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Fostering Critical Thinking through PBL-SSI in Renewable Energy Topic among High School Students

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Abstract

Fostering critical thinking stands out as a paramount objective in learning, warranting diligent cultivation and refinement. This study uses a Problem Based Learning (PBL)-Socio-Scientific Issues (SSI) learning model for renewable energy materials to enhance students' critical thinking skills. This research utilized a quantitative method with a one-group pretest-posttest design, and the sample comprised 33 students from SMAN 3 Samarinda. Data collection involves assessments with ten questions in the form of essays. Conclusions from the research show that using PBL with SSI learning models on renewable energy can foster students' capacity for critical thinking. After the learning process, 21 out of 33 students were classified as critical, and 12 out of 33 students were classified as very critical, with an average N-Gain value of 0.69, which is included in the medium category, and a paired (2-tailed) T-Test Sig value of 0.000, which indicates there is a significant influence from the use of PBL-SSI. This research provides insights into how teachers might use this approach in the classroom to help students become more adept critical thinkers in the twenty-first century by giving them resources to broaden their critical thinking skills.
Keywords: critical thinking; PBL-SSI; renewable energy

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INTRODUCTION

Due to the ongoing changes in global needs, education in the 21st century demands that students possess cognitive and social skills, academic knowledge, and comprehension (Haryanti, 2017; Uliyandari et al., 2021; Zubaidah, 2018). In the 21st century, one indispensable skill is the capacity for critical thinking (CT) (Griffin & Care, 2015; Toheri et al., 2020; Zubaidah, 2016). To solve the difficulties of the industrial era 4.s0 and produce innovative ideas, critical thinking abilities are becoming increasingly necessary (Indah & Fauzan, 2019; Mahmud & Wong, 2022). Critical thinking skills are fundamental for individuals to navigate and thrive in global society 5.0, enabling effective professional and personal engagement (Linh et al., 2019; Nuraida, 2019).

Critical thinking skills are high-level thinking skills in analyzing problems and ideas to find solutions according to reason and knowledge (Azizah et al., 2018; Ericson, 2022; Gunawardena &

Wilson, 2021). Within the Indonesian educational context, the cultivation of critical thinking emerges as a pivotal component in shaping the Pancasila student profile, emphasizing the multifaceted development of individuals grounded in national ideology (Basri et al., 2019; Badan Standar Kurikkulum dan Asesmen, 2022).

Even though critical thinking abilities are crucial, Indonesian students possess comparatively few (Aprilia et al., 2023; Fitriani et al., 2020; Suarniati et al., 2018; Utami et al., 2018). One of the contributing factors to the low level of students' critical thinking skills is the dominance of teacher-centred learning approaches in schools, which fail to adequately cultivate students' critical thinking (Mabrurah et al., 2023). Facts from the field confirm this, demonstrating that rote memorization trains students for most learning, which involves conventional methods or lectures (Agustin et al., 2017; Darwoto, 2023; Rizkita & Mufit, 2022).

Some instructional techniques linked to enhancing critical thinking skills include problem-solving, student-centred learning, explicit and focused instruction on critical thinking, and formative evaluation (Samson, 2016; Hall et al., 2021). PBL is an option that allows students to develop the critical thinking skills they need (Anggraeni et al., 2024; Fadilla et al., 2021; Gustomo Arifin, 2020). Applying PBL is appropriate because it focuses students on solving complex real-world problems (Suwastini et al., 2021). Through a methodical approach to problem-solving, students' thinking capacities are maximized, allowing them to continuously refine their thinking skills (Darling-Hammond et al., 2020; Fadilla et al., 2021).

The problems used in the problem-based learning model should be related to real problems in everyday life (Kardoyo et al., 2020; Sismawarni et al., 2020; sTortorella & Cauchick-Miguel, 2018). One of the problems that is effectively used in PBL is Socio-Scientific Issues (SSI). SSI refers to societal difficulties or dilemmas intertwined with scientific concepts, often characterized by solutions that are ambiguous or contextually contingent (Wilsa et al., 2017). SSi in PBL is beneficial because it gives real-world context, increases critical thinking skills, promotes learning motivation, raises social consciousness, and prepares students for the future. Examples of applications include analyzing the causes of the world energy crisis, the intricacy of solar energy, designing sustainable energy systems, and others.

There has been much study on PBL to increase students' critical thinking skills, but very little on integrating PBL with ISS, particularly in physics education. PBL-SSI is a model that makes SSI the basis for problem orientation in learning. It would be fascinating to investigate the possibility of including socio-scientific issues in the PBL, which is thought to teach students how to build CT. Hence, this research aims to explore the impact of a Problem-Based Learning model based on socio-scientific issues on the critical thinking skills of high school students in renewable energy material.

