Research on Social Arithmetic Design Based on Realistic Mathematic Education (RME) for Junior High Schools

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Abstract— This study was aimed at producing an RME-based social arithmetic learning path to assist the students in figuring out the concepts of profit, loss, break-even, along with the percentage, gross, net, and tare, discount, double discount, and simple interest. This research was a design research that combined the Plomp model with the Gravemeijer & Cobb model, which consisted of 3 stages, namely the experimental preparation stage, the experimental design stage, and the retrospective analysis stage. In the first stage, a Hypothetical Learning Trajectory (HLT) and the student worksheets in the form of student books using the RME approach through literature studies were designed. In the second stage, the HLT trial was carried out on 6 small group students who had different abilities which were categorized on some level such as high abilities, moderate abilities, and low abilities. Furthermore, in the third stage, an analysis of the trial results was carried out and it was found that the overall learning design with the topic of social arithmetic based on the RME approach could be used for learning. Contextual problems given to the students were related with their daily life, thus the cases provided a stimulus to the students in learning mathematics with the topic of social arithmetic. In sum, HLT designed on the topic of social arithmetic based on the RME approach was able to facilitate students in understanding and finding social arithmetic concepts.

Index Terms— Junior High School, Research on Social Arithmetic Design, Realistic Mathematic Education (RME).

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1 INTRODUCTION

Social arithmetic is one of the topics in mathematics learning in grade VII / semester two for junior high school students, which plays an important role in daily life. It is categorized important because the social arithmetic topic discusses things that occur in everyday life, especially in buying and selling activities that occur in both traditional and modern markets (mini markets, malls). Its activities include calculating the selling price, purchasing price, profit, loss, break-even, discount, gross, net, and tare [1].

Up to this point, the social arithmetic topic has been presented in the form of textbooks that tend to be monotonous or mechanistic which is conducted by giving explanations, formulas, sample questions and exercises [2]. The following Figure 1 is an example of presenting social arithmetic concepts in textbooks guided by teachers and students.
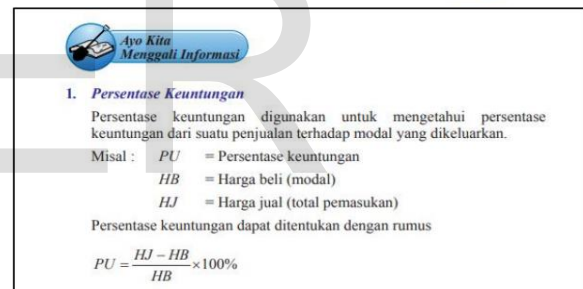

Figure 1. Examples of Social Arithmetic Material Presentation in the Mathematics Book For grade VII in Junior High Scool Regarding Profit Percentages

In Figure 1, it can be seen that the formula for calculating the percentage of profit provided is immediately followed by the examples to show how the formula works. In addition, if a thorough observation is conducted in the learning sequence contained in the handbook, this sequence does not contribute to the learning development of students, especially the development of their mathematical problem solving abilities. Moreover, the available textbooks generally tend to encourage teachers to teach mathematics mechanically and algorithmically [3,4,5].

As a matter of fact, the current handbooks used by the teachers have not facilitated the students in building their knowledge and the books have not helped to develop the meaningful mathematics learning activities. Additionally, students only receive an explanation from the teacher then they are demanded to memorize the formula with the aim that they can carry out the exercises given. Erikssson et al. [6] stated that there are many things that are more important in the learning process than memorizing formulas which will produce a

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higher quality and meaningful learning, such as connecting each case, and emphasizing the relationship between ideas.

Based on the description above, a solution is required to tackle these cases and the solution offered is the RME approach on studying mathematics with the topic of social arithmetic. The advantages of the RME approach are due to several previous studies which showed that LIT had an influence in building mathematical concepts of students [7], [8], [9], [10], [11], [12].

The learning sequence with the RME approach is started by providing contextual issues which can stimulate the students to use informal knowledge and strategies in solving problems [7] because students are directly involved in the contextual problem solving process given so students are not required to memorize the formula. By using the RME approach, it is expected that the learning objectives can be achieved such as meaningful, active, and creative learning.

Based on the designed learning sequence, students are given contextual problems that can be solved using their informal knowledge at the beginning of the lesson. Additionally, contextual problems will also facilitate learners to use their own symbols or strategies and this process is called horizontal mathematics. After experiencing a similar process and being empowered by simplification and formalization [13], students will use language or a more formal strategy in solving contextual problems that will lead students to reinvent formal mathematics called vertical mathematics (14,15,16) .

