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DEVELOPING REALISTIC MATHEMATICS EDUCATION MATERIAL TO BUILD STUDENTS MATHEMATICAL UNDERSTANDING CONCEPTS GRADE VII JUNIOR HIGH SCHOOL ON LINEAR EQUATION IN TWO VARIABLES

Aris Budiyanto[1]*, Neng Nurwiatin[1], Ismah[2]

[1]Program Studi Pendidikan Matematika, STKIP Kusuma Negara
[2]Program Studi Pendidikan Matematika, Universitas Muhammadiyah Jakarta

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ABSTRAK

Pendidikan merupakan salah satu cara mengembangkan pemikiran untuk mengaplikasikan ilmu yang telah dipelajari dalam kehidupan sehari-hari serta mengembangkan kemampuan pemahaman konsep dalam memecahkan masalah yang lebih kompleks. Di sekolah sering ditemukan pembelajaran yang belum memfasilitasi pengembangkan kemampuan tersebut, hal ini dapat dilihat dari materi ajar masih menggunakan permasalahan formal matematika dan metode pembelajaran belum berpusat kepada aktivitas siswa. Penelitian ini bertujuan untuk mengembangkan bahan ajar matematika berbasis *Realistic Mathematic Education* dalam membangun pemahaman konsep matematika, mengetahui kualitas dan respon siswa terhadap sajian bahan ajar. Populasi penelitian ini adalah siswa kelas VII SMP dengan sepuluh siswa sebagai subjek penelitian yang dipilih secara *purposive sampling* berdasarkan hasil evaluasi dan keaktifan selama pembelajaran. Bahan ajar dikembangkan berdasarkan model 4-D yang direkomendasikan oleh Thiangrajan dan dimodifikasi menjadi *defined*, *designed*, dan *developed* yang terdiri dari lima aktivitas dan empat soal pemaham konsep siswa. Data diperoleh melalui angket, hasil kerja siswa dan lembar wawancara. Selanjutnya instrumen dilakukkan validitas oleh dua dosen dan dua guru matematika. Sementara penelitian awal dilakukan studi literatur, observasi, dan menganalisis proses pembelajaran serta pencapaian kompetensi kurikulum. Berdasarkan hasil validasi oleh pakar diperoleh nilai V_a=3.31 dinyatakan valid. Sementara berdasarkan uji coba lapangan ketercapaian pemahaman konsep matematika E=33.14 dengan kategori efektif. Hasil wawancara siswa mengenai sajian bahan ajar juga menunjukan dapat membantu pemahaman konsep dalam menyelesaikan permasalahan yang lebih kompleks. Berdasarkan uji validitas oleh ahli dan hasil pengerjaan aktivitas bahan ajar yang dikembangkan berdasarkan masalah kontekstual berhasil secara efektif digunakan dalam membangun kemampuan pemahaman konsep matematika dan layak digunakan dalam proses pembelajaran.

Kata kunci: Bahan ajar, Pemahaman konsep matematika, Pendidikan matematika realistik, Sistem persamaan linier dua variabel.

INTRODUCTION

Education is the most important factor in sustainable progress and an indicator of the stability of the welfare of a nation, this has also been explained in Indonesian National Educational Law number 23 of 2003 which states that national education should be able to play a role in providing human beings with character as a manifestation of civilization and nation building. Mustafa (2014) stated that the human development index at the level of education in Indonesia is still relatively low, at 14.6% in ranked 60th out of 61 countries which lower than neighboring Malaysia which has a percentage of 28%, or is one of the 10 countries with low literacy levels. The cause of low mathematics achievement is

***Correspondence Address**
E-mail: budiyanto.aris@stkipkusumanegara.ac.id

inseparable from the poor learning system implemented in most schools. Developed mathematics instruction only gives birth to rote memorization without facilitating students to develop thinking skills.

Based on the preliminary research on mathematics instructional material used in schools from one of the publishers that had been circulated and used in instructional process, they had not been able to optimize the achievement of mathematical concepts understanding. There were still many students who make mistakes in using symbols, models, and diagrams to represent mathematical concepts. Students were also less able to distinguish and compare concepts to represent in another form. These were happens because the instructional process does not motivate students and teacher tends to used traditional learning process. The topics, exercises, and evaluation just served form the instructional material had been used in general form of mathematic without bridged student from real life situation to mathematic model. Alam (2013: 150) state that the most developing mathematics teaching only gives birth to rote learning, it does not train students to develop mathematical thinking skills, and they answer the questions without understanding how to represent the concept in solving the problem. Conceptual understanding is interconnected concepts or procedures to understand mathematic by forming knowledge and expressing in another way that easily understood to solve more complex problems (Rochaminah & Angraeni, 2016).

