



THE DEVELOPMENT OF RESEARCH-BASED LEARNING MODEL WITH SCIENCE, ENVIRONMENT, TECHNOLOGY, AND SOCIETY APPROACHES TO IMPROVE CRITICAL THINKING OF STUDENTS

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DOI: 10.15294/jpii.v6i2.10680

Accepted: July 12th, 2017. Approved: August 30th, 2017. Published: October 17th, 2017.

ABSTRACT

Learning physics in SMAN 1 Bukittinggi was conducted through theories and practicum that verified the theories. The preliminary survey on the implementation of physics learning showed that teachers had not yet applied research-based learning. There were still many students who had not yet mastered the learning of physics. Supporting facilities such as physics laboratory and the equipment had been available, but they are not yet optimally utilized. Research-based learning model is one of learning models that can improve critical thinking skill and students' learning outcome. The research is aimed at developing research-based physics learning model with Science, Environment, Technology, and Society (SETS) approaches which was valid, practical, and effective to improve students' critical thinking. This research used a 4D model from Thiagarajan. The instruments of the research were interview guidance, observation sheets, validation sheet of the learning model and the instructional materials, questionnaire response of teachers and students, critical thinking skill test, and assessment sheet of skills and attitudes. The result of the research showed that the developed learning model and the instructional materials belonged to the category of valid which was in accordance with the expert judgment. The learning model and the instructional materials belonged to the category of practical based on the result of the observation, and the response of teachers and students. The implementation of Research-based Physics Learning with SETS approach was effective in improving critical thinking skills and learning outcomes of the students.

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Keywords: research-based; SETS; critical thinking

INTRODUCTION

Science and technology currently grow very rapidly. Students are required to master science and technology, so that they are able to assess the impact and benefits of technological development on natural and social environment in the community. Efforts to improve the quality of students cannot be separated from the educational process. Educational policy change made by the government is one form of efforts to improve the quality of education in Indonesia. One of such efforts was the change of Education Unit

Level Curriculum into the 2013 Curriculum. The implementation of the 2013 Curriculum is followed by the provision of student books and teacher books which were given freely. In addition, socialization was also done to teachers about the implementation of this curriculum in learning.

The 2013 Curriculum embraces the idea that science cannot be transferred from teacher to student. Students are subjects who have the ability to actively seek, process, construct, and use knowledge. Students should be given the opportunity to construct knowledge in the learning process. The 2013 Curriculum emphasizes on the competence of graduates who have characters, and have skills and knowledge integrated in the learning materials. Learning using the 2013

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Curriculum based on scientific activities can be done with a scientific approach. This approach involves observing, asking, trying, reasoning, and communicating.

Physics is one of the subjects that examine natural phenomena using scientific methods. The subject of physics is not only about mastering the knowledge in the form of facts, concepts, or principles, but also an experience in the process of discovery using the skill of scientific process. Physics learning should be carried out with a scientific approach. The materials of physics are expected to increase the knowledge and admiration of students to the greatness of God. Therefore, the subject of physics can be mastered by the students, the teacher must use learning model and the instructional materials in accordance with the 2013 Curriculum.

The results of the preliminary survey at SMAN 1 Bukittinggi showed the instructional materials used by teachers had not shown any learning steps with a scientific approach yet. In addition, the teaching materials used by teachers had not yet varied. Teachers had implemented the learning model in accordance with the 2013 Curriculum. There had not been many teachers (34%) who had used information technology to make learning more interesting. The activities of students in learning still lacked, and students tended to be passive. The motivation of students in learning was also low because there was no variation that teachers used in learning. Students were less able in solving physics problems because they were less critical in finding problem solutions, and they still lacked in mastering the physics concepts. These can be seen from the questionnaire results of the Critical Thinking Skill of the students in physics subjects by using the California Critical Thinking Skill Test.

From the analysis, it was found out that the average of the students' critical thinking skill was 65.2% which meant that the critical thinking skill of the students was still lower than the expected ideal condition, so that it needed to be improved. From the analysis of the indicators of critical thinking skill, 69.5% of the students had the ability to analyze, 64% had the ability to evaluate, 64.1% to make inference, 69% in deduction, and 59% in induction in learning. One of the causes of low critical thinking skills of students was the application of learning models that had not grown motivation, interest, and critical thinking skills of students. One of the causes of the students' low critical thinking skills was the application of learning models that had not improve

motivation, interest, and critical thinking skills of students. The students' low critical thinking skill influenced their learning outcomes. The daily test results of grade X students of SMAN 1 Bukittinggi were categorized as fair. The average classical of students mastery learning was 63.7%.