In sum, the purpose of this study is to design HLT in mathematics learning by implementing the social arithmetic topic with the RME approach in which HLT is designed to be implemented for grade VII students. The arithmetic topic provided is profit, loss, break even, percentage, gross, net, and tare, discount, and simple interest.

2 METHODOLOGY

This research method was a design research by Gravemeijer and Cobb in which it was conducted by designing the learning social arithmetic topics using the RME approach. The implementation of this research was assisted by using instruments in the form of Hypothetical Learning Trajectory (HLT) and student worksheets in the form of student books.

In the preparation stage of the experiment (preparing the experiment), there were several literature studies on the topics used to design HLT. It was aimed at gathering all the data and materials needed to design HLT. The next activity was designing the HLT which was very dynamic in nature so it was able to be revised depending on the trial process.

At the experimental design stage (The Design Experiment), the HLT design was tested in a small group consisting of six students of grade VII 1 in MTsN 2 Pasaman. At this stage, the six students were divided into 2 groups, each group consisted of 3 students who had high, intermediate and low abilities. In fact, the skills of these selected learners varied from high to low abilities.

In the retrospective analysis stage (The Retrospective Analysis), the results of data analysis from the teaching experiment stage were used to develop designs for further learning. In addition, the technique used for collecting data in this re-

search were field notes, video recordings of learning, photo documentation, observations, questionnaires and interviews and the data were collected to describe the implementation of HLT. This design research scheme was illustrated in the following figure:
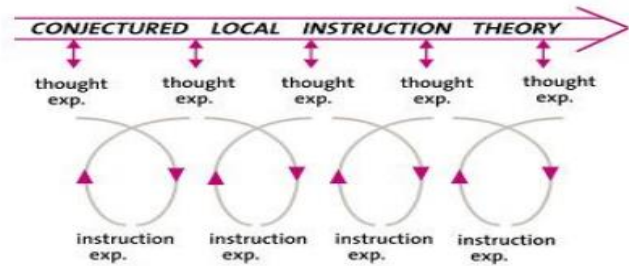

Figure 2. Reflection Correlation between Theory and Experiment

3 RESULTS AND DISCUSSION

a. *Preparing for The Experiment*

This stage was started with a review of the literature on the 2013 curriculum of seventh grade mathematics student book and several research journals. Based on the literature review, the HLT was designed along with the objectives to be achieved.

Table 1. HLT Design

The Activities on the designed HLT
1. The concept of profit and loss, break-even and the percentage. 1.1 Determining what happens to 3 sellers of rambutan fruit in the context of purchasing and selling and using the concept of profit and loss, break-even and the percentage.
2. The concept of gross, net and tare. 2.1 Finding the concept of gross, net, and tare through the context of rambutan fruit packaged in different containers.
3. Discount concept 3.1 Finding the concept of discounts and double discounts through the context of rambutan fruit that was purchased by giving a 25% discount with 20% + 5%
4. The concept of simple interest 4.1 Finding the concept of a simple interest given by the bank to those who saved. 4.2 Figuring out the concept of the simple interest given by a borrower to a party that lent the capital.

The results of the analysis were presented in Table 1 in which this table was used as the main reference in developing learning tools during the trials by using the student worksheets. Then the HLT designed was discussed with the school

teacher before it was applied in the trial.

The Design Experiment

The designed HLT was implemented to six students with different abilities. Then, the students were divided into 2 groups whose level varied from high, medium, and low abilities. The results of the small group evaluation are explained below.

1. Finding the concept of profit, loss and break-even through the context of purchasing and selling from 3 rambutan fruit sellers.

The purpose of this activity was to build students' understanding about the concepts of profit, loss, and break-even, as well as the percentage of profit and loss through the context of purchasing and selling of 3 rambutan fruit sellers, then the teacher challenged the students to determine what each seller's experiences from selling rambutan fruit and determine the amount and the percentage of profit or loss.

