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Is the Use of Student Worksheets on Environmental Concepts and Their Changes Based on Scientific Methods Effective in Improving Students' Critical Thinking Ability?

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Abstract-This study aimed to determine the implementation of student worksheet based on scientific methods on students' critical thinking ability. This study is a descriptive research with quantitative approach. The subjects of this study were 25 students of Science Education Department. The research design used is one group pre-test and post-test. The data collected by observation sheet of students' activities related to the indicator of critical thinking ability, test of critical thinking ability and student's questionnaire response to the uses of scientific methods. The data was analysed quantitatively with N-gain to determine the improvement of students' critical thinking ability. The result of this study showed that the student worksheet can bring out the critical thinking activities which most dominant are inference and advanced clarification, and the improvement of students' critical thinking ability based on N-gain is 0,3 with medium category, and the average response of students to LKM 86.7 with a good category.

Keywords: critical thinking, student worksheet, scientific methods

Introduction

Critical thinking is one of the compulsory competencies that students must have in the 2013 curriculum (Sabar & Maureen, 2014). According to Berliner (2009), critical thinking is a vehicle to prepare future generations to survive the changing times. Students who have critical thinking skills will better assess the importance of a thinking process that involves various aspects both logical and analytical. This ability is needed to solve life's increasingly complex problems (Karakoc, 2016; Kusaeri & Ridho, 2019; Listiani, 2018; Mardiyana, 2017). This description indicates that critical thinking is a necessity that cannot be negotiated.

Bagheri & Ghanizadeh (2016) states that students who have the ability to think critically will have strong motivation, will be accustomed to independent learning and tend to be more ready to compete with other students (Kusaeri & Aditomo, 2019; Tee et al., 2018). In the end, there will also be a culture of reasoning among them. With this ability, students can more easily understand concepts, are sensitive to problems that occur in their environment and are able to apply concepts to different situations. The problem is how to design learning that can develop one's potential to have critical thinking skills.

A number of researchers (eg. Amali, Kurniawati, & Zulhiddah, 2019; Astuti & Setiawan, 2013; Astuti, 2016; Permana, 2018) agreed that science has a potential role in developing critical thinking skills. In this connection, the science teacher or lecturer has a strategic role in helping students develop their critical thinking skills. Learning that must be carried out by a science teacher or lecturer is learning that is able to provide students with space for thinking in understanding concepts and making justifications. Not learning that solely invites students to remember or memorize concepts or solve routine problems with the science formula as exemplified by the teacher.

Science learning will be able to provide students with thinking space, if learning is designed to encourage various activities of students that involve thinking, asking questions, conducting experiments (although simple), working in teams, applying science concepts, making conclusions and communicating the results of activities he has done (Indayati, 2017; Indayati, 2020). When students participate in all these activities, they will be able to develop a deeper understanding of the science ideas and concepts they are learning. In addition, the interaction of students in various activities can stimulate their thinking skills and problem solving abilities (Nugroho, Widada, & Herawaty, 2019)(Widada et al., 2019).

In this social interaction, students mutually solve problems together with their peers, and sometimes receive limited assistance (scaffolding) from their peers or from teachers. Interaction between students and peers and teachers will also increase social skills (Indayanti, 2006). However, creating such conditions and situations is not easy (Ennis, 2011). No exception for the context of the lecture.

On the one hand, students are unique individuals (psychologically). Each of them has different characteristics, even different ways of learning (Febriani, 2016). On the other hand, designing science learning that can encourage various student activities cannot be separated from the role or involvement of students as lecture participants. For this reason, science learning must be designed to accommodate the needs of students to carry out various activities as previously desired. One of them is packing the learning materials appropriately so that they are suitable for the student's condition, such as in the form of student worksheets (LKM).

There are at least 2 (two) scientific arguments that emphasize the importance of using LKM to encourage student involvement in science learning (Febriani, 2016; Juselani, Pardimin, Prihatni, 2019; Rahayu & Budiyono, 2018). First, with LKM students get the opportunity to be actively involved in exploring the science material that is being studied, so that they gain practical hands-on experience. Learning that is no longer theoretical can make it easier for students to understand the material comprehensively. Second, LKM is a form of teaching material in printed form, in which there is already a guide in carrying out learning activities (understanding science concepts, conducting observations or experiments), sample questions, quizzes or questions that refer to the competencies to be achieved. Based on that, this paper wants to examine the effectiveness of the MFI design that integrates the steps of the scientific method.

