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Students' Critical Thinking Skills with The Implementation of Sustainability Learning to Energy Conservation and Transformation Material Based on The POE (Predict-Observe-Explain) Model

Siti Aisyah Siregar[1*], Yuliani[2], Raharjo[3]
[1,2,3] Universitas Negeri Surabaya, Surabaya, Indonesia

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ABSTRACT

Objective: The challenges of the 21st century with massive technological developments and the energy crisis that is currently plaguing various countries around the world, including Indonesia, are a big task for the world of education to make all elements, including students, aware and care about the energy crisis that has hit so it is necessary to integrate in the learning process the application of sustainable learning with the POE (Predict-Observe-Explain) learning model to train students' critical thinking skills. **Methode:** The study employs descriptive quantitative methods. The data were processed quantitatively and then interpreted qualitatively. **Result:** The data analysis obtained a significant value on students' critical thinking skills with a pretty good category, with a percentage of the average value of students' critical thinking skills in the poor category. **Novelty:** This study is expected to be considered in further developing the application of sustainable learning with the POE model because this learning has novelty in developing other innovative learning. Another novelty found in the material taken in this study is very appropriate with the application of the continuous learning POE model to train students' critical thinking skills.

INTRODUCTION

Technological developments in recent years have occurred very quickly and massively; this development began during the Industrial Revolution 4.0 in 2011; this is also marked by the continued increase in digitalization technology in terms of more adaptive and responsive systems. One of the demands that the millennial generation needs to have in the industrial era 5.0 is critical thinking skills (Apdillah et al., 2022; Arifah et al., 2021; Gürdür Broo et al., 2022; Saphira et al., 2022). Not just critical, but positive critical thinking. This ability will be difficult to replace by technological developments. An article says that one of the skills that students need to have in the 21st century is critical thinking skills. The skills required today in the 21st century are creativity, critical thinking, communication, and collaboration (Jatmiko et al., 2021; Rahmadita et al., 2021; Rizki et al., 2022).

Among the most frequently discussed learning skills are critical thinking skills. Critical thinking skills are believed to have an essential role in interpreting, analyzing, evaluating, concluding, and explaining the argument (Alsaleh, 2020; Din, 2020; Shaw et al., 2020; Supena et al., 2021; Wale & Bishaw, 2020). Information today is straightforward to access from various technological media such as social media, television, YouTube, and Google. However, the concern is that information from these sources cannot be fully used but must be sorted out first because much information is a hoax and does not guarantee accuracy.

Educational for Sustainable Development (ESD) was first coined by UNESCO. ESD sees problems based on environmental, social, and economic pillars. These three pillars are indeed related to current global problems and issues and are also related to the sustainability of human life. So, with ESD, students are aware of sustainability in dealing with global problems and think critically about ways to overcome these environmental problems. The current independent curriculum can be one of the effective strategies for creating an educational environment that supports sustainable development. Education has a vital role in raising awareness and understanding of sustainability. An independent curriculum can incorporate knowledge of sustainable development's goals, principles, and values into the learning process (Ahel & Lingenau, 2020; Timm & Barth, 2021). With these values and principles, students can develop better critical thinking skills about global issues and learn to apply these skills in real life. It can also encourage student engagement in the application of sustainability learning.

Several studies are related to critical thinking skills and the application of sustainability learning, namely regarding students' critical thinking skills and sustainability awareness in science learning for implementing education and sustainable development (Ekamilasari et al., 2021). Embedding ESD in Indonesia in facing global problems. However, there needs to be research on students' critical thinking skills by applying sustainable learning on energy conservation and transformation material based on the POE (Predict-Observe-Explain) model.

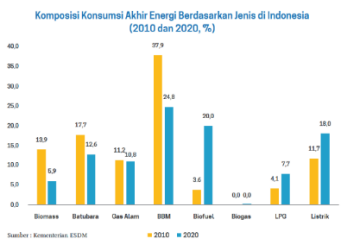
Technology development requires teachers to be more creative and innovative in preparing and managing learning in the classroom. Teachers must be current with technological developments and master various learning strategies and relevant applications to attract interest and motivate students to learn (Amelia et al., 2021). One of the learning models that can optimally facilitate students' critical thinking skills is the POE learning model. This strategy involves students in predicting a phenomenon, making observations through experiments or demonstrations, and finally explaining the results of the experiment and the results of their previous predictions. The POE model is also efficient for creating student discussions about science concepts.

