is unnecessary. In fact, multiplication can be solved by addition and subtraction. There is no carrying process in the multiplication. Using the context, we can reduce the students' error in doing multiplication.

3. The multiplication with bigger numbers

The activity continued with an investigation of multiplication with a bigger number, that was 16×16. Students were asked to determine the results of the multiplication by using other strategies than the vertical multiplication. They were expected to be able to generalize the method that has been found previously on multiplication 6×9 to solve multiplication 16×16. In this context, students' flexibility to multiplied numbers was developed. Students started to look for efficient ways to solve the problem accurately.

b. The context of division

The first context given to students was the following story: "Fitra Suseno wants to put 28 pieces of cake in plates to prepare for the party. He wants to put 7 pieces of cake on each plate. He wants to know how many plates he needs".

In the above context, students were shown with a simple context about dividing the same amount of food on each plate, which is 7 pieces of cake each. Based on this context, students were expected to be able to understand the meaning of the division by grouping strategy. The context of the story actually involves the division of $28: 7$. However, the completion of the context will lead students to solve the division problem by reducing it repeatedly until it runs out and resulted in 4.

The second context provided was also in the form of a story as follows: "Bandut Primary School will hold a tour. The number of teachers and students is 372 people. The capacity of 1 bus is 50 people. How many buses does the school have to order for accommodating everyone?"

The second context presents more challenges to students because in the second context involves 372 divided by 50 with a remainder. This context helps students develop their logic in the completion. Students were expected to be able to discover the concept of division by breaking 372 into 50s. As the expected results, students got 7 groupings of 50 and the remainder was 22. The next challenge was to reason the number of buses that must be ordered, whether 7 or 8 buses. Thus, we expected the grouping strategy would appear.

c. Math congress in the classroom

Mathematical class congresses were conducted after all students had found their own ways to solve multiplication and division problems. This congress was a presentation from students about the methods they use. Presentation is an important part of RME because students are not only learning to share but also to develop concepts of thoughts and to organize them to be conveyed to others. Students who are presenting must be prepared with all possible questions and answers. It makes students to be able to build deeper knowledge from others. The mathematics congress provides a room for students to discuss the methods they use. and to inspire each other about strategies in multiplication and division.

d. The multiplication and division test

The development of student knowledge was measured by the re-examination of multiplication and division of cube and cuboid volumes. The test results were analysed and compared with the pre-test. The indications of the development of students' abilities can be seen from the increase of the average score and the increase in the number of students who passed the minimum passing score.

Based on the activities that have been carried out with the RME approach, the results of the learning improvement were as follows:

a. The students’ discovery through the context of counting fruits

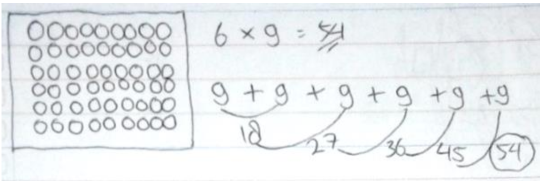

Figure 10. The discovery of the first multiplication model.

The completion found in Figure 10 shows that the student used the repetitive addition strategy to count the fruits in the picture.

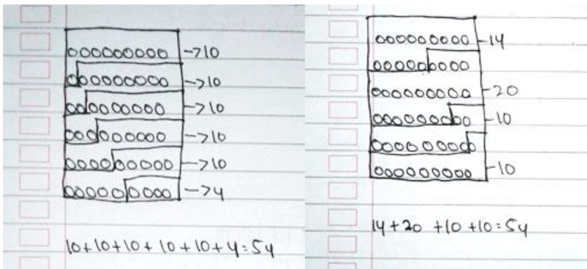

Figure 11. The discovery of the second multiplication model.

Figure 11 presents the strategies used by the student in grouping 10 and 20. The idea was very helpful to facilitate the calculation.

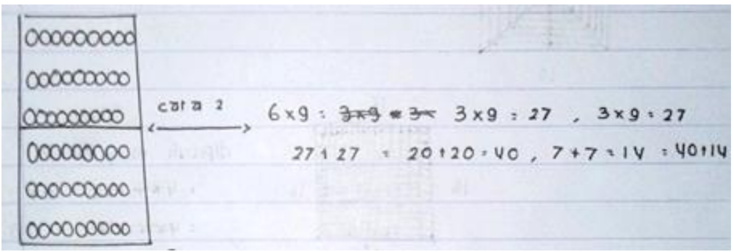

Figure 12. The discovery of the third multiplication model.

In Figure 12, the student used a strategy similar to the previous one. He broke down the 6×9 into 3×9 plus 3×9. The interesting part was at the step of $27 + 27$, the student changed it into $20 + 20$ plus $7 + 7$ to make it easier to add.

