

E-LKPD Based on Socio-Scientific Issues: A Means of Developing Science Literacy and Critical Thinking in The Era of The Independent Curriculum

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Abstract: Against the background of the limitations of learning media in facilitating the learning needs of students, as well as the importance of critical thinking skills and science literacy in facing global challenges. The independent curriculum is an approach designed to meet the learning needs of students flexibly, but still requires the active role of teachers in conveying essential concepts, so the development of SSI-based e-LKPD is expected to be an effective learning innovation to develop students' critical thinking skills and science literacy. The purpose of the study is to measure the effectiveness of SSI-based e-LKPD on environmental pollution materials on students' science literacy and critical thinking. The use of the liveworksheet application is used for interactive learning media. This type of research is quasi-experimental design with the one group pretest-posttest design method. The research was conducted in grade VIII of junior high school in Tanggamus district with a total of 128 students. Data analysis uses n-gain test and t-test. The results of the analysis obtained an n-gain of 33 in the control class and 53 in the experimental class. This value is in the range of 40-55 with the category of less effective. Furthermore, the results of the t-test showed a significant difference between the control and experimental classes ($p < 0.05$); reject H_0 , thus that SSI-based e-LKPD is effective in improving critical thinking skills and science literacy of junior high school students.

Keywords: Critical Thinking Skills; E-LKPD; Science literacy; Socio Scientific Issue (SSI)

Introduction

Mastery of science literacy and critical thinking skills is essential in facing global challenges, including health and environmental issues. Science literacy includes not only an understanding of scientific concepts, but also the ability to make decisions based on valid and relevant information. Strong science literacy enables individuals to understand the relevance of science to everyday life, assess the risks and benefits of science and technology, and respond wisely to socio-scientific issues. However, low science literacy in society can lead to misinformation, which in turn affects understanding and trust in available information (Hogstrom et al., 2024). To face this challenge, critical thinking skills are needed to sort, analyse and evaluate

information to make it more accurate and accountable (Sjogten et al., 2023).

In the context of education, the development of science literacy and critical thinking skills can be done through a socio-scientific issues (SSI) based approach. This approach allows students to discuss socially relevant scientific issues, such as environmental and health problems, so as to deepen scientific understanding, hone analytical skills, and formulate logical solutions. Research shows that SSI-based modules significantly improve students' scientific literacy with n-gain scores reaching the medium category (Muntari et al., 2024).

Furthermore, a meta-analysis revealed that using SSI in learning has a positive impact on students' scientific literacy compared to using the lecture method

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(Çalik & Wiyarsi, 2024). However, the implementation of SSI in learning still faces challenges, such as the low science literacy of teachers and the gap between learning materials and student needs (Siswanto et al., 2023).

The use of digital media, such as e-LKPD (electronic Learner Worksheet) based on SSI, is one of the innovative solutions to improve science literacy and critical thinking. e-LKPD allows students to learn interactively through features that support higher order thinking skills (HOTS) and create a more engaging learning experience (Gaurisankar et al., 2022). Research also shows that the integration of e-LKPD with project-based (PJBL) or problem-based (PBL) approaches increases student motivation and engagement in the learning process (Novianto, 2023; Saputra et al., 2024). However, the application of SSI-based e-LKPD in the Merdeka curriculum is still not widely implemented, so further development is needed to adapt to the needs of differentiated learning (Virmala, 2023).

In the era of the Merdeka Curriculum, the development of SSI-based e-LKPD is becoming increasingly relevant because it supports differentiated learning, according to the needs and characteristics of students. In addition to improving science literacy and critical thinking skills, SSI-based e-LKPDs also encourage students to better understand everyday scientific issues, such as climate change and health technology. With this approach, students not only learn theory, but are also directly involved in solving real problems relevant to their lives. The implementation of interactive learning, based on student needs, and supported by technology is a strategic step in creating a more meaningful and quality science education.

Method

This study used a quantitative approach with a quasi-experimental design model through the development of a one group pretest-posttest design method. The population of this study were 8th grade students in junior high schools in Tanggamus district. The sampling technique used cluster random sampling technique. This research was conducted in class 8C and 8E as the research sample. The number of students used was 128 students. Data analysis in this study is in the form of quantitative data. Quantitative data comes from the results of the analysis of science literacy skills and critical thinking skills of students to determine the effectiveness and results of student responses to the use of SSI-based e-LKPD. Further data analysis through the stages of n-gain test and t-test.

