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Development of Mathematics Learning Tools with Problem Based Learning Model on Matrix Material to Facilitate Students' Critical Thinking Ability

Wiyana Pertiwi*, Yenita Roza, Putri Yuanita
Postgraduate Mathematics Education, FKIP, Universitas Riau, Pekanbaru, 28293, Indonesia

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A B S T R A C T

The ability of students to think critically in mathematics is is still low. The lack of learning tools that are considered to facilitate students' mathematical critical thinking skills is one of the cause it. The purpose of this study was to develop a mathematics learning tool with a quality problem-based learning (PBM) model to facilitate students' mathematical critical thinking skills. The learning tools developed consisted of a syllabus, lesson plans (RPP) and student worksheets (LKPD) on the matrix material for class X SMK. This research was a development research using the Borg and Gall model. The development consists of six stages, namely: 1) research and data collection; 2) planning; 3) development of the initial product draft; 4) initial field trials; 5) revised trial results; and 6) dissemination and implementation. The subject of this research trial was the students of SMK Nurul Falah Pekanbaru. The instrument used was validation instrument for the syllabus, lesson plans, and student worksheet. Based on the results of the validation data analysis, it shows that the learning tools developed were very valid. The results of the validation of the syllabus were 85.11; the average RPP score was 86.02; and the average LKPD score was 86.40. The average student response questionnaire to the initial field trial was 85.93 with the very practical category. The learning device developed was valid and practical for use by class X SMK students.

1. Introduction

Learning tools are preparations prepared by the teacher so that the implementation and evaluation of learning can be carried out systematically and obtain the expected results (Nazarudin, 2007). The learning process can run well if the teacher is able to arrange learning tools and is able to carry out the learning

* Corresponding author.
E-mail: wiyanapertiwi@gmail.com
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process according to plan (Afdareza. Et al, 2020). Zulfah (2017) said that the learning tools used in the learning process consist of a syllabus, lesson plan (RPP), student worksheets (LKPD), teaching materials and learning outcome tests.

Based on observations and analyzes conducted by researchers on the learning tools used by teachers in several SMK Pekanbaru, information was obtained that the learning tools made by the teacher still had weaknesses that needed to be fixed, the teacher had not developed learning tools in accordance with Permendikbud number 22 of 2016. This is in line with research conducted by Heleni and Zulkarnain (2018) which shows that the syllabus developed by the teacher is not in accordance with the existing components in Permendikbud number 22 of 2016, the lesson plans developed by teachers are not based on the syllabus and the worksheets used contain a summary of the material and a collection of questions that are not in accordance with the principles of learning curriculum 2013.

The weakness of the learning tools based on observation and analysis that the researchers did is the first weakness, namely KD in the syllabus has not used the KD contained in Permendikbud number 37 of 2018. The second weakness is in the preparation of RPP in the development of indicators of competency achievement that has not used operational verbs (KKO) The third weakness is that the learning resources used by teachers and students are in the form of student worksheets (LKPD) which are used less interactive because they only contain material summaries, sample questions and practice questions. Exercise questions in the LKPD are only questions that are still abstract in nature, not questions that are found in everyday life so that the LKPD does not guide students to find the concept of lessons only requires students to work on questions. Teachers should be more creative in developing LKPD. The LKPD developed by the teacher is expected to develop the thinking skills of students. Moreover, in mathematics learning, the dominant relies on the ability to think (Syahbana, 2012). LKPD and the questions contained in the LKPD should be able to improve the thinking skills of students. In the 2013 curriculum, one thing that you want to achieve is to produce a generation who has the ability to think critically. In line with the skills needed in the 21st century or what is known as 4C, one of which is critical thinking skills (Putri, et al, 2020). The ability to think critically is a very important part of learning mathematics (Putri, et al, 2020). Students need to be equipped with the ability to think critically so that in the learning process it can be used to analyze and solve problems they face in everyday life (Sari, 2015).

Critical thinking is thinking rationally in assessing something (Karim, 2015). According to Sulistyani (2015) critical thinking is the ability to think that is valuable for someone to be successful in the modern world where logical conclusion is very important in living life. Fisher (2008) suggests six indicators of critical thinking skills, namely: identifying problems, gathering various relevant information, compiling a number of alternative solutions to problems, making conclusions, expressing opinions, and evaluating arguments. In line with Facione (1990), there are 6 categories of critical thinking skills, namely: interpretation,

analysis, evaluation, inference, explanation, and self-regulation. Mathematical critical thinking skills are reasonable and effective thinking skills that focus on concentrating what to believe or do, with indicators of interpretation, analysis, evaluation and inference.

