Development of Learning Tools with the Discovery Learning Model to Improve the Critical Thinking Ability of Mathematics

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A B S T R A C T

This research was motivated by the still limited learning of mathematics as a means of supporting learning in the 2013 Curriculum. The purpose of this study was to produce some products in the form of learning devices (syllabus, RPP and LKPD) on the material for the flat side building of VIII Middle School with discovery learning models that meet valid, practical, and effective criteria for improving students mathematical critical thinking skills. Learning tools are developed using the 4-D model, which are define, design, develop and assess. The research instrument used was an instrument of validity in the form of a validation sheet to assess the feasibility of the syllabus, RPP and LKPD as well as a practical instrument in the form of a teacher observation sheet activity in applying the discovery learning model and student questionnaire responses to assess the practicality of LKPD. The results of the validation of the experts stated that the product developed reached a valid category with an average rating of 76.67% for syllabus, 76.67% for RPP and 88.04% for LKPD. Learning devices are considered very practical in small group trials with an average response of 96.44% students and large group trials from the observation sheet of teacher activity 93.71% and the average response of students 87.77%. The learning tools have been proved to improve students mathematical critical thinking skills in terms of an average N-gain of 0.53 in the medium category.

1. Introduction

Mathematics learning tool is one form of preparation made by the teacher before teaching. A learning device is a device that is compiled using objects of natural, social, artistic and cultural phenomena and in learning using a scientific approach

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(observing, asking, gathering information, associating, and communicating) and using Technology, Information and Communication (ICT) facilities (Dewi, et al, 2014).

Based on the results of observations and analyzes conducted by researchers on the learning tools used by teachers in several Pekanbaru high schools, information was obtained that the learning tools made by the teacher still had weaknesses that needed to be corrected. The first weakness is that the preparation of the RPP in the section on developing indicators of competency achievement based on KD has not used the correct operational verb (KKO). Another weakness is that in the core activities the details of existing learning activities are not in accordance with the learning model used.

The second weakness is the learning resources used by teachers and students in the learning process in LKPD in the form of student worksheets (LKPD) and other supporting books provided at schools make more use of learning resources developed by others such as publishers. LKPD used is less interactive because the structure of LKPD only contains a summary of material, a collection of formulas, example problems, and practice questions. The LKPD structure gives students a narrow view of mathematics subject matter because the material, sample questions, and question exercises that are presented lack explanation. One branch of mathematics namely geometry which is considered difficult by most students, it clearly makes a negative impact on their ability to understand geometry (Roza, et al, 2017).

Based on the weaknesses in developing lesson plans and the lack of learning resources developed by the teachers themselves, it is necessary to develop learning tools that are in accordance with the 2013 curriculum. Every teacher in the education unit is obliged to compile learning tools in a complete and systematic manner so that learning takes place interactively, inspiratively, fun, challenging and motivating students to participate actively, as well as providing sufficient space for creativity initiatives according to the talents, interests, physical and psychological development of students (Tanjung, et al, 2018). This is in line with the opinion of Jaya (2014) which states that to improve and improve the quality of the learning process and learning outcomes, it is necessary to harmonize the learning process that is supported by good tools by developing learning tools. Learning tools developed must be in accordance with the conditions, needs and characteristics of students and contain all the components required by the minister of education regulation (Yulius, 2017).

In the 2013 curriculum critical thinking skills are needed by students given that science and technology are developing very rapidly and allows anyone to obtain information quickly and easily with abundant resources from various places and anywhere in the world. An important ability that must be possessed by every individual in this globalization era is critical thinking (Kalelioglu & Gulbahar, 2013; Kriel, 2013; Aizikovitsh-Udi and Cheng, 2015). Critical thinking is needed to filter out information that is worthy of acceptance or rejection (Kalelioglu and Gulbahar, 2013). Critical thinking skills are an effective way to improve students'

understanding of mathematical concepts because these skills can help in interpreting, analyzing, evaluating and presenting dates in a logical and sequential manner (Chukwuyenum, 2013).

The ability to think critically is very important in its nature and must be instilled early on both at school, at home and in the community. Critical thinking is a directed process and clarity is used in systematic mental activities such as solving problems, making decisions, persuading, analyzing assumptions and conducting scientific research conducted by people who are tolerant with an open mind to broaden their understanding (Johnson, 2009). Critical thinking skills are organized into 6 categories, namely: interpretation, analysis, evaluation, inference, explanation, and self-regulation (Facione, 1990). Mathematical critical thinking skills are reasonable and effective thinking abilities that focus on concentrating what must be believed or done, with indicators: interpretation, analysis, evaluation and inference.

