# A RME-based Social Arithmetic Design Research for Junior High School

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**Abstract**— This study aimed to create a social arithmetic learning trajectory which based on RME approach to assist students in finding the concepts of profit, loss, break even, percentage, discount, tax, interest rate, bruto, netto and tarra. The design research followed three stages in Gravemeijer and Cobb's design research. The stages are preparing for experiment, designing experiment and retrospective analysis. In the first stage, Hypothetical Learning Trajectory (HLT) and student's worksheets that based on RME approach were designed through literature study. While in the second stage, a HLT test simulation was conducted on six students with different range of mathematics skill working together in two small groups. Analysing the test result is done in the last stage. The result indicated that the whole social arithmetic learning design was appropriate for students' needs. The problems given were based on students' daily life or contextual problem. So, the students were expected to find the concept and solve the problem easily. Thus, using HLT on RME-based social arithmetic topics can helpful in building student's conceptual understanding.

**Index Terms**— Instructional Design, Social arithmetic, RME, Learning Trajectory, Design Research.

## 1 Introduction

SOCIAL arithmetic is one of the mathematics topics in junior high schools which play a major role for students in learning mathematics. It is a branch of mathematics which almost involved in every aspect of students' daily life such as calculating the overall value, unit value, purchase price, selling price, profit, loss, discount, bruto, tarra and netto [1]. The concept of social arithmetic presented in mathematics textbooks tends to be mechanistic, follow formal and strict procedure [2].

Figure 1 below is an example of arithmetic social concept presented in teacher and student guidebook.

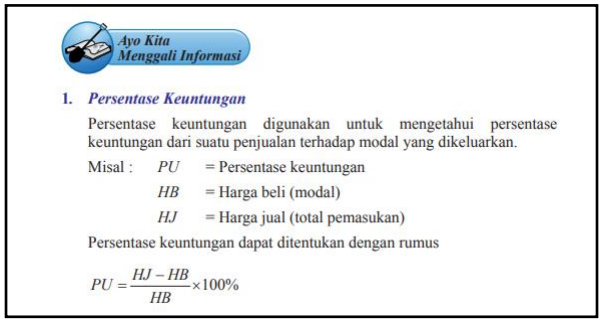


Figure 1. An example of social arithmetic problems found in Teacher and Student Guidebook

The figure showed the formula for calculating the percentage of profit. The formula was directly given in detail and followed by examples and solutions. This process also affected and turned teacher's teaching method into mechanistic procedure [3],[4],[5].

The current guidebooks have not fulfilled its purpose to facilitate students in finding the concept and developing contextual learning. They effortlessly receive the conclusion, formula and start memorizing each formula. Eriksson [6] stated that there are better goals and method in learning, memorizing formula and concepts is not one of them. To make a better quality of learning process, teacher should focus on relating mathematics with daily life problem, enhancing problem-solving skill and correlating ideas.

Based on the explanation above, a solid solution is needed to solve these issues. The writer suggested using Realistic Mathematics Education (RME). This approach was chosen after a thorough observation on several results of successful research. They showed great results and great impacts for students understanding [7], [8], [9], [10], [11], [12]. Integrating RME approach to learning trajectory could stimulate students to utilize students' background knowledge and strategies to solve problems [7] because they are engaged in solving the problem. Instead of memorizing every formula or concepts, students will learn better in active and contextual learning.

In implementing this designed learning trajectory, at the beginning of the lesson students are expected to answer contextual problems which could be solved with their current background knowledge. The contextual problems will also facilitate students to use their own symbols or their own strategy. This process is called horizontal mathematics. After experiencing a similar process and empowered with simplification and formalization (see [13]), students will use more formal language or strategies in solving contextual problems. The journey, that will bring students to re-invent a formal mathematical, is called vertical mathematization [14], [15], [16].

The aim of this research is to design hypothetical learning on social arithmetic topics through RME approach. It was implemented for students in grade VII. The social arithmetic topics discussed are profit, loss, break-even and its percentage, discount, tax, interest rate, bruto, netto, and tarra.

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## 2 METHOD

The method applied in this research is the design research develop by Gravemeijer and Cobb. It started with designing social arithmetic learning topics based on RME. The implementation was carried out through two main instruments, Hypothetical Learning Trajectory (HLT) and student worksheets. This research design consisted of 3 stages, namely preparing the experiment stage, the design experiment stage and the retrospective analysis stage [17].

