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The Effectiveness of Problem Based Learning (PBL) Based Socioscientific Issue (SSI) to Improve Critical Thinking Skills

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ABSTRACT

The purpose of this research was to see how effective the Problem Based Learning (PBL) based Socioscientific Issues (SSI) is at improving critical thinking skills. The sample used was grade seven in junior high school 4 Lamongan with 2 classes and each class contains 15 students. The design of the learning materials trial used One-Group pre-test post-test design. Tests of critical thinking skills and student answer sheets were used to collect data. Techniques of data analysis used N-gain, paired t-test, and independent t-test. The result of this research is as follows: The effectiveness in terms of the critical thinking skills test the category increase is high, there is a significant difference between the test before and after learning with PBL based SSI and there is no difference N-gain in the two group classes and students' responses are classified as very good. Based on data analysis, it can be concluded that PBL with SSI is effective to improve critical thinking skills. The implications of this study are PBL-based SSI has the potential to be an innovative solution and alternative for improving critical thinking skills.

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INTRODUCTION

The development of technology, information, and industry in the 21st century has had a significant impact on society. Culture and lifestyle are strongly influenced by electronic devices which make information accessible freely so that the teacher's role as a source of information can not be maintained. Rapid changes in information technology are changing and reshaping society and giving birth to new terms. One of the new terms is the information age society. In an information society, individuals must understand, interpret, and use scientific data; generate new ones, and have the ability to solve problems (Demirel, 2009). Apart from that, current developments also have an impact on job opportunities that can be obtained by school graduates. Now and future, jobs do not require routine work but rather skills that cannot be replaced by technology. If we do not adapt to the changes that occur, then we can not compete in the present era. The world of education must also change the education system so that school graduates can survive in the future. Indonesian education has made efforts to improve education by implementing the 2013 curriculum, which has student-centered learning. The 2013 curriculum focuses on the development of Critical, Creative, Communication, Collaboration (4C) skills, that need to be applied in learning, one of which is science learning.

In science learning, critical thinking skills are one of the 4C's abilities that need to be developed. Critical thinking is defined as a set of skills and dispositions that enable a person to solve problems logically, reasonedly in making decisions about what to believe or not believe, and attempt to think independently by balancing the problem-solving process (Ennis 1993;

Gotoh, 2016). Critical thinking skills are very important in the information and technology era where information must be filtered intelligently and critically. Critical thinking skills are considered a vital skill for the 21st century, so they are the educational outcomes desired by educators (Tosuncuogl, 2018). Critical thinking skills need to be applied in all learning processes, because it develops students' ability to carry out complex cognitive reasoning processes, which include critical thinking, solving non-routine problems, and building and evaluating evidence-based arguments (Santos, 2017).

Based on a preliminary study conducted at SMP Negeri 4 Lamongan by giving critical thinking skills with indicator critical thinking Facione (2011) interpretation, analysis, explanation, inference, and evaluation questions to 29 students, it was found that students' critical thinking skills were still low. The ability to think critically at interpretation is 20.0%, analysis 24.8%, inference 13.8%, explaining 32.2%, and evaluation 20.6%.

Based on the results of the preliminary study, students' critical thinking skills need to be improved. Students' critical thinking skills can be developed using the Problem Based Learning (PBL) model. PBL is a basic process for identifying problems, considering options and making informed choices (Greenstein, 2012). PBL is a learning model that increases students' active participation in the learning process by exposing them to real-world problems and empowering them to conduct investigations (Arends, 2013) so that it can help students develop higher-order thinking skills like critical thinking, knowledge construction, collaborative learning, and independent learning (Orozco & Yangco, 2016). PBL learning has the advantages: 1) Encouraging teamwork in the completion of assignments 2) Encouraging learners to become self-regulatory and independent learners 3) Fostering critical thinking and interpersonal abilities (Arends, 2013).

PBL learning can be integrated with Socioscientific Issues (SSI). SSI is a complicated, open, mostly contentious, and socially significant scientific problem with multiple possible solutions but no definitive answers. (Topcu, 2010; Zeidler et al., 2011). Give place of SSI in science education aims to provide a more meaningful learning experience by integrating to real-life problems. (Topcu, 2010). Scientific data can be critically analyzed, evaluated, and decision-making with SSI integration (Bossér et al., 2015).