The concept of society 5.0 considers the presence of technology and globalization as an integral part of humans themselves. That is, everyone must try to think about creating a balance between the role of society and knowledge understanding (Harayama, 2017). Various policies have been developed by the government to prepare Indonesian citizens in the global arena by developing a curriculum that gives freedom to teachers and students to determine a learning system that focuses on the development of students' thinking, creativity, and expertise skills, thus leading to critical thinking that aims to be able to solve problems well (Yasmansyah & Sesmiarini, 2022). While Pushpanadham (2020) state that education in the global era does not only focus on the demands of the current situation but also anticipates what may happen in the future so that teachers need various learning techniques in meeting the demands of education that continue to develop dynamically. This indicates that everyone to be successful in life needs a good understanding and integrating it with real life.

Once of the learning approach that uses contextual problems is Realistic Mathematics Education. Indonesia itself is known as the Indonesian Realistic Mathematics Learning (PMRI). According to Stemn (2017) Realistic Mathematics Education is used to facilitate students to develop mathematical thinking concepts by emphasizing the use of contextual learning conditions and visual representations in learning. Using contextual problems are important to bridge student understanding education. The past research conducted by Mutia, Effendi & Sutirna (2020) shows that the use of contextual problems in learning mathematics can help students express their mathematical ideas. In addition, the teacher as a facilitator needs to enable students to solve problems in the context of mathematics during the learning process. While, Furtado et al. (2019) argued that Contextual problems are defined as problems with experientially real contexts in the Realistic and these problems can function as the basis for connecting informal and formal knowledge of mathematics so they can help student better grasp formal mathematics situation. Furthermore, Hough et al. (2015) argues that realistic educational goals enable students to visualize mathematical processes using real-world contexts and the development of mathematical modeling which is easily obtained by students because it is based on prior knowledge.

Nu'man (2019: 120) mentions the benefits of preparing instructional materials were content used in accordance with curriculum demands, creativity in creating interesting materials, and can foster student motivation according to the needs or characteristics of students. Furthermore, Tanjung & Nababan (2018) proposed that to developed instructional materials can be divided into 4 stages, namely define, design, develop, and disseminate or better known as 4-D models (Four-D Models). Learning that focused on students had an influence on mathematics learning outcomes, students had more interest and confident when they learned with their own production and construction trough the instruction process and the topic relevant to the needs of students or contextual approach (Pangestu & Yunianta, 2018).

Therefore an instructional process was needed that could support the formation of students' understanding of mathematical concepts by integrating learning from contextual problems into more complex mathematical problems.

RESEARCH METHOD

The type of research that will be used was research and development. The instruction materials developed are in the

form of Student Worksheets (LKS). The development of instructional materials was based on a 4-D model which includes defined, designed, developed, and dissemination. These development activities can be explained as follows:

a. Defined: activities at this stage are to determine the development requirements by analyzed need through preliminary research. Begins with potential problems mapping which include knowing and collecting data regarding the subject matter of analyzing the syllabus, competency standards, competencies, and material indicators to be used.
b. Designed: At this stage, the preparation of instructional material designs was initiated according to the Realistic Mathematical Education principles. The mathematical concepts understanding instrument also developed using NCTM aspects of mathematical concepts understanding which will later be tested and validated by experts.
c. Developed: The designed product was validated by experts consisting of experts and mathematics teachers. The validity test was carried out by giving a questionnaire to the validator to find out the suitability of the realistic mathematic education principles of the developed instructional materials, the suitability of indicators for instructional materials, and the suitability of competency problems for students' understanding of mathematical concepts, then the validation results were used for further product improvement.
d. Dissemination: Products that had been developed and declared valid by the validator then the next stage was testing the product on the subject to determine the effectiveness of the product. Besides this, interviews with subjects will also be conducted to find out students' responses to the instructional materials which include aspects of realistic mathematic education principles, aspects of clarity of instructions, aspects of language, and aspects of graphics.