Efforts that need to be made by teachers to improve students' mathematical thinking ability are to improve the effectiveness of mathematics learning. An effective teacher is a teacher who uses various methods in accordance with the culture of learning and the level of students to ensure that students achieve conceptual understanding and also learning objectives (Amirullah, 2018). Teachers must have the ability to innovate in learning that can motivate students to learn more actively, creatively and systematically in solving problems (Ginanjar et al., 2019). Development of learning tools must be arranged with the right learning model. One of them chose the learning model that is discovery learning model that is able to make students active in the learning process and able to direct students to find their own concepts to be learned. Discovery learning models can improve students' mathematical critical thinking skills (Kurniati et al., 2017; Haeruman et al., 2017; Martaida et al., 2017; Rohaumah et at., 2018).

Discovery learning model is a learning model that makes students actively discover mathematical concepts. Discovery learning is a learning model that is designed so that students can discover concepts and principles through their own mental processes (Zarkasyi, 2015). The development of valid, practical and effective learning tools is needed to help teachers implement the 2013 curriculum. The author is interested in developing mathematical learning tools with a discovery learning model in order to obtain valid, practical, and effective learning tools to improve students' mathematical critical thinking skills in class VIII Middle School

2. Methodology

The type of research used was research development or research and development. The learning tools developed were Syllabus, RPP, LKPD, and mathematical critical thinking skills test questions. This learning device was developed with a 4-D model. According to Thiagarajan (Endang Mulyatiningsih, 2014) the 4-D model consisted of four stages of development, namely define, design, develop, and disseminate or be

adapted into a 4-D model, namely defining, designing, developing and spreading. This development research was carried out in the Mathematics Education Postgraduate Program at the University of Riau and trials were carried out at SMPN 25 Pekanbaru in class VIII students in the Even Semester 2018/2019.

The development procedure consisted of 1) the defining stage includes (a) initial-final analysis, (b) student analysis, (c) task analysis, (d) specification of the objectives of learning outcomes, and (e) material analysis, 2) design phase includes (a) syllabus design, (b) RPP design, (c) LKPD design and, (d) mathematical critical thinking ability test item design, 3) development stage includes, (a) expert validation, (c) small group trial, (d) large group trial, 4) disseminate stage.

The instruments used to collect data in this study were validation sheets, practicality and effectiveness sheets of student learning outcomes with mathematical critical thinking ability test questions. Validation sheets were arranged to assess the components contained in the mathematics learning tool that is developed in accordance with the discovery learning model and mathematical critical thinking ability test questions. The form of this validation sheet was a structured and unstructured questionnaire. Structured questionnaire was used to get the assessment scores used for the validity of the Syllabus, RPP, and LKPD as well as mathematical critical thinking skills test questions, student questionnaire responses, observation sheets of teacher activities. Unstructured questionnaire was used so that the validator gives advice related to the product as a basis for implementing the revision. Rating categories used the rating categories of Sugiyono (2014) which are modified from the category are very appropriate, appropriate, not appropriate and very not appropriate. Learning tools are said to be valid if the percentage of validity is more than 70% (Akbar, 2013).

In this case the researchers used teacher activity observation sheets and distributed students' questionnaires. The evaluation category of the teacher observation sheet uses the assessment category from Sugiyono (2014) which is modified from the very appropriate, appropriate, inappropriate and very inappropriate categories. The assessment category of students' questionnaire responses uses the Gutman scale assessment category, yes or no. Learning tools are said to be practical if the percentage of practicality is more than 70% (Akbar, 2013).

Effectiveness data was used to measure the effectiveness of mathematics learning tools with a discovery learning model developed for students' mathematical critical thinking skills. This instrument was a mathematical critical thinking ability test item. Learning tools are said to be effective if the p value $< \alpha = 0.05$ so that it can be stated there are differences in the average value of the tests of mathematical critical thinking skills pretest and posttest. Effective learning tools if the average N-Gain is in the medium classification.

3. Results and Discussion

The results of this study describe the process of developing learning tools (Syllabus, RPP, and LKPD) mathematics in VIII grade junior high school. The development process uses the 4D development model which includes the define stage, the design phase, the develop phase, and the disseminate stage.

The define stage that is discussed is the beginning of the final analysis, student analysis, task analysis, material analysis, formulation of learning objectives. Researchers conducted interviews with mathematics subject teachers to obtain initial final analysis data. Interviews were conducted in several Pekanbaru high schools with mathematics teachers in class VIII. The interview results show that there are still obstacles in developing the 2013 curriculum, the models and methods of learning that have been applied have not varied. Learners need a means to make students active in learning. Students are not familiar with the problem of mathematical thinking ability. Worksheets have not been able to facilitate students to find their own knowledge. Less than 50% of students have good skills.

