



Development of Learning Device Based on 21st Century Skill with Implementation of Problem Based Learning to Increase Critical Thinking Skill of Students on Polyhedron for Grade 8th Junior High School

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ABSTRACT

This research aims is to produce a learning device based on 21st century skills with the implementation of problem-based learning to increase the critical thinking skill of students on polyhedron for grade 8th junior high school. The type of this research is development research using Plomp's model, there are (1) preliminary research phase; (2) the prototype phase; and (3) assessment phase. The results of this research are a learning device based on 21st century skill with the implementation of problem-based learning to increase the critical thinking skill of students on polyhedron for grade 8th junior high school. The results of the syllabus, RPP, LKPD validation and critical thinking skills show valid and very valid criteria with values of 3.19; 3.32; 3.26; and 3.13. In the final product test phase, learning devices were used through pre-experimental research to see the increase in critical thinking skills and there was an increase in the critical thinking skill of students using learning devices. This means that the learning device based on 21st century skill with the implementation of problem-based learning to increase the critical thinking skill of students on polyhedron for grade 8th junior high school has been valid, practical, and effective.

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1. Introduction

The development of the times demands the existence of an increase in the quality of education, this is by developments developed in the education curriculum in Indonesia. The curriculum is a separate plan and regulates the objectives, contents, and learning materials as well as the ways used as guidelines for

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organizing learning activities to achieve certain educational goals (Rusman, 2008). The Purpose of Indonesian Education in Law Number 20 the Year 2003 concerning the National Education System for generations of people who believe and are pious, virtuous, intelligent, and creative. Educational objectives are then implemented in the curriculum. The 2013 curriculum is to prepare Indonesian people to have the ability to live and be personal for a country that is faithful, productive, creative, innovative, and effective and capable of supporting social, national, state, and world civilization life.

Solfitri, et al (2017) said that the implementation of the 2013 curriculum would run well without problems that could be discussed with various preparations, including teacher guidance related to the 2013 curriculum. One form was being carried out by the teacher preparing learning devices that support the implementation of the 2013 curriculum, including mathematics. Appropriate learning devices are a very important factor in participant preparation. The learning process can run well if the teacher can make a learning device and can manage the learning process by the plan. Trianto (2009) said the learning device is a device used in the learning process. Mathematics learning devices that are by the 2013 curriculum are learning devices with the scientific agreement and applying learning models.

School-based curriculum standards reveal that students must have a set of mathematical competencies that are manifested after the learning process occurs (Hutapea, 2019). Students' thinking skills must be developed to understand mathematics correctly (Heleni, et al, 2018). One of the goals of mathematics learning listed in the 2013 Curriculum is mathematical problem-solving. Mathematical problem solving is defined as an area of cognitive psychology that deals with the process of solving problems (Pal, et al, 2017).

Researchers conducted observations and interviews to find out the learning devices used at school. The results of researchers' interviews with five junior high school teachers in Pekanbaru showed that 15% of teachers developed tools and used them in the learning process, while 85% of teachers only used existing learning devices. Existing learning devices come from publishers or the results of the Subject Teachers' Conference (MGMP). Based on the results of the interview it was found that the teacher had difficulty in compiling the 2013 curriculum learning devices, especially learning devices that apply learning models. The teacher does not understand the procedures for preparing the Learning Implementation Plan (RPP). The teacher does not fully understand the essence of each component of the lesson plan. Changes in the curriculum affect changes in the composition of components in the lesson plan. The researcher found that the RPP prepared by the teacher was not by Permendikbud number 103 of 2014 or Permendikbud number 22 of 2016. The weaknesses of the RPP prepared by the teacher were: 1) On the indicators of competency achievement, not using the appropriate operational verbs; 2) In the core activities the details of the existing learning activities are not by the learning model used.

The lesson plans are arranged according to the rules in the curriculum. The curriculum currently in effect is the 2013 curriculum, so the lesson plans that are compiled now are different in structure from the lesson plans in the curriculum for curriculum curriculums. Other learning devices in the form of LKPD used only contain a summary of the material and a collection of questions. LKPD does not contain learning activities that involve students directly in discovering mathematical concepts. LKPD like this does not provide learning experiences and does not encourage the development of thinking skills for students. The teacher as a professional educator is expected to arrange the learning devices and develop them according to the situation and conditions. Learning devices are developed by development procedures that pay attention to the characteristics and needs of students. One of the learning devices that must be developed by the teacher is the mathematics learning device.