This research is limited to the development stage with consideration of time and cost limitations. The product was validated by experts and practitioners to assessing the achievement of the product on the established validity requirements. Meanwhile, the effectiveness test was carried out by testing the product to students and measuring the achievement of the ability to understand mathematical concepts through the analysis of the results of students' works. The specifications of students who are used as subjects for the effectiveness test are selected on the basis of learning achievement and mathematical ability. The following is an illustration of

research implementation procedure in developing instructional materials:

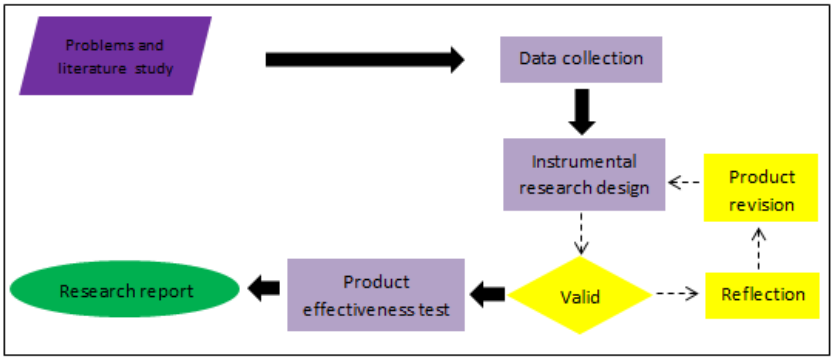


Figure 1. Research Implementation Procedure

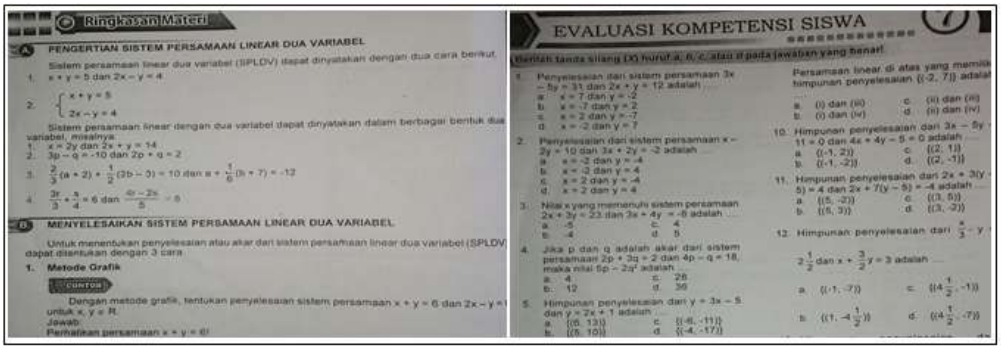
Interviewed data were taken through direct interviews with students during the learning process. Interviews were conducted to determine the extent of students' responses to the presentation of instructional materials developed in fostering learning motivation and building students' understanding of mathematical concepts. Aspects that were explored during the interview process were aspects of RME learning, aspects of clarity of instructions, linguistic aspects, and graphic aspects. The quantitative data then was analyzed by determining the average score on each indicator and then determining the validity score. The instructional materials developed are declared valid if the achievement of the minimum average score is in the valid criteria.

The data analysis of the effectiveness test was in the form of a descriptive analysis technique. Each competency test represents an ability indicator of certain mathematical concepts understanding. The determination of the effectiveness score is obtained by calculating the average score. The analysis technique of the interview was in the form of a narrative descriptive analysis about students' interest in the presentation of realistic mathematics education principles, clarity of instructions, the language used, and the graphic display of the product.

RESULT AND DISCUSSION

This research produces instructional materials to build students' conceptual understanding of linear equation in two variable based on realistic mathematics education principles. The instructional materials are developed consisted of five student activities and four mathematical concepts understanding questions. The first research phase of defined began by conducting a literature study, observing and analyzing the instructional process and the use of instructional materials during

studying, and competency curriculum. By the result, students have not been facilitated enough to be able to develop their mathematical concepts understanding ability as seen from the results of the pre-test carried out. There were still many students who make mistakes in using symbols, models, and diagrams to represent mathematical concepts. Students were also less able to distinguish and compare concepts to represent in another form. These were happens because the instructional process does not motivate students and teacher tends to used traditional learning process. The topics, exercises, and evaluation just served form the instructional material had been used in general form of mathematic without bridged student from real life situation to mathematic model.


Ringkasan Materi

PENGERTIAN SISTEM PERSAMAAN LINEAR DUA VARIABEL

MENYELESAIKAN SISTEM PERSAMAAN LINEAR DUA VARIABEL

1. Metode Grafik

Contoh

EVALUASI KOMPETENSI SISWA

Berikan tanda silang (X) huruf a, b, c, atau d pada jawaban yang benar!

