Development of mathematical learning devices based on realistic mathematics education (RME) in senior vocational school

A Andison¹ and A Armiati¹
¹Mathematics Department, Universitas Negeri Padang, Padang, Indonesia

Abstract. This study is development of mathematical learning devices based on Realistic Mathematics Education (RME) in the chemical engineering expertise program in students in class XI senior vocational schools that supports valid, practical and effective problem-solving skills. This research is development research. The method used in the research is the method of developing Plomp with stages: (1) preliminary research (initial research), (2) prototyping phase (development stage), and (3) assessment phase (assessment phase). The product is a learning device. Learning tools developed include: (1) Lesson plan and (2) Student Worksheets. (1) analyzing the needs, (2) the draft development process, (3) drafting the development, (4) expert reviews and trials carried out in several stages namely (a) expert review and learning media experts, (b) analysis and revision I, (c) expert review of learning design, (d) analysis and revision II, (e) individual trials and small group trials, (f) analysis and revision III, (g) field trials: class and teacher, (h) analysis and revision IV, and (i) end product development results.

1. Introduction

Based on the Decree of the Director General of Primary and Secondary Education Number 06 / D.D5 / KK / 2018 June 7, 2018 [1] regarding the Expertise Spectrum of senior vocational school / Islamic Vocational School, explained that there are 9 fields of expertise in senior vocational school, one of which is Technology and Engineering. The field of technology and engineering expertise is further divided into expertise programs, one of which is chemical engineering. Chemical engineering is one of the expertise programs in vocational secondary education that has good job prospects in the current era of globalization. Mastery of technology by the young generation in carrying out the objectives of bringing forward the era of globalization. One of the biggest industrial fields is the chemical industry, so it requires chemical graduates who are experts and skilled in mastering chemical engineering to support the development and mastery of the technology. Therefore, indirectly, as a preliminary statement, graduates from the vocational chemistry engineering program are competent so that they can drive the industrial wheels.

Mathematics learning in Vocational School has a goal contained in Permendiknas Number 59 of 2014 [2] concerning Vocational curriculum and its level, which states that in mathematics learning students are expected to be able to improve the ability to understand mathematical concepts, mathematical reasoning, mathematical problem solving, mathematical communication. One of the mathematical abilities that can improve students' mathematical abilities, including the ability to solve problems. The problem solving ability requires a focused thinking process to generate ideas, ideas or develop the possibility of solving the problems faced. Suherman [3] states that the problem solving process provides an opportunity for students to be actively involved in studying, searching, finding their own information to be processed into concepts, principles, theories or conclusions.

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Solving this problem itself is an important part of the mathematics curriculum itself, especially in the process of learning mathematics. Where in the learning process students may be able to apply and deliver orally or in writing so that they can gain experience from the knowledge and skills they have. Therefore, with the application of these students guided to think systematically and initiative in dealing with a problem. The low assessment of the ability to solve the problem is also exposed in the acquisition of the results of the PISA study [4] obtained that Indonesia is still unable to show brilliant achievements in fields of reading, science and mathematics. Indonesia was only ranked 69th out of 76 participating countries in the field of mathematics. "Mathematical questions in PISA measure more problem solving ability, reasoning ability, argumentation and communication skills PISA OECD [5].

The low mathematical problem solving ability stated in the results of the PISA study above is an indication that students' mathematical abilities have not been achieved optimally. From these results by researchers through a preliminary study with a problem-solving ability test on students at SMK Negeri 1 Koto Besar in Dharmasraya District, it is still said to be low, it can be seen from the results of the test analysis of students' problem solving abilities obtained an average of 1.3 on a scale of 4.00. The cause of the low problem-solving ability in SMK Negeri 1 Koto Besar, namely in the process of learning mathematics in the schools, shows that there is a tendency for learning activities to be dominated by teachers and students only as subjects of learning. This can be seen from students only paying attention to what is conveyed by the teacher while the feedback from the learning activities from the students has not been seen, indirectly in this case the students have no special attention to learning or can be said to be passive by only listening to learning from the teacher. So that students' interest in mathematics learning delivered by teachers is low. In this case it is also seen with the habit of students accustomed to working on routine questions and the teacher has not yet accustomed to giving open-ended or non-routine questions to students.