In preparing the experiment stage, there were several literature studies discussed to determine the topics for designing HLT. This first stage included collecting all data and material to design the HLT. The next activity was designing HLT. The second stage was quite flexible since it gave room for any researcher to revise the designed HLT. This activity solely depends on the test simulation result.

After that, in the design experiment stage, the designed HLT was tested on a small group which consisted of six chosen students from Class VII C in SMPN 19 Kerinci. The writer acted both as a researcher and a teacher to collect the data. These students were assigned into two groups. Each group has three members who have different range of mathematics skill; advanced, intermediate, and low level. To make the selection easier, the mathematics teacher helped in choosing the participants.

Finally at the third stage, the retrospective analysis stage, the result obtained from the teaching experiment stage was evaluated for further use in developing the design in the next learning activity. To describe how the HLT implementation should be conducted, data were collected through observations, interviews, checklist, videotaping, and analyzing the students' works. The procedure of this design research is illustrated in the following figure.

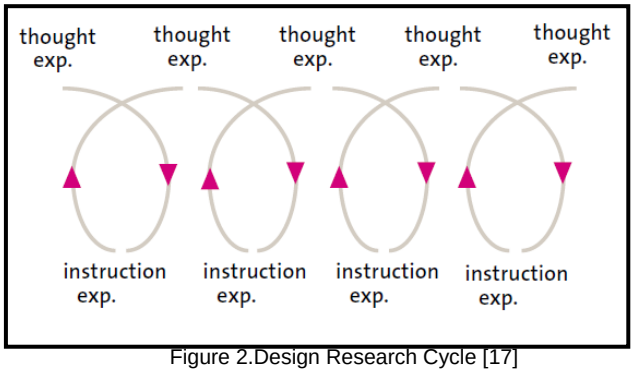



Figure 2.Design Research Cycle [17]

## 3 RESULTS AND DISCUSSION

The description of RME-based social arithmetic design research for junior high school students that started from the preparatory stage of the experiment to the retrospective analysis stage is described as follows.

### 3.1 PREPARING FOR THE EXPERIMENT

This stage began with a literature review where researcher did deep analysis on student mathematics guidebook for grade VII and several journal references. After the review was completed, HLT was designed that contained learning objectives. Analysis result is compiled in Table 1. This table served as the first main reference in developing learning media when conducting the trial, such as student worksheets. Furthermore, the designed HLT must be discussed with the mathematics teacher before the test is conducted.

TABLE 1
THE DESIGN OF HLT

| Learning Activities in the Designed HLT |
|---|
| 1. The concept of profit, loss, break-even and its percentage.<br>1.1 Solving problem. Determine what happened to the three fruit sellers in buying and selling activity.<br>1.2 Using the concept of profit, loss, break-even and its percentage. |
| 2. The concept of discounts and taxes.<br>2.1 Discovering the concept of discount through contextual problem. Choosing hijabs based on the discount given<br>2.2 Discovering the concept of tax through the context of Value-added Tax (VAT).<br>2.3 Using the concept of discounts and taxes. |
| 3. The concept of interest rate<br>3.1 Discovering the concept of a single interest through a contextual problem; a bank to its customers.<br>3.2 Discovering the concept of a single interest through a contextual problem; a debtor and a creditor. |
| 4. The concept of Bruto, Netto, and Tarra. |

### 3.2 THE DESIGN EXPERIMENT

The designed HLT was tested on six students with diverse mathematics skill. They were working in two different group. Each group had three members who possessed advanced, intermediate and low skill. The following results describe the evaluation on those small groups.

**1. Discovering the Concept of Profit, Loss, Break-even and its percentage.**

The purpose of 1.1 activity is to build students' understanding on the concepts of profit, loss, and break-even, as well as profit and loss percentage through the context of trading between three fruit sellers. Next, the teacher ordered students to determine what each trader experienced from selling fruit and determined the amount of profit, loss and its percentage.

In this group activity, both group determined what kind of problem faced by those three fruit sellers. The first group used the overall purchase price and selling price. On the other hand, the second group identified the problem by using the purchase and selling price per kg.