Figure 2. The Instructional Material Found Trough Initial Observation

The next phase was designed of instructional materials to build students' conceptual understanding of Linear Equation in two variable materials based on realistic mathematic education principles. The following is a complete explanation regarding each activity in the developed teaching materials:

a. First activity: define linear equation in two variables

The material given in the first activity aims to direct students' understanding of finding the concept of a system of linear equations in two variables. The apperception given is to remind the components of the concept of a linear equation in one-variable, namely coefficients, variables and constants value. The *model of* in the first activity was formed when students compared the growth of sprouts in dark and light places, then the *model for* was formed by identifying the components that make up liner equation in two variables mathematically. Students contribute ideas by providing reflections or opinions that are built individually or in groups about the effect of light on the growth of sprouts. The following is the development of the first activity:

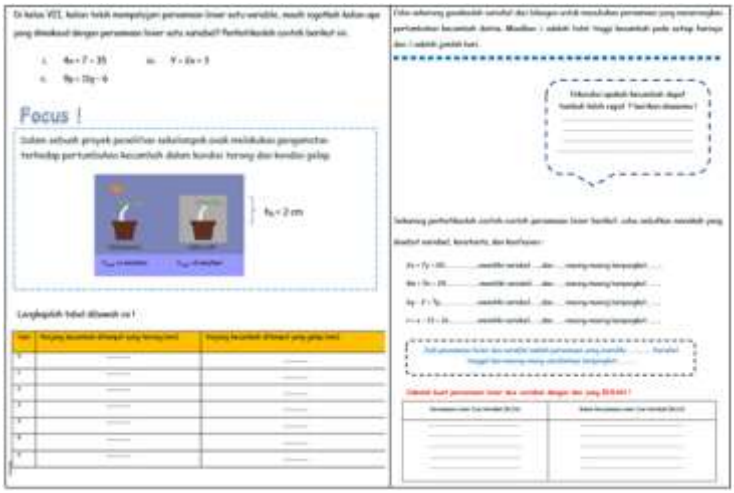


Figure 3. Find Concept of SPLDV Activity

Additionally, the contribution of students in understanding the concepts given when they are able to provide and distinguish which includes examples and non-examples and explain the reasons correctly related to the problem given. In the first activity, the topic found the concept of Linear Equation in two variables by linking science lessons, namely growth and development with mathematics topics.

b. Second activity: define solution of linear equation in two variable

The indicator for the second activity is that students are able to determine solutions of the contextual problems related to a system of linear equations in two variables. The realistic problem that is developed is the case of a child who has a sum of money that his parents gave him to buy stationery for school needs. Students based on the process of observation and analysis try to find the possibility of how much stationery can be obtained with the amount of money they have. The following are the second activity:

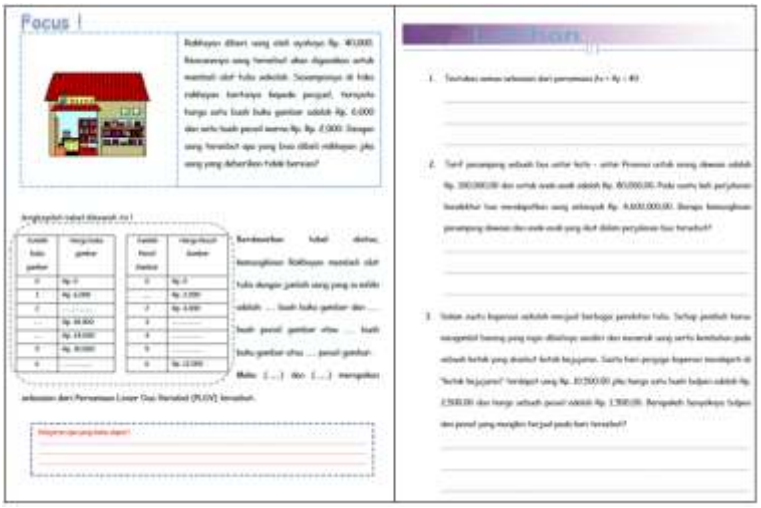


Figure 4. Define Solution of SPLDV Activity

Student interactivity appears when students studying in a groups trying to solve a given problem. Through this activity, students are also expected to be able to give contribute thoughts, ideas, or ideas in obtaining knowledge independently with the teacher directing according to the abilities of the students. In this activity students have started to practice using a mathematical form in the form of a table of possible values and counting and matching the number of stationery that may be obtained with the money they have. The problems given in the second activity include social arithmetic which is closely related to solving a system of linear equations of two variables. In the practice section, students begin to use formal mathematical problems using general forms or also make mathematical models first to solve problems.

c. Third activity: define mathematical model based on daily activity by linear equation in two variables principle.