Based on the research of Armiati et al in La'ia [6], the causes of mathematics subjects in Vocational Schools are less desirable, namely learning devices and teaching materials used by teachers are general, namely learning devices and teaching materials used together with learning tools and teaching materials used in high school. From the results of observations of researchers at SMK Negeri 1 Koto Besar in Dharmasraya District, the lesson plan is still general in nature as it is used in high schools in general, so the expertise program in this case chemical engineering does not appear to be reflected in the learning implementation plan made and carried out by the teacher. The lesson plan made by the teacher still looks general in nature or it can be said that it has not shown its own characteristics for learning mathematics in the chemical engineering expertise program of SMK Negeri 1 Koto Besar, Dharmasraya Districs. Learning tools such as lesson plan and students worksheet, are known to have not been able to engage students actively and giving questions has not led to an increase in students' mathematical problem solving abilities. The steps of the core activities in the lesson plan are still considered not specific. Like observing the lesson plan, it has not elaborated in detail the use of comparison in daily life and there is no teacher activity directing students to show character that must be included in the learning tool in the 2013 curriculum in observing the use of comparison. Then in the activity of asking there is no activity of the teacher to conclude the answers to student questions.

Based on the analysis of learning devices in this case the lesson plan used by the teacher, there are inequalities and inequalities from the lesson plan towards the application into the learning process, so that it is perceived to have an adverse effect on the quality of students in learning or the quality of students in understanding learning material. Therefore it is necessary to develop lesson plan that facilitates students to develop their knowledge and accommodate students to develop problem-solving abilities.

Therefore, for the realization of the implementation of learning in order to achieve the learning objectives in this case planned to arrange learning devices namely lesson plan and students worksheet based Realistic Mathematics Education (RME). The learning device that will be developed is a learning device that contains the characteristics of RME. Treffer [7] formulated five characteristics of RME, namely: the use of context, the use of models for progressive mathematics, the use of the results of the construction of students, interactivity, relevance. Based on these characteristics, it can be seen that students need to communicate their ideas in an effort to resolve contextual problems, how students
produce and construct their thoughts, how students actively participate in discussions, negotiations, and how students are responsible for their answers to questions that arise.

The RME approach is also suitable for use in senior vocational school that have many expertise programs, including the chemical engineering program. Because the RME approach uses contextual problems that are relevant to the world of students. The use of contextual problems can be associated with the skills program of students in SMK, so that students have an interest in learning mathematics. So that the teacher can direct students to achieve the learning goals planned by the teacher.

2. Method
This research is a development research. The development procedure in this study follows the development procedure of the Plomp model. Step-by-step development of learning tools that refers to the development model Plomp [8] are as follows: (1) the stage of preliminary study (preliminary research), (2) the stage of development (prototyping stage), and (3) the assessment phase (assessment phase). The product developed in this study is a learning device consisting of a lesson plan and a Student Worksheet. With results where learning tools must meet valid, practical and effective criteria.

3. Result and Discussion
3.1 Result
In this study the development process was carried out by beginning with initial research by researchers at SMK Negeri 1 Koto Besar, Dharmasraya Districts. Observation activities carried out in class IX is an analysis of the learning process, covering: student analysis, material analysis and competency specifications. Then the next step that is carried out is the stage of development, namely designing the initial prototype of the learning device. Arranging the components of the lesson plan and students worksheet that will be designed. Then the final stage is the assessment stage. Validation and trial activities are activities carried out at the assessment stage. Validation in this study aims to assess the feasibility of development products that will be tested. Then the trial itself was carried out consisting of small group trials and large group trials. Where in this case a small group trial was conducted on 5 students. While the trials in large groups were carried out at SMK Negeri 1 Koto Besar in class IX of the chemical engineering program (Industrial Chemistry) where there were 30 students.