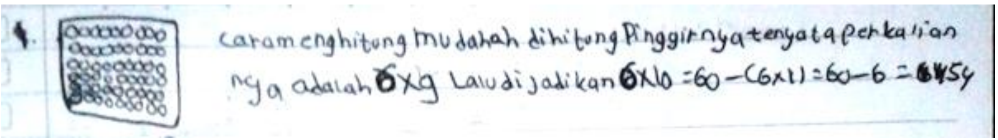

Figure 13. The discovery of the fourth multiplication model.

The strategy used in Figure 13 was interesting because the student changed 6×9 to 6×10. The result of multiplication was 6×10 minus 6×1. It was an elegant strategy because the multiplication 6×9 is close to 6×10. By changing it into 6×10, the multiplication became easier.

After the activity in the context of fruit was finished, students were invited to conduct an investigation with a multiplication of a bigger number, it was 16×16. At this stage, the students were expected to be able to generalize the models that had been developed to solve 9×6. The following are some of the students' findings and their explanations.

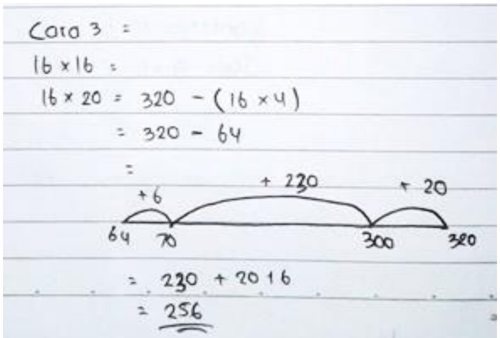

Figure 14. The first multiplication model of 16×16.

As shown in Figure 14, the student changed the multiplication of 16×16 into 16×20 then subtracted it by 16×4. The interesting point was when subtracting 320 by 64, the student used the number line model. Students who used models apparently were able to do multiplication such as 16×20 and 16×4.

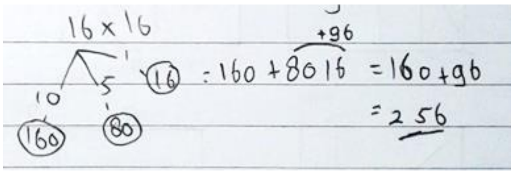

Figure 15. The second multiplication model of 16×16.

The solution presented in Figure 15 was interesting and efficient. The students changed the multiplication of 16×16 to 10×16 plus 5×16 and 1×16. This model helps them to do multiplications. 10×16 is usually easy for students. Meanwhile, the result of 5×16 is half of 10×16. In general, this model is indeed an efficient strategy in solving multiplication.

b. Students' discoveries through the context of calculating plates to hold snacks and ordering buses

The following are students' discoveries and their explanations:

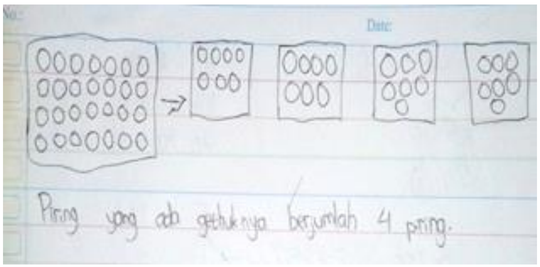

Figure 16. The first strategy in distributing passengers.

As Figure 16 shows, the student drew food groupings with the number in which per group is 7. The result obtained is 4.

Figure 17 illustrates the student's discovery in the bus context which involved $372 : 50$.

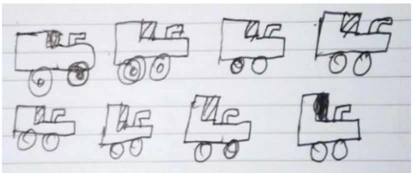

Figure 17. The second strategy in distributing passengers.

In finding the solution, the student drew 8 buses as a result of the division. The model was situational because it used the images mentioned in the context of the given problem. Although the result was correct, the solving model was less efficient because drawing takes more time.

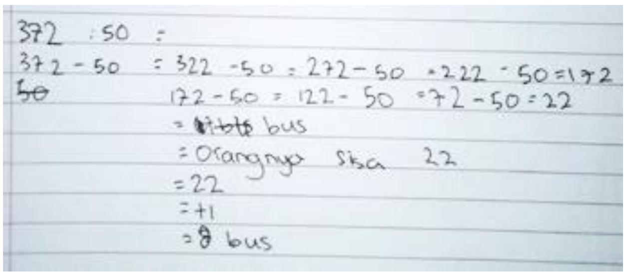

Figure 18. The third strategy in distributing passengers.

The solution shown in Figure 18 used a repeated subtraction with 22 as the remainder. The use of the model was efficient because it only subtracted 50 for 7 times. However, the model was easy for the students who already had mastered the subtraction.