The test questions used in this study are written test methods to measure students' critical thinking skills and science literacy on environmental pollution material.

The instruments used were 5 essay questions in accordance with the indicators of competency achievement (IPK). Students' critical thinking skills and science literacy can be seen from the acquisition of values through test activities given at the end of learning. In Tables 1 and 2, the lattice of students' critical thinking and science literacy instruments are presented.

Table 1. Student Critical Thinking Instrument Grid

Indicator	Sub Indicators	Item Number	Number of Items
Analysis	Identifying problems	1 a, 2b,4a	3
	Analyze relationships and interactions	3B, 4C,5A	3
	Analyze arguments	1c,2c	2
Evaluation	Assessing the relevance of facts to support an argument	2a	1
	Propose actions with solutions	1b,4b,	2
	Identify an informed argument	3a	1
Conclusion	Presenting conclusions based on the facts of the research	4d	1
	Presenting the results of the consideration	3c,5b	2

Table 2. Science Literacy instrument grid

Indicator	Sub Indicators	Item number	Number of Items
Science content	Knowledge of understanding natural phenomena	1a	1
	Knowledge of changes to nature through human activities	1b,5a	1
	knowledge berasal from source	1c,5b	2
	Search for other information		
Science Context	Understanding the situation that contains the process of applying science	4a, 2c	2
	Identifying science issues	2b	1
	Explaining the phenomenon of science	2a,4b	2
	Using evidence and scientific data	3C,4D	2
Process Science	Identifying phenomena scientifically based on studies	3B,4C	2
	Using scientific evidence	3a	1

The effectiveness of e-LKPD on critical thinking skills and science literacy skills was measured through pre-test and post-test questions. The results of this test were analysed using the n-gain test. The analysis used is the n-gain formula. The following is the n-gain formula:

$$(N - gain) = \frac{(skor\ posttest) - (skor\ pretes)}{(skor\ maksimum) - (skor\ pretest)} \quad (1)$$

The n-gain results are included in the criteria and percentage of student scores. The following is the distribution of student score categories in Table 2.

Table 2. Percentage and category of student scores

Percentage (%)	Category
80%-100%	Excellent
70-79%	Good
60%-69%	Keep
50%-59%	Less
0%-49%	Very Less

Arikunto, (2016)

After going through a series of n-gain tests in the control and experimental classes, then a t-test was conducted to determine the difference in the results of the application in the two classes. The hypothesis test

used is the Independent t-test. The research hypothesis is:

H₀: Both population data are identical (there is no difference in effectiveness between the use of e-LKPD in control and experimental classes)

H₁: Both population data are not identical (there is a difference in effectiveness between the use of e-LKPD in control and experimental classes)

If the sig value > 0.05; then H₀ is accepted, meaning that there is no difference in the average use of e-LKPD in the control and experimental classes. If the significance value ≤ 0.05; then H₀ is rejected, meaning that there is a difference in effectiveness between the use of e-LKPD in the control and experimental classes.

Result and Discussion

Result

The use of SSI-based e-LKPD is presented to meet the learning needs of students. The results of quantitative data analysis using the n-gain test illustrate the effectiveness of the questions on each research variable. The following is an overview of the n-gain value of each indicator in Junior High School in Tanggamus, presented in Figure 1 and 2.

