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DEVELOPING SCIENCE LEARNING MATERIAL WITH AUTHENTIC INQUIRY LEARNING APPROACH TO IMPROVE PROBLEM SOLVING AND SCIENTIFIC ATTITUDE

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ABSTRACT

This research was conducted to (1) produce science material learning based Authentic Inquiry Learning which is appropriate to improve problem solving and students scientific attitude; (2) know the potency of developing scientific attitude in science learning material based authentic inquiry learning; and (3) know the potency of developing scientific attitude in science learning material based authentic inquiry learning. The research method was Research and Development (R & D), by pointing to Four D models and Borg & Gall Model. There were 4 main phases (define, design, develop, disseminate) and additional phases (preliminary field testing, main product revision, main field testing, and operational product revision). The instruments used included product validation questionnaire, problem solving test, observation sheet of problem solving, and scientific attitude questionnaire. Result data of validation, problem solving test, scientific attitude questionnaire were analyzed descriptively. The result showed that : (1) science learning material based authentic inquiry learning that was developed was considered as very good by expert lecturers and teachers, and it was appropriate to use in learning process; (2) science learning material based authentic inquiry learning could improve students' problem solving; (3) science learning material based authentic inquiry learning could improve students' scientific attitude.

Keywords: learning material; authentic inquiry learning

INTRODUCTION

Indonesia has to be ready to face a global challenge in this 21st century. The demands include students that need a mind, verbal and written communication, team work, creativity, research skill, and problem solving to compete and grow well in the future. However, education environment does not facilitate to teach those skills to students. Students are clever on text, but poor in applying. Students are less at socializing in real life, strange with learning context to the real life and strange towards the conceptualization process, so they claim science as pure theory. Students do not understand the benefit and the meaning of why they learn science. Besides, they often succeed in solving a simple problem, but they face difficulty even failure if the problem context changes little. Indeed, as what was stated by Setyawan that someone was tended to use his cognitive creatively, by continuously modifying and using the concept to compromise with daily problems (Kurniawan, 2013).

Heuvelen (Wijayanto, 2011) presented result survey done by American Institute of Physics in the United States that the most commonly used competence for workers were competence in problem solving, team work, and communication. As the resulting survey done by Council Science and Technology in British showed that about 30% workers used science in some of their working aspects and problem-solving skill was

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always needed in many occupation or expertise. But a research done by Organization for Economic Cooperation and Development (OECD)-as international research organization- showed that education in Indonesia placed the second lowest after Tunisia in problem solving competence and third lowest after Brazil for science competence. This result was saddening. The reasons could be suggestions how human resource in Indonesia should be developed through education, especially in science.

Osborne & Collins stated that most students like to work at laboratory by cook book type, which presents detail steps one by one. It is what makes laboratory activity becomes boring, and it does not relate to real life (Koretsky *et. al.*, 2012). Duschl & Bybee (2014) also added that science learning by *doing in Science* could improve students knowledge about science and how dynamically science was produced, competed, and repaired. Surly to make this kind of learning, teachers have to face a big challenge and responsibility to support students to learn to improve their understanding and skill to face real life.

Based on the explanation above, a social skill like problem solving is important to be oriented in science learning. Attitude aspect is also one of those that cannot be ignored in science learning, and it is necessary to be created in students mind so that they become a superior human resource, enable to conform intellectual, emotional, and spiritual aspects, enable to improve many intellectual potencies they have optimally and equally.

Teachers could put scientific attitude through research activity done by students, either experiment or exploration. Teachers are aware that scientific attitude is important, but it gets less attention for the purpose of learning. It makes scientific attitude is often ignored because teachers also face difficulty in designing strategy or learning approach to improve scientific attitude and document result study of scientific attitude. However, as it was explained by Kaplan (Prokop et al., 2011) that some researches had proven there was a positive relation between scientific attitude and students' cognitive result study. Kaplan also stated that "students achievement in science is, together with attitudes, the most important indicator, or predictor, of the science education outcome" (Prokop et al., 2011).

Education, including quality of science education, is demanded to build good human resource. Besides, science learning also has a principle to create students become long life learner since education cannot be described as life preparation, but it should be seen as the art of life itself. Fitriani et al. (2016) stated that "science learning in school could be applied by connecting the materials in the learning with real life." As a consequence, strategy or innovative learning approach are needed to make them real. Two innovative approaches are authentic learning and inquiry approach.