At the beginning of the activity, the two groups did not have a solution in solving the problem. For this reason, the teacher provided a probbing question so the students observed the problems for each case, starting from Mr. Andi, Mr. Budi and Mr. Candra to analyze what happened to each trader. In addition, the students found a settlement idea by determining the purchasing and selling price then comparing them to find out what happened to each trader. The answers of the two groups can be seen in Figure 3 below.
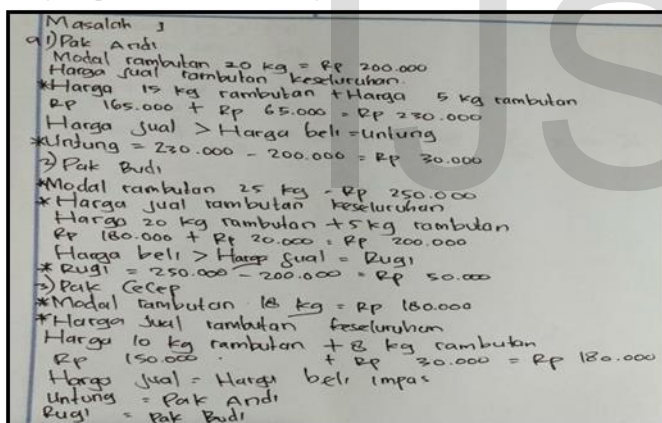

Figure 3. The students' answer sheets for the activity 1.1a Tahap *Small Grup*

In Figure 3, it can be seen that the two groups was able to determine the strategy used in solving the problem. First, to determine the conditions experienced by sellers, the students decided the initial capital or purchasing price of each rambutan fruit, then they analyzed the results obtained from the sale of rambutan and the difference between the selling price and the purchase price. After finding the difference, the two groups gave conclusions for each trader who got profit, lost, and break-even.

Figure 4. Students' Answers on Activity 1.1a Determining the Profit and Loss Percentage of Small Group Stage

In Figure 4, it can be seen that the two groups was able to determine the percentage of profit and loss, using the concept of comparison. Previously, in determining the percentage of profit and loss in activity 1.1a, students were clueless about the ideas for problem solving. For this reason, the teacher prepared a probbing question by providing another understanding that the percentage of profit is what percentage of profits he / she profits from the issued capital. To find the percentage of profit, the teacher provides a probbing question related to the the previous material in the form of comparison. This is in line with with the characteristics of RME, namely intertwining, related to other topics.
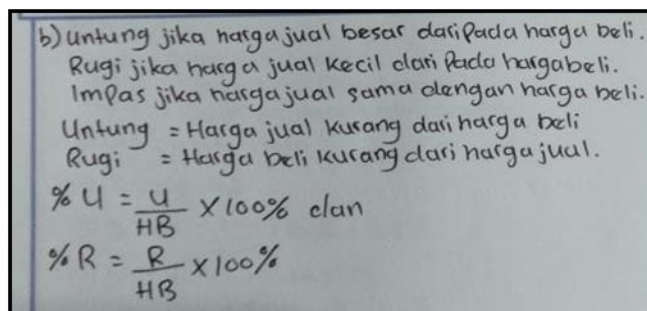

Figure 5. Student's Answers to Determine the Percentage Pattern of Profit and Loss in Activities 1.1b Small Group Stage

In vertical mathematics in activity 1.1b, question b, both groups easily solved the case because their answers were correct and students already comprehended the meaning of profit, loss, break even and the percentage. It was obvious that students were able to determine those using symbols and mathematical operations, then students also created a percentage formula for profit and loss.

1. Figuring out the concept of Gross, Net and Tare through the activity of comparing the gross, net and tare weight written on each item.

The aim of this activity was for students to find the concept of gross, net and tare by paying attention to the gross, net and tare weight listed on each product, then the students were expected to be capable in comparing the written gross, net and tare weight for each item with the intention of attaining the correlation among these three elements. Hence, this activity was carried out by providing pictures of 3 types of products with different weights, with each product listed as gross, net and tare weight. Then the students explored the concept of gross, net and tare based on the information in the picture given and the correlation among the gross, net and tare, so the students did not not only find what the term meant but also found the correlation of the three elements by determining the percentage.

While completing this activity, the students had been able to solve the contextual problem given. Additionally, the students finished the activity by using image media based on the image illustrations provided. Students' answers to activity 2.1 can be seen in Figure 6

Figure 6. Students' Answers for Activities 2.1 Small Group Stage

According to Figure 6, it can be seen that Group 1 and Group 2 had been able to conclude that gross was the weight of the entire package and the contents of the product, the net was the weight of the package contents and the tare was the package weight even though the method of conveying in the form of writing was different but with the intention was the same. As a matter of fact, the vertical mathematics in activity 2.1, question c, the two groups effortlessly solved the case because the answers to questions a, and b had been answered correctly and the students already comprehended the meaning of gross, net and tare. Hence, they were able to determine the gross, net and tare correlation along with the percentage of tare on each item.