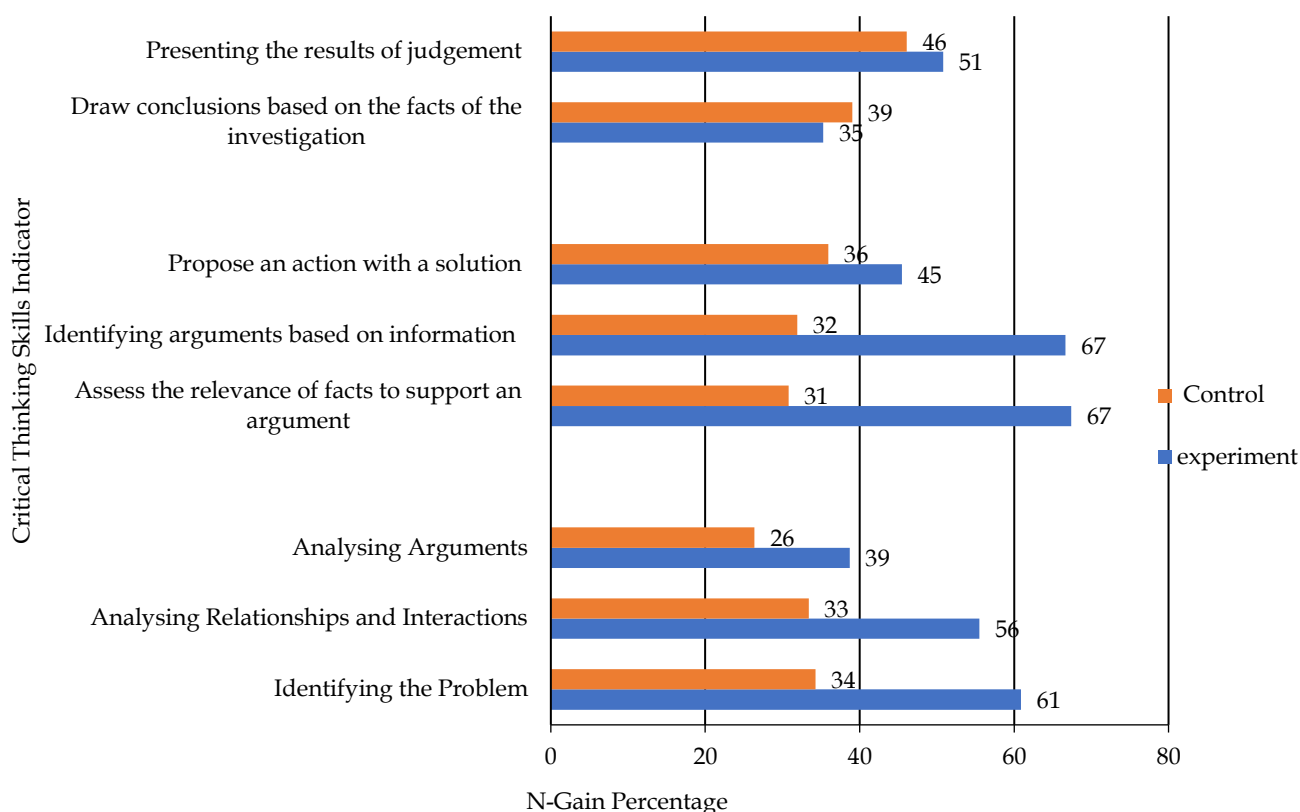


Figure 1. N-Gain Percent Critical Thinking Skills of Junior High School Students in Tanggamus.