Authentic learning happens when the teacher provides a chance for students to learn and help them to inquire actively, solve the problem, and think critically and reflect problems in daily life. Inquiry approach teaches students how scientists work. This approach can motivate students to become thinker, curious, cooperative and problem solver. Based on this reference study, it needs urgently the combination of authentic learning and inquiry approach to making innovative learning that can support students inquiry towards world change. Teachers in science learning, with authentic inquiry approach, can teach their students to observe object and natural phenomena, by using society potency as a learning source, and become connectors between school and its environment. Besides, learning process should be emphasized on actual problems that are directly related to real life and useful for society life or contextual quality.

To teach students by using authentic inquiry learning needs learning the material. A complete learning material would help teachers in teaching, and students in learning process. A learning material ensures to reach the purpose of learning. A systematic learning material to train problem solving and scientific attitude is hard to find. Besides, books and students' science worksheet nowadays are rigid and boring for students, so they are less interested in science (Asa, 2011). Besides, published learning materials also pay less attention to students scientific attitude and tend to present science as a body of information, not research method. Based on these backgrounds, it is necessary to develop science learning material based on authentic inquiry learning in order to improve problem solving skill and scientific attitude.

Research questions in this study are: (a) how is the quality of science learning material based on authentic inquiry learning according to experts and teachers if it is seen from the material, graphic, presentment, and language aspects?; (b) can science learning material based on authentic inquiry learning approach improve problem solving skill?; (c) can science learning material based on authentic inquiry learning approach improve scientific attitude? The purposes of this study

are to know: (a) the quality of science learning material based on authentic inquiry learning approach seen from material, graphic, presentment, and language aspects; (b) the potency in improving problem solving skill by using science learning material based on authentic inquiry learning approach, (c) the potency in improving scientific attitude by using science learning material based on authentic inquiry learning approach.

METHODS

Research methods used in this study referred to four D models and Borg & Gall. Development procedures consisted of 4 main phases (define, design, develop, and disseminate) and additional phases (preliminary field testing, main product revision, main field testing, and operational product revision) that were taken from Borg and Gall procedure. Define phase was a phase of collecting first data by literature review and field survey. In this phase, the writer analyzed local potency around the school, curriculum, learning condition, and students characteristics. The design phase was a phase of developing the first product by preliminary field testing, main product revision, main field testing, and operational revision.

Subjects in this study were students JHS grade VII and VIII in some schools in Yogyakarta. This study was done on May – November 2015. The instruments included:

1. Questionnaire of learning material validation used to get data about product review from experts and science teachers of JHS towards the developed learning material. This questionnaire included: material, language, presentment, graphic, and inclusiveness of authentic inquiry learning aspect, and inclusiveness of problem solving and scientific aspects.
2. Scientific attitude questionnaire was used to know the improvement of students' scientific attitude. The indicators of scientific attitude used were indicators developed by Harlen (2000).
3. The test was used to know the improvement of students' problem solving skill after doing learning process by using material based on authentic inquiry learning. Test instrument was arranged based on the indicators available in standard basic competence in materials adapted to students' problem solving indicators. Problem solving indicators included: (1) identifying problem; (2) formulating problem; (3) finding alternative solutions; (4) choosing the best solution; (5) fluency in solving the problem; and (6) quality of problem solving result. For problem solving skill, each
4. item in the question was given maximum score 4, and the result of each aspect was converted into scale 5 category and counted its N-gain score.
5. Observation sheet was used to support improvement data of students' problem solving skill got from the test. The instruments were a questionnaire and observation sheets using Likert scale 1 to 4 score and the resulting sore was counted its average in each aspect, then converted into scale 5 category.

RESULTS AND DISCUSSION

Based on the result analysis of local school nature potency (all objects in the school yard and the environment around), we got a specific object for science learning with all problems for students. Then the result was syncronized with science material in the applied curriculum (Curriculum of unit level education & Curriculum 2013). The result of syncronization was in Table 1.

Table 1. Syncronization between local potency and JHS science curriculum

Specific Object	Scientific Problem Question	Material in Science Curriculum
River Code	Is the river polluted? What should effort be made to solve it?	Water Pollution
Food franchise outside school	Is the ingredients of food at school safe? How to detect and what effort should be made to keep the food ingredients safe for health?	Addictive Substances in Food
Mount Merapi, River	How do the objects around change?	Object Change
Hydrallic fish pool, big tree, group of hyacinth	How is the photosynthesis?	Photosynthesis
Crowded street	What is the effect of dirty air? How to minimalize dirty air?	Air Pollution

Based on the analysis result of local school potency and curriculum, science material themes taken as a title in accordance with Curriculum of Unit Level Education were Addictive Substances in food, Protecting Our Earth from Air Pollution, Water for Life and themes in accordance with curriculum 2013 were: Objects Change around us, Photosynthesis.