The critical thinking skills of students in Indonesia are still low. In 2015, the PISA study showed that Indonesia was ranked 65 out of 72 countries for math ability with a score of 386.The average score for the Mathematics National Exam (UN) of students of SMK Nurul Falah Pekanbaru in 2018 was 39.94 on a scale of 0-100. From the average results of this national exam, it can be concluded that the critical thinking skills of vocational school students are still low. One learning model that can train students' critical thinking skills is a problem-based learning model (Reta, 2012). Implementation of PBM can increase learning motivation and critical thinking skills (Sari, 2015). PBM is a learning model that uses real problems found in the environment as a basis for gaining knowledge and concepts through the ability to think critically and solve problems (Fakhriyah, 2014). If usually the learning process begins with the provision of learning material and then continues with giving problems, then learning with PBM provides problems as the beginning of the learning process (Zulfah, 2017). The PBM model is carried out by providing stimulation in the form of problems which are then carried out by problem solving by students which are expected to increase students' skills in achieving learning material (Armis & Suhermi, 2017).

The PBM model is very suitable to be applied to material related to everyday life (Fitria, et al, 2020). According to Ramziah (2016), one of the mathematics learning materials that is difficult for students is a matrix, students have difficulty when given story questions related to everyday life. Based on the problems found, it is necessary to develop learning tools to improve existing learning tools. Based on Nurafiah's (2013) research, it was found that there was a difference in the increase in critical thinking skills of students who obtained PBM compared to conventional, in PBM students were given the breadth to find the right solution according to what they understood. The PBM model makes students actively participate in the learning process (Atika, et al, 2020).

Therefore, researchers developed learning tools through the PBM model on matrix material as a means to facilitate students' mathematical critical thinking skills. Based on this description, this study aims to produce mathematics learning tools through problem-based learning models on valid and practical matrix material to facilitate students' mathematical critical thinking skills.

2. Methodology

The form of this research was Research and Development. Development research is a way of developing new products or completing imperfect products (Mulyatiningsih, 2012). The learning tools developed were syllabus, lesson plans, and student worksheet. The Research and Development with the Borg and Gall development model (Mulyatiningsih, 2014) consist of 10 stages, namely: (1)

research and data collection; (2) planning; (3) development of the initial product draft; (4) initial field trials; (5) product revision; (6) field testing of the main product; (7) operational product revisions; (8) field trials; (9) final product revision; and (10) dissemination and implementation. In this study, the main product field test stage, operational product revision, field trial, and final product revision were not carried out. This is because all vocational schools in Pekanbaru City were closed due to the Covid-19 pandemic which did not allow researchers to carry out research on a large scale.

The data collection technique in this study was to provide a questionnaire to collect data validity. The instruments used were validity instruments in the form of syllabus validation sheets, RPP validation sheets, and student worksheet validation sheets. Validation sheets are prepared to assess the components contained in mathematics learning tools developed in accordance with the problem-based learning model (PBM). The form of this validation sheet is a structured questionnaire used to obtain the assessment score used for the validity of the syllabus, RPP and LKPD. The assessment category used is Sugiyono's (2014) assessment category, which is very suitable, appropriate, unsuitable, and unsuitable. According to Akbar (2013), a learning device is said to be valid if the percentage of validation is more than 70%. The students' questionnaire response category assessments used the Gutman scale rating category yes or no. According to Akbar (2013), learning tools are said to be practical if the percentage of practicality is more than 70%.

3. Results and Discussion

This research is a development research. The products produced from this study are mathematics learning tools in the form of syllabus, lesson plans, and student worksheet that meet valid and practical criteria to facilitate students' critical thinking skills. Learning tools developed using problem-based learning models on matrix material. The development used is the Borg and Gall model which includes: 1) research and data collection; 2) planning; 3) development of the initial product draft; 4) initial field trials; 5) revised trial results; and 6) Dissemination and Implementation. The results of this study describe the process in developing learning tools in the form of syllabus, lesson plans and LKPD on the matrix material for class X SMK using a problem-based learning model.