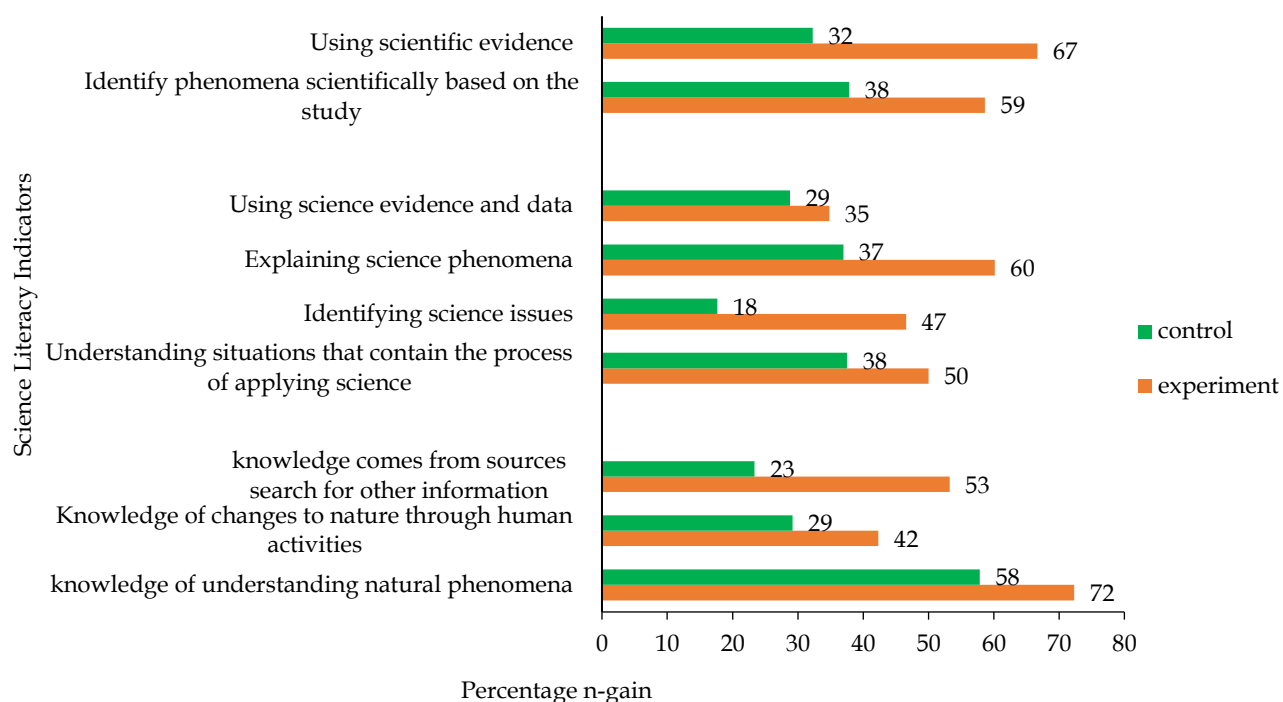


Figure 2. N-Gain Percent of Science Literacy of Junior High School Students in Tanggamus

Based on the data in Figures 1 and 2, it is confirmed that SSI-based learning is effective in improving students' understanding of basic science concepts through the presentation of relevant real phenomena. However, the science context aspect recorded the lowest improvement, especially on the indicator 'identifying science issues,' which was 47% in the experimental class and only 18% in the control class. The low result on the science context aspect indicates that students still have difficulty in connecting science concepts with more complex social issues.

Meanwhile, the high score on the science content aspect in the control class indicates that traditional learning remains effective for improving mastery of basic concepts. However, low scores on science context, such as on the indicator 'identifying science issues' which only reached 18%, indicate the limitations of the conventional approach in facilitating students to

understand the relevance and application of science in everyday life. Based on these results, SSI-based learning requires strengthening, particularly on the science context aspect, to help students develop the skills to identify and analyse science-related social issues through contextual exercises and in-depth discussions. Significantly and specifically, it can be seen that the average increase in science literacy in the experimental class reached 54%, much higher than the control class which only reached 34%. This shows that the SSI approach has a significant impact on improving students' science literacy.

Furthermore, the n-gain results were conducted t-test to obtain an in-depth analysis of the use of e-LKPD in the control and experimental classes whether there was a significant difference. The results of the t-test analysis are presented in Table 3.

Table 3. Hasil Uji Independent sample t-test

		Levene's Test for Equality of Variances		t-test for Equality of Means						95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference		Lower	Upper
nGain_Persen	Equal variances assumed	30,910	,000	5,871	126	,000	19,23732	3,27674		12,75275	25,72188
	Equal variances not assumed			5,871	92,812	,000	19,23732	3,27674		12,73019	25,74444

Based on the results of the t-test, a sig value (2-tailed) of $0.00 < 0.05$ was obtained. With the rejection criterion H_0 , it can be concluded that there is a significant (real) difference in effectiveness between the use of e-LKPD in the control class and experiments on students' critical thinking skills and science literacy in the independent curriculum.

Other supporting data that helps in this study is data from student responses after using E-LKPD. The following are the results of the analysis for the student responses of each indicator in the aspects of language, media, and material. The following are the details of the results of the analysis of student responses for each indicator contained in Figure 3.