Analysis of students obtained from the results of the preliminary test. The results of the analysis of the students' answers showed that students still had difficulty solving questions about the construction of flat side spaces with indicators of mathematical critical thinking skills test of students. Task analysis consists of an analysis of core competencies (IC) and basic competencies (BC) related to the material developed. KI and KD are then described in measurable indicators. The results of the analysis of this task serve as a reference in determining the subject matter / material that supports the achievement of competence.

Material analysis aims to identify the main parts of the material on the flat side space studied by students, namely the surface area and the volume of the flat side space (cube, beam, prism and pyramid) for 6 meetings. Based on the analysis of the tasks and materials obtained learning objectives to be achieved in LKPD to build flat side space with a discovery learning model to improve the ability to think critically mathematically.

The results of the design phase are in the form of preliminary designs of learning tools which include syllabi, lesson plans and LKPD. The syllabus and RPP designs are adjusted to the syllabus and RPP components in Permendikbud No. 22 of 2016 and the learning activities are adjusted to the steps of the discovery learning model. The LKPD design consists of providing stimulus with contextual non-routine problems that are adjusted with indicators of mathematical critical thinking ability, student activities that are adjusted to the discovery learning model and contextual practice questions and adjusted to indicators of mathematical critical thinking ability. One example of LKPD display in Figure 1.

Figure 1. Cover and initial appearance of LKPD

The develop phase aims to produce a draft of learning tools with a revised discovery learning model based on input from experts. The steps in this stage include a) expert validation, b) small group testing c) large group trials. The validation results are in the form of an assessment of the syllabus, lesson plans, LKPD, critical thinking skills test questions, observation sheets of teacher activity and student questionnaire responses. The assessment was conducted by 3 validators. Validation results can be seen in Figure 2.
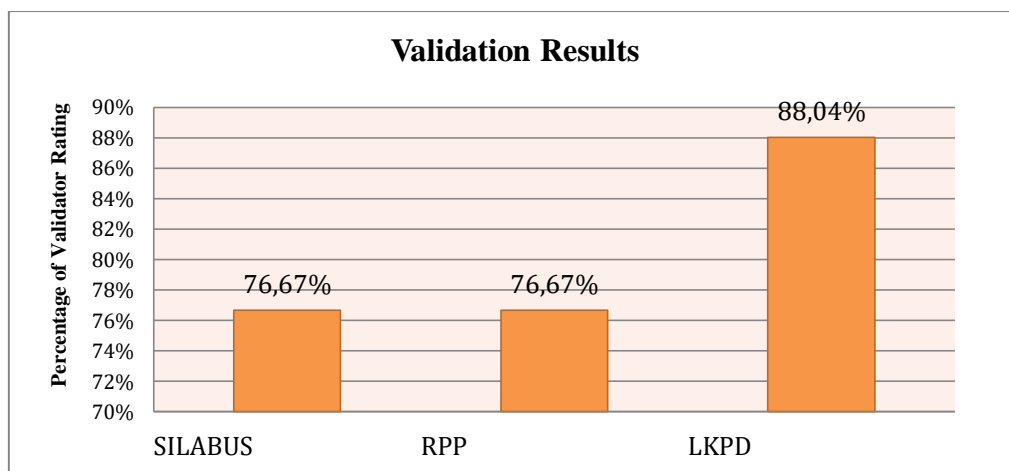

Figure 2. Validation Results from the validator

Based on Figure 2, the average rating for the syllabus reached 76.67% with the valid category, for the RPP it reached 76.67% with the valid category and for LKPD it reached 88.04% with the very valid category. The three validators concluded that the syllabus, lesson plans and LKPD could be used with minor revisions. The results of practicality can be seen from small group trials using student questionnaire responses. The results of practicality from large group trials using teacher activity observation sheets and student questionnaire responses. The results of practicality can be seen in Figure 3.
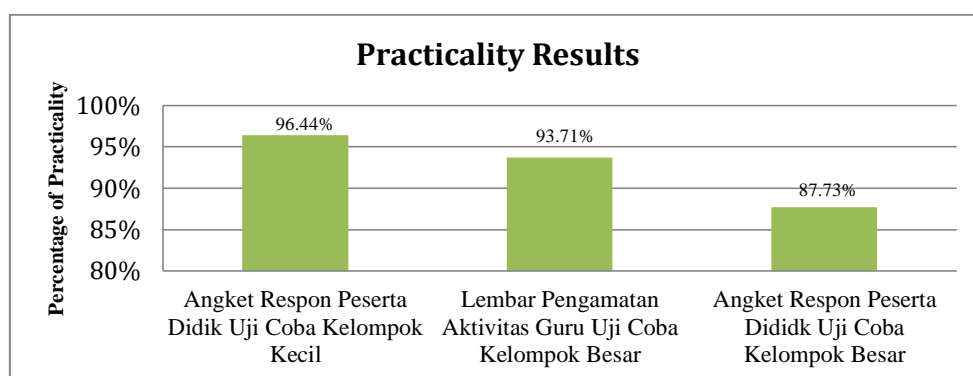
Figure 3. Practical Results