The material used in the PBL based SSI can be found in the global context of environmental issues such as climate change or global warming. The increase in the average temperature of the earth's surface that continues to occur due to human activities is one of the causes of the material importance of global warming. Many daily activities from various sectors such as transportation, industry, agriculture, and forestry sectors contribute to climate change so that the future ecological balance is disturbed. To prevent disturbing the ecological balance, consider the importance of educating conscious individuals about the environment.

Based on results by Orozco and Yangco (2016), students who receive learning instruction with PBL had a higher post-test average score on critical thinking skills tests than students who do not receive learning instruction with PBL. SSI integration has the potential to provide students with opportunities to critically examine and evaluate scientific information and to engage in debate and decision-making (Bossér et al., 2015). The supporting learning theory is 1) According to Piaget's learning theory, children have a natural curiosity that encourages them to actively form representations in their minds about the environment they experience, so encouraging them to start an investigation. 2) Constructivist theory of learning, which emphasizes the need for students to investigate their environment, find their own ideas, and construct their knowledge (Arends, 2013; Suprihatiningrum, 2014). 3) Vygotsky's theory which emphasizes the social aspects of learning can be seen in PBL learning at the organizational stage of students' learning and investigations to complete tasks by exchanging ideas or sharing tasks.

The purpose of this study is to describe the effectiveness of the SSI-based PBL model in improving critical thinking skills, including student responses and critical thinking skills.

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RESEARCH METHOD

This study used a design One Group pre-test post-test design (Sugiyono, 2016). The research subject is seven grade students junior high school with 2 classes and each class contains 15 students. The research design can be described as follows

O_1	X	O_2

Figure 1. Research design

(Sugiyono, 2016).

Information:

O_1 : Pre-test, to determine students' knowledge before being given treatment
X : Treatment, learning process with PBL model-based SSI
O_2 : Post-test, to determine students' final knowledge after being given treatment

This is the development stage of material adapted to the 4-D models with modification, for more detail, see figure 2.