1. Through the activity of purchasing rambutan fruit, students were able to construct a price formula after a discount.

The Contextual problems in 3.1 facilitated the students to do the horizontal mathematic concept of discounts and double discounts. In activity 3.1, students conducted a vertical mathematic of the discount concept. In this contextual problem, students were able to explore their comprehension toward the difference on the discount and double discount through the context of determining the price of rambutan fruit.

During the process of finishing this activity, the two groups were able to solve contextual problems by calculating the amount of the discount and the price after the discount. The answers of the two groups to activity 3.1 can be seen in Figure 7.

Figure 7. Students' Answers to Activities 3.1a Small Group Stage

According to Figure 7, it is obvious that the group was correct in determining the discount price and the price after the discount. For 3.1a answer sheet, the students were able to determine the discount price by multiplying the discount percentage with the initial price, then finding the price after the discount subtracts the initial price from the discount given by the seller. Furthermore, to determine the price of the seller who gave a double discount, students decided the first discount price, determined the second discount price, added up the first and second discount prices, and last, they subtracted the initial price from the number of discounts given by the seller. Last, the teacher questioned why students effortlessly distinguished between the discounts and double discounts, the reason was because they often found the similar cases in buying and selling activities at the end of the year or Eid.

Figure 8. Students' Answers for Activity 3.1b Small Group Stage

In vertical mathematics for activity 3.1b, each group conducted a discussion and they were able to solve the case. Thus, both groups found the formal concepts of discount and double discount and they were able to determine them by using symbols and mathematical operations in which the students also succeeded to create a discount percentage formula.

1. HLT Determines Simple Interest

a. By discovering the concept of a simple interest given by the bank to saving parties.

During this activity, the teacher gave a contextual problem regarding the activity of saving a certain amount of money in the bank with a set of simple interest, then the teacher challenged the students to determine whether the amount of savings for 2 years was enough to go on an Umrah ride.

While solving the math cases provided, students were accustomed to solve the problems according to problem-solving steps. As a result, Group 1 and Group 2 were able to immediately solve the problem. The following is the answers of the students.
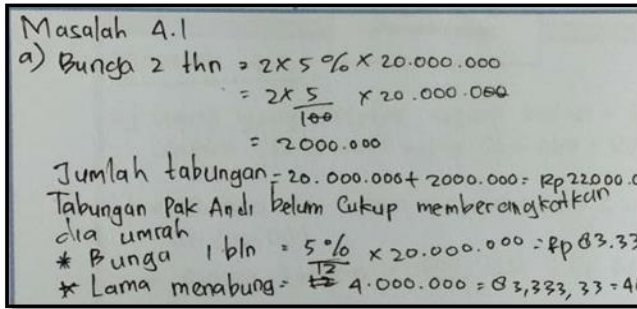
Figure 9. Students' Answers for Activity 4.1a Small Group Stage

In Figure 9, it appeared that both groups had understood the cases by writing down information on the questions. In detail, the student elaborated the information in order to facilitate problem solving and the problem solving strategy given was correct in determining whether Pak Andi's savings were sufficient. For solving the problems of parts b and c, they immediately solved the cases without any significant obstacles. Thus, the students were finally able to solve b and c cases based on their understanding on simple interest during saving.

The students were immediately able to calculate the amount of interest because on the percentage of discount, tax and profit materials they were used to find out the nominal amount if the percentage was obtained. Moreover, the students' answers also correctly stated that the money saved for 2 years was not enough to go to Umrah. From the instructions for the question "Should Mr. Andi take out his savings in a period of time, so that his savings are just right for going to Umrah", and the probing questions that the teacher gave during the discussion made the students understood that Mr. Andi had to look for interest per month and Mr. Andi's final savings had to match. 22 million which meant that the interest earned must be 2 million. Based on the answers of the both groups, it was concluded that the students were able to tackle this 4.1 case.
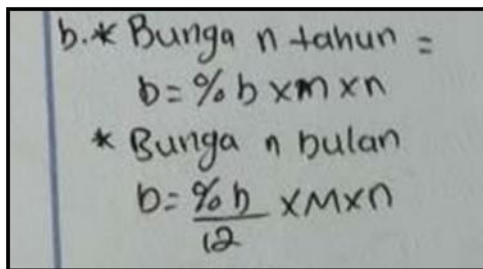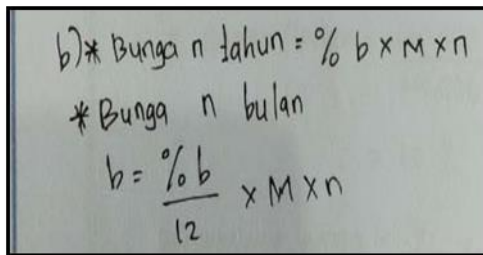

Figure 10. Students' Answers to Activity 4.1b Small Group Stage

Based on Figure 11, it appeared that the two groups was able to find the concept of simple interest when saving in a more formal concept in line with the objectives to be achieved in question b. In the process of accomplishing the case, group 1 was faster than group 2. On the other hand, Group 2 also observed the answer of group 1 on the board to answer question b.

a. Figuring the concept of a simple interest provided by the bank to the party that lends capital.