The novelty of this research is the application of the POE model with the concept of sustainable learning and energy material, which is very important for students to learn at this time in order to protect the earth through the POE learning syntax can affect the learning activities of students to be more active because with clear syntax it makes learning more enjoyable. After all, students are involved in the learning process. The POE learning model has three essential aspects: prediction, observation, and explanation (Prabawati, 2020). With the POE model, students will play an active role in the learning process because it goes through stages at the beginning, namely predicting or making conjectures from the problems presented, then the second stage of observing objects that will be used as solutions to problems, then the third stage of explanation where students will be asked to explain the initial predictions and observations that have been made (Istiqomah et al., 2019). Critical thinking questions are a pre-test consisting of 4 questions and a post-test of 10. Table 1 shows examples of questions given in the pre-test and post-test tests.

Table 1. Pre-test question and answer.

No	Critical Thinking Indicators	Question Indicator	Questions	Score Criteria
1.	**Interpret** predictions of changes in energy forms	Presented an event. Students are asked to explain changes in energy forms	Nadia pushes her bike as it passes through an uphill road. Where did Nadia get the energy to push her bike? Answer: Nadia can push her bike because she has energy from within her body. The energy comes from the food sources he eats. Therefore, food energy is converted in the body into energy to be able to move and carry out activities.	**Point 1**: The answer only explains the energy changes that occur **Point 2**: The answer is appropriate where the energy is obtained but cannot be explained correctly **Point 3**: The answer already explains where the energy comes from and the changes that occur.

Table 2. Post-test question and answer.

No	Critical Thinking Indicators	Question Indicator	Questions	Score Criteria
2.	**Evaluate** various processing energy sources.	Presented diagrams of the utilization of various energies in Indonesia	1. Consider the following diagram!  From the chart above, fossil-based energy sources such as non-renewable oil and risky oil prices in the global market show our country's very high dependence on this energy. What steps must be taken so that dependence on fossil energy does not backfire on Indonesia? Answer: Indeed, the government must implement various policies related to fossil-	**Point 1**: The answer only writes down what energy is utilized **Point 2**: The answer already explains what energy is used, but the explanation does not include an apparent reason **Point 3**: Complete and detailed explanation

No	Critical Thinking Indicators	Question Indicator	Questions	Score Criteria
			based energy sources so that they are no longer used as the primary energy source because their number is decreasing, causing environmental problems due to overexploitation. So, it is necessary to realize the development of new renewable energy or EBT that is affordable and environmentally friendly.	

RESEARCH METHOD

The procedure in this research is shown in Figure 1. This quantitative descriptive research explores a phenomenon in a group of individuals (Sugiyono, 2017). The object under study is the critical thinking skills of junior high school students. This research was conducted in the 2023/2024 academic year, involving 34 students as research subjects of class 8A Junior High School 1 Gedangan students. The subjects were selected by purposive sampling or selected based on specific considerations by paying attention to the ability of students who found the most cases of low science learning outcomes.

Figure 1. Research flowchart.

The research instrument used is a test of students' critical thinking skills consisting of 10 description questions adjusted to 5 indicators of critical thinking. Critical thinking indicators include (1) Interpretation, (2) Analysis, (3) Evaluation, (4) Inference, and (5) Explanation. Critical thinking skills are trained sequentially (Facione, 2015; Neswary & Prahani, 2022; Rohmah & Prahani, 2021; Saphira & Prahani, 2022). Therefore, each indicator item is represented by 2 question items that aim to obtain valid and relevant data. First, the research begins with preliminary activities, which include the planning stage and determining the research subject. Second is the preparation stage for the critical thinking skills test questions. Third is collecting data obtained from student activities working on test questions. Fourth is the data analysis stage, which is data processing activities carried out by researchers. Fifth is the conclusion drawing, which is the final stage; from this stage, the answer to this research is obtained (Sugiyono, 2017).

The research data analysis was carried out by calculating the average achievement score of students' critical thinking skills indicators as a percentage (Eliana, 2020). The average score achieved was then categorized based on the critical thinking skills assessment criteria in Table 1. Calculate the average percentage value of students' Critical Thinking Skills achievement scores using the following formula.

$$P = \frac{n}{N} \times 100\%$$

Information:
P: Percentage of final grade
n: the number of scores obtained
N: Maximum number of scores

Meanwhile, the interpretation of students' critical thinking skills, which will be linked to indicators of students' critical thinking skills, can be seen in Table 3.

Table 3. Skills category scale.

Qualification	Percentage (%)
Very high	90-100
High	80-89
Enough	65-79
Low	55-64
Very Low	0-54

(Nawawi, 2020)

RESULTS AND DISCUSSION

Results

Researchers gave pre-test questions at the beginning of the meeting to see students' critical thinking skills before research using the POE model and sustainable learning on energy conservation and transformation material. After the pre-test, the results still needed improvement because many students needed to understand sustainable learning better by analyzing environmental problems. After applying sustainable learning using the POE model, Table 4 shows the critical thinking skills assessment results.