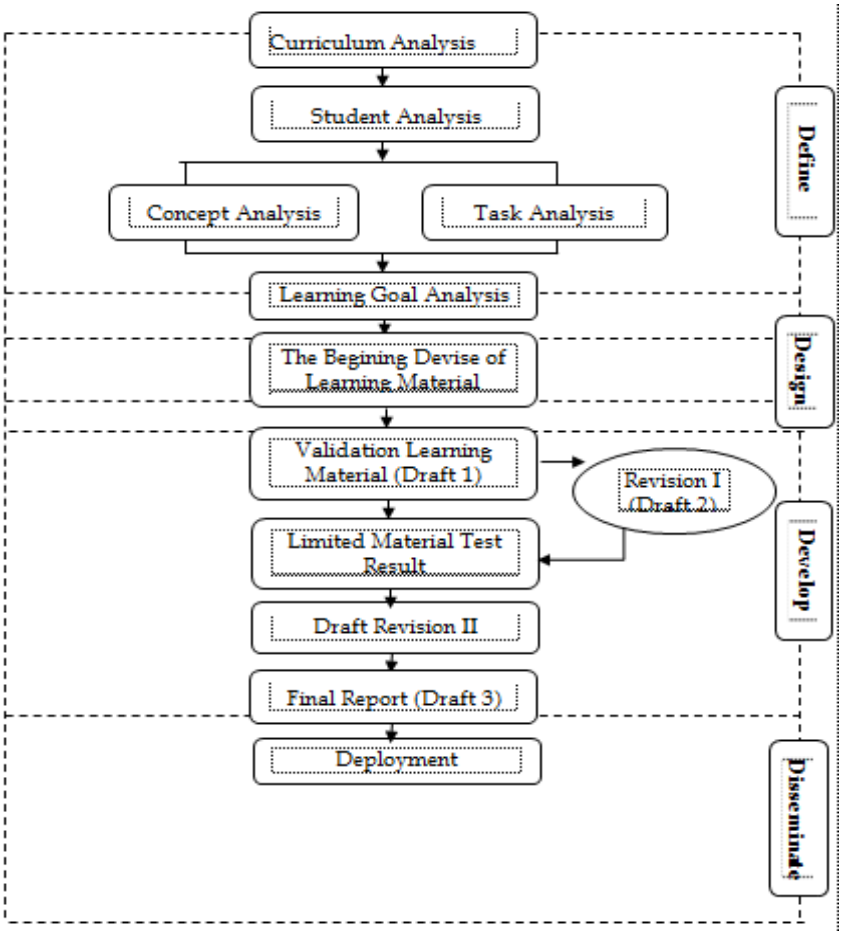

Figure 2. Flowchart 4-D Models

A test sheet for critical thinking skills and student responses was utilized to assess the effectiveness of PBL-based SSI. A test and a questionnaire were used as the methods. The results of the critical thinking test were analyzed using normalized Gain analysis (N-gain) to determine the increase in critical thinking skills, paired t-test to determine the significant increase in critical thinking skills pretest and post-test with t-test results sig < 0.05, and an independent t-test to determine whether the N-gain of the two classes were not significantly

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different with t-test results sig ≥ 0.05. PBL-based SSI is declared effective if the increase in the critical thinking skill test score is 0.31, the paired t-test with sig value < 0.05, and the independent test has a significance value of ≥ 0.05 and student responses get a percentage of > 60%.

RESULTS AND DISCUSSION

Critical Thinking Skills

Students' critical thinking skills were assessed by a written test in the form of an essay, which was carried out twice, before and after learning with PBL based SSI. After that, the pre-test and post-test were analyzed using N-gain score. The following are the results of the N-gain analysis of the two classes which can be seen in Table 1.

Table 1. N-gain Critical Thinking Skills

Class	Pre-test	Post-test	N-Gain
VII-E	15,83	76,17	0.72
VII-F	19,83	78,00	0.73

Based on Table 1. students in class VII-E got an average N-gain critical thinking score of 0.72 with a high category, while students in class VII-F got an N-gain critical thinking score of 0.73 with a high category. PBL based SSI is declared effective because the increase in the critical thinking skill test score is ≥ 0.31. The number of students who got N-Gain in the high, medium, and low categories in both classes are presented in Figure 3.

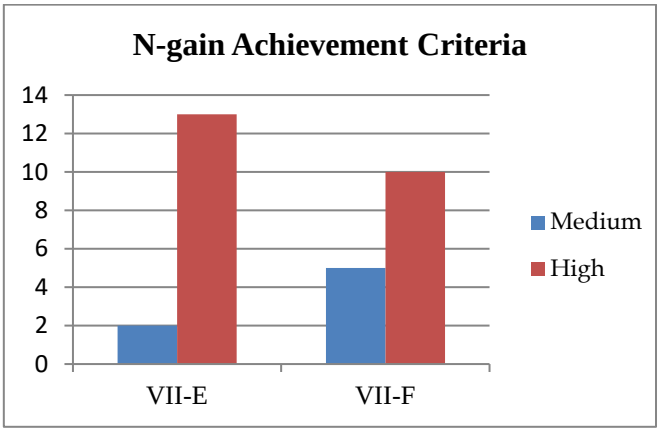

Figure 3. Criteria for N-gain

Based on Figure 3 it is known in class VII-E, 13 students in the high category and 2 students in the medium category, while in class VII-F has 10 students in the high category and 5 students in the medium category. This shows that learning with PBL based SSI can improve students' critical thinking skills. The improvement of students 'critical thinking skills varies due to the students' ability to absorb different information. Students' ability to solve problems is influenced by intelligence (intelligence). Because if students have high intelligence, they can quickly solve the problems faced and vice versa with students who have low intelligence (Bagia, 2016). Guiterez (2011) improves students' critical thinking skills through the integration of SSI problems in learning. Before the statistical test is carried out, it is necessary to test the normality with SPSS, the results of which are shown in Table 2.