Based on the analysis of students characteristics, the developed scientific attitudes were curiosity, respect towards facts and cared towards the environment. Learning material focused on developing problem solving skill and scientific attitude, because they were important things that should be developed as century 21 demands. It was also as preparation to face curriculum 2013 that explicitly stated main competence like skill and attitude. The developed learning materials were: Pocket Book and Addictive Substances in food, Protecting our earth from air pollution, water for life, e-module objects change around us.

The format of learning material or pocket book was as the following: (1) learning instruction; (2) Competence; (3) Supporting Information; (4) Exercises; (5) Worksheet Instruction; (6) Evaluation. The format of students worksheet was adapted from LKPD, such as (1) Activity Title; (2) Purposes; (3) Tool and Material; (4) Work Procedure; (5) Data Table; (6) Discussion Material. Earning material in this study was arranged based on authentic inquiry learning approach, it was the combination of guided inquiry and authentic learning. Inquiry approach was facilitated with paying attention to the steps in a worksheet like formulating the problem, formulating a hypothesis, collecting data, analyzing data, taking a conclusion, and generalizing. Authentic learning approach was characterized by the contextual problem, investigating activity to help improving students' thought, collaborating, students product, using various learning sources, and or reflecting.

Validators' assessment toward the product of science learning material based on authentic inquiry learning approach

Validating science learning material with authentic inquiry learning approach was done by three expert lecturers and 3 teachers (practitioners). The result was on Table 2. Table 2 showed that science learning material that was developed by using authentic inquiry learning approach was considered as very good in most aspects (material, graphic, language, presentment). The suggestions and critics by validators towards science learning material based on authentic inquiry learning approach were:

1. Indicators and learning purpose did not reflect basic competences,
2. The purpose of "knowing" should be changed into appropriate verb for Inquiry and Problem Solving activities,
3. Concept emphasize in learning material in students' worksheet was not so good,
4. Local potency/ environment should be explained more detail,
5. Concept map should be revised because there were little mistakes and explained more clearly by using words descriptors,
6. Cognitive chain should be paid attention and adjusted with activity steps and discussion question in learning material,
7. It needed more reference especially in work procedures in students worksheets,
8. Term consistence should be paid more attention,
9. There were some sentences that did not fulfill language grammatical and Structural,
10. Punctuation should be rechecked,

The follow up of suggestion and critics above were done, and the product of learning material was repaired as the following:

1. Repairing indicators and purposes by adding materials loaded in basic competences,
2. Adding word "observe," "find," "suggest

Table 2. Lecturers and teachers validation towards science learning material based on authentic inquiry learning approach

Appropriateness	Lecturers		Teachers	
	Score	Category	Score	Category
Relevant requirement of material	3,64	Very Good	3,76	Very Good
Relevant requirement of language	3,53	Very Good	3,47	Very Good
Relevant requirement of presentment	3,73	Very Good	3,74	Very Good
Relevant requirement of graphic	3,71	Very Good	3,61	Very Good
Average	3,65	Very Good	3,65	Very Good

idea or solution'' as purposes,
3. Adding questions in discussion to make science learning material references wider,
4. Emphasizing school local potency by presenting facts at the beginning of activity by looking at contextual and school local potency,
5. Repairing concept map in learning material by checking the appropriateness of sub-concepts with main concepts and adding words descriptors,
6. Evaluating activity that was appropriate with theme, checking question order so that it was relevant to cognitive chain,
7. Giving instruction in students' worksheet so that they opened more references,
8. Repairing punctuation with the correct language grammar and structure,
9. Changing image in cover to be relevant with theme,
10. Repairing display to be more simple but still interesting.

Science learning material based on authentic inquiry learning approach was developed and repaired based on the relevant suggestions. All lecturers and teachers had given assessment that developed science learning material had already used authentic inquiry learning approach including contextual problems were taken, inserting investigation with steps of inquiry approach (formulating problem, formulating hypothesis, testing hypothesis, analyzing data, taking conclusion, developing new problem), students had chance to collaborate, students produced something, using many learning sources, students reflecting. Besides, validators also stated that the developed science learning material loaded problem solving with indicators to identify and formulate the problem, give an alternative solution, and do the best solution.

Learning material product that was revised in accordance with validators suggestion and critics was tested to the subjects, students grade VII and VII of JHS. This test was done to know the potency of science learning material with authentic inquiry learning approach to improving problem solving and scientific attitude.