Table 4. Student critical thinking skills assessment.

No	Student Name	Pre-test Score	Post-test Score	Average Percentage	Qualification
1	DA	50	75	75%	Well
2	NF	65	75	75%	Well
3	WS	50	70	70%	Well
4	AS	50	75	75%	Well
5	MAW	75	97	97%	Very good
6	ANS	60	65	65%	Well
7	ZNA	50	60	60%	Enough
8	ACS	70	80	80%	Well
9	MLA	75	85	85%	Very good
10	RBA	60	70	70%	Well
11	SIM	78	95	95%	Very good
12	AQA	50	65	65%	Well
13	MMC	55	60	60%	Enough
14	FI	50	55	55%	Enough
15	MI	50	87	87%	Very good
16	MB	35	40	40%	Not enough
17	SQ	75	80	80%	Well

No	Student Name	Pre-test Score	Post-test Score	Average Percentage	Qualification
18	HP	60	75	75%	Well
19	SAA	40	55	55%	Enough
20	MDH	78	95	95%	Very good
21	FRA	70	78	78%	Well
22	ABN	40	45	45%	Not enough
23	MAY	30	45	45%	Not enough
24	APP	45	50	50%	Enough
25	SDA	60	78	78%	Well
26	WM	52	55	55%	Enough
27	MR	35	40	40%	Not enough
28	AD	72	80	80%	Well
29	SP	55	70	70%	Well
30	WC	65	75	75%	Well
31	ZM	45	55	55%	Enough
32	RD	67	75	75%	Well
33	BP	55	65	65%	Well
34	MRD	45	50	50%	Enough
		PERCENTAGE QUALIFICATION			
	Very Less			0%	
	Not Enough			11%	
	Enough			23%	
	Well			51%	
	Very Good			14%	
		AVERAGE VALUE QUALIFICATION			
	Very Less			0%	
	Not Enough			42%	
	Enough			55%	
	Well			73%	
	Very Good			9%	

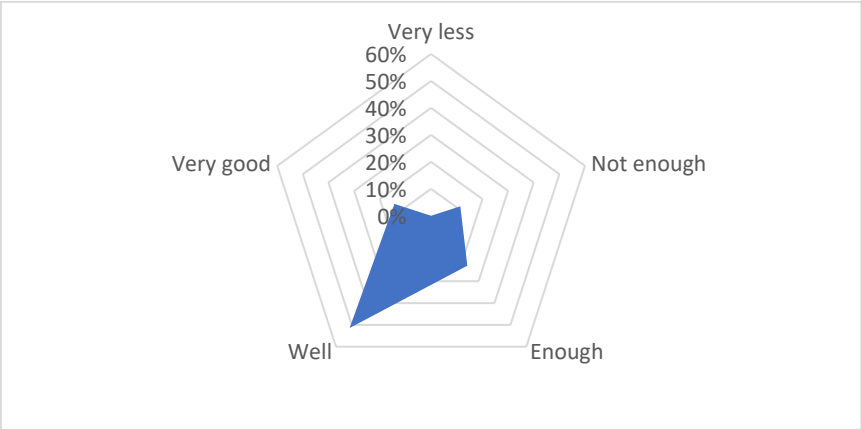


Figure 2. The percentage of students is based on the grouping of critical thinking skills.

Table 5. The average value of students is based on indicators of critical thinking skills.

Anderson's Steps	Value Percentage (%)	Category
(1) Interpretation	70	Well

Anderson's Steps	Value Percentage (%)	Category
(2) Analysis	34	Not enough
(3) Evaluation	16	Not enough
(4) Inference	26	Not enough
(5) Explanation	14	Not enough
Average	32	Not enough

The research results that have been carried out are data on indicators of critical thinking skills of class VIII-A students of Junior High School 1 Gedangan categorized as good, as presented in Table 5.

Table 6. Desciptive statistic.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Analysis	1	16	16	16
	Explain	1	16	16	33
	Evaluation	1	16	16	50
	Interpretation	1	16	16	66
	Inference	1	16	16	83
	Mean	1	16	16	100
	Totally	6	100	100	

Table 7. Statistic of indicator critical thinking skills.