The lack of students' ability in mastering the concept of physics was because they were not equipped with necessary skills to master it such as problem-solving skills, science process skills, critical thinking skills and reasoning skills. The lack of briefing of these abilities could be seen from the learning process of Physics which mostly used lecturing method which was explanations of theories, elaborations of formulas with the help of mathematics, and solving physics problems. Many teachers admit that the use of lecturing method in physics learning fails to instill the mastery of physics concept (Hake, 1998; McDermott, 2009; Redish, 2003). As a result, students did not have the necessary skills to solve problems and were unable to apply the material they had learned.

In accordance with the problem analysis, one solution to overcome the problem was to foster the motivation of students in the learning of physics, so that learning became more meaningful for them. Meaningful learning can improve the students' knowledge as a whole. Students' motivation can be increased by applying a learning model that involves students actively. Therefore, a model of physics learning that could improve critical thinking skills of students was developed. The learning model should be integrated with the appropriate approach so as to improve the students' critical thinking skills. The appropriate learning model for this problem was the research-based learning model with the approach of science, environment, technology and society (SETS). The research-based learning with SETS approach was expected to help students solve problems and encourage students in improving high-level thinking skills, one of which is critical thinking skill.

Research-based learning is a student centered learning model that integrates research into the learning process. The learning process is the implementation of the combination of research and meaningful learning. Research-based learning is multifaceted, referring to various learning methods, so that all students' learning outcomes come from a simple research that they do, for example through experiments and field studies (Wardoyo, 2013; Griffith, 2008; Jyrhämä, 2008; Kynäslahti, 2006). Research-based learning provides opportunities for students to formulate

problems, review theories, construct hypotheses, collect data, analyze data, and conclude the results obtained.

Poonpan (2005) states that "Research-based learning is an effective way to change students' learning and to practice about how to learn by doing. Research-based learning is a system of instruction which uses an authentic learning, problem solving, cooperative learning, hands-on, and inquiry discovery approach, guided by a constructivist philosophy". Prahmana (2015) defines research-based learning as a model of learning which is authentic, problem solving, cooperative, contextual (hands on and minds on), and inquiry discovery approach based on a constructivist philosophy, so that students can improve their learning independence, critical thinking skills, creativity and communication skills. Research is an activity to discover, develop and test the truth of knowledge and summarize the findings obtained (Wardoyo, 2013).

The competencies acquired by students after research-based learning are: (a) to have an understanding of the concepts of physics and research methods; (b) to be able to solve problems creatively, logically and systematically; and (c) to have a scientific attitude that always seeks truth, and be open and honest (Arifin, 2010). The results of relevant research that has been done shows that the application of research-based learning that is life skill-oriented can increase the activity and the mastery of the essential concepts of university students in thermodynamics. The use of research-based student worksheets in physics learning is effective in improving the competence of students (Usmeldi, 2015a). Research-based learning with a scientific approach to effectively improve science process skills of students (Usmeldi, 2016a).

The SETS approach is an integration of science, environment, technology, and society (Maghfiroh, 2012). Learning with SETS approach is an integrated learning that is expected to teach students to have an integrative ability in four elements, namely: science, environment, technology, and society. The SETS approach can encourage students to study science in its entirety, take advantage of it in technology applications, know its impact on the environment, and know its impact on the development of society. According to Nuryanto (2010), SETS is a learning approach that links its four elements, namely science, environment, technology, and society in learning process. The subject matter is tied to concrete examples related to the community around the student, so that students can understand the ma-

terial easily. According to Minarti (2012) learning with the SETS approach can form students who have reasoning skills and comprehensive thought when they are faced with a problem. In learning with SETS approach, both the teacher and the students have a decisive role in the achievement of the learning objectives. The role of the teacher is to create a thinking pattern that sees the future with its implications, and take the students to always think critically in solving problems (Nuryanto, 2010; Nugraheni, 2013).