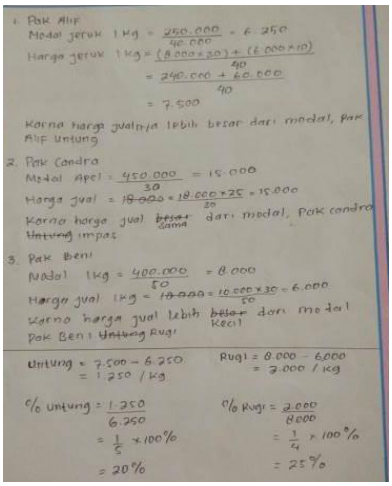


Figure 3.Students' answer sheet in Activity 1.1

The strategy drawn by the second group was almost correct. However, they made an error in the first earlier answer. They mistook the selling price per kg for mangoes and apples. All members of group 2 fully understood that the selling price per kg written in the problem was the price for purchased apples and mangoes. To solve this matter, teacher guided them with probing question to make them comprehend the root of the problem.

Unfortunately, these students were not able to determine the percentage for both profit and loss. They did not understand what is the meaning of profit and loss percentage. As predicted, teacher would give probing question to help them out. She gave a simple definition of profit percentage, the profit gained apart from the beginning capital. To calculate the profit percentage, the teacher gave another probing question by relating to previous topic, proportion. This process reflects the characteristics of RME, intertwining or relating one topic to another.

The objectives in activity 1.2 are students are able to identify the concept of profit, loss, break-even and its percentage in the previous activity, draw conclusion and turn it into formal form. Each group discussed and passed the problem. The second group made a small mistake in determining the loss percentage. The teacher advised them with indirect probing question, "is it appropriate to use HJ in determining loss percentage?".

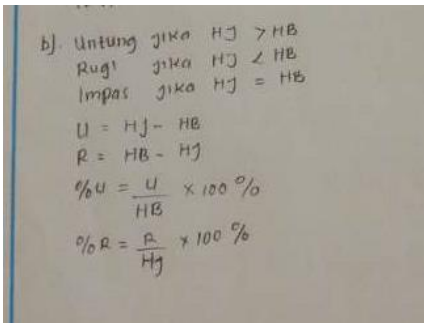


Figure 4.Students' answer sheet in Activity 1.2

You shall check your previous activity answer sheet. As instructed, the students reviewed their answer in the previous activity and revised their answer. Generally, students could be guided through probing question to achieve objectives.

**2. Discovering the Discount and Tax Concept**

The objective of activity 2.1 was to explore students' understanding on discounts in determining the actual price paid after receiving a price cut. In the pre-teaching activity, students enthusiastically to give feedback about discount in their neighborhood. They recalled all places and limited time to get discount for products.

Discussing contextual problem was the main activity in activity 2.1. Teacher asked the students about how they described the problem with their own sentence, and how they would solve it. The students grasp the definition of discount by activating their background knowledge. To ensure their understanding, they asked the teacher, "The discount for first hijab is 10% of the actual price, isn't it?". All students' responses reflected that they had the same perspective on the contextual problem and how to solve it.

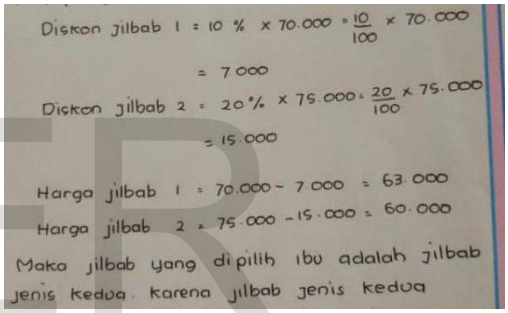


Figure 5.Students' answer sheet in Activity 2.1

In figure 5, students understood the concept of discount. They knew that discount is a price cut, so they have to pay less for the product.

In activity 2.2, teacher instructed the students to work on their own, define value-added tax (VAT) and draw conclusion. In the contextual problem exercise, there were the actual price product, tax percentage, and the product price after tax. These data were analyzed by the students to draw conclusion and define VAT. This process was expected to assist students in finding that VAT is a consumption tax or additional price for every purchased product.

While the students were working in group, teacher observed how they extracted information from the contextual problem. They almost did the same approach as the previous discount activity. They determined the tax first, multiplied the tax percentage with the printer price and predicted on how to solve the problem. Yet they were in doubt to calculate it between the prices that father has to pay or the printer price. Teacher assisted with a guided question, "does the amount of tax obtained through multiplying percentage and paid price?" The students proceeded to choose the printer price to calculate the tax. Both groups succeed and understood why father pay more than the actual price. A tax is an additional price for purchased products.

