Designing reasoning problem of linear equations with two variables through compare and exchange activities

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Abstract. This study aims to design reasoning problems of linear equations with two variables through comparing and exchange activities. This is focused on how students use the compare and exchange activities to find a way to solve linear equations with two variables with mathematics concepts in human’s daily activities is chosen as a design underlines activities in the design based on a Realistic Mathematics Education (RME). RME based teaching has been adopted by countries including Indonesia with the so-called Pendidikan Matematika Realistik Indonesia (PMRI). This study was used to design research as an approach. We first develop hypothetical learning trajectories (HLT) of the learning we designed. Data collected in this study included students’ written works, observation notes, and video-records. The data were analyzed by comparing the actual learning process and the hypothetical learning trajectories (HLT). The data also showed that the students' activities to be more flexible strategies to solve for equations.

Keywords: Design Research, Compare and Exchange Activities, Linear Equations, PMRI

1. Introduction
Mathematics is a subject that has an important role in daily life, this is because many problems in everyday life that require mathematics. One of the material in mathematics learning is a two-variable linear equation. Two variable linear equations are the initial topics of algebra taught in class 7. [1] suggests that algebra is the gateway of all branches of mathematics. So algebra is very important to be mastered by students because implicitly or explicitly algebra is used in daily life activities both directly and as a prerequisite.

In fact, among algebra students, it becomes a common problem, because the difficulty of algebraic material makes students lazy, and students tend to avoid it once they study this algebraic topic [2]. Many students have difficulty to understand the concept in solving linear equation with one variable [16,17]. Students’ errors analysis is one of the important tools to diagnose the difficulties experienced by students who require direct handling [18]. The teacher can ask students about what problems they encounter when solving problems, observe student’s reactions and analyses errors committed by student [19]. The second obstacle is problems in mathematical processing that consists of transformation, process skills, and encoding answers [20].

In Indonesia algebra is a major problem in mathematics learning, evidenced by several international studies that have been followed, such as in PISA 2003, algebra and measurement are significantly more difficult for Indonesian students from numbers, geometry, and data [3]. The results of the 2009 PISA study show that from algebraic results as a whole, only 41.4% of students can
answer correctly. This is very small compared to the problem in other materials [4]. From the results of these studies, it can be concluded that algebra still needs to be considered during learning.

[5] suggests that solving linear equations is a very important concept in algebra so that to study this topic, students must struggle to balance conceptual and procedural knowledge. In addition, [6] say that one to solve equations is through the concept of balancing. Because the concept of balancing is the basis for solving linear equations. So that learning is needed that can bridge students to understand the material of linear variables two variables.

The demands of the 2013 curriculum, learning must be context-based. Because current learning emphasizes teaching meaningfully by linking it with realistic daily life. So that a learning approach is needed in accordance with the demands of the curriculum and the problems faced by students. One learning approach that is in line with these problems is the Indonesian Realistic Mathematics Approach (PMRI). According to [7] PMRI is a theory that starts with "real" problems that have been experienced by students, emphasizes the "doing mathematics" process skills, discussions and collaborations, mutually arguing with classmates, discovering mathematical concepts and use math in solving problems. PMRI can also develop student competence in terms of creativity and communication [8]. This is in line with the demands of the 21st century. Learning and innovation skills consist of communication, collaboration, critical thinking, and creativity skills (4CS)[9]. Based on the above, an individual in the 21st century is required to have the ability to think critically and creatively in solving problems.

Based on the description above, with the existing problems, appropriate learning is needed. Learning by using PMRI can familiarize students to explore their own knowledge, student involvement in learning is also very concerned. This is also in line with Permendikbud (2014), namely learning is carried out based on activities with several characteristics such as interactive and inspirational, challenging and motivating students to actively participate. Therefore, researchers are interested in designing activities with 4C skills, there are two variable based PMRI linear equation learning. It clearly shows that students need to understand the meaning of the questions before going through the mathematical processing in order to produce the correct answers [15].

2. Method
The method in this study is the method of development research or formative evaluation development research [10]. This study develops SMP problems in the PISA model on algebraic material invalid and practical mathematics learning. This study consisted of two stages, namely the preliminary and formative stages of evaluation which included self-evaluation, expert reviews and one to one (low resistance to revision) and small groups and field tests (high resistance in revision) [10].

Preliminary is preparation at this stage an analysis of the curriculum and textbook of students in class VII of SMPN 1 Palembang will be analyzed, then determine the place and subject of the study by contacting the principal and the mathematics teacher at the school to be the location of the study and other preparations. Such as arranging research schedules and cooperation procedures with classroom teachers to be used as research sites.