Developing students' problem solving skill by using science learning material with authentic inquiry learning approach

The test was done limited to students grade VII or VIII of JHS based on the materials given. Students' problem solving observation was done during learning process with science learning material with authentic inquiry learning approach, problem solving test was given before (pretest) and after learning (post test) or only post test. The result of problem solving post test was as on Table 3.

Table 3. Students' problem solving post test result

Problem solving skill aspects	Average score	Category
Identifying problem	3,43	Very Good
Formulating (analyzing) problem	3,36	Very Good
Finding alternative solutions	3,08	Good
Choosing alternative solution (best)	3,05	Good
The fluency in solving problem	3,72	Very Good
The quality in problem solving result	3,34	Very Good
The average of problem solving skill	3,33	Very Good

Table 3 showed that most aspects of students' problem solving skill were very good based on the post test result. Finding and choosing alternative solution were categorized as good. The result of the N-gain score from problem solving skill tested twice as Table 4 showed.

Table 4. Pretest and post test result of problem solving

Problem solving skill aspects	Score	
	Pretest	Posttest
Identifying problem	1,91	3,55
Formulating (analyzing) problem	1,91	3,36
Finding alternative solutions	1,96	2,91
Choosing alternative solution (best)	1,85	2,90
The fluency in solving problem	1,99	3,86
The quality in problem solving result	1,88	3,38
The average of problem solving skill	1,92	3,33
N-Gain Score	0,68	
Category	Medium	

Table 4 showed that there was an enhancement on students' problem solving skill by using

science learning material with authentic inquiry learning approach. It was showed from N-gain score value which was 0,68 (medium category). In general, all aspects of students' problem solving skill improved. Besides using test, students' problem solving during learning process with science learning material based on authentic inquiry learning approach were observed per each meeting.

Table 5. The result of students' problem skill observation

Problem solving skill aspects	Meeting no-		
	1	2	3
Identifying problem	2,03	2,48	3,41
Formulating (analyzing) problem	2,40	2,64	3,27
Finding alternative solutions	2,45	2,47	3,30
Choosing alternative solution (best)	2,61	2,69	2,94
The fluency in solving problem	2,09	3,01	3,23
The quality in problem solving result	2,78	2,58	3,26

Test result showed that problem solving skill could improve by using science learning material based on authentic inquiry learning approach. It was because either inquiry approach or authentic learning approach could improve problem solving skill. The inquiry could train high ability to think skill, including problem solving skill for identifying the problem, formulating the problem, and finding alternative solution aspects. Inquiry approach could facilitate students to think higher to develop a process in understanding principle and concept (Friedel *et.al.,* 2008:72). Pratt and Hackett added that "…. teaching science by inquiry involves teaching students science process skill, critical thinking, scientific reasoning skill used by scientists (Ergul *et. al.,* 2011). Inquiry based learning could improve intellectual and creativity through thinking process (Lawson, 2010), develop science literal, knowledge, concept understanding, scientific attitude (Anderson, 2002), critical thinking, process skill (Anderson, 2002; Panasan & Nuangchalem, 2010). Sukma & Ibrahim (2016) stated that "Teaching and materials for active learning of guided inquiry-integrated bowling campus are proved to be able to increase learning outcome of Junior High School student". The research result of Hairida (2016) showed that inquiry based module with authentic assessment in addictive substances material was effective to improve students inquiry skill and critical thinking, N-gain score of experiment class was higher than control class.

Lombardi (2007) stated that authentic learning was focused on complex problems that might be faced in real life and solution of that problem, that would create a condition which demands students to be able to improve their high analyzing skill and communication. Authentic learning also facilitate students to solve the problem with many alternative solutions. Emphasized by Harris & Rooks (2010) that recent education research result shows new perspectives which are appropriate to use in science learning and apply in science activities related to daily life (contextual). It made students think about problems in life (contextual) and apply their science knowledge so that they used their ideas, tried to understand deeper as well as their knowledge on ho to observe in science. In this case, students' science knowledge could improve when they were given a chance to participate observation activity to solve the contextual problem. So, the combination of authentic approach and inquiry, authentic inquiry learning, could possible improve all aspects of problem solving (identifying problem, formulating problem, finding alternative solutions, choosing alternative solutions, the fluency in solving problem, the quality in solving the problem).

Developing scientific attitude by using science learning material based on authentic inquiry learning

Based on the assessment by expert lecturers and teachers, the developed science learning material had potency to improve scientific attitude with details: (1) the score of curiousity reached 3,57 from lecturers and 3,87 from teachers; (2) the score of respect towards facts reached 3,67 from lecturers and 3 from teachers; (3) the score of care towards environment reached 4 from lecturers and teachers. The result was also emphasized with students questionnaire which showed science learning material with authentic inquiry learning approach as Table 6, 7 and 8 showed.