METHOD

The study comprised 33 students from class 10, SMA N 3 Samarinda. This study was conducted from February to March 2024 and takes a quantitative approach with a one-group pretest-posttest design (Fraenkel et al., 2012). Students' critical thinking skills are measured by ten self-made essay questions referring to critical thinking indicators: elementary clarification, basic support, inference, advanced clarification, strategy, and tactics (Ennis, 1996), and have gone through validity and reliability tests to guarantee their quality (DeGhett, 2014). Questions were tested twice, before and after treatment with the PBL-SSI

learning model in renewable energy materials. Then the student scores were divided into five critical thinking categories according to Table 1 (Razak, 2017). The students' pretest and post-test scores were then analyzed using N-Gain value analysis and paired t-tests. IBM SPSS v.25.0 for Windows was used for all data analysis.

RESULT AND DISCUSSION

Data on students' pretest and post-test results on renewable energy material was obtained from the research results. This data shows students' critical thinking skills at the pretest and post-test. The score is categorized based on the CT criterion, as shown in Table 1.

Table 1 Category of students' critical thinking skills

Value (Scale 0-100)	Number of Students		Criterion
	Pretest	*Post-test*	
$80 \leq x \leq 100$	-	12	Very Critical
$65 \leq x < 80$	-	21	Critical
$55 \leq x < 65$	2	-	Quite Critical
$40 \leq x < 55$	2	-	Less Critical
$0 \leq x < 40$	29	-	Very Less Critical

(Razak, 2017)

Table 2 N-Gain analysis results

N-Gain Score	Criterion	*f*	%
$x \geq 0{,}7$	High	19	57.58
$0.3 < x < 0.7$	Moderate	14	42.42
$x \leq 0.3$	Low	0	0

Pretest Average	*Post-test* Average	*N-Gain*	Criterion
26.7	77.33	0.69	Moderate

N-Gain analysis can provide an overview of improving students' critical thinking skills before and after being treated in the form of learning using the PBL-SSI learning model. Based on Table 2 regarding the percentage of students' N-Gain scores, it is known that the most significant percentage is in the high criteria of 57.58%. Based on the examination of N-Gain values, students had an average N-Gain value of 0.69, which falls within the moderate criterion.

A paired t-test was used to determine whether the pretest and posttest scores differed significantly. The paired t-test result indicates that the two-tailed significance value (Sig.) is 0.000, less than 0.05, which means there is a significant difference in students' CT when applying the PBL-SSI to renewable energy materials.

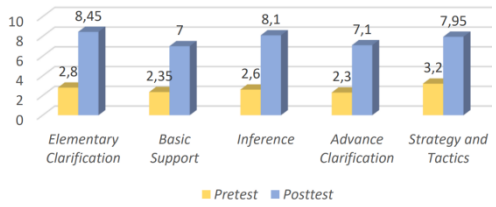

Figure 1 Graph of average test scores for each critical thinking skills indicator

Based on Figure 1, it can be seen that the application of the PBL-SSI in this research has improved students' critical thinking skills for each indicator. The indicators of critical thinking skills that experienced the most significant increase were the skills in elementary clarification, followed by improvements in skills inference, strategy and tactics, advanced clarification, and basic support. Skills with the lowest improvement do not mean the PBL-SSI model needs to be better to train critical thinking skills. Many factors can cause low improvement in indicators, such as a lack of time to provide instruction focusing on these indicators, so that students receive less practice and feedback, such as analyzing information and providing reasons.

This research aligns with Sunarti (2020) and Wilsa et al. (2017), whose findings indicate that using a problem-based learning model affects students'

critical thinking skills. The PBL model involves students facing real problems to train their critical thinking skills (Tortorella & Cauchick-Miguel, 2018). This finding is supported by Joshi (2020), who states that PBL will involve students in active, collaborative, and student-centred learning to improve their critical skills. The PBL model uses real-life problems as a context (Fidan & Tuncel, 2019; Seibert, 2021). This research uses Socio-Scientific Issues (SSI) as the basis for problem orientation in learning. Roberto & Bernando (2012) revealed that critical thinking skills can be developed in students by using SSI in the classroom through discussions about controversial topics and social sciences. This opinion is supported by Pandela's (2019) research, which shows that applying SSI in education can improve critical thinking skills.

CONCLUSION

According to the study's findings and data analysis, PBL with SSI improves students' critical thinking skills in renewable energy topics. This is shown by analysis using the paired t-test to obtain a Sig value. (2-tailed) is 0.000, and the N-Gain value is 0.69. Following the instructional period, 11 out of 33 students demonstrated a level of critical thinking categorized as "very critical," while the remaining 22 out of 33 students fell within the "critical" category. These results affect how science teachers might use this approach in the classroom to help students become more adept critical thinkers in the twenty-first century by giving them the tools to expand their critical thinking skills.

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