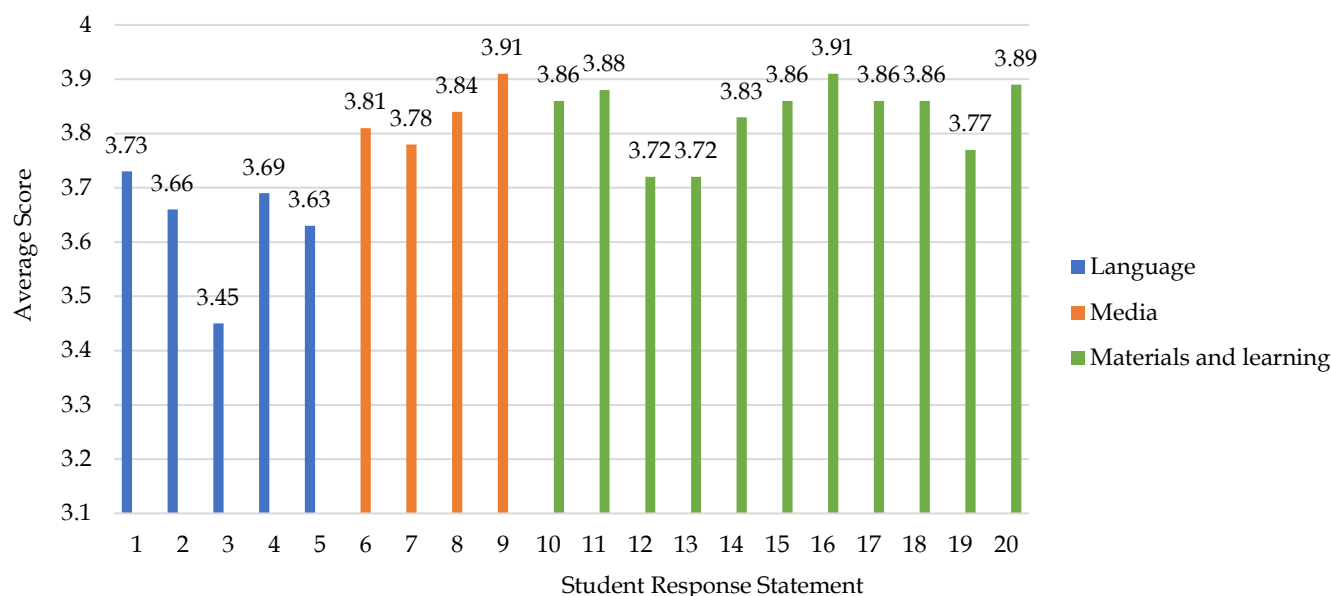


Figure 3. Results of Student Response Analysis

Based on Graph 3, the results of the analysis of language, material, and media aspects respectively obtained an average score of 89%, 94% and 97%. The results of the analysis of student responses showed that the e-LKPD used obtained the predicate of "very good". Thus, the aspects of language, media, and materials as well as learning in e-LKPD meet the standards of student needs.

Discussion

Analysis of test result data *n-gain* 35 in the control class and 53 in the experimental class. These results show that the categorology is less effective. Furthermore, the t-test obtained a value sig (2-tailed) $0.00 < 0.05$; then reject H_0 . Based on the results of this analysis, although *n-gain* in the poor category, after the T-test was carried out, there was an average difference between the experimental class and the control class in the aspects of critical thinking skills and science literacy. Some of the factors that affect the results of this study are that SSI-based learning is a new approach for students, so it is necessary to adapt to the learning process that emphasizes the exploration of scientific and social issues in depth. According to Skinner's theory of behaviorism,

repeated habituation helps students form new patterns of behavior that support critical thinking skills and science literacy (Slife & Williams, 2014). Therefore, it is necessary to familiarize the learning process by using e-LKPD, so that students are more interested and involved in the learning process. The process of repetition is very important in learning, so that it can improve the achievement of learning outcomes. Experiential learning and interaction with the environment, as explained by Bandura that strengthens the internalization of concepts and skills through habituation of students being able to internalize the concepts and skills trained, so that SSI-based learning has the potential to improve critical thinking skills and science literacy in a sustainable manner in the future (Patton, 2021).

The SSI approach takes time and practice to achieve effectiveness, given the complexity of the expected skills (Zeidler & Nichols, 2009). The significant average difference between the experimental and control classes shows the potential of SSI-based e-LKPD in supporting the gradual development of critical thinking skills and science literacy, so that e-LKPD has a significant influence on the learning process. E-LKPD is presented to guide students in constructing learning concepts (Hidayat and Aripin, 2023). Learning is oriented by

presenting problems and practicing analytical thinking so that students can achieve maximum learning competence compared to traditional learning (Indarti et al., 2018).

In addition, the use of e-LKPD is in accordance with constructivist learning theory which encourages student participation in Piaget's learning in (Anwar, 2023). Students' responses to e-LKPD reflect a process of forming knowledge that starts from the process of understanding and interpreting learning materials. The results of this study provide various information about learning experiences through insights derived from existing social issues so as to provide solutions to environmental problems. This E-LKPD will also motivate education observers in designing teaching media that are more responsive, effective, and interactive.

Various activities in the e-LKPD will motivate students so that they are actively involved in solving environmental problems. In addition, students carry out the process of analyzing, evaluating and concluding the activities as a result of the discussion. As a result of the discussion of science issues presented, students not only learn about scientific phenomena but students' way of thinking critically analyzes is developed to solve problems in daily life (Khovivah, dkk., 2022). Other opinions were put forward by Rohmaya (2022) that SSI-based science learning makes an important contribution in improving students' understanding of science issues relevant to daily life. With this approach, students not only become more skilled in science literacy but also better prepared to face future social and scientific challenges.