Critical thinking is one of the more complex forms of thinking activity which involves activities in analyzing more specific ideas, differentiating, choosing, identifying, assessing, and developing them in a more perfect direction. Critical thinking is a process and an ability to make rational decisions. Ennis (1996) proposes that the test to measure critical thinking skills is developed from five indicators, namely: (1) analysis, measuring the ability to understand the meaning of varied data, experience, and assessment; (2) Evaluation, measuring the ability to judge information and state the results of one's reasoning; (3) Inference, measuring the ability to identify the information needed to make conclusion; (4) Deductive reasoning, measuring one's ability which is started from general idea or a premise to a specific conclusion; (5) Inductive reasoning, measuring one's ability which is started from a premise or an application related to knowledge or an experience to a general conclusion.

Research-based physics learning with SETS approach is expected to be able to improve students' critical thinking skills, mastery of physics matter, and scientific attitude. In connection with that matter, the research problem was formulated as follows: (1) How did the process of developing research-based physics learning model with SETS approach improve critical thinking skills of students? and (2) How was the validity, practicality, and effectiveness of research-based physics learning model with SETS approach?

METHODS

The research activities were carried out to obtain information about the user needs, while the development activities were carried out to produce research-based learning models with SETS approach. The research design used the 4D research and development method by Thiagarajan. According to Thiagarajan (Trianto, 2010), the stages of the 4D model are *define*, *design*, *develop*, and *disseminate*. The subject of the research was the physic learning model for high

school students. The respondents of the research were students and physics teachers of SMAN 1 Bukittinggi. The instruments of the research were interview guidance, observation sheets, learning model validation sheets, lesson plan, students' worksheets, teachers' and students' response questionnaire, critical thinking skill test, and assessment sheets of skills and attitudes.

Based on the type of data, the data were analyzed qualitatively and quantitatively. The data of learning model validation, lesson plan, students' worksheets, questionnaires, and assessment were analyzed descriptively, and compared to the criteria of validity, practicality, and effectiveness of learning model, lesson plan, and students' worksheets. The data of learning implementation were analyzed qualitatively by revising the legibility and the action steps in the student's worksheet. The revision was conducted in accordance with the observation results done by the observer to the learning implementation, and the opinions of experts and peers.

RESULTS AND DISCUSSION

Research-based Physics Learning Model with SETS Approach

Based on the preliminary survey results and the critical thinking skill analysis of the students, a research-based physics learning model was designed with SETS approach. The integration of the SETS approach in the research-based

learning process was done by adjusting the learning steps. Research-based learning is a learning model that integrates research procedures in the learning process. Research is an important tool to improve the quality of learning. The research component consists of background problems, problem formulation, literature studies, methods, research results and discussion.

Learning with the SETS approach is a learning that can educate students to have an integrated ability in science, environment, technology, and society. SETS approach can encourage students to learn science completely and make use of it in technology applications, and learn its impacts on environment and its influence on society development. There are six stages of research-based learning model with SETS approach namely: (1) identifying problems related with environment, technology, and society; (2) formulating the problem; (3) reviewing theory; (4) formulating hypothesis; (5) collecting and analyzing data; and (6) interpreting and concluding research result.

Validity of Learning Model

Research-based physics learning model with SETS approach was validated by four expert judgments. Aspects assessed by the expert judgment were the feasibility of the content, the construction, and the language. The validation of the learning model and the instructional materials (lesson plan, students' worksheet, and assessment) can be seen in Table 1.

Table 1. The Validation Result of Learning Model and the Instructional Materials

Validation Aspect	Expert Judgment				Average	Category
	HM	RM	IM	KR		
Learning model	83	82	73	83	80.3	Valid
Lesson plan	78	82	79	77	79	Valid
Students' worksheet	73	79	79	74	76.3	Valid
Assessment	78	80	84	82	81	Valid

The validation result of the learning model, lesson plan, student worksheet, and assessment indicated that the learning model and the instructional materials were categorized valid.

Practicality of Learning Model

The experiment of the learning model was done to obtain the practicality data of the model and the instructional materials. The experiment of research-based learning model with SETS approach was conducted in four meetings (face to face). The experiment of the learning model involved physics teachers of SMAN 1 Bukittinggi as observers. Observers were in charge to obser-

ve the implementation of students' learning and activities. The practicality of the learning model was reviewed from the learning implementation, and the response of the teachers and the students. The observation result of the learning implementation showed that the learning model could be implemented by the teachers and the students. The teachers' responses to the implementation of learning show that the learning models are a very practical category. The teachers' response on the lesson plan, the students' worksheet, and the assessment of research-based physics learning model with SETS approach was categorized practical (Table 2).