According to Tanjung (2018), every teacher in the education unit is obliged to compile learning devices completely and systematically so that learning takes place interactively, inspiratively, fun, challenging and motivates students to participate actively, as well as providing sufficient space for creative initiatives according to talent, interests, physical and psychological development of students. The learning devices developed are syllabus, lesson plans (RPP) and student worksheets (LKPD), learning media and learning achievement tests. The syllabus is a reference for the preparation of learning frameworks for each subject matter study. Trianto (2009) RPP is a guide to the steps to be taken by the teacher in the learning activities arranged in the activity scenario. LKPD are sheets containing tasks that must be done by students in learning activities that are accompanied by instructions or steps to complete a task that has the basic competencies to be achieved (Depdiknas, 2008).

The 2013 curriculum aims to prepare Indonesian people to have the ability to live as individuals and citizens who are faithful, productive, creative, innovative and effective and able to contribute to social, national, state, and world civilization life. The 2013 curriculum began to implement learning oriented towards 21st century education. The 21st century requires every individual to have the skills or skills both hard skills and soft skills to be able to enter the world of work and be ready to compete with other countries. In line with that opinion, the National Education Association (Winataputra, 2013) states that 18 types of 21st Century Skills need to be provided to each individual, where one of the 21st century skills is Learning and Innovation Skills which consists of 4 aspects, namely critical thinking (critical), communication (communication), collaboration (collaboration), and creativity (creativity).

Frydenberg, et al (in Hidayah, 2017) also stated that to face learning in the 21st century, everyone must have critical thinking skills, knowledge, and digital literacy skills, information literacy, media literacy and mastering information and communication technology. One of the 21st century abilities that must be mastered is a critical thinking skill. Redecker said that critical thinking skills include the ability to access, analyze, synthesize information that can be learned, trained and mastered (in Hidayah, 2017). Critical thinking skills also describe

other skills such as communication and information skills, as well as the ability to examine, analyze, interpret, and evaluate.

The 2013 curriculum content standard explains that in mathematics content students are expected to be able to show attitude, logical, critical, analytical, creative, careful and thorough, responsible, responsive, and not easily give up in solving problems. Moore (2010) states that if critical thinking skills are applied in mathematics and natural knowledge, the achievement of students in these subjects will increase. Critical thinking that is trained in mathematics learning is a reflective thinking ability that focuses on making decisions about what is believed and must be done (Ennis, 2011).

One of the characters' cognitive view is Facione (in Normaya, 2015) organizes critical thinking skills into 6 categories, namely: interpretation, analysis, evaluation, inference, explanation, and self-regulation. Learners tend to memorize the formulas and stages of completion without understanding the correct concepts and procedures. This fact shows that the ability of Indonesian students is in low order thinking (Balitbang, 2013). The low achievement of students' critical thinking skills shows a gap in the expectations of the education world with the facts that occur in the field. The low critical thinking skills of students are caused by several factors that influence the learning process, it can be from the factors of teachers, students, and other supporting factors for the implementation of learning.

Based on the results of observations at the SMPN 4 Pekanbaru on 24th March 2019, it shows that mathematics learning in class VIII of junior high school of 33 students has not been able to maximize students' critical thinking skills. Students in the learning process are asked to work on the questions that exist in teaching materials and textbooks, only some students take the problem seriously while other students copy the work of their friends. Most schools do not teach students to think critically or solve problems. Worksheets contain facts that require students to remember only, so the evaluation ability test is limited to memorization (Yennita, et al, 2018). This problem is caused because students are confused about using the concept of subject matter, so students only try to get the final answer without understanding how to solve it.

One of the recommended learning models in the 2013 curriculum that can be used to increase critical thinking skills is problem-based learning (PBL) (Arends, 2012). Problem-based learning is a student-centered learning approach that organizes curriculum and learning in unstructured situations and provides real-world problems (Arends, 2012). Characteristics of the problems raised in PBL are authentic problems that are used as a milestone for investigations and discoveries. Besides, in practice, the implementation of PBL requires that students collaborate and arrange the division of tasks between students (Arends, 2012). In line with this opinion Jonassen (2011) argues that PBL syntax requires a variety of thinking activities through the presentation of problems.

One branch of mathematics that is most directly related to the lives of everyday students is geometry. Geometry is one branch of mathematics concerned with questions of shape, size, the relative position of figures, and the nature of space. According to Purnomo (in Zamani, et al, 2016) the results of students' geometry tests are still less satisfactory when compared with the results of other mathematical material tests including building material that needs to be increased.