The use of e-LKPD as an effort to digitize the learning process is an important effort in digital learning innovation to improve the quality of education (Rahyu, D.K., 2021). E-LKPD is part of meeting the learning needs of students in accordance with the nature of the times. Currently, the development of technology and gadgets is very close to students. The use of e-LKPD will help increase learning motivation because it is more interesting, interactive and effective (Marion, dkk., 2023). In addition, e-LKPD is part of a form of environmental awareness to reduce the use of printed products that use paper, so that students are more sensitive to environmental sustainability issues (Amtonis, 2022) and (Saputra, dkk., 2024).

The context of science learning is very important to involve local potential and the learning environment around students that is tailored to the student's learning needs (Wilujeng et al., 2017). SSI-based science learning helps students understand social science issues that are closely related to daily life (Rohmaya, 2022b), (Zeidler et al., 2019) and (Yuliasri, and Rahayu, 2016). Social science

problems packaged in learning will encourage the strengthening of concepts, meaningful learning, development of thinking skills, development of skills in problem solving, and skills in identifying alternative solutions by conducting information searches. (Latip, dkk., 2024), (Rahmavati, D.K., 2018) and (Putriana, 2020). Based on this analysis, the approach to social issues around the student's learning environment is one of the strategies to improve students' critical thinking skills and science literacy. This is in agreement with (Birdsall & Kelly, 2022) that a person's ability to criticize global affairs is determined by the individual's ability to understand the scientific issues around him. So, citizens who are aware of the understanding of the scientific issues around them are needed to be able to understand complex issues globally. This research applies digitalization in LKPD. Digitization of technology used in the form of e-LKPD made in *liveworksheet*. The use of interactive features in e-LKPD has been proven to reduce boredom and can increase student motivation and engagement in learning (Saputra, dkk., 2024). In line with this, the interactive features developed provide positive responses to students in an effort to improve high thinking skills (HOTS) so that they can be a practical and effective medium to increase student engagement (Gaurisankar et al., 2022).

Critical thinking skills developed through experimental activities in e-LKPD will affect science literacy (Anas, et al., 2020). This can be seen in experimental activities, students not only understand scientific concepts, but students can apply their knowledge directly. In addition, in this learning process, students are trained to read and conduct literature studies both in print and digitally. Based on this, students can practice meta-analysis skills in the thinking process and develop their literacy skills (Nurchayani et al., 2021). In line with this, Husniyyah et al., (2023) argued that learning with the SSI approach allows students to relate scientific concepts to relevant social science issues. In line with this, students' ability to argue and think critically about scientific implications in everyday life. Experimental activities and scientific practice can improve the understanding of scientific concepts and connect with students' real experiences (Normawati et al., 2022). e-LKPD exploration activities using digital technology will increase student interaction so that it helps in developing the ability to explore scientific concepts visually and practically (Çalik & Wiyarsi, 2024). e-LKPD exploration activities with problem solving are solved with a more integrative and meaningful approach. A learning approach that focuses on a holistic learning experience will improve students' science literacy skills (Fitria et al., 2022). Based on this, it

is very important to learn that prepares students to be ready for future scientific challenges (Kelp et al., 2023).

The use of e-LKPD is expected to make the learning process more flexible and interactive by facilitating access to teaching media. This SSI-based E-LKPD is a real action of learning innovation as an effort to improve the quality of the learning process that facilitates the learning needs of students in accordance with the nature of nature and the nature of the times. This is evidenced by a contextual learning process through the presentation of problems relevant to the student's learning environment so as to provide solutions to environmental problems.

Conclusion

The results of the analysis obtained an n-gain of 33 in the control class and 53 in the experimental class, meaning that this study was in the less effective category. Furthermore, the results of this study showed significant differences between the control and experimental classes ($p < 0.05$); reject H_0 , thus that the use of SSI-based e-LKPD is effective on critical thinking skills and science literacy of junior high school students. This finding confirms that SSI-based e-LKPD is an effective and relevant learning tool to fulfil students' learning needs, as well as inspiring enrichment of context-based learning materials. Based on the conclusions in the study, it is recommended to enrich learning practices with innovations and other learning methods, so that learning is more contextual and in favour of students in accordance with the nature of nature and the times. In addition, future researchers can develop SSI-based e-LKPD with content coverage that is in accordance with the characteristics of certain regions and explore the integration of other technologies such as AR to provide a more interesting and interactive learning experience.

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Author Contribution

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Conflicts of Interest

The authors state that there is no conflict of interest. The funder is stated in publishing the results of the research.

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