Table 2. Practicality Result Based on Teachers' Response

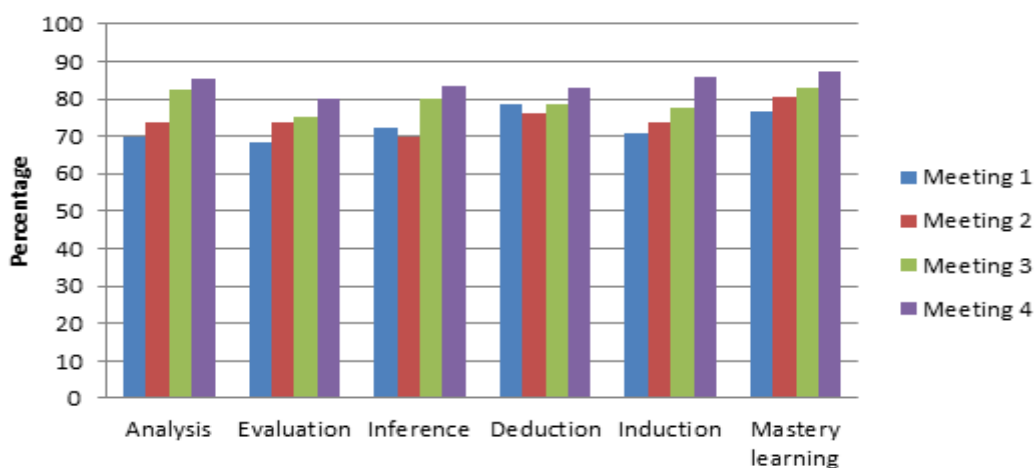
The Instructional Materials	Average (%)	Category
Learning model	89.97	Very practical
Lesson plan	80.3	Practical
Students' worksheet	78.9	Practical
Assessment	75.7	Practical

The most students (89.60%) stated that research-based physics learning with SETS approach was practically implemented. Thus, rese-

arch-based physics learning with SETS approach was practical to use to improve students' critical thinking skills.

Effectiveness of Learning Model

The effectiveness of research-based physics learning model with SETS approach to improve students' critical thinking skills was reviewed from the students' competence in the areas of knowledge, skills and attitudes. The valuation of the students' knowledge was conducted by giving quiz at the end of each meeting. The valuation of the knowledge was focused on the aspect of the students critical thinking skill by using essay assessments. The average of students' critical thinking skills and mastery learning on each meeting can be seen on Figure 1.

**Figure 1.** The Average of Students' Critical Thinking Skills and Mastery Learning

The Figure 1 shows that students' Critical Thinking Skills showed that there was an increase on every meeting on indicators of analysis, evaluation, and induction. Indicators of inference and deduction decreased slightly in meetings 1 and 2. The average score of the students' critical thinking skills from the four meetings was 76.9. Percentage mastery learning of students increased at every meeting.

The students' learning outcomes are presented on Table 3. The average learning outcomes of students in the knowledge domain was

76.9 and the mastery learning percentage of the students was 87.5 on the fourth meeting. The average score of students' learning outcomes in the skill domain was 83.4, and the percentage of mastery learning was 90.6% on the fourth meeting. The average score of students' learning outcome in the attitude domain was 83.9.

The average score of students' learning outcomes in the knowledge domain include good categories, skills and attitudes include very good category. More than 85% students had fulfilled the score of defined mastery learning criteria.

Table 3. Students' Learning Outcome

Learning Outcome	Meeting (direct)				Average	Category
	1	2	3	4		
Knowledge	71.9	73.2	78.8	83.5	76.9	Good
Skill	77.2	82.4	84.4	89.7	83.4	Very good
Attitude	76.2	81.6	86.3	91.7	83.9	Very good

Thus, it can be stated that research-based physics learning with SETS approach was effective to improve students' critical thinking skills. The research-based physics learning model with SETS approach developed in this research was stated valid, practical, and effective in improving critical thinking skills of the students. The improvement of students' critical thinking skills is the impact of research-based learning with SETS approach. Redhana (2008) states that SETS approach is a unity in the learning process, so that students have high-level of thinking skills, which one of them is critical thinking skill. Yulistiana (2015) concluded that the use SETS approach could improve students' critical thinking skill and students' mastery of learning. Purwandari (2015) states that physics learning using SETS-based physics modules can improve students' critical thinking skills. Learning the inquiry model with SETS approach on the topic of solubility and solubility products can improve the critical thinking skills of students (Rahma, 2012).