The activity in the third phase is to create a mathematical model based on daily activity problems based on the concept of a linear equation in two variables. At the beginning of the problem the context is given in the form of the difference in the length and width of the basketball court in front of the class. Departing from the problem students are instructed to determine the length of the center line of the field.

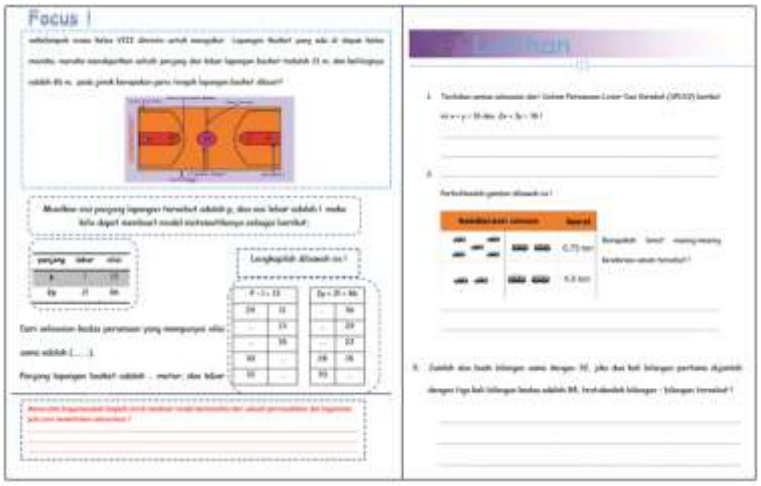


Figure 5. Define Mathematical Model Activity

With the concept of the rectangular area formula and the knowledge they had at the previous meeting, students tried to complete the table and determine solutions based on the problems given. One of the contributions expected from students is to provide conclusions regarding the steps to determine the solution of linear equation two variables by making mathematical models based on realistic problems in daily life.

Students are also trained to work on formal mathematical problems in the form of a comparison of the number of ages that must be solved with the concept of a linear equation two variables.

d. Fifth activity: Fine solution of linear equation in two variables using graphic and substitution method.

The problem about the comparison of the ages of family members in the fourth activity is designed to build students' understanding regarding solving problems with a linear equation two variable using graph and substitution methods. The opening problem begins by presenting illustration pictures and story questions, then students are instructed to make a mathematical equation model based on the problem and complete the value table, before giving generalizations related to the problem given, students describe sequential pairs of x and y values in plane diagram coordinates. The following is an illustration of activity four:

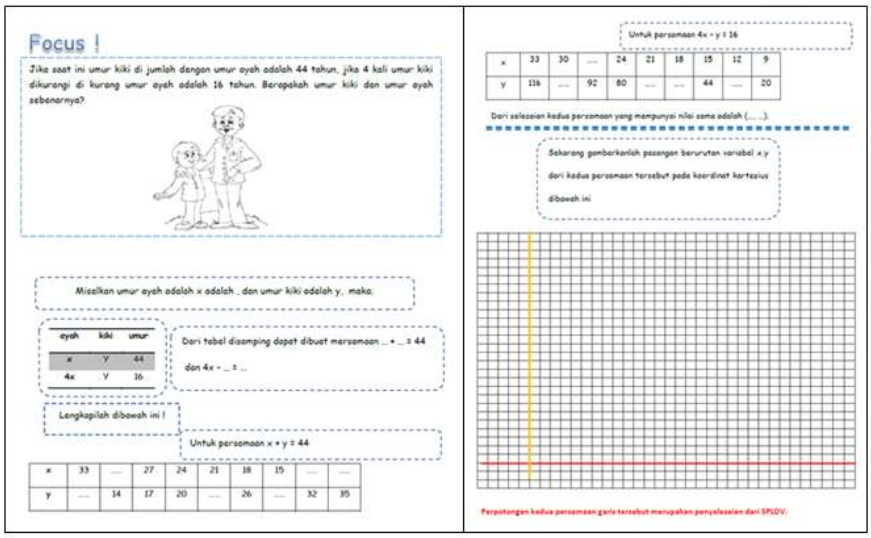


Figure 6. Define Solution of SPLDV Using Graph

Based on the results of the installation of the values of x and y as well as a straight line graph between the two equations, it is hoped that students will be able to gain knowledge that to find out the solution of a linear equation in two variables using the graphical method is to pay attention to the point of intersection of the two lines in Cartesian coordinates. Furthermore, students try to complete the solution using the substitution method with the same equation, it is hoped that the solution between the graph method and the substitution of the equation values will produce the same value.