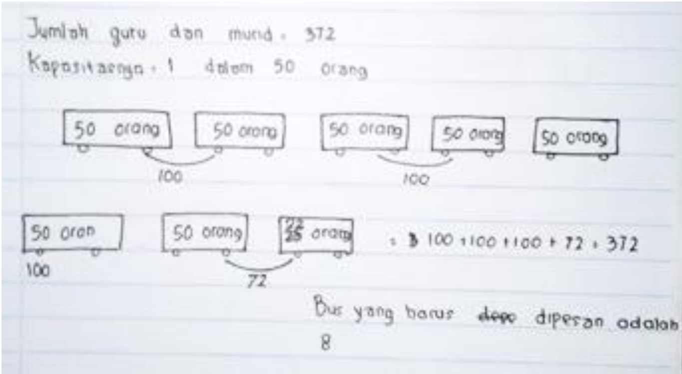

Figure 19. The fourth strategy in distributing passengers.

The solution presented in Figure 19 was done by drawing buses containing 50 passengers each. The passengers were added up to 350. The remainder of 22 passengers were accommodated by an additional bus. Thus, the number of bus that needs to be ordered was 8. The division solution model used repeated addition.

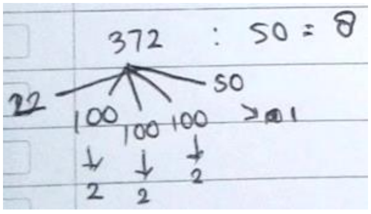

Figure 20. The fifth strategy in distributing passengers.

The solution illustrated in Figure 20 was attractive and efficient. The settlement was done by breaking the division of $372\colon 50$ to three groups of $100\colon 50$ and a group of $50\colon 1$ with a remainder of $22\colon 50$. In the context of booking a bus, the result was 7 plus 1 bus for 22 passengers only.

c. The comparison of the test results before and after RME and its analysis

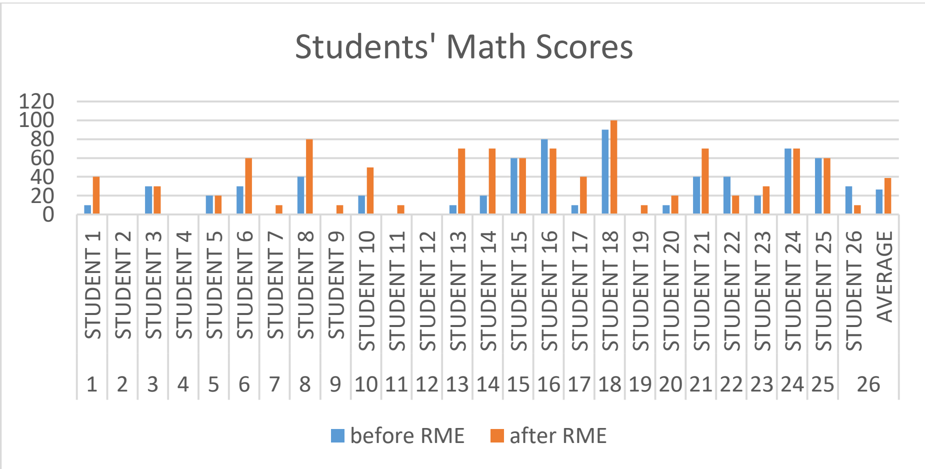

Figure 21. The list of the exam scores.

Figure 21 shows the data for exams before and after the implementation of RME. The data presented are the mathematics test scores of 5th-grade students in SD Bandut in the topic of cube and cuboid volumes. Test 1 was the pre-test that carried out before the implementation of RME. Meanwhile, test 2 was the result of post-test.

Based on the data above, there are some differences that can be seen from the results of exams before and after the implementation RME. In the pre-test, there were three students passing the minimum passing score, that was 70. In the post-test, there were seven students passing the minimum passing score. The highest score in the pre-test was 90, while the highest score in the post-test was 100. There was an increase in the average score, that was 26.54 in the pre-test to 38.85 in the post-test. Moreover, there were less students who scored 0 (from seven students in pre-test to three students in the post-test).

The increase of students' score is related to the chosen mathematical problems that enable students to use different strategies in solving problems. The strategies that students used are the reflection of their prior knowledge. While working on the problems, students relate their strategies to the mathematical concepts, in which influences students' understanding about the topic (Hiebert, 1984). To sum up, the implementation of RME has helped the 5th-grade students of SD Bandut in improving their multiplication and division ability.

Conclusion

Based on the discussion, we conclude that the implementation of RME has been able to improve the ability of the 5th-grade students of SD Bandut in solving multiplication and division problems. Students were given an opportunity to build their own knowledge and to gain a deeper understanding on the concepts of multiplication and division. These affect students to think logically in solving multiplication and division problems and to emerge different strategies other than vertical multiplication and division. All in all, the implementation of RME were able to increase the creativity of the 5th-grade students of SD Bandut in solving multiplication and division problems.

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