Designing at this stage a question grid design is carried out, Prototyping: Self-evaluation, a self-assessment of the results of the design of the PISA model on an algebraic material was made by the researcher. Expert Reviews, the design of the problem made by the researcher was validated by experts, colleagues and mathematics teachers. It’s reflected in the comment by expert review, then responses, expression, and student’s understanding when solving the problem [3]. Products designed to be seen, assessed and evaluated. The validity test carried out is the test of content validity, construct validity test, and language validity test. Suggestions from the validator are used to revise the design of the problem made by the researcher. Responses and suggestions from the validator about the design that has been made are written on the validation sheet as material to revise and state that the learning device is valid. One-to-one, the researcher asked three students with various levels of ability as a tester. The comments obtained were used to revise the design of the PISA model problem that the researcher had made.
Small Group, the results of revisions and comments from expert reviews and one-to-one are used as the basis for designing problem in the next stage. The design of this question was tested on small groups of non-research subjects to see the practicality. The students were asked to give a response to the PISA model problem tested. Based on the results of the tests and responses of these students the problem were revised and corrected again. At this stage also evaluated the appearance and use of the problem to see the responses, assessment and practicality of the problem and the results as input to revise the design of the problem to the next stage. The results of this stage are expected to produce valid and practical PISA model problem.

Field Test, the trial was carried out on the actual research subject as a field test. Products that have been tested in a field test must meet the quality criteria. [11] suggests that three quality criteria are: validity (from experts, peers and mathematics teachers), practicality (its use is easy and can be used in the learning process), and problem have a potential effect seen from the results of tests of students’ mathematical reasoning abilities.

Data collection techniques used was the walkthrough, document, observation, and an interview. Then the data were analyzed by the qualitative descriptive method to describe the result of each step of development.

3. Result and discussion
This research produced two problems that require proportional reasoning for get the answer. However, in this paper, researchers only covered one problem that intertwined converse and inverse proportion.

3.1. Preliminary
In preliminary, Preparation At this stage an analysis of the curriculum and textbook of students in class VII of SMP 1 Palembang will be analyzed, then determine the place and subject of the study by contacting the Principal and the mathematics teacher at the school to be the location of the study and other preparations, such as arranging research schedules and cooperation procedures with classroom teachers to be used as research sites.

3.2. Formative evaluation
3.2.1. Self evaluation. In self-evaluation, proportional reasoning problems that designed evaluated by researchers. The revision result called prototype I.

3.2.2. Expert reviews and one-to-one.
Expert reviews and one-to-one phases were conducted in parallel to see the validity of the problem. Prototype I was validated by experts based on existing criteria both regarding content, construct, and language. While the process of one-to-one involved three students of seventh-grade of the junior high school, namely AA (high-ability), BB (medium-ability), and CC (low-ability).

The students are asked to read and examine the problem so that the researchers can find out the responses, constraints faced, and understanding of students in solving the problem. The responses and obstacles that observed focus on legibility and clarity of problems. Table 1 shows the validation result from expert reviews and one-to-one phases.

| Validation  | Comment/Response         | Revise                        |
|-------------|--------------------------|-------------------------------|
| Expert reviews | • Add more questions     | • Add to “dan gambarkan”       |
|             | • Deleted word           | • “representasi”               |
|             | • Students think that the add the word | • Change “pcs” to “jaket” |
| Students    |                          | • Add to “lalu”                |

Furthermore, the researchers revised the problem based on the results of expert validation and one-to-one. It can be concluded that the problems have designed are categorized as valid problems. It’s reflected in the comment provided by expert, then responses, expression, and student’s understanding when solving the problem [17].

Figure 2. Problem after revision

In one-to-one phase researchers get students work data in solving problems that have been designed. From the three students with different cognitive levels (high, medium, low) researchers found that the strategies they used were different. The mathematical problem-solving tasks that have been developed have potential effect in exploring mathematical problem solving ability of the primary school students [21].
Figure 3. AA’s strategies solve the problem

Other strategies, can be seen in figure 4.

Figure 4. BB’s strategies solve the problem

After going through the process Development consisting of 3 stages prototype and three cycle process revisions based on validator suggestions and testing on students, obtained by the device the questions developed can be categorized as valid and practical. Legitimate validator, almost all validators declare good based on content. Students’ understanding about solving the problem which had given [11, 12], most of the students solve the problem and involved themselves on discussion, arguments and communicate their opinion about the solution [12,13].

4. Conclusion
This research has produced valid problem using “compare and exchange” as context to see how student’s strategies to solve the problem. We can conclude the validity from all expert validator state that the problem well designed from content, construct and language point of view. Some students’ answers can also be used to identify who uses compare and exchange to solve problems that have been developed.

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