The level of implementation of the discovery learning mathematics model of learning devices in small group trials is obtained from the results of the questionnaire responses of students as many as 8 students who have high, medium and low achievements. Based on the questionnaire responses of students it can be concluded that the discovery learning model of learning tools on the material of the flat side class VIII SMP has a very practical level of implementation with an average of 96.44%. The next researcher, revised the LKPD. Revisions made include repairs to typing errors, improvements in the students' answers column that are judged to be too inadequate, and improvements to the instructions sentences in the LKPD with sentences understood by students.

The level of implementation of the discovery learning mathematics device in the large group trial was obtained from the observation sheet of the teacher's activity and the student questionnaire responses of 30 students. The average observations of teacher activity in implementing discovery learning reached 93.71% which met the criteria very well.

Based on the questionnaire responses of students in large group trials it can be concluded that the discovery learning model of the VIII SMP flat material has a very practical level of implementation with an average of 87.77%. Learners stated that the LKPD that was developed helped them in learning the material to build flat side spaces. LKPD is easy to understand and students feel happy learning to use LKPD because LKPD's appearance is attractive with good cover colors and attractive images. In addition, learning by using LKPD trains them to discover for themselves the formula for surface area and volume of flat-side space.

The existence of learning tools with discovery learning models can facilitate teachers and students in developing students' mathematical critical thinking skills. Based on the assessment of teacher activity and student assessment it can be concluded that the developed device is easy to use and implement in learning mathematics.

Learning devices with discovery learning models that have been used in large group trials are revised again, then testing the effectiveness in different classes. This effectiveness test was conducted to obtain the students' mathematical critical

thinking ability test scores using the mathematical critical thinking ability test instrument. The results of tests of mathematical critical thinking ability of students pretest and posttest can be seen in Figure 4.
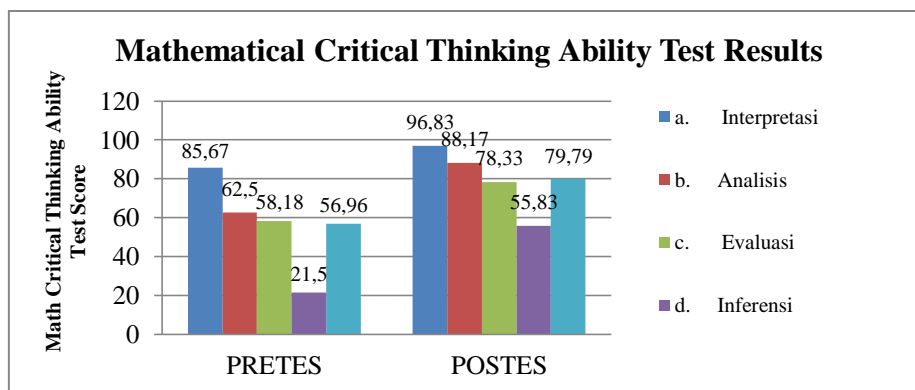

Figure 4. Test Results for the Effectiveness of Pretest and Posttest Students' Mathematical Critical Thinking Ability

The effectiveness of the product development is reviewed based on the average score of the students' critical thinking ability tests reaching 79.79 which is in good classification. Based on the t-test pretest and posttest mathematical critical thinking skills obtained p value of 0,000. The significance level $p < \alpha = 0.05$, so it can be concluded that H0 is rejected or there is a difference in the mathematical critical thinking ability of students before and after using the device. The average N-gain obtained from the comparison of the average value of pretest and posttest mathematical critical thinking skills in using mathematical learning tools with discovery learning models is 0.53 with the category of "medium".

Based on these results the mathematical learning device with the discovery learning model is effective for improving students' mathematical critical thinking skills in the material of the flat side class VIII SMP. In line with Martaida's research (2017) about "the effect of discovery learning model on student's critical thinking and cognitive abilities in junior high school which concluded that the critical thinking abilities of students who are taught with discovery learning are better than students who are taught by conventional learning. The discovery learning model can improve students' mathematical critical thinking skills (Kurniati, 2017; Martaida, 2017; Rohaumah, 2018).

4. Conclusion

This development research resulted in a mathematical learning tool in the form of syllabus, lesson plans, and LKPD on flat side space building material that applies the discovery learning model. Researchers develop mathematical learning tools using the 4D model (Define, Design, Development and Disseminate). The results of the validation of the experts stated that the product developed reached a valid category. Learning devices are considered very practical and effective in improving students' mathematical critical thinking skills.

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