With a LKM design like this it is expected to make it easier for students to solve problems in the environment scientifically on environmental materials and their changes. This topic discusses environmental science materials with the following sub-materials, including: ecosystems, air pollution, soil pollution, water pollution, natural resources, and healthy and unhealthy settlements (Mukono, 2006). In this sub-material, there are many problems in the environment that can be solved by students, for example: damage to environmental ecosystems due to human activities, water pollution, air pollution, land pollution, exploitation of natural resources that cannot be renewed excessively, and unhealthy settlements polluted by household waste.

Not many studies have focused on and focused on developing LKM for science courses. The results of literature search, most researchers are more concerned with developing student worksheets (LKS) or student worksheets (LKPD) for elementary and secondary science learning (for example: Amali, Kurniawati, & Zulhiddah, 2019; Astuti & Setiawan, 2013 ; Marsa, Hala, & Taiyeb (2016); Widodo, 2017). Of course there are many other researchers who have carried out similar studies, but they have not been written here. Meanwhile, a handful of researchers have tried to develop LKM for science lectures as done by: Alpindo & Dahnuss, 2019; Fajarianingtyas & Herowati, 2018; Sari, Widodo, Martini, Suyanto (2019) and). Alpindo together with Dahnuss developed a game-assisted LKM in basic physics subjects, Fajarianingtyas and Herowati using LKM to improve concept understanding in science learning innovation courses. Meanwhile, Sari and her team developed an Activity Based-Lesson-Learn-Reflection LKM to improve science process skills and character education for science teacher candidates.

Based on the facts above, this paper intends to examine the effectiveness of LKM based on scientific methods to improve critical thinking skills. The context based on scientific methods and critical thinking is what distinguishes and becomes the novelty of this study compared to the three previous researchers. LKM is implemented in learning environmental material and its changes in which it presents contextual problems of everyday life. Specifically, this paper intends to describe: (1) student activities in carrying out the stages of the scientific method (2) the results of the initial and final tests of critical thinking skills and (3) student responses to the use of scientific method-based LKM. The explanation in this paper ultimately wants to confirm that the use of scientific method-based LKM is an effective solution to deepen students' understanding of the substance or concept of the environment and its changes and the ability to solve problems in daily life scientifically, as well as support the formation of attitudes and habits of students to always think, ask questions, make observations, work in teams and various other scientific activities.

Method

This research is a descriptive study with a quantitative approach. Descriptive research is used when describing student activity in the stages of the scientific method and student responses to the scientific method-based LKM. Quantitative research is used when looking at the impact of implementing the use of scientific method-based MFIs. To see the impact of using a scientific method-based LKM, a one group pre-test and post-test design was used. That is, the portrait of students' critical thinking skills before and after learning using LKM based on scientific methods is compared. The research design is presented in Table 1.

Table 1. Research Design

Group	*Pre-test*	Treatment	*Post-test*
PIPA	Y_1	X_1	Y_2

Information:
PIPA: 1st semester students of science education study program
X1: Implementation of LKM based on scientific methods
Y1: The test before the implementation of the MFI based on the scientific method
Y2: The test after the implementation of LKM based on scientific methods

The subjects in the study were 25 first semester students of the Science Education study program at UIN Sunan Ampel Surabaya. At the time of the research, they were taking Basic Science courses, especially environmental materials and its changes. Data were collected through student activity observation sheets, critical thinking skills tests, and student response questionnaires to the use of scientific methods. The student activity observation sheet contains 4 (statements) indicators of student critical thinking, including: providing basic explanations, building a basis for making conclusions, concluding and providing further explanations. The critical thinking ability test being tested is in the form of a description (as many as 4 items). Each item tests the level of analysis and evaluation thinking (if using Bloom's taxonomy reference). Meanwhile, the student response questionnaire sheet consists of 8 statements, each of which uses 4 rating scales to answer them. This questionnaire sheet is used to explore student responses to the LKM based on the scientific method being developed.

Furthermore, the data collected was analyzed as follows. Data from student activity observations were analyzed using the percentage of student activity that occurred during the observation ($\%A_M$)

$$\%A_M = \frac{\sum F_A}{\sum F_S} \times 100\% \qquad \text{(Hobri, 2010)}$$

with $\sum F_A$ is the frequency of student activity that appears during observation and $\sum F_S$ is the frequency of all student activities on the indicator. Test result data (both pre-test and post-test) were analyzed using normalized gain (N-gain) which was adapted from Hidayaturrohman, Lesmono & Prihandono (2017) using the following formula.

$$N - gain = \frac{\bar{X}_{sd} - \bar{X}_{sb}}{100 - \bar{X}_{sb}}$$

Information:

$\bar{X}_{sd}$: Average test scores after the implementation of the scientific method-based LKM

$\bar{X}_{sb}$: Average test scores before the implementation of the scientific method-based LKM

Furthermore, the N-gain results were confirmed according to the criteria in Table 2.