N	Valid	6
	Missing	0
Mean		32
Median		29
Std. Deviation		20
Range		56
Minimum		14
Maximum		70

Discussion

Based on Tables 6 and 7, statistics of the result obtained a mean score of 32, a median of 29, a standard deviation of 20, a range of 56, a minimum value of 14, and a maximum value of 70. From these statistical data, we can know the statistical test results of students' critical thinking indicators. Figure 1 shows the percentage of answering critical thinking skills questions by applying sustainability learning using the POE model. The "outstanding" category is 14%, with a total of 5 students; almost half are in the "good" category of 51%, with 18 students. The "sufficient" category was 23% with eight students, and the "insufficient" category was 11% with four students. This aligns with previous research that concluded that sustainability awareness and students' critical thinking skills are critical to overcoming environmental problems (Ekamilasari et al., 2021). Then, based on the scores of students who are in the "inferior" category, the average score is 0, in the "insufficient" category has an average score of 42, in the "sufficient" category has an average score of 55, in the "good" category has an average score of 73, and in the

"outstanding" category has an average score of 91.80 so that the overall average value is 52.

Based on Vygotsky's opinion, in the learning process, the teacher provides opportunities for students to take over responsibility for learning independently and manage their learning process while still being guided by the teacher. Table 4 shows that the overall percentage of critical thinking skills indicators with the application of sustainability on the material of conservation and energy transformation of the POE model at Junior High School 1 Gedangan is in the insufficient category with an average percentage (32%). The interpretation indicator (70%) is in the excellent category, while the analysis indicator (34%) is in the insufficient category. Then, the evaluation indicator (16%) is in the insufficient category, inference (26%) is in the insufficient category, and explanation (14%) is in the insufficient category. Based on table 2 shows that all indicators of critical thinking skills consisting of interpretation, analyzing, evaluating, inferring, and explaining skills obtained the highest average value of 70% in the "interpretation" skill with the "good" category, and other indicators obtained less value.

The interpretation indicator, with a percentage score of 70%, shows that students are categorized as good in interpreting or making predictions related to environmental issues related to energy conservation and transformation material; this also shows that students' interpretation skills are good. The following critical thinking skills indicators, namely analyzing 34%, evaluated by 16%, concluding by 26%, and explaining 14% are still in the deficient category; this shows that students are still lacking in analyzing environmental problems properly during observations, then evaluating students are still lacking in assessing various problems related to environmental issues, then concluding students are also still lacking in providing appropriate solutions related to environmental problems, as well as explaining skills that are still not well-honed (Lu et al., 2021; Moşteanu, 2021; Novita et al., 2022; Septaria & Dewanti, 2021).

Piaget expressed his opinion in constructivist learning theory that the learning process needs to emphasize three essential things; the first is actively constructing. This is applied in research at the POE model stage, namely predicting; the second is actively forming links contained in the observation stage (Astiti et al., 2020; Trisnayanti et al., 2023; et al., 2021), and the third stage is interaction with other students, this is by the explained stage where students are formed into several study groups (Agusti et al., 2019; Rahmawati et al., 2022).

CONCLUSION

Fundamental Finding: Based on the processing and analysis of the research data that researchers have obtained in the field, students' critical thinking skills get good results by applying continuous learning of the Energy Conservation and Transformation material POE model. The percentage results of answering critical thinking skills questions with a suitable category of 18 students shows that almost half get a good category score. As for the percentage of success of critical thinking skills indicators, according to Facione (2015), namely the interpretation indicator is in the excellent category, the analysis indicator is in the category of less, the evaluation indicator is in the category of less, the inference indicator is in the category of less, and the explanation indicator is in the category of less. It can be interpreted that students need help in analyzing, evaluating, concluding, and explaining sustainability learning, which has complex problems in the environment. **Implication:** Regardless of the difficulties faced by students in critical thinking, teachers must always provide students with an awareness of the importance of sustainable

learning so that, later, students have competencies that are by current needs. **Future Research:** Teachers should be able to integrate critical thinking indicators with sustainable learning POE model with various technologies and other learning media such as interactive games, making interesting teaching modules, and so on. **Limitation:** The limited literature obtained by researchers means that in the future, there must be more and more who participate in research related to sustainable learning that integrates learning with technology and specific skills.

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*__Siti Aisyah Siregar, S.Pd. (Corresponding Author)__
Postgraduate of Natural Science Education Programme,
State University of Surabaya,
Kampus Lidah Wetan, Jalan Kampus Lidah Unesa, Surabaya 60213, Indonesia
Email: siti.21026@mhs.unesa.ac.id

Prof. Dr. Yuliani, M.Si.
Postgraduate of Natural Science Education Programme,
State University of Surabaya,
Kampus Lidah Wetan, Jalan Kampus Lidah Unesa, Surabaya 60213, Indonesia
Email: -

Dr. Raharjo, M.Si
Postgraduate of Natural Science Education Programme,
State University of Surabaya,
Kampus Lidah Wetan, Jalan Kampus Lidah Unesa, Surabaya 60213, Indonesia
Email: -