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The Development of Science Worksheet Based on Inquiry Science Issues to Improve Critical Thinking and Scientific Attitude

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Abstract. This study aims to (1) produce science worksheet-based Inquiry Science Issues which is appropriate to improve students' critical thinking and scientific attitude, (2) know the potency of developing critical thinking in science worksheet based Inquiry Science Issues, (3) know the potency of developing scientific attitude in science worksheet based Inquiry Science Issues. The research method uses Research and Development (R & D), by pointing to Four D models. There were 4 main phases (define, design, develop, disseminate). The instruments used included product validation questionnaire, critical thinking test, observation sheet of critical thinking, and scientific attitude questionnaire. Result data of validation, critical thinking test, and scientific attitude questionnaire were analysed descriptively. The result showed that: (1) science worksheet based inquiry science issues that was developed was considered as very good by expert lecturers and teachers, and it was appropriate to use in learning process; (2) science worksheet based inquiry science issues could improve students' critical thinking; (3) science worksheet based inquiry science issues could improve students' scientific attitude. Based on the analysis, science worksheet based inquiry science issues is potential to improving students' critical thinking and scientific attitude at junior high school.

1. Introduction

Learning in the 21st century is producing students who are able to compete in a global era to solve increasingly complex problems. Therefore learning should be oriented to the skills that support in solving the problem, not least in science learning. Science teachers are responsible for helping students to acquire and be able to understand Nature Of Science (NOS) [1]. In the learning process of science, learning emphasizes the achievement of NOS, where NOS understanding helps students to understand science including content, scientific skills, character and scientific attitude [2]. It is further explained that by learning science students will acquire the skills and understanding of science that is the principles of science, the concepts of science, the skill of doing scientific and reasoning procedures, and understand that science is a human effort (National Research Council, 2000: 8). Science is a systematic knowledge of nature and is a process for studying the universe. The process is obtained through scientific activities in the form of data collection through observation, experiments and inference through investigation [3]. It is further explained that IPA is a way of thinking in solving problems related to natural objects, how to investigate various phenomena and problems of nature, the collection of knowledge, and its relation to technology and society.

In teaching science teachers need to choose an approach that can promote the nature of science, one of the appropriate learning approaches is inquiry [4]. Through the inquiry approach will develop process



skills such as observing, inference, calculating, analyzing data and interpreting. In scientific inquiry not only develops process skills, but also combines scientific reasoning and critical thinking to develop scientific knowledge (nature of science and scientific inquiry). Thus, the process of learning science through inquiry in accordance with its essence, namely as a way of investigating that will facilitate students to conduct investigations. [5]. By doing an inquiry the students will practice asking questions, looking for proof of a problem to find more accurate information. Inquiry-based learning will help students to develop rational ways of thinking, critical thinking skills and scientific literacy [6]. Scientific literacy and way of thinking is very important to make decisions in solving problems or issues in the environment. Issues in the surrounding environment can be raised in the learning process of science as a matter to be investigated. Implementation of learning that involves issues will train problem solving, so it will improve high-level thinking skills, discussion skills, investigation, and understanding of science facts [7]. Characteristics of learning with the approach of inquiry science issues are students oriented in a scientific question formulated based on the issues presented, formulate problems or questions, students will formulate hypotheses, gather evidence, test the hypothesis, and formulate conclusions to answer questions that have been formulated [8]. Learning that emphasizes issues will facilitate students to solve them through inquiry so that they will develop thinking skills as well as argumentative [9].

The results of a preliminary observation on the learning process in junior high school students showed a fact that some critical thinking such as observing, measuring, predicting and communicating were not observed in the learning process. These facts indicated that science learning process skills was needed to be improved. Based on the results of interviews with the science teacher the scientific attitude also needed to be improved. Therefore, it is necessary to develop students' worksheet based on inquiry science issues in order to develop attitude (scientific attitude) and critical thinking skill of junior high school students.

2. Method of Research

2.1. Design of research

This research used the method of Research and Development (R & D) which adapted to the four-D model by Thiagarajan. The research phases included define, design, develop and disseminate.