Tabel 2. Kriteria Peningkatan Kemampuan Berpikir kritis

Score Interval	Improvement Criteria
$\mathbf{N - gain > 0,3}$	Low
$\mathbf{0,3 \leq N - gain \leq 0,7}$	The middle
$\mathbf{N - gain > 0,7}$	High

Furthermore, the student response questionnaire data were analyzed using the formula for the percentage of student responses ($\%R_M$). LKM is said to get a good response from students if the percentage of positive student responses is ≥80% of students involved in this research activity (Hobri, 2010).

Results and Discussion

The explanation in this section begins with a presentation of the results of student activity observations. This observation was carried out to obtain a real picture regarding the demands of student activity as in the stages of the scientific method. The results of student activity observations during the implementation of the scientific method-based LKM are presented in Table 3.

Table 3. Observation Results of Student Activities
During the Implementation of Scientific Method Based LKM

No	Indicator	F	%
1	Provide a basic explanation, including: formulating problems and hypotheses	12	48
2	Building a basis for making conclusions, including: testing hypotheses (determining variables,	20	80

	determining experimental procedures, and conducting experiments) and analyzing data from hypothesis testing		
3	Conclude	22	88
4	Provide further explanation, including: making scientific paper reports	19	76

Based on Table 3, it shows that there is 1 indicator whose percentage is below 75%, namely the 1st indicator. This indicates that these activities still need attention. There are several assumptions why this indicator has not been well mastered by students. Students are not used to formulating problems or making hypotheses as the main causative factor. Both abilities require relatively high thinking for students. Therefore, they need to be given more time to continue to practice on how to formulate problems well and formulate hypotheses easily/ accurately. In the end they become trained in carrying out these two activities properly.

Another suspicion that it is very likely contributes to the low percentage of the 1st indicator, is because the lecturers are fixated on trying to maintain the timeliness of the allocated time at each learning stage, so that they do not provide guidance to students on that indicator. When lecturers pay less attention to students when they are in the task of formulating problems and formulating hypotheses, the impact is that there is also an inaccurate understanding among them. Perhaps the understanding among students that the hypothesis is the answer to the problem formulation. So, when students experience problems in formulating problems, it will be followed by obstacles in formulating hypotheses.

Whereas the power of science learning in order to build scientific thinking skills lies in the ability to formulate problems and formulate hypotheses. Both can spur the development of various thinking abilities of students (Liandari, Siahaan, Kaniawati, & Isnaini, 2017).

To see the effectiveness of using LKM based on scientific methods, the other hand looks at the test results of students' critical thinking skills. Table 4 presents a summary of the results of the critical thinking skills test (before and after learning using a scientific method-based LKM).

Table 4. Summary of the Results of the Critical Thinking Ability Test

Category	Pre-test	Post-test
Completed (T)	9	20
Not complete (TT)	16	5
Average	57,2	70,04
N – gain	0,3	

From Table 4, information is obtained that quite a lot of students (16 people) are in the incomplete category during the pre-test, because the scores obtained are less than 70. However, this condition changed after learning using a scientific method-based LKM. There are only 5 students who have not finished yet. From the results of the analysis of the students' answers, several weaknesses were found that made them unable to answer or even if they could answer, the answers were not correct or wrong.

Of the 4 questions tested, students who were included in the incomplete group (both on the pre-test and post-test), had difficulty starting to identify what was known and asked in the questions. For example, in questions 1 and 4 (in the pre-test) and questions 2 and 3 (on the post-test) which ask about the formulation of problems and hypotheses of an environmental material problem and its changes. This fact is certainly in line with what happened when observing student activity. They are very lacking in terms of providing basic explanations that include formulating problems and hypotheses. This means that they do not understand the problems that exist in the questions so that they cannot formulate problems specifically according to the existing problems. This has an impact in formulating hypotheses, namely that they have not been formulated specifically to provide temporary answers according to existing problems.

It can be seen from the students' answers when answering the following problems "The phenomenon of flooding that always hits DKI Jakarta has received special attention from the Indonesian biodiversity foundation. Damage to the biotic components of the ecosystem due to urban development can have a negative impact on the city and its surrounding areas. The phenomenon of flooding in Jakarta will continue to occur, if no efforts are made to repair the damage to the biotic components of the ecosystem. "The formulation of the problem expressed by the students, for example, is how to overcome flooding in Jakarta? The hypothesis expressed that the flood phenomenon in Jakarta can be minimized if the population does not litter. This answer is less specific and relevant to answer the existing problems. Formulation of problems and hypotheses that are more specific and relevant to the above problems, for example, how to deal with floods in Jakarta which are caused by damage to the biotic components of the ecosystem? As for the possible hypothesis, the intensity of flooding in Jakarta can be minimized if reforestation in Jakarta is increased (every development must pay attention to an environmental impact analysis).