e. Fifth activity: define solution by elimination method

The fifth activity is designed using a context problem in the form of selling

jerseys by a soccer club in the form of shirts and hats. The problem is designed so that students gain knowledge of solving a system of linear equations with in variables using the elimination method. Prior knowledge related to the substitution method is needed at this stage, so students must be able to relate the various concepts of knowledge they already have. The *model for* in this activity is designed in such a way as to work on the *form of* mathematical equations resulting from context problem modeling at the beginning of the activity. The following is an illustration of the problem given:

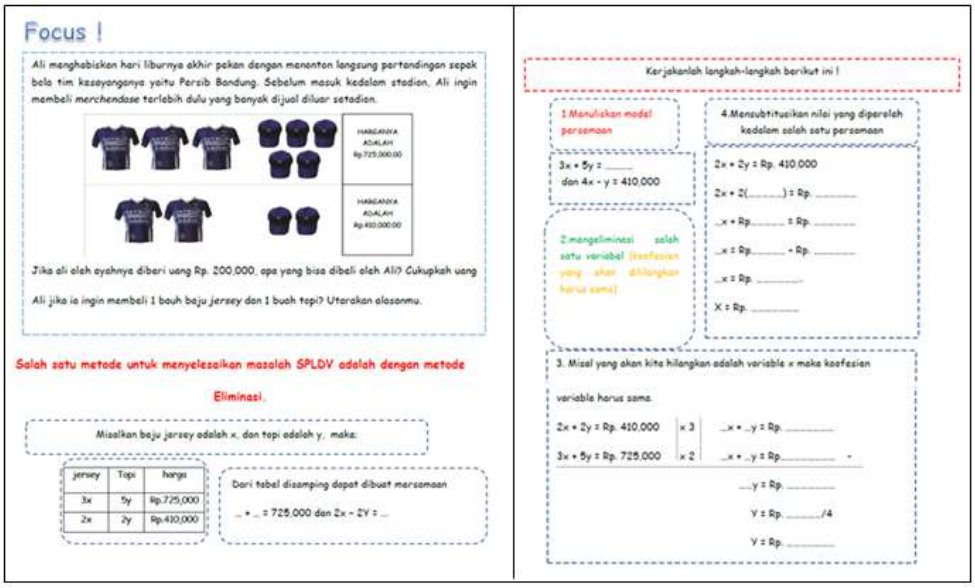


Figure 7. Define Solution of SPLD Using Elimination Method

In the last activity of the worksheet that was developed, exercises were given in the form of formal mathematics commonly found in school mathematics problems. Some of the questions are given in the form of problem solving so that students are trained to use the ability to analyze problems and not just solve problems by applying the knowledge of basic concepts that they memorize.

f. Evaluation of mathematical concept questions

After carrying out various activities designed at previous activities, students are assessed on how far their knowledge is related to the knowledge obtained. The evaluation questions developed consist of four questions that contain the principles of realistic mathematics education development and the characteristics of understanding mathematical concepts.

The next phase of this research was developed, in this phase the instructional material test to the validators that consisting of two mathematics education lecturers and two school teachers. The aim is to determine the feasibility of the instructional materials developed before being used practically in

the actual learning process.Validation of instructional materials consists of product presentation validation and competency test developed in order to measure students' ability to understand mathematical concepts. Based on Sugiyoyno et al. (2015) this is the following criteria:

Table 1. Validity Criteria

Validity Score (V_a)	Validity Criteria	Note
$v_a = 4$	Very Valid	Doesn't need revision
$3.25 \leq v_a \leq 4$	Valid	Doesn't need revision
$2.50 \leq v_a \leq 3.25$	quite valid	Partial revision
$1.75 \leq v_a \leq 2.50$	Not valid enough	Partial revision
$1 \leq v_a \leq 1.75$	Invalid	Total revision

The product validation at the initial stage by four experts stated that the results of the validity test on the indicators of the realistic mathematics education learning approach obtained v_a = 3 is quite valid with a partial revision description. Then, the indicator of curriculum suitability obtained v_a = 3.15 is valid enough with a partial revision statement. Those are the results of the validation by experts:

Table 2. Validity of Instructional Material Indicators

Instruction Material Indicator	V_1	V_2	V_3	V_4	$\sum_{j=1}^{i} v_{ji}$	I_i
Realistic Mathematic Education Aspect						
Activity 1	9	11	14	13	47	11.75
Activity 2	10	12	15	12	49	12.25
Activity 3	10	11	15	14	50	12.50
Activity 4	10	10	14	13	47	11.75
Activity 5	8	12	15	12	47	11.75
Total	47	56	73	64	240	60
Curriculum Suitability Aspect						
Defining of linear equation in two variables	2	3	4	3	12	3.00
Solution of linear equation in two variables	2	3	4	4	13	3.25
Mathematical modeling	3	3	4	4	13	3.25
Graphic and substitution method	3	3	3	4	13	3.25
Elimination method	3	3	3	3	12	3.00
Total	13	15	17	18	63	16.50

From the validation results, it can be concluded that the development of mathematics instructional materials to build students' mathematical concepts understanding does not need to be revised significantly but still pays attention to expert suggestions and comments as though the use of variables must be consistent, create problem that may have not specific answer, create learning activities that are able to

distinguish graphs and substitution methods. Those were used to improve the developed instructional material.

Meanwhile, the indicator of the aspect of understanding the mathematical concept obtained by v_a= 3.19 is valid enough with a partial revision statement. Those are the results of the validation by experts:

Table 3. Validity of Instructional Material Indicators

Indicators		V_1	V_2	V_3	V_4	$\sum_{j=1}^{i} v_{ji}$	I_i
Question 1	K1 & K2	3	3	4	4	14	3,50
Question 2	K4	3	3	4	3	13	3,25
Question 3	K3 & K7	2	3	4	3	12	3,00
Question 4	K5 & K6	2	2	3	4	11	2.75
Total		10	11	15	13	50	12,75

Researchers revise the instructional materials that were developed in accordance with expert recommendations for resubmitted to the same validators. The revalidation decisions of the instructional materials developed were declared valid and there was does not need for revision.

The analysis of the competency test begins with scoring indicators ability of mathematical concepts understanding in students' work on test instruments. This is the following criteria for assessing the effectiveness of students' conceptual understanding (Sugiyono et al., 2015):

Tabel 4. The Students Mathematical Concept Development Criteria

Score Interval	Level	Criteria
37 – 40	4	Effective
33 – 36	3	Effective
29 – 32	2	Not yet effective
≤ 28	1	Not yet effective

Question number 1 measures students' analytical skills and understanding of concepts related to the linear equation function in two variables. Students were asked to evaluate whether the equation $y = -x$ was a linear equation in two variables or not, and were asked to give the right reasons. The following were the subject's answer of question1:

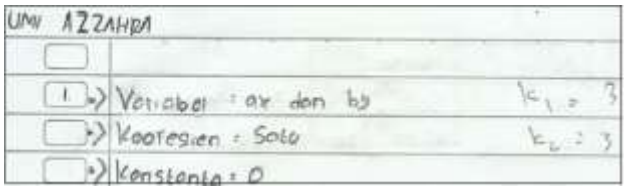


Figure 8. Student Answer of First Worksheet

Question number 2 measures students' logical ability in dealing with problems and making appropriate mathematical models. Most of students are able to understand the problem and create a mathematical model by first making a frequency value table. The following are student answers regarding this question:

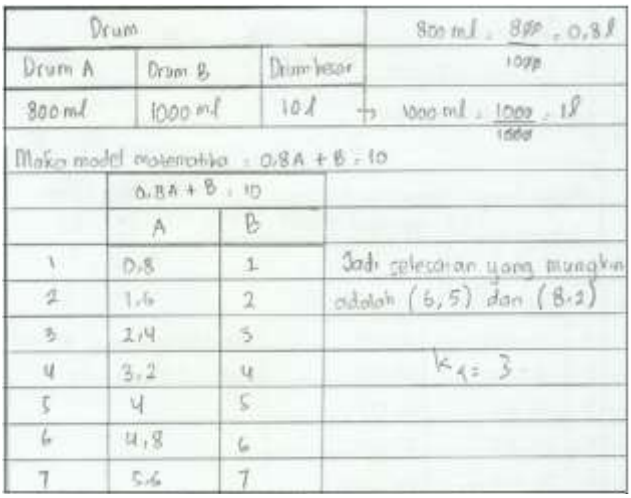


Figure 9. Student Answer of Second Worksheet

On the question number 3 still using contextual problems in accordance with daily life, in addition to students being asked to analyze problems and create mathematical modeling, students are asked to determine the solution. The following are student answers to these questions:

Figure 10. Student Answer of Third Worksheet

The last question number 4, the context problem presented to students, is already a formal mathematical problem. The problem is in the form of a rectangular geometry story based problem-solving whose length and width are known, then students are asked to determine the wire frame to form the square using the concept of a linear equation in two variables. The following are students' answers to these problems:

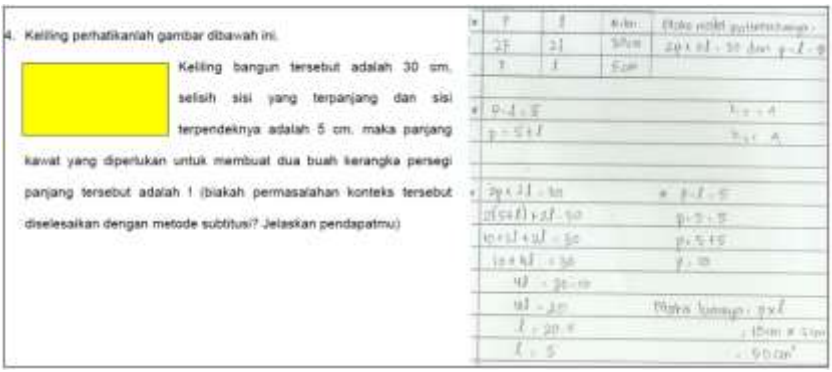


Figure 11. Student Answer of Forth Worksheet

The subject ability analysis showed that, the S1 can define concepts verbally and in writing. S2 identifies and creates examples and non-examples. S3 uses symbols, models, diagrams to represent a mathematical concept. S4, S5, S6, S7 changes one form of representation into another form. S5 recognizes various meanings and interpretations of concepts. S8 can identify the meanings of a concept and recognizes the conditions that determine the concept. While S9 and S10 have abilities to differentiates and compares concepts. Meanwhile, the results of student work on the questions instrument, it was obtained that E = 33.14. The criteria for the effectiveness of mathematics instructional materials developed to build conceptual understanding for E = 33.14 are effective and feasible to be applied to build students' understanding of mathematical concepts in the material. This is student mathematical concept understanding score:

Table 5. Validity Criteria

Subjects	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Question 1	8	8	6	8	8	8	5	8	4	5
Question 2	3	3	3	3	3	3	4	3	4	3
Question 3	8	7	8	7	7	6	7	7	6	4
Question 4	8	8	8	4	6	7	7	6	7	4
Total	38.6	37.1	35.7	34.3	34.3	34.3	31.4	32.9	30	22.9

The results of student interviews show that the developed instructional material base on realistic mathematics education, those are using contextual problems, linking with other concepts or lessons, using student production or construction, using models, and interactivity during the instruction process could helped students mathematical concepts understanding. Students show interest in learning using the developed instructional materials, because they learn in a structured way from contextual problems to formal forms of mathematics that helped them to understanding concepts and did generalizations and abstractions on more complex problems.

The development of instructional materials in building students' conceptual understanding in the linear equation in two variables still has shortcomings and needs further refinement, such as creating or adding more varied learning context activities, so that students have more references to understanding concepts in abstracting mathematical problems. Interactivity of students in producing ideas or ideas should be emphasized more during the instruction process so that students' understanding is more evenly distributed between students who are high and low able to overcome. Nevertheless, the product of developing instructional materials build understanding of students' concepts has several advantages. Those are, the instructional materials can be used to build mathematical concepts understanding especially in schools that are research locations., the product can be used as a good source and learning material because it has been proven to be able to build students' mathematical concepts understanding, the product can guide students to find their own mathematical concepts through real context activities that exist in the student's environment, the instructional material have undergone several stage of validation by experts through the provision of suggestions and input in developing and perfecting instructional materials.

CONCLUSION

The instructional materials developed have met the principles of understanding mathematical concepts and aspects of realistic mathematics education learning. The product that have been declared valid by the validator, have good quality and are suitable for use in learning to build understanding of students' mathematical concepts, was effective and suitable to be used to build students' understanding of mathematical concepts. The Analysis of the results of interviews with students on the presentation of realistic mathematics education can foster student learning motivation.

In order to be used in learning with a more optimal time, teachers need to get used to using RME-based learning. In addition, teachers must be able to create conducive situation, and have other knowledge related to students in order to create an ideal learning situation. The paradigm of students' thinking towards mathematics must also be changed, from boring mathematics lessons by only working on problems in the form of numbers and memorizing formulas, with mathematics lessons that is close to students' daily activities and their environment.

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