Research Result

Before developing learning tools, first designed the format and design of the learning devices to be developed. The choice of format and design is adjusted to the steps of the problem-based learning model and Permendikbud number 22 of 2016. Furthermore, the researcher makes designs and develops learning tools. The advantages of the learning tools that the researchers developed are in the syllabus, learning activities are arranged based on a problem-based learning model (PBM) with a scientific approach, on the lesson plans that the researchers developed, preliminary activities and closing activities contain all aspects according to

Permendikbud number 22 of 2016 and core activities are arranged based on the problem-based learning model to facilitate students 'mathematical critical thinking skills (KBKM), and the content section of the LKPD contains contextual problems with problem-based learning model activities to facilitate students' mathematical critical thinking skills (KBKM). After completion, the learning device was validated by three validators. One example of the LKPD display in Figure 1.

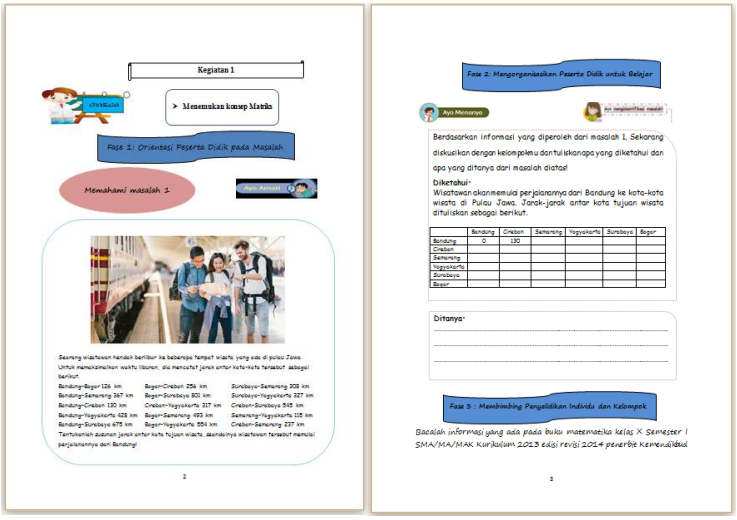

Figure 1. Display of LKPD contents 1

The LKPD design in Figure 1 is a LKPD design on the material to find the matrix concept using a problem-based learning model (PBM).

1. Validity of Learning Tools

The validator's assessment of the learning tools developed, namely the syllabus, RPP and LKPD, obtained the average score of the validation results as in table 1.

Table 1. Results of the Validation for Syllabus, RPP, and LKPD

Average Score of Validation Results	Syllabus	RPP	LKPD
	85,11%	86,02%	86.40%
Criteria	Very Valid	Very Valid	Very Valid

Based on the criteria for the validity of learning devices, the syllabus, lesson plans and student worksheets developed are in the very valid category.

2. Practical Learning Devices

The trial was carried out on 8 students of class XII Accounting SMK Nurul Falah Pekanbaru who have heterogeneous abilities, 2 high-skilled people, 4 medium-skilled people, and 2 low-ability people. Based on the results of the student

response questionnaire to the LKPD used, it was found that the total average of LKPD-1, LKPD-2, LKPD-3 and LKPD-4 was 85.93. Based on the criteria of practicality, it can be concluded that the LKPD developed is in the very practical category.

Discussion

This development research was conducted with the aim of producing valid and practical learning tools (syllabus, lesson plans, LKPD) using problem-based learning models to facilitate students' mathematical critical thinking skills on matrix material. The learning tools developed were assessed for their validity and practicality. The learning tools that have been developed will be validated by three validators. After the learning device is validated, it will be revised according to the suggestions of the validator.

Researchers analyzed the results of the validation of the syllabus developed. The assessment aspects contained in the syllabus include two aspects of assessment, namely: (1) content assessment aspects, (2) construction aspects. Content assessment aspects consist of syllabus identity, formulation of competency achievement indicators, assessment techniques, determination of time allocation, and selection of learning resources. The construction aspect consists of learning activities. The results of the assessment of the syllabus identity are 87.50% with a very valid category, the results of the assessment of the formulation of competency achievement indicators, namely 83.33% in the valid category, the results of the assessment of the assessment technique of 79.16% in the valid category, the results of the assessment of the determination of time allocation 91.66% with the very category. valid, the results of the assessment of the selection of learning resources were 87.50% with a very valid category, and the results of the assessment of learning activities were 84.72% with the valid category. So, the average rating of the syllabus is 85.11% with the very valid category. However, there are suggestions and improvements from the validator, namely the validator suggests adding a stage of a scientific approach to learning activities to make it more visible in which phase in the PBM model activities are observing, asking, gathering information, reasoning, and communicating.