Table 2. Tests of Normality

	Class	Shapiro-Wilk		
		Statistic	Df	Sig.
N-gain	VII-E	.897	15	.086
	VII-F	.960	15	.692

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According to Table 2, the normality of the N-gain test for class VII-E is 0.086 and class VII-F is 0.692. The test results of the two classes obtained a probability (sig)> 0.05. As a result, Ho is acceptable, meaning that the data is normally distributed. Because the data were normally distributed, the data were also analyzed using a paired t-test and can be seen in Table 3.

Table 3. Paired t-test

		Mean	Std. Deviation	t	Df	Sig. (2-tailed)
VII-E	*Pre-test - Post-test*	-6.03333E1	4.41858	-52.884	14	.000
VII-F	*Pre-test - Post-test*	-5.81667E1	5.78380	-38.950	14	.000

Based on the paired t-test, it shows that the sig value in both classes is 0.000. This shows the sig value < 0.05, and t is negative, which means that there is a significant difference between the results of the pre-test and post-test, so that there is an effect of using the PBL based SSI learning model on improving students' critical thinking. These findings are supported by Amin et al., (2020), who found that the PBL model had a significant impact on students' critical thinking skills. There are significant differences in critical thinking skills before and after the application of PBL learning (Lapuz & Fulgencio, 2020).

PBL can help students increase their soft skills, such as critical thinking. (Suryanti & Supeni, 2019). According to other researchers, the PBL-based SSI model has a considerable impact on critical thinking skills development and cognitive learning outcomes (Wilsa et al., 2017), and using the SSI problem as a learning context has a significant effect on students' critical thinking skills (Pratiwi et al., 2016). Zeidler et al. (2011) give a place for SSI in science education, students' can make ability decisions, analyze, synthesize, and evaluate. Fadilah MS et al., (2020) statement that learning designed with a student-centered model will improve critical thinking skills and make students motivated in learning. Student-centered learning can insert aspects of critical thinking and give more meaning to learning to provide high-quality learning on aspects of critical thinking (Ahaddin et al., 2020).

This result is supported by the theory of Piaget is children have an innate nature of curiosity, this curiosity will encourage them to actively construct representations in their minds about the environment they experience so that they will be encouraged to carry out investigations. According to Piaget, learning is a process of acquiring individual knowledge through continuous interaction with the environment. Interaction with the environment, the intellectual function is growing (Dimyati & Mudjiono, 2008).

In addition to improving critical thinking skills, PBL based SSI has benefits in the social aspects of cooperation. Vygotsky's theory which emphasizes the social aspects of learning can be seen in PBL based SSI learning at the organizational stage of students' learning and investigation. At this stage, the social aspect of working together and discussing with peers occurs to complete tasks or problem solving by exchanging opinions or sharing tasks so that their critical thinking skills can improve through controversial issues of daily life. Vygotsky argued that in addition to teachers, peers also affect the cognitive development process of children (Slavin, 2011). Kardoyo et al., (2020) stated that PBL can improve students' critical thinking skills and students with their groups can work together to solve problems. The next test is the homogeneity test, which is shown in Table 4.

Tabel 4. Test of Homogeneity

		Levene Statistic	df_1	df_2	Sig.
N-*gain*	Based on Mean	1.441	1	28	.240
	Based on Median	1.380	1	28	.250
	Based on Median and with adjusted df	1.380	1	27.979	.250
	Based on trimmed mean	1.513	1	28	.229

Based on Table 4, it is obtained a significant value of 0.240. This value is following the testing criteria, if the probability value (sig) is more than 0.05 then H_0 is accepted, which means

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that the N-gain data of the two classes are homogeneous. The data are normally distributed and homogeneous, so an independent t-test can be performed.

Table 5. *Independent t-test*

		t-test for Equality of Means		
		t	F	Sig. (2-tailed)
N-gain	Equal variances assumed	-.389	8	.700

In addition, an independent t-test was also carried out in this study. An independent t-test was used to determine the difference in the N-gain of the two classes. Based on table 5, it can be seen that the significant value is ≥ 0.05 so there is no significant difference in the N-gain between classes VII-E and VII-F. Critical thinking skills for both classes have improved because they use the same tool, namely PBL based SSI, and both classes' learning implementation was great.