After they get the learning treatment using scientific method-based LKM, most students who experience difficulties in that section, finally begin to be able to make problem formulations more specifically and relevant to the problems being asked. Including they began to be able to make hypotheses well too. As a result, the post-test results show a reduction in students experiencing incompleteness. Of the original 16 students who did not complete, only 5 did not.

Table 4 also provides information that there is an increase in the average pre-test and post-test scores by 22.84. The increase in the pre-test to post-test scores was also supported by the N-gain value of 0.3. This means that there is an increase in students' critical thinking skills after the implementation of LKM learning based on scientific methods. This increase is more due to the fact that through learning using LKM based on scientific methods, students can actively construct their understanding through direct experience of observing, formulating problems, formulating hypotheses, determining variables, making procedures to making conclusions which are carried out collaboratively with their friends.

This is in accordance with Piaget's theory, that cognitive development is a process in which students actively build their understanding through direct experiences and interactions with peers or with lecturers (Nur, 1998). In this context, students construct their understanding or knowledge continuously through a process of assimilation and accommodation. That is, the understanding that is built on new material or concepts about the environment and its changes is associated with the material or concept it already has. After that, modify the material or concept that already exists in his mind with new materials or concepts (Kusaeri, Aditomo, Ridho, & Fuad, 2018).

The other side that was traced from the test of the effectiveness of using LKM based on scientific methods was obtained through a questionnaire. This is to uphold a sense of justice, and also to obtain balanced input. Assessment of effectiveness is not only obtained from lecturers or observers. But also the student side needs to explore the input to the learning process that has been carried out. The results are presented in Table 5.

Table 5. Questionnaire Results of Student Responses to the Implementation of LKM Based on Scientific Methods

No	Statement	%
1	LKM encourages students to work together and collaborate when solving given problems	96
2	LKM provides the widest possible opportunity to explore the problem	92
3	LKM presents problems or questions that encourage thinking and finding the right solution	96
4	The MFI guides how to formulate problems and formulate hypotheses	84
5	The MFI guides how to determine appropriate variables and problem-solving procedures	88
6	LKM has an attractive appearance (layout, images and letter composition)	84
7	LKM uses language that is easy to understand	76
8	The instructions for the LKM are presented clearly and are easy to understand	80
9	Feel happy with learning using LKM based on scientific methods	84
	average	86,7

Based on Table 5, it is found that the average overall student response to LKM is 86.7. If confirmed by the previous provisions, the student response to this LKM is in the good category. This means that learning using LKM based on scientific methods has received a positive response from students. They feel comfortable with learning using LKM based on scientific methods (84 or as many as 20 students responded positively to this aspect).

Very positive responses were shown in two aspects, where each received the highest appreciation (96%), namely (1) MFIs encourage students to work together and collaborate when solving given problems and (3) MFIs present problems or questions that encourage thinking and find the right solution. In other words, the presentation of questions and guidance given by MFIs really hits them to think and collaborate when solving existing problems.

However, there are two aspects that still get a bad response from students. For example, only 76% of students gave positive responses related to language and only 80% thought the instructions used in LKM could be understood easily. The rest is of the opinion that these two aspects need to be improved so as not to cause interpretations that are very likely to differ between students. The use of inappropriate punctuation marks is something that they complain about. However, overall the MFIs used have been positively welcomed by students. Another meaning, the scientific method-based LKM is effectively used in the context of science lectures.

Conclusions and suggestions

Based on the results and discussion of this study, the researcher made conclusions regarding the results of the implementation of the scientific method-based Student Worksheet (LKM) on environmental material and its changes, including: 1) there are 2 student activities related to the most dominant critical thinking skills, namely concluding and providing further explanation

2) there is an increase in critical thinking skills based on the N-gain of 0.3 with the medium category and 3) the average student response to LKM is 86.7 in the good category.

Based on the above conclusions, the suggestions given by the researchers include: 1) MFIs based on scientific methods can be used by lecturers as a medium of learning on environmental materials and their changes to improve students' critical thinking skills; 2) students' critical thinking skills can be improved by using different LKM and materials so that students are accustomed to solving science problems with the right solution; and 3) the ability to think critically and its enhancement can be researched using techniques and a wider scope so as to be able to create the next generation with scientific insight.

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