Table 6 showed that generally, students curiousity grew well. It means that science learning material with authentic inquiry learning approach could improve students' curiousity.

Table 7 showed all aspects of respect towards fact could improve well, even for objective aspect was categorized very good by using science learning material with authentic inquiry learning approach. It meant that science learning material with authentic inquiry learning approach could

Table 6. Questionnaire result of curiousity

Indicators of curiousity	Minimun average score	Average score	Category
Paying atention to new things	4	3,55	Very Good
Observing or trying to answer curiousity	4	3,40	Very Good
Enthusiastic to search the answer	4	3,49	Very Good
Looking for information spontantly from book or other sources	4	3,14	Good
Formulating problem on science students' worksheet stimuates students' curiousity	4	3,36	Very Good
Rerata		3,39	Very Good

Table 7. Questionnaire result of respect towards facts

Indicators of respect towards facts	Maximal average score	Average score	Category
Objective	4	3,33	Very Good
Not manipulating data	4	3,12	Good
Rechecking the result	4	2,98	Good
Taking conclusion	4	3,06	Good
Admitting conclusion to be temporary	4	2,63	Good
Average score		3,02	Good

Table 8. questionnaire result of care towards environment

Indicators of care towards environment	Pretest		Posttest	
	Average score	Category	Average score	Category
Know and understand the indicators of care towards environment	2,81	Good	3,69	Very Good
Enable to give idea about care topwards environment	2,82	Good	3,68	Very Good
Persuade students to care towards environment	2,67	Good	3,30	Very Good
Average	2,77	Good	3,57	Very Good
N-Gain score	0,65			
N-Gain score category	Medium			

improve students' respect towards fact.

Table 8 which there was en enhancing score and category in students care towards the environment. The score after post test was higher than pretest with N-gain score 0,65 (medium category). Three aspects of care towards environment were categorized very well after using science learning material. It meant that science learning material based on authentic inquiry learning could grow students' care towards the environment.

The questionnaire results of Table 6, 7 and 8 showed that science learning material based on authentic inquiry learning could grow or improve students' scientific attitude. It was because inquiry could improve scientific attitude. Inquiry learning could sharpen process skill and understanding concept better, and also improve students' scientific attitude (Ergul et al., 2011 ; Viera et al., 2011) stated that teachers should believe that teaching with inquiry approach could stimulate students to study and it was not the pure process of transferring knowledge because world change becomes more complex, there might be many situations with no solution. Khusniati (2012) also stated that "learning which applied inquiry could improve many characteristics such as critical thinking, creative and innovative, curiousity, respect to others' opinion, polite, honest, and responsible."

Besides that, Lombardi (2007) said that authentic learning provided a learning process to students to reflect either individual or group, and could cause them adopt many roles and think from many views. Authentic learning could also enable affective skill (value, respect, and care) and conative skill (act, decide, and commitment) to improve (Lombardi, 2007).

Based on the reasons above, authentic inquiry learning indeed could improve students' scientific attitude. Learning with authentic inquiry learning approach could teach many attitudes needed in learning to improve scientific attitude as stated by Klausmeier & Goodwin (1971) that learning which could improve attitude needed to focus on problem, providing example of attitude, help students to arrange the goal of attitude, ask students to give reason towards their attitude, give feedback and correction, and emphasize.

Based on the result of this study it could be stated that learning with authentic inquiry learning approach could improve students' problem solving and scientific attitude, and also create meaningful science learning process. Reiter (2015) said that "Meaningful learning implies the active involvement of the learners/students in whatever is being taught. It is based on a holistic approach to the learners, calling for their cognitive, emotional and behavioral attention". (Drake (2014) also said that meaningful learning was not only active in thinking but also active in behavior and attitude. Authentic inquiry learning was a learning referring to the authentic scientific inquiry, where Schwartz & Crawford (2006) emphasized that "authenticity as it pertains to the practice of scientific inquiry, conducted by scientists, within the community of science." Learning could be said authentic if it was done by observing, worked by scientists, in community/ science environment. It meant that learning should bring problems in an environment which related to science and observe to solve the problem. Schwartz & Crawford (2006) also stated that the main difference between inquiry and authentic learning was in their meaning.

CONCLUSION

Science learning material with authentic inquiry learning approach was considered to be very good, seen from material, presentment, graphic, and language aspects by lecturer and teacher, and it was appropriate to be used in learning process,

Science learning material with authentic inquiry learning approach could improve students' problem solving skill,

Science learning material with authentic inquiry learning approach could improve students' scientific attitude.

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