Geometry material taught to students in class VIII includes building flat side spaces. PBL model is one of the learning models that is suitable for teaching material to build flat side space, because the implementation of some forms of flat side building is often found in daily life, making it easier for students to understand the real geometry. Some development research on the development of learning devices has been done before. Sulistyani (2015) on the development of building learning devices in junior high schools with a problem-based learning approach and producing devices that are more effective than conventional learning devices in terms of achieving basic competencies, critical thinking, and attitudes towards mathematics.

The development of valid, practical and effective learning devices is urgently needed by teachers to implement the 2013 Curriculum. This research aimed to produce a learning device based on 21st century skill with the implementation of problem-based learning to increase the critical thinking skill of students on polyhedron for grade 8th junior high school. The development of learning devices uses the development model proposed by Plomp (2013), namely: (1) the initial investigation phase (preliminary research); (2) the prototype phase (prototyping phase); and (3) assessment phase.

Researchers develop a learning device in the form of syllabus and lesson plans that serve as guidelines for teachers in implementing the learning process. Researchers also developed LKPD which were used by students to investigate and construct knowledge about polyhedron which includes the surface area of cube and cuboid, volume of cube and cuboid, surface area and volume of the prism, and surface area and volume of the pyramid. The purpose of development in this research is to produce a learning device based on 21st century skill with the implementation of problem-based learning to increase critical thinking skills of students on polyhedron for grade 8th junior high school valid, practical and effective.

2. Methodology

This research includes development research (research and development) which aims to produce learning devices with the implementation of problem-based learning to increase critical thinking skills in the material of polyhedron classrooms in class VIII SMP. Research and development (research and development) is a research method used to produce certain products (Sugiyono, 2008). This research follows the phases of the development of the Plomp model (2013), namely (1) the initial investigation phase (preliminary research); (2) the

prototype phase (prototyping phase); and (3) the assessment phase. The subjects of this study were students of class VIII of SMPN 4 Pekanbaru.

Preliminary Research

The first phase of the Plomp model is the initial investigation phase. In this phase, curriculum analysis, student analysis and teaching material analysis are carried out. Curriculum analysis is performed to determine the curriculum used by schools. The analysis of learning devices was done by interview techniques and document study. The researchers conducted some interviews with five junior high school mathematics teachers in Pekanbaru. Then, the researchers studied the document to know the learning devices used by the teacher. The material analysis was done by analyzing the competencies contained in Basic Competence (BC). Based on the results of the analysis in the material that contained in the BC, the researchers developed a learning tool with the scope of the material, namely: (1) surface area of cube and cuboid; (2) volume of cube and cuboid; (3) surface area and volume of the prism; and (4) surface area and volume of the pyramid. Analysis of student characteristics was done by observing and analyzing student's critical thinking skills. The critical thinking skill analysis of students was done by the test results based on indicators. Build upon the results of the needs analysis, the researchers designed a learning device based on 21st century skill with the implementation of problem-based learning to increase critical thinking skills in the material of polyhedron in class VIII SMP.

Prototyping Phase

The second phase is the prototype phase. This phase is based on the results of the analysis conducted. The developed learning devices consisted of the syllabus, lesson plans, and LKPD. At this stage, the collection of relevant references as material to design learning devices is carried out on the material on a polyhedron. The syllabus, lesson plan, and LKPD design are adapted to the components contained in the Basic and Secondary Education Process Standards. The syllabus was designed using a scientific approach and implementation problem-based learning models for four meetings and integrated with 21st century skills.

Assessment Phase

The third phase is the assessment phase. The learning device was further validated by three validators. Learning devices would be valid if the percentage of validation is more than 70% (Akbar, 2013). The validation results were analyzed to be revised according to the suggestions of the validators. After the learning devices were validated by the validator, the next step is a limited trial phase. At this stage, LKPD was tested on eight students of third grade in SMP Negeri 4 Pekanbaru who had studied polyhedron material. The students at the limited trial phase were chosen based on advice and consultation with mathematics subject teachers.

Then, the students learned using the developed LKPD an answered questionnaire of responses which aimed at assessing aspects of the material, appearance, and use of LKPD. LKPD would be practical if the percentage of practicality is than 70%. The researcher then revised the LKPD based on the results of a limited trial that had been carried out. The revised learning devices at the limited trial phase were then tested on 33 students of class VIII-6 in SMP Negeri 4 Pekanbaru. The field trials were conducted in four meetings to see the practicality of the syllabus, lesson plans, and LKPD developed. At this stage, the researchers pretended to be a teacher who used learning devices in the classroom, while the real teacher acted as an observer.

