The Development of Learning Devices with Realistics Mathematics Education Based in Program of Mechanical Engineering and Automotive Engineering

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Abstract - The aim of this research is to develop the math learning devices with RME-based in mechanical engineering and automotive engineering programs for students of grade 10. The devices designed are adjusted to the students’ major. The students of mechanical engineering learn about design, construction and operation of machinery, while automotive engineering students focus on the design and construction of cars. Learning devices were designed in the form of lesson plans and students’ worksheets. The development model used in this research was Plomp model. This paper focuses on the preliminary research. The preliminary research covers needs analysis, curriculum analysis, concept analysis and students analysis. The instruments used were questionnaire sheets, interview sheets, and observations. Data analysis technique is a qualitative data analysis technique. The result of the preliminary research shows the learning devices made by the teachers were universal for all major and ignore the character of each major, neither mechanical engineering nor automotive engineering. The curriculum analysis done toward the syllabus and KD of math and the productive subjects related. The result of this preliminary research will be a guidance in prototype of learning devices that will plan.

1. Introduction
The advancement of a nation depends on the quality of education and creativity of its nation to produce the reliable, quality, and competent human resources. Mathematics is one of the sciences that plays an important role in production of competent human resources. Mathematics is a compulsory subject in vocational schools. Vocational High School is an educational institution which prepares students with various programs and has expertise in students’ knowledge and skills, allowing them to get a good job. This is in accordance with Article of Depdiknas [1] about national education system states the vocational education is an institution which prepares the students to work in the certain field.

The fact in the field shows the solving problem ability of the students in the vocational school were relatively low. This case is supported by the early research done by the researcher to see the problem solving ability of the students mathematically in one of vocational high school in Indonesia by giving some items of questions about mathematical problem solving to the students. The questions in Picture 1.
The students in one of vocational high school in Indonesia got the task from the teacher to design a conventional lathe machine as picture below:

If in the design, the length of the machine is 6 cm longer than its width and double amount of the width is equal to the length plus 15. Decide!

a. Length and width in the sketch!

b. The length of the threaded shaft if its length 1/3 out of the length of the sketch!

**Picture 1. Exercise in Books**

Based on the assessment done by the researcher, there were no students could answer that question correctly. It can be seen from some answer sheets in picture 2:

**Picture 2. Students’ answer sheets in Mathematical Competency Test**

Based on some answer sheets above, the researcher concludes that there were some indicators of mathematical problem solving ability of the students which were not reached yet, some of them are: the students could not comprehend the case well because they cannot elaborate the elements they know correctly and completely; they got wrong in deciding the length of the sketch. The students could not make model the mathematic problem with “\(p=l+6\)” as well. Therefore, the students could not apply the appropriate strategy to solve the problem well, it made the students could not solve the question well. The researcher agrees with the students ability of mathematical problem solving belongs to low level. Wahyuni [2], Nuryana [3] and Supianti [4] states the importance of mathematical problem solving ability was not in line with the reality on the ground, that students' mathematical problem solving ability was still relatively low in Vocational High School. This case is also supported by the result of the research done by Sumartini [5], it shows the achievement of the vocational school students in mathematics was relatively low, particularly in the mathematical problem solving ability. Refer to the data got, 73% out of the students has the mathematical problem solving ability in less ability level. It means, more than 50% out of the students have very low mathematical problem solving ability.

The factor influence the low of mathematical problem solving ability of the students is the learning devices designed by the teacher did not present the learning proses which can elicit the students interest because the mathematics was not connected towards the application of the students major. Dalby [6] states vocational classes reinforce perceptions that mathematics is an isolated and irrelevant subject, addressing this disconnection requires a pedagogical approach and classroom culture that
links mathematics learning with vocational values. The findings suggest that adopting mathematics classroom practices that reflect the surrounding vocational culture creates greater coherence for students and has positive effects on their engagement with mathematics learning. It agrees with Armiati’s opinion in La’ia [7] who states the reason why the math is not interesting for the vocational students. It is caused by the learning devices used by the teacher in vocational school relatively universal like the teacher in Senior High School do. That matter was also found by the researcher when conducted observation and interview with the teacher in two vocational high school in Indonesia, where the learning devices used by the teacher is not appropriate to the students need. The learning devices designed and used by the teacher is relatively universal which there is no difference of the devices used for one major with the other one. The lesson plan did not reflect the character of each major in the same level of grade. The lesson plan did not guide the teacher to present the contextual problem which is connected to the students’ major. Since there is no contextual problem presented by the teacher about the related major or expertise competence, it effects the students problem solving ability is not accustomed.