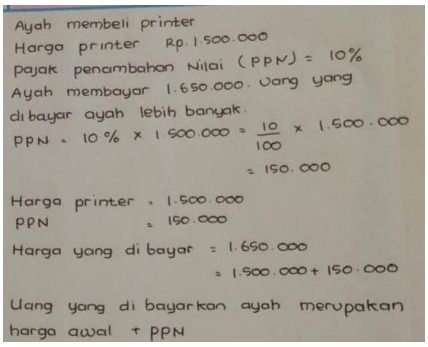



Figure 6.Students' answer sheet in Activity 2.2

Figure 6 described that students were able to explain why dad has to pay extra for the printer. They wrote that dad paid for both the printer and the tax. That was why the price is higher than the product price since it included tax.

In contextual activity 2.3, students would work on mathematical concepts of discount and tax. Students tried to solve a contextual problem about a discounted watch, and it price after tax was added. Both group succeed in solving this problem. They calculated the amount of discount and tax first. Then, they subtracted the watch price with discount and added the tax later. Figure 7 contains students answer sheets in activity 2.3.

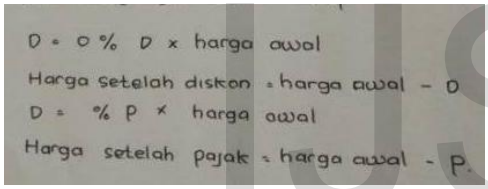



Figure 7.Students' answer sheet in Activity 2.3

### 3. Discovering the concept of Interest rate and its Practice

Both groups succeed to solve the given contextual problem in activity 3.1. In figure 8, students were able to determine the total saving of Mr. Alif for two years. They calculated the interest for one year and applied the same procedure for two years. They could tell directly the amount of interest due to excessive drill in the profit, discount, tax and percentage activities. As long as they figured out the percentage, the rest was easier.

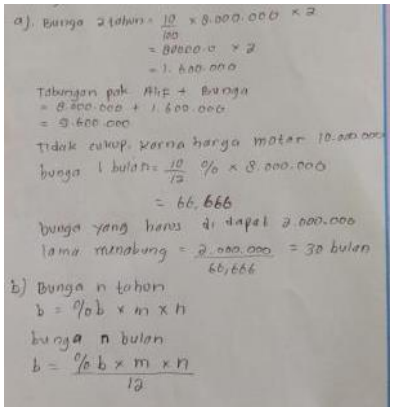


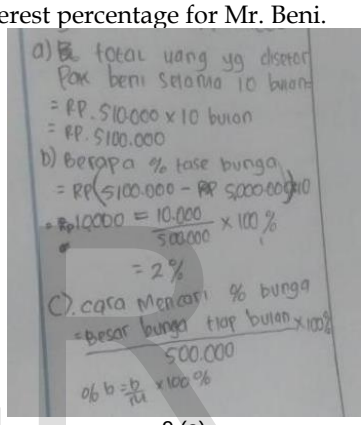

Figure 8.Students' answer sheet in Activity 3.1

They could determine the amount of savings for two years by calculating the interest and the initial savings. The direction in the worksheet was "How many months does Mr.Alif have to wait until his savings is enough to buy a new motorcycle?".

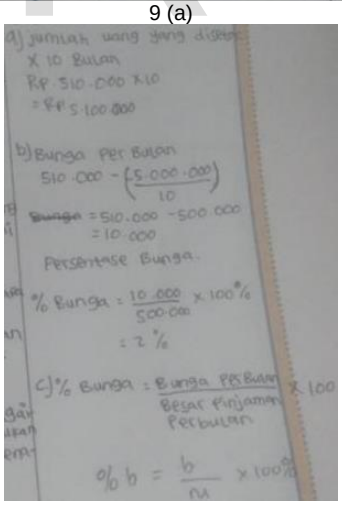
Teacher's probing question also played a role in assisting students to solve the problem. They started to calculate the amount of interest for each month. Even though, both groups solved the problem. The second group had better deduction and the answer was close to learning objectives. So, one of the members presented the result in math congress in front of the class.

To determine the concept of single interest, both groups have followed the formal concepts which in line with learning objectives. Group 2 had the upper hand since they figured out the formal concept faster than Group 1.

In activity 3.2, both groups once again succeed to solve the contextual problem. Both groups were able to calculate the amount of 10 months installment loan. They knew how to determine the interest percentage for Mr. Beni.