Student Response

Student response is a response or reaction of students after participating in learning. The results of student responses to learning activities using the SSI-based PBL model were obtained using student response questionnaires. Student response questionnaires are given at the end of learning to students after participating in the entire learning process. Learning equipment is stated to be practical if the student's response is ≥ 61% (Riduwan, 2013). The results of student responses to learning can be seen in Table 5.

Table 5. Student Response

No	Statement	VII-E		VII-F	
		Response (%)		Response (%)	
		Yes	No	Yes	No
1	The learning process of the PBL based SSI was interesting and fun	100,0	0,0	93,3	6,7
2	I am more active in learning the SSI-based PBL model	80,0	20,0	93,3	6,7
3	SSI based PBL learning model gives me motivated and makes meaningful learning	80,0	20,0	86,7	13,3
4	The learning process aroused my curiosity	86,7	13,3	93,3	6,7
5	By forming groups for learning, I can more easily study and discuss with my friends during learning	100,0	0,0	100,0	0,0
6	Learning materials are related to everyday life so that it makes me understands more in everyday life	100,0	0,0	93,3	6,7
7	The presentation and display of the worksheets is interesting and motivating to learn	86,7	13,3	80,0	20,0
8	Student textbooks, the learning atmosphere, the way the teacher taught in learning was interesting and made it easier for me	93,3	6,7	93,3	6,7
9	Learning PBL based on SSI allows me to improve my critical thinking skills	93,3	6,7	86,7	13,3
10	The test questions given are in accordance with the material that has been taught	93,3	6,7	100,0	0,0
11	Student worksheets and textbooks use language that is easy to understand	86,7	13,3	86,7	13,3
	Average	90,9	9,1	91,5	8,5

Based on Table 5, explains that students give a positive response to learning using the SSI-based PBL model with each class obtaining an average percentage of 90.9% for class VII-E with the very good category and 91.5% for class VII- F with very good category. Learning material is stated effective if the student's response is ≥ 61% (Riduwan, 2013). Each individual has a different perception due to different perspectives, experiences, and knowledge of a particular

object so that they respond according to what they experience. These results are supported by the results of device validation which are generally categorized as valid and very valid and the implementation of the two classes of learning is also carried out very well. To create positive relationships with students, the way the teacher speaks and acts must reflect a teacher who respects and must ensure that all students are treated equally so that students respond positively to activities and learning model updates that are carried out. outside the classroom during the learning process (Alfiyanti et al., 2020).

Students give a positive response to learning because the PBL based SSI learning process is interesting and fun by forming groups in learning so that students can be more active, easier to learn, and discuss with friends during learning. This is supported by Hmelo-Silver's (2004) statement that PBL facilitates small groups, tutorial instruction, and active learning. Members of the group must work together to ensure that everyone participates fully, no single person has a monopoly on assignments and discussions (Silva et al., 2018). Vygotsky's theory emphasizes the social aspects of learning which can be seen in PBL based SSI learning at the organizational stage of students in learning and investigation. At this stage, students will conduct investigations to solve problems related to science and social so that interaction and social care, and critical thinking skills will develop. According to Thakur et al., (2018), 80.0 percent of students believe that PBL gives space for social interaction because of its collaborative approach, which is built on the idea of peer discussion and learning, therefore developing learning confidence.

Students also gave positive responses to SSI-based PBL statements which enabled me to improve my critical thinking skills. This is because learning with the PBL model can develop students' critical thinking skills (Kong et al., 2014) and SSI integration in learning has the potential to allow students to critically examine and evaluate scientific information (Bossér et al., 2015).

CONCLUSION

Based on the results, it shows that PBL-based SSI learning is effective to improve critical thinking skills. This is indicated by the average N-gain of the two classes in the high category, a statistically significant increase at 5% alpha and the mean N-gain is not different for the two classes. Furthermore, both classes responded positively, with a very good category. This research implies that the learning model of PBL based SSI can be an innovative solution and alternative for improving critical thinking skills. Further research with additional relevant materials and more subjects could enhance this research even more.

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