The teacher was given an observation sheet and questionnaire responses to assess the learning devices used. While the students were given a questionnaire response after the learning process ended. The students assessed the credibility of LKPD that had been used in the learning process. Then the data would be analyzed by using an average percentage. According to Akbar (2013), learning devices would be said to be practical if the percentage of practicality is than 70%. The researchers then revised the learning devices based on the results of field trials that had been carried out.

The learning devices were used through pre-experimental research with the Intact-Group Comparison design. The experimental design involved two classes, namely the experimental class and control class. The control class was conducted in the VIII-9 class SMP Negeri 4 Pekanbaru. Meanwhile, the experimental class was conducted in VIII-10 class SMP Negeri 4 Pekanbaru.

The experimental class was treated by the learning process which used the learning devices that were developed, while the control class, which was a comparison class of learning process, did not use learning devices that were developed. The researchers gave critical thinking skill tests to students after the trial was conducted for four meetings. The student test results in the experimental class and the control class were analyzed to see an increase in critical thinking skills. The effectiveness of the learning kit had been done by comparing the critical thinking skill test results with minimal learning completeness.

The learning devices would be effective if the critical thinking skill of students in the experimental class had been reached a minimum of 80% learning completeness (Wahyu, 2016). The learning devices that had been tested were then revised again as needed. The researchers reported the results of researching learning devices in polyhedron material class in the second grade of SMP in the results of the seminar. The research article was then published in a journal.

3. Results and Discussion

The result of this study was developing a learning device based on 21st century skill with the implementation of problem-based learning to increase critical thinking skills in the material of polyhedron in class VIII SMP. The result of the

learning devices is in the form of syllabus, lesson plans, and LKPD that arranged for four meetings on polyhedron materials.

The result of the research needs analysis at the research and data collection stage showed that the learning devices used had not met the 2013 Curriculum rules. The researchers examined the 2013 curriculum and other related theories to develop learning devices, to determine learning models that could engage learners to be active and to find out what abilities students must have. One of the alternatives, the researchers developed a mathematics learning device based on 21st century skill with the implementation of problem-based learning to increase critical thinking skills in the material of polyhedron in class VIII SMP.

Researchers designed a learning device based on needs analysis. One component developed in the syllabus was learning activities. Learning activities were developed in general by using a scientific approach to polyhedron materials. The learning activities were arranged according to the learning material in the syllabus. One component developed in the lesson plan was learning activities. The learning activities contained stages of problem-based learning with critical thinking skill indicators. The learning activities contained stages of problem-based learning, it can be seen in Table 1.

Table 1. Learning Activities with the Implementation of Discovery Learning

Description of Activities	Stages of Discovery Learning
Students were given problems related to the material to be studied at LKPD.	The Orientation of students to the problem
Students were asked to identify problems that existed in LKPD	Organizing students to learn
Students gathered a variety of relevant information to solve problems, find the formula and solve the problem in LKPD by reading references such as math material book in class VII which was published by the Ministry of Education and Culture	Guide individual and group investigations
The student presents the result in front of the class	Develop and present the work
Students and teacher will analyze and evaluate the problem-solving process	Analyze and evaluate the problem-solving process

Learning activities that contained critical thinking skill indicators can be seen in Table 2.

Table 2. Learning Activities with critical thinking skill Indicators

Description of Activities	Indicator
Students are asked to understand the problem shown by writing known or asked questions correctly.	Interpretation
Students are asked to identify the relationships between the statements, questions, and concepts provided in the problem shown by making mathematical models correctly and giving explanations correctly.	Analysis
Students are asked to use the right strategy in solving problems, complete and correct in doing calculations.	Evaluation
Students are asked to make conclusions correctly.	Inference

A component developed in LKPD was organizing students to learn which was complemented by problems related to learning material. The organizing students to learn of LKPD can be seen in Figure 1.