The first phase was a phase of collecting data by literature review and field survey. Moreover, the writer analyzed curriculum, science issues based on content, students characteristic, learning condition, identification the variable of critical thinking and scientific attitude. The second phase was to design the product of students' worksheet based on Inquiry Science Issues. The third phase was to develop the main product, the main product revision based on the experts, main field testing and operational revision. The last phase was a dissemination of product.

The main field testing has been done at 2016 for collecting the student's critical thinking and scientific attitude. The sample is chosen with cluster random sampling technique while the criteria of the samples have normal and homogeneity data. The number of students are 120 students Junior High School grade VII in school in Yogyakarta.

2.2. Instrument

The data collection was done by the instruments in this research included 1) Questionnaire of student worksheet validation used to get data about product review from science teachers and the experts; 2) Scientific attitude questionnaire was used to know the improvement of students' scientific attitude; 3) the improvement of student's critical thinking was measured not only by tests' instrument but also observed by observation sheet, observation sheet was used to support improvement, data of students' critical thinking.

2.3. Data Analyses

The improvement of critical thinking by instrument test was analyzed by N-Gain by Hake $\langle g \rangle$, a value of obtained $\langle g \rangle$ was consulted with three categories, namely (1) high: $\langle g \rangle \geq 0.7$; (2) medium: $0.3 \leq \langle g \rangle < 0.7$; and (3) low: $\langle g \rangle < 0.3$.

While the feasibility of student's worksheet and observation sheet using Likert scale 1 to 4 score and the resulting score was counted its average in each aspect, then analysed qualitatively based on the classification of four categories, namely: (1) very good: the interval score $3.25 < X \leq 4.00$; (2) good: $2.50 < X \leq 3.25$; (3) Poor: $1.75 < X \leq 2.50$; and (4) very poor: $1.00 \leq X \leq 1.75$.

3. Results and Discussion

3.1. Define Phase

In this first phase, we have to know the need assessment that contribute to provide data to develop the product of research. The result of this phase found that students' critical thinking and scientific attitude was low.

It can be seen from several aspects of critical thinking, for example several students could not make a question of the problem, they nor confident to solve the problem and make a right decision when solve the problem. Whereas teacher need to design the learning science to appear students' curiosity. The result of this study was end product student's worksheet based on Inquiry Science Issues which can improve the student's critical thinking and scientific attitude at additive and addictive substances.

3.2. The Design Phase

In design phase, need to design the product of students' worksheet based on Inquiry Science Issues. The design of student's worksheet develop to support learning activities, which have several components, namely title, objective, an introduction based on science issues, tools and materials, work step, observation on data, discussion and conclusions.

The inquiry science issues approach refers to learning that exposes students to science issues on additive and addictive substances and facilitates students to solve them through investigations [10] The orientation in the inquiry phase is oriented to science issues, so the stages of learning inquiry science issues include six stages, namely orientation on science issues, formulating problems, formulating hypotheses, gathering evidence, testing hypotheses, and formulating conclusions [11]. In this study, a problem in inquiry focused on science issues which identified in daily life.

3.3. Develop Phase

Based on the result analysis of science issues in daily life, we got several issues in additive and addictive substances that appropriate with a curriculum of unit level education & curriculum 2013 in Indonesia. The result of issues was in Table 1.

Table 1. Identification of Issues in Subject Matter

Specific Issues	Scientific Problem Question	Material in Science Curriculum
Food outside school	Is the food at school safe?	Additive substances
Poisoning preservatives	Why people get poisoning preservatives?	
Foods containing rhodamine B	How to detect food coloring and formalin? How to choose safe preservative and dye as an alternative in additive food?	
Chicken on the market contains formalin		
electric cigarette (Vape) replacement cigarettes	Is it true that electric cigarette is better than a tobacco cigarette? How we can detect nicotine?	Addictive substances

The student's worksheet focused on developing student's critical thinking and scientific attitude, due to they were significant things that should be advanced in science learning as 21st century demands [8]. It was also explicitly stated main competence like skill and attitude in curriculum 2013. The results of analysis of student's characteristic firstly scientific attitude that have to develop were curiosity, respects toward facts, and open mindedness. Secondly, aspects of student's critical thinking were formulating questions, analysis discussion, problem-solving, decision making and communication.