After the activities are carried out based on the steps mentioned above, the results of the validation of the learning device, namely lesson plan, students worksheet and research instruments, are detailed in the following table 1:

| No. | Devices and Instruments | Validation results | Criteria |
|-----|-------------------------|--------------------|----------|
| 1   | Plans for lesson plan   | 80%                | Valid    |
| 2   | Student worksheets      | 78%                | Valid    |
| 3   | Mathematical problem solving ability assessment rubric | 79% | Valid |
| 4   | Teacher activity observation sheet | 80% | Valid |
| 5   | Student activity observation sheet | 80% | Valid |
| 6   | Questionnaire for student responses | 80% | Valid |
| 7   | Mastery test for teaching materials | 80% | Valid |

The results of the trial of learning devices that contain the characteristics of Realistic Mathematics Education (RME) in the SMK Negeri 1 Koto Besar in class XI of the Chemical Engineering expertise program are detailed in Table 2 below:

| Learning Tool Criteria | Test Results |
|------------------------|--------------|
| Practical              | The trial results of practicality criteria, namely the level of implementation of learning devices is 82%. Based on the criteria stated that the implementation of the learning tools in the trial met the criteria both |
Effective

1. The results of the test of the effectiveness of the test sheet of student activities that meet the criteria well with a percentage of 83%
2. The trial results of the effectiveness of the teaching materials mastery test are fulfilling the criteria for classical completeness with a percentage of 89%
3. Mathematical problem solving ability, namely by percentage is a good category

3.2 Discussion
Learning devices that will be developed are learning devices that contain characteristics Realistic Mathematics Education (RME). Treffer [7] formulated five characteristics of RME, namely: the use of context, the use of models for progressive mathematics, the use of the results of the construction of students, interactivity, relevance. Based on these characteristics, it can be seen that students need to communicate their ideas in an effort to resolve contextual problems, how students produce and construct their thinking, how students actively participate in discussions, negotiations, and how students account for their answers to questions that arise.

The development of learning devices that contain RME characters developed in the learning process in Vocational High School 1 Koto Besar is able to provide better changes to learning where there is an enthusiastic increase through two-way learning between teachers and students through active students in learning. Ullya et al [9] stated that students who learn to use RME-based teaching materials can increase involvement in learning so that they are not rigid in communicating and motivated to enrich their learning experiences. Sembiring et al [10] also stated that RME is widely recognized as providing one of the best and most detailed elaborations of a problem-based mathematical approach.

The involvement of students in learning can help them to improve their understanding of the material so that the level of productivity and ability to solve problems indirectly will also be influential. According to Sutawidjaja in Putra [11] explained that, solving mathematical problems is the best way to improve one's mathematical abilities, especially for those who want to play a role in the development of mathematics and its use.

Guarantee the learning device has a content validity and device construction developed learning must meet valid criteria. From the trial phase to know the level of validity to the development of the pursuit in this case obtained average percentage of scores from the validator for the lesson plan is 80%, while the percentage of the average score of the results of the validation device students worksheet is 78%, so the criteria are based set for lesson plan and student worksheets is valid criteria.

Practical and effective criteria are criteria that must be met in the development of learning devices. As mentioned before it determines the practical criteria it is obtained based on trials against large groups. Where as for the purpose of measuring practical and effective criteria is to find out the truth of the application of learning devices in accordance with the objectives to be achieved. The practical criteria referred to in this study are seen based on observation of teacher activities where based on the implementation of learning devices that meet the criteria both. While effective criteria are seen based on observations of student activities that meet good criteria, the results of the teaching materials mastery test meet the classical completeness criteria, where based on student questionnaires provide positive responses and mathematical problem solving abilities students achieve good categories.

4. Conclusion
Development of learning devices based on the Realistic Mathematics Education (RME) approach to the chemical engineering program at SMK Negeri 1 Koto Besar, namely the development of learning devices Lesson plan and student’s worksheet which are developed are valid, practice and effective. For this reason, this device can also be used in other material as a whole in one basic competency by adjusting to the characteristics of students and paying attention to the preparation of learning tools for time allocation, methods, learning approaches that are implemented.
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