9 (a)




9 (b)

Figure 9.Students' answer sheet in Activity 3.2

The first group calculated the interest percentage based on overall amount of interest and the amount of loan. Meanwhile, group 2 took another approach, they calculated the interest percentage through monthly loan. At the end, both groups were able to determine the concept of interest percentage formally.

### 4. Bruto, Netto and Tarra

The main objective in activity 4 is to find the concepts of bruto, netto and tarra. Students observed the weight, bruto, netto and tarra in each product. Students were expected to discover the definition of bruto, netto and tarra and how these three related.

The activity was started with observing three different pictures. Each product has different bruto, netto and tarra listed in the package. Following the procedure, students discussed in group trying to assume the definition of bruto, netto and tara and finding how they are related. Both groups have completed this contextual problem successfully.

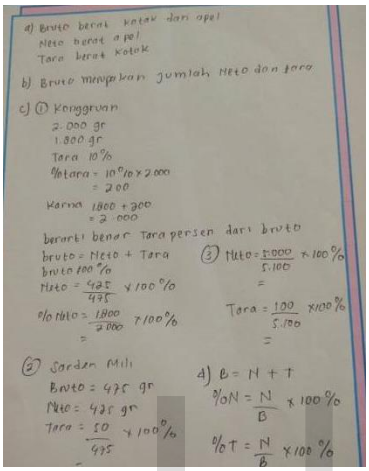


Figure 10.Students' answer sheet in Activity 4

In figure 10, both groups concluded that bruto is the total weight of the item/content and the package, netto is the net weight (only the content) and tarra is the weight of package. Even though, they presented the conclusion differently, at least they grasped the main idea. They also succeed to explain the relation of bruto, netto and tarra in part B.

In part C, figure 10, students were able to identify the percentage for netto and tarra. Group 1 made a small error at the first try. They mistook the percentage for tarra and used netto instead. Hence, this error was already predicted in the HLT planning. Teacher assisted with probing question, "Could you observe the tarra percentage in the first product thoroughly? Try to compare it with the weight in second product." Students observed as instructed and made a keen observation. They revised the answer and complete exercise in part C as depicted in figure 10.

In part D activity 4, vertical mathematics activity, both groups answered the question well because they have practiced solving problems in part A, B and C. They have understood the definition, concepts and relation of bruto, netto and tarra using mathematics symbols and operations. At last, they they were able to generate the correct formula for netto and tarra percentage.

### 3.3 RETROSPECTIVE ANALYSIS

After the teaching and learning process ended, the researcher and the class teacher evaluated the whole implementation and activies of the design research. Several students were able to solve the problem independently. They seemed as a quick learner who solve the problem and find the concept without any help needed. However, some needed guidance and probing question in discovering the concepts.

Based on the results of the design test, a data of learning trajectory that consists of contextual problem, understanding problem, creating draft, and drawing conclusion is obtained. The activities designed had already foretold students' responses and feedback. So, the practitioner won't encounter any difficulty in dealing with unforeseen trouble to achieve learning objectives. There were four principles of RME approach implemented in this experiment. They are guided reinvention, didactical phenomenology, emerging models, and horizontal and vertical mathematization [14], [15], [18].

The principle of guided reinvention is reflected in the process of discovering four concepts of social arithmetic learning objectives. Finding concept activity started from informal procedure toward formal procedures. The principle of didactical phenomenology could be seen in daily phenomenon. The principle of emerging models is written in students answer which created based on their own model. The principle of horizontal and vertical mathematization are illustrated in the students whole process in drawing conclusion and achieving learning objectives.

The whole RME-based social arithmetic design research has passed the standard and can be used for learning and teaching process with a little bit of improvement in adding more exercises. The contextual problems are daily life problem which stimulates students to find the social arithmetic concepts. The problem in Activity 4, there was only one problem about bruto, netto and tarra. In fact, students need more contextual problems so they won't find any difficulties dealing with various problems in the future.

## 4 CONCLUSION AND SUGESSTION

Based on the result and findings that have been explained, the writer concluded that RME-based social arithmetic design research gave huge contribution to students' learning trajectory. Learning process becomes more meaningful because the discussed problems are real and contextual problems. This RME-based social arithmetic design research has passed the standard and can be used for learning and teaching process. It is expected to stimulate and enhance students' skill in discovering social arithmetic concepts. Thus, using HLT on RME-based social arithmetic topics can helpful in building student's conceptual understanding. Finally, the RME-based social arithmetic design research should be researched further to achieve efficient learning objectives.

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