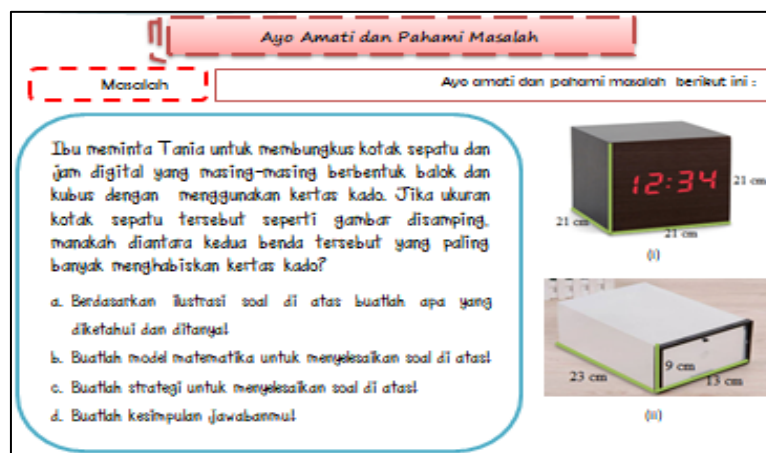


Figure 1. Organizing Students to Learn

Then, the learning device was validated by three validators. The results of the learning devices validation can be seen in Table 3.

Table 3. Results of Validation of Learning Devices

Learning Device	Score	Criteria
Critical Thinking matter	3,13	Valid
Syllabus	3,19	Valid
RPP	3,32	Very Valid
LKPD	3,26	Very Valid

The results of the questionnaire responses of students at the limited trial stage showed that LKPD had fulfilled the practical criteria. The results of the limited trial can be seen in Table 4.

Table 4. Limited Trial Results

Learning Device	Meeting to-				Average	Criteria
	1	2	3	4		
LKPD	92,19	91,96	91,29	94,20	92,41	Very Practical

The results of the students' questionnaire responses, teacher's questionnaire responses, and observation sheets at the field trial stage indicated that the learning devices had fulfilled practical criteria. The results of field trials can be seen in Table 5.

Learning devices were then used through pre-experimental research with the Static-Group Comparison design. The final product test results showed that the critical thinking skill test results of students in the experimental class were better than the results of the critical thinking skill test of students in the control class. It

described that there was an increase in critical thinking skill students using learning device with the implementation of problem-based learning to increase critical thinking skills in the material of polyhedron in class VIII SMP.

Table 5. Results of Field Trials

Instrument	Average Percentage	Criteria
Questionnaire responses of students	89,95	Very Practical
Teacher Response Questionnaire	89,35	Very Practical
Observation Sheet	90,34	Very Practical

The results showed that the learning device based on 21st century skill with the implementation of problem-based learning to increase critical thinking skills in the material of polyhedron in class VIII SMP was valid, practical, and effective. The implementation of the problem-based learning model was one of the alternatives to increase the critical thinking skills of students in mathematics. Tanjung (2018) suggested the implementation of problem-based learning strategies could increase critical thinking skills.

The final product test results indicated there were some differences in critical thinking skills students in the experimental class and the control class. Critical thinking skills test results in the experimental class showed that 27 out of 33 students achieved minimal learning completeness, with a percentage of critical thinking skills achievement of 81.8%. Critical thinking skills test results in the control class showed that 11 of 33 students achieved minimal mastery learning, with a percentage of critical thinking skill achievement of 33,33%.

Wahyu (2016) suggested that learning devices were said to be effective if the critical thinking skills of students in the experimental class reached a minimum of 80% learning completeness. The results showed that the critical thinking skills achievement of students in the experimental class reached a minimum mastery of 81.8%. It means that the learning devices used by students in the experimental class were effective in increasing critical thinking skills. In line in Putri, et al's research (2019) about "Development of Learning Tools with the Discovery Learning Model to Improve the Critical Thinking Ability of Mathematics", the discovery learning model can improve students' mathematical critical thinking skills.

Learning devices, in the form of syllabus and lesson plans, were produced to facilitate the teacher in creating an active learning process. The resulting LKPD facilitates students to construct knowledge independently. Students understood the learning material presented in LKPD. Clear LKPD usage guidelines made students were able to do LKPD well. The problems contained in LKPD were oriented to contextual problems, so students were aware of the usefulness of mathematics in everyday life. Learning devices that had been produced were effective in increasing the critical thinking skills of students.

4. Conclusion

Development research conducted had resulted in a product in the form of a learning device based on 21st century skill with the implementation of problem-based learning to increase critical thinking skills in the material of polyhedron in class VIII SMP. The results of the learning device validity met the very valid criteria. Learning devices were already practical based on the results of limited trials and field trials. The final product test results showed that there was an increase in the critical thinking skill of students using these learning devices.

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