Validating student's worksheet based on Inquiry Science Issues was done by two expert lecturers and two science teachers as practitioners. The results of the student's worksheets were on Table 2. Table 2 note that the worksheet that was considered in the very good category in most the aspects.

Table 2. The Result of Validator's Assessment towards the student's worksheet based on Inquiry Science Issues

Aspects	Lecturers		Science Teacher	
	Score	Category	Score	Category
Requirement of material	3.7	Very good	3.6	Very good
Requirement of presentment	3.4	Very good	3.3	Very good
Requirement of language	3.3	Very good	3.3	Very good
Requirement of graphic	3.7	Very good	3.5	Very good
Average	3.6	Very good	3.5	Very good

The results of the assessment indicated that the developed worksheet developed was eligible for use in the learning process after being revised in accordance with the advice and input of the validator. The suggestion by validator towards inquiry science issues student's worksheets were 1) the lines of interface between concepts are made with arrows to make it easier to read concept maps, 2) If there was a foreign term, write it in italics, 3) explore critical thinking skills in the learning process, 4) minimize material that leads to misinterpretation and misconception for junior high school students, 5) images were less communicative and less interesting, 6) there were still sentences that will be difficult to understand for junior high school students, so need to minimize the words that were not needed, 7) Cover was made more interesting, make sure the student focus directly to a worksheet title and a picture more communicative. Based on the suggestion by validator, students' worksheet was revised.

3.4. Disseminate phase

The last phase of the research is applied student's worksheet based on Inquiry Science Issues in science learning. The revision product was used in science learning process with Inquiry science issues approach. Teaching and learning proses using this product have result of students' critical thinking and scientific attitude.

3.4.1. Developing Student's Students' Critical thinking by Using Student's Worksheet based on Inquiry Science Issues

During the implementation worksheet in learning, there were 3 observers that observe critical thinking skills and scientific attitude. A result of critical thinking skills were measured by not only observation sheet but also using instrument test.

Based on limited testing, it showed that the application of the developed student's worksheet could increase the critical thinking skills learning a process. The results of the instrument test analysis of the average score of normalized gain (<g>) showed the improvement of critical thinking skills in a high category.

Table 3. The result Test of Critical Thinking Skills

No	Aspect	pretest	Posttest
1.	Maximum score	69	95
2.	Minimum score	60	72
N-Gain		0.3	0.8
Category		low	high

The improvement of critical thinking skills was support from observation of critical thinking skills by an observer. Data of observation was observed by science teacher and 3 observer and the result was on Table 4, the average of student's critical thinking skills was a very good category.

Table 4. Data Observation of Student's Critical Thinking Skills

Aspect	score	Category
formulating questions	3.7	Very good
analysis discussion	3.5	Very good
problem-solving	3.8	Very good
decision making	3.7	Very good
communication.	3.2	good
average	3.6	Very good

Inquiry learning is a learning that emphasizes the discovery of something through the process of seeking by using scientific steps [12]. In inquiry, students are expected to critically find problems in life and seek creative solutions. In order to learn science in scientific inquiry, science learning must be supported by thinking skills. Inquiry approach is way of asking a question, seeking information, and finding new ideas related to an event. That is the Inquiry approach, students learn by using cause and effect, relational and critical thinking [13]. Implementation Inquiry Science Issues worksheet gave student how to solve the problem (very good category) and how to making a decision (very good category). On the other hand, both of them was excellent, since student had issues as a problem and searching how to solve it.

3.4.2 Developing Student's Scientific Attitude by Using Student's Worksheet based on Inquiry Science Issues

Implementation inquiry approach in science learning was expected to critical students to find problems in life and seek creative solutions. In order to learn science in scientific inquiry, science learning must be supported by thinking skills.