Based on the case above, in the learning process of mathematics, the teachers are hoped to be able to manage the convenient, attractive, innovative learning process, and push the students’ interest to learn the mathematics. The material should be applicable, adjusted to the students’ major and real life, in order to reach the learning goal and to improve the students’ ability of mathematical solving problems.

According to the problems above, the low ability of the mathematical problem solving of the students indicated by the less optimal of lesson plan and learning material made by the teacher, this case should find the solution. Based on PERMENDIKBUD [8] about the standard process of primary and secondary education. It states the design of the math learning devices is a part of the lesson plan which can improve the ability of the students in learning process and as the proponent to make the math learning goal is reached. Therefore, it should be held some improvement toward the learning devices in the vocational school. One of the solutions is by developing the learning devices with the realistic mathematics education Approach.

The result of the research done by Zakaria and Syamaun [9] states the Realistic Mathematics Education Approach encourage students to participate actively in the teaching and learning of mathematics. Thus, Realistic Mathematics Education Approach is an appropriate methods to improve the quality of teaching and learning process. RME approach is one of the contextual approach uses the daily life context of the students which can improve the mathematical problem solving ability of the students. It is supported by the research done by Fitriani and Maulana [10] who states “the students who study about math by using RME have the higher percentage average of problem solving ability than the students use the traditional approach in calculating, especially in application.” In line with it, the result of the research done by Kesumawati [11] and Susanti [12] also state the improvement of the mathematical problem solving ability of the students who is taught by PMR approach is better than those taught by the conventional approach. Laurens [13] states the students who were taught with RME achieved better than the students who were involved in conventional learning. This research finding has suggested that it is important for teachers to empower students’ intellectual ability through RME and games in order that meaningful and contextual learning can be generated. It is recommended that future research will explore the effect of RME on students’ attitude, problem-solving ability, learning interest, or other variables related to mathematics learning.

The RME approach is chosen because the indicator in the mathematical problem solving ability can be train and improve through learning by using characteristics and principles in the RME approach itself. It can raise the students’ problem solving ability. Refer to that case; it can be concluded that RME is suitable to be applied for the students in vocational school because the material used in the RME learning materials has the connection to the real life which is easy to be understood and imagined by the students and can help the students to understand the mathematics, belongs to the vocational school students of mechanical engineering and automotive engineering program.
Based on the problems above, the researcher is going to do the development research under the title the development of learning devices with RME-based in the program of mechanical engineering and automotive engineering for the vocational school students. The difference between this research and the previous research was that the learning devices developed were adjusted to the vocational students’ expertise program, namely mechanical engineering and automotive engineering.

2. Materials and Methods
The research done by the researcher belongs to the development research. Borg and Gall [14] states that the development research is the research method used to develop and validate the products used in the learning process. According to Plomp & Nieven [15], the development research consists of 3 stages: preliminary research, development or prototyping stage, and assessment stage. In the stage of preliminary research, there are some activities done. Those are need analysis, curriculum analysis, concept analysis, and students’ analysis. The result of the preliminary research is used as the start point to develop the learning devices will design. In the prototype stage, the development process of the product developed based on the result of the preliminary research. The prototype stage includes design, development, and formative evaluation. Things would be done in this stage are developing the products in the form of lesson plan and student workshed with RME-based. Formative test in the development stage is done through one to one, small group, and field test evaluation. Formative evaluation stage is done by doing the evaluation towards contents or format in the product designed based on the formative test result. In the assessment stage, the assessment stage of the prototype result which has been revised is doing the practicality test and the effectiveness test in the huge group/limited test. The evaluation done in this stage is semi-summative evaluation. Interview data, observation sheets, and questionnaire data were analyzed using qualitative data analysis techniques. Reduction of data, presenting data, and drawing conclusions.

3. Result and Discussion
The need analysis was done for (1) collecting the information in form of the basic and general problem in mathematics, (2) seeking the needs level towards the learning devices used RME-based to improve the students’ ability of mathematical problem solving. This activity was done by doing observation in mathematics class at two of vocational high school in Indonesia. Based on the observation and interview done to the teacher, the researcher earned the information about the learning process of math ran conventionally and was not running as in Curriculum of 2013 totally. The ability of the students to study was getting low. They were not active and not enthusiastic in following the class activity due to just paid attention to the teacher’s explanation. Then, the learning devices used by the teacher were relatively general for whole major. The lesson plan designed by the teacher was not applied in the learning activity. The teachers also did not use the worksheet designed by themselves or even from the publisher. The students did not have any source book to study, and only teachers do. It agrees with Maizendra [16] who states that lesson plans designed by the teacher was in accordance with the provisions of the 2013 curriculum, but in practice it has not been implemented properly. The lesson plans was still general in nature which has not given a different character in each skill program.