In this activity, both groups were able to solve contextual problems given in which both groups succeeded to determine the total money deposited, the percentage of loan interest and the formula to determine % of interest charged. The answers of the two groups to activity 4.2 can be seen in Figure
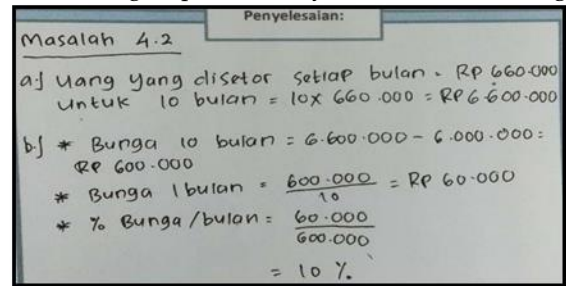

Figure 11. Students' answer for Activities 4.2.a and 4.2.b Small Group Stage

According to Figure 11, the students were able to determine the amount of installments for 10 months. In addition, they also determined the total percentage of the interest that the Credit Union will charge Mr. Budi. Both of Group 1 and 2 calculated the percentage of interest charged based on the total interest rate and the size of the loan. Furthermore, for activity 4.2 part c, students were challenged for obtaining the formula to determine the percentage of interest on the loan given. The followings are the answers of the two groups for activity 4.2 part c.
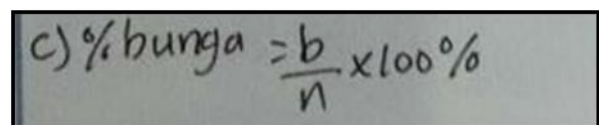

Figure 12. Students' Answers to Activity 4.2.c Small Group Stage

From the picture above, it can be seen that the answers of the two groups are the same. Both groups were able to formally determine the concept of the percentage of interest accurately. Moreover, the result of retrospective analysis of this case was it has been able to stimulate the students to construct a simple interest concept charged by the credit union on the party taking the loan.

Retrospective Analysis

After the learning process was conducted, the researcher evaluated the impact of the implementation of the learning design. As a result, there were a lot of students who quickly comprehended and solved the cases, then built their own knowledge. However, there were also those who experienced difficulties during the learning process by using this method.

Based on the results of the design trial, a learning trajectory was obtained, starting with contextual problems, understanding the problem, creating a solution model and concluding. Additionally, a lot of designed activities created various kinds of answers from students where each answer was anticipated in order to achieve the learning objectives. This trial process used the RME approach which contained 4 principles such as guided reinvention, didactical phenomenology, emerging models, and horizontal and vertical mathematic. [14, 15, 17]

The principle of guided reinvention was illustrated by the process of finding the concept of the 4 social arithmetic learning objectives given such as finding concepts starting from informal procedures, then informal strategies were found useful for formal procedures. In addition, the principle of didactical phenomenology was illustrated by the phenomena used in each activity in which the principle of emerging models was illustrated in students' answers who tried to solve problems with their own models. The principle of horizontal and vertical mathematization was also demonstrated during the process of problems solving to obtain conclusions and general concepts to achieve goals.

In general, the mathematics learning design based on the RME approach with the topic of social arithmetic has been appropriate to be used in mathematics learning process. However, there were several things that need to be added, such as the HLT 1 case which was presented by providing only one case even though the students understood the calculation of the percentage of profit and loss during the learning process, it should be added again. This was conducted with the aim that the students did not experience difficulties in the next experiment.

4 CONCLUSION

Based on the research, calculations and discussion that had been described, it can be concluded that the mathematics learning design based on the RME approach to the arithmetic topic was a learning design that had an influence in the development of students' thinking skills. As a result, the learning process became more meaningful because it was started with the contextual problems.

In sum, HLT on the topic of RME-based social arithmetic was able to facilitate the students in understanding and building their knowledge on social arithmetic topics. Therefore, it is expected that the learning design based on RME on social arithmetic topics will be developed in a higher quality so the learning objectives will be maximally achieved.

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