Research-based learning can improve students' skills in solving problems, thinking critically, and finding knowledge (Srikoon, 2014; Alshehry, 2014). The research-based learning is effective in improving the mastery of physics concepts and students' generic abilities (Usmeldi, 2015b). Research-based learning can improve the science process skills in physics (Usmeldi, 2016a). Research-based physics learning with scientific approach is effective in improving students' science literacy (Usmeldi, 2016b). Research-based learning can increase students' curiosity about the subject matter (Lui, 2011; Walkington, 2011).

The inquiry methods used in research-based learning can improve cognitive skills, critical thinking skills, scientific work skills, and scientific attitudes of the students (Cahyani, 2014; Sulistijo, 2017; Hairida, 2016). According Trisnasih (2013) in his research that the application of research-based learning could increase the activity, the skill and the knowledge of students in science lessons. Irianti (2007) in her research concluded that the SETS approach was effective for teaching students in physics learning on camera and periscope material. SETS-based science learning can improve the learning outcomes, the process skills, and the activeness on every meeting (Yulistiana, 2015). Research-based learning model with SETS approach was implemented in the laboratory.

The importance of laboratory activities to understand the concepts of physics for students is proposed by Ivins and Raghubir. According to

Ivins (McComas, 2005) Laboratory activities are more effective in helping students learn physics than learning from discussions. Raghubir (McComas, 2005) found out that students showed high level of cognitive ability when they actually acquired knowledge through laboratory activities rather than using the laboratory to verify the theories that had been studied. The inquiry practicum activities are more challenging for students in finding the concept of physics than the verification activities. Cox & Junkin (2002) in their researches found out that the inquiry practicum activities could improve students' skills in conducting practicum. Deters (2005) and Weaver (2008) in their researches found out that the inquiry practicum activities could improve students' skills in thinking logically, solving problems, and give impressive experience of laboratory activity. Guided Inquiry-based practicum learning can improve the critical thinking skills of students (Wulandari, 2013).

Research-based physics learning with SETS approach can make students master physics competence completely, not only master the knowledge and the skills but also the care to the environment, technology, and society. The process of attitude habituation was assessed from the beginning when students perform an attitude indicator until it becomes a habit. The formation of attitude takes a long time, as stated by Nugroho (2011) that the formation of attitudes takes place in several stages to change personal attitude that starts from dissatisfaction, followed by having a logical and rational vision, having the courage to take risks and responsibility until the stage of consistent. In the consistent stage, it can be said that there is a change in the person's attitude. It is certainly not easy considering various challenges faced by students every day. Therefore, within a few meetings of learning, it was difficult to know the students' level of consistency.

Learning activities with SETS approach can improve students' problem-solving skills because the learning activities begin with the problem presentation. The students are required to solve problems that exist in their environment. In the final stage of learning, students are expected to be able to master the material of physics and solve problems. Prahmana (2015) defines research-based learning as a problem solving learning system with the point of view of problem formulation, problem solving, and communicating the benefits to foster learning independence, critical skills, creativity, and good communication skill.

CONCLUSION

The research had resulted in research-based physics learning model with SETS approach. Research-based learning is a learning model that integrates research procedures in the learning process. Learning with SETS approach is a learning that is able to teach students to have an integrated ability in science, environment, technology, and society. SETS approach can encourage students to study science as a whole, use science into technology applications, and study its impact on the environment and society development. Stages of research-based learning model with SETS approach are: (1) identifying problems related with environment, technology, and society; (2) formulating the problem; (3) reviewing theories; (4) formulating hypothesis; (5) collecting and analyzing data; and (6) interpreting and concluding research result.

The developed learning model was valid, practical, and effective in increasing students' critical thinking skill. The average of students' critical thinking skill was good. More than 85% of students mastery learning on the knowledge and the skill competence. The skills and the attitudes of the students were very good.

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