The students analysis was to know the ability of the students, the researcher gave the test about mathematical problem solving ability. Based on the analysis, the researcher found the ability of the students about mathematical problem solving was relatively low. The data collected was used as the guidance to the development stage or prototype stage.

The curriculum analysis was done to get the overview about the characteristics of the uneven semester will be taught to the students of grade X at vocational school, involving the materials, developing the indicators of the problem solving ability and learning goal, selecting the appropriate strategy, and choosing the suitable lesson to use with RME approach. In this stage, the researcher analyzed the curriculum used in vocational school for Math subject and productive subject of mechanical engineering and automotive engineering program. The analysis done toward the syllabus and basic competence of math and the productive subjects related. The data would be collected by
documentation. Based on the analysis, the curriculum used is curriculum of 2013, however it still needs improvement. The changes of learning indicator before and after analysis it can be seen in The Table 1.

| Before Analysis                                                                 | After Analysis                                                                 |
|--------------------------------------------------------------------------------|--------------------------------------------------------------------------------|
| 1.3.1 Determine the set of resolutions in a two-variable linear equation system | 3.3.1 Determine the general shape of the system of linear equations two variables of the contextual problem given. |
| 1.3.2 Determine the value of a variable in a system of linear equations two variables in a contextual problem | 3.3.2 Determine the set of solutions to the system of linear equations two variables of the contextual problem with the substitution method. |
| 3.3.3 Determine the set of systems for solving linear equations two variables from contextual problems with the elimination method. | 3.3.4 Determine the set of completion systems for linear equations two variables from contextual problems with the combined method. |
| 3.3.5 Determine the set of system solutions for linear equations two variables from contextual problems with the graph method. | 3.3.6 Determine the set of completion systems of linear equations two variables of contextual problems with the matrix determinant method. |
| 4.3.1 Solve the problem of the system of linear equations two variables in life | 4.3.1 Resolve the contextual problem of two-variable linear equation systems related to mechanical engineering and automotive engineering programs |

Afterwards, the researcher also analyzed the correlation between basic competence in math and basic competence in the productive subject in the mechanical engineering and automotive engineering for grade X. The results of the analysis can be seen in the Table 2.

| Mathematics | Knowledge | 3.3 Determining the value of a variable in a system of two variable linear equations in a contextual problem | 4.3 Presenting the problem solving system of two variable linear equations |
|--------------|-----------|----------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------|
| Productive  | Knowledge | 3.1 Understand the functions of equipment and technical drawings (Mechanical Engineering Drawings). | 4.1 Sort equipment and technical drawings (Mechanical Engineering Drawings). |
| 3.4 Apply geometric construction drawings (Mechanical Engineering Drawings). | 4.4 Shows geometric construction drawings (Mechanical Engineering Drawings). |
| 3.4 Understanding geometric construction drawings based on the shape of construction | 4.4 Group geometric construction drawings based on the shape of the construction |
| 3.12 Apply how to disassemble, repair and install outer and inner tires. | 3.2 Applying Additional Electrical Equipment (Accessories). |
| 3.9 Analyze the area of the image | 3.9 Analyze the area of the image |
Concept analysis was done to decide the content and lesson will be involved in the learning devices, analyze the concepts and the correlation of each, and arrange the contents systematically. In this stage, the researcher analyzed to the concept will be discussed in the math subject, then find the correlation between the concept and material and arrange systematically. The data would be collected by concept documenting. Based on the concept analysis, found the arrangement of the material as follow: number of numbers, logarithm, absolute value, system of two-variable linear equations, linear inequality system of two variables, arithmetic sequence and sequence, geometric sequence and sequence.

The students analysis is done to find the characteristics of the students related to the academic capability, their environment, their motivation, what kind of teaching materials they like. The result will be guidance in designing the appropriate worksheet to motivate the students in learning process. The students analysis is conducted by interview and questionnaire to the students of mechanical engineering and automotive engineering for grade X. Based on the analysis, the researcher attained the information which the students did not like math because of boring, it decreases the students’ interest to study about math. On the other hand, the assumed that math is difficult to understand. It influences the students get difficulty in following the activity in math class. They considered that math is a horrible subject and cannot apply in the daily life. The data collected were analyzed descriptively and then the information from the students were filtered and used as the guidance in the developing stage or prototype stage.

4. Conclusion
Based on preliminary research it can be concluded that learning process of math ran conventionally and was not running as in Curriculum of 2013 totally. Then, the learning devices used by the teacher were relatively general for whole major. The ability of the students about mathematical problem solving was relatively low. They were not active and not enthusiastic in following the class activity due to just paid attention to the teacher’s explanation. The results of preliminary research would be used as a guideline for making prototype rme-based learning devices in the mechanical engineering and automotive engineering programs. For further researchers can develop rme-based learning tools for other expertise programs.

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