Furthermore, the researchers analyzed the results of the validation of the lesson plans developed. The assessment aspects contained in the RPP include two aspects of assessment, namely: (1) content assessment aspects, (2) construction aspects. The aspects of content assessment consist of identity, formulation of competency achievement indicators, formulation of learning objectives, assessment techniques, selection of media, learning tools and resources. The construction aspect consists of the formulation of learning activities. The results of the assessment of RPP 1 are 86.11% with the very valid category, the RPP 2 are 85.76% with the very valid category, the RPP 3 are 86.45% in the very valid category, and the RPP 4 are 85.76% with very valid category. So, the average assessment of RPP is 86.02% with very valid category. The RPP is in accordance with the RPP component of Permendikbud No. 22/2016. However, there are several suggestions and improvements from the validator, namely the validator

suggests replacing the core activities in the orientation phase of students on the problem, namely the activities of students are asked to observe the problems in LKPD -1, LKPD-2, LKPD-3 and LKPD-4 are the problems in the LKPD. Researchers replaced the existing problems in LKPD-1 to become the problem of a tourist's vacation trip in several areas on the island of Java, the problems in LKPD-2 became the problem of two Emerald Residence residential shop complexes that have the same size and the same building shape. The problems that exist in LKPD-3 are problems with purchasing bags and shipping costs on the Shoope application. The problems that exist in LKPD-4 are the problems of providing basic foodstuffs to people affected by the Corona virus.

In the RPP the validator suggests replacing the assessment aspects, namely the scoring guidelines to be equated with an assessment rubric, namely interpretation, analysis, evaluation and inference. The researcher replaces understanding the problem, which is shown by writing the known and questionable questions appropriately into an interpretation, which is shown by writing the known or questionable questions appropriately. The researcher switches to identifying the relationships between the statements, questions, and concepts given in the problem, which is shown by making the right mathematical model and giving the right explanation into analysis, which is shown by making the right mathematical model and explain appropriately. Researchers replace using the right strategy in solving questions, complete and correct in doing calculations to evaluation, which is shown by using the right strategy in solving questions, complete and correct in doing calculations. Researchers replace drawing conclusions appropriately to inference, which is indicated by drawing conclusions correctly.

Furthermore, the researchers analyzed the data from the validation results of the developed LKPD. The assessment aspects contained in LKPD include six aspects of assessment, namely: (1) feasibility aspects of content, (2) aspects of language eligibility, (3) aspects of feasibility of activities / observations of students, (4) aspects of feasibility of views, (5) aspects of feasibility of Feasibility of presentation, and (6) Aspects of Feasibility of Implementation and Measurement. The results of the assessment of LKPD 1 were 86.11% with the very valid category, the results of the assessment of LKPD 2 were 86.90% with the very valid category, the results of the assessment of LKPD 3 were 86.50% in the very valid category, and the results of the assessment of LKPD 4 were 86.50% with very valid category. So, the average LKPD assessment is 86.40% with a very valid category. So it can be concluded that the developed LKPD has met the didactic, construction and technical requirements. However, there are suggestions and improvements from the validator, namely the validator suggests replacing the sentence in problem 2 in LKPD-4, namely words in the presence of the Corona virus outbreak, words with the Corona virus outbreak sound like grateful words. The researcher changed the sentence in problem 2 in LKPD-4 to welcome Eid and as we know Indonesia is being hit by the Corona virus disaster.

The learning device that had been revised, then the researcher tried out the learning device namely LKPD to 8 students of class XII Accounting at SMK Nurul Falah Pekanbaru who have heterogeneous abilities, 2 high-skilled people, 4

medium-skilled people, and 2 low-ability people. This is done to see the practicality of the LKPD that has been developed. The results of the student's questionnaire response to the LKPD in the initial field trial were 85.93, meaning that the LKPD developed was "very practical" used by students. However, there are suggestions and comments from students so that the filling column in the LKPD is enlarged because the filling column in the LKPD is too small so the answers that will be filled in by students do not fit in the filling column.

4. Conclusion

Based on the results of the validation of learning tools in the form of syllabus, lesson plans, and student worksheets, it can be concluded that the learning tools developed have met the validity criteria. Based on the results of the student response questionnaire analysis, it can be concluded that the learning tools developed have met the criteria for practicality. Overall it can be concluded that the developed syllabus, lesson plans and student worksheets are valid and practical for use by class X SMK students.

The development research conducted has produced products in the form of learning tools (syllabus, lesson plans, and student worksheets) using problem-based learning models to improve the critical thinking skills of class X SMK students. Learning devices are declared valid after going through the validation process, and are declared practical after going through a limited trial process.

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