In addition to science learning is also learned accordance with standard processes that will develop not only critical thinking but also a scientific attitude (scientific attitude) [14]. In this study student's scientific attitude was observed by observation sheet, and the result presents on Table 5.

Table 5. Analysis Student's Scientific Attitude

Aspect	score	Category
Curiosity	3.6	Very good
respects toward facts	3.0	good
open mindedness	3.5	Very good
Average	3.4	Very good

Based on Table 5, the aspect of curiosity has a very good category, during science learning using a worksheet based on inquiry science issues, teacher asked to student for searching related information of the problem. Curiosity has characteristics to find something, enthusiasm in learning and discover how to investigate [15]. Student investigated the problem by asking the question and formulating a way to solve the problem. It takes some problem solving skills, ie discussions that can help to construct knowledge, supported by existing reference sources [16].

4. Conclusion

Feasibility level of student worksheet based on inquiry science issues to realize the scientific attitude and critical thinking in science learning according to the validator included in the category very good. Student Worksheet-based inquiry science issues effectively develop critical thinking and scientific attitude with a very good category and N-Gain test critical thinking was high category.

Based on the analysis, science worksheet based inquiry science issues is potential to improving students' critical thinking and scientific attitude at junior high school for several aspect. Aspect of critical thinking are formulating questions, analysis discussion, problem-solving, decision making, and communication, while aspect of scientific attitude are curiosity, respects toward facts and open mindedness in additive and addictive substances topic.

References

- [1] Buaraphan K 2011 *J. Sci Educ Technol.* **21** 353-369
- [2] Faikhamta C 2013 *Res Sci Educ.* **43** 847-869
- [3] Lederman N G, Antink A, Bartos S 2014 *Sci. Educ.* **23** 285-302
- [4] Piliouras P, Plakitsi K, Seroglou F, Papantoniou G 2017 *Res Sci. Educ.* pp 1-16
- [5] Demirdöğen B, Hanuscin D L, Kondakci E U, Köseoğlu F 2016 *Res Sci Educ.* **46** 575-612
- [6] Villardón-gallego L 2016 *Procedia-Social and Behavioral Sciences* **217** 65-73
- [7] Cahyarini A and Rahayu S 2016 *Jurnal Pendidikan IPA Indonesia* **5 (2)** 222-229
- [8] Dema O and Moeller A K 2012 *Teaching culture in the 21st century language classroom.* (Lincoln: University of Nebraska) pp. 75-91
- [9] Pratiwi Y N, Rahayu S, Fajaroh F 2016 *Jurnal Pendidikan IPA Indonesia* **5 (2)** 164-170
- [10] Zion M and Mendelovici R 2012 *Science Education International* **23(4)** 383-399
- [11] Hastuti P W, Tiarani V A, Nurita T 2018 *Jurnal Pendidikan IPA Indonesia* **7 (2)** 232-238
- [12] Lederman N G, Lederman J S, Antink A 2013 *Int. J. Educ. Math. , Sci. Technol (IJEMST)* **1(3)** 138-147
- [13] Duran M and Dökme I 2016 *Eurasia Journal of MAtematics, Science & Technology Education.* 12 (12) 2887-2908
- [14] Erdogan S C 2017 *J. Educ. Pract* **8(6)** 164-170
- [15] Zetriuslita, Wahyudin, Jarnawi 2017 *Int. Educ. Stud.* **10 (7)** 65
- [16] Mukhopadhyay R 2013 *IOSR J. Humanit. Soc. Sci.* **8 (6)** 21-25

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It is hoped that the use of student 'worksheet based on inquiry science issues will be able to develop critical thinking and students' scientific attitude. Science learning with investigating activities will train students' psychomotor skills and attitudes.

Students who perform scientific activities students' thinking ability will increase, students are able interpret results of investigation activities, in addition students can construct their own knowledge so that students will be enthusiastic, curious, respect for data and open minded. With the use of Student worksheets can be a learning material that will realize meaningful learning and in accordance with the nature of science (nature of science).