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E-Worksheets Based on STEAM-PJBL with Local Coastal Wisdom to Improve Critical Thinking Skills

Endang Widi Winarni[1*], Debi Heryanto[2], Yusnia[3], Neza Agusdianita[4], Endina Putri Purwandari[5], Andang Wijanarko[6]

[1234] *Faculty of Teacher Training and Education, University of Bengkulu, Indonesia.*
[56] *Faculty of Engineering, University of Bengkulu, Indonesia.*
Corresponding E-mail: endangwidi@unib.ac.id

Abstract: This research aimed to investigate the influence of electronic student worksheets based on STEAM and Project-Based Learning (PjBL) with local coastal wisdom content to improve the critical thinking abilities of fifth-grade students in Group V elementary schools in Bengkulu City. This research employed a quantitative approach using a quasi-experimental method with a Matching Only Pretest-Posttest Control Group Design. The population of this study comprised all elementary schools in Group V, Bengkulu City. The sample consisted of fifth-grade students from SDN 09 and 02 Bengkulu City, selected using Cluster Random Sampling. The research instrument used was a critical thinking skills test with a pretest and posttest. The data was analysed quantitatively using descriptive statistics, prerequisite tests, and hypothesis testing. The t-test was used to test the hypothesis. The results showed that the significance value (2-tailed) was 0.000 < 0.05 at a 5% significance level. The average scores of the experimental class (80.28) and the control class (50.21) showed a significant difference between the learning outcomes of the experimental and control classes. It can be concluded that the experimental class using electronic student worksheets based on STEAM and PjBL significantly influenced the students' critical thinking abilities. In conclusion, this study found a significant influence of electronic student worksheets based on STEAM and PjBL on the critical thinking skills of fifth-grade students in Group V elementary schools in Bengkulu City.

Keywords: critical thinking, electronic student worksheets, elementary school, Project-Based Learning, STEAM

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1. Introduction

Critical thinking is one of the essential abilities that must be developed in the 21st Century. Critical thinking is a mental process to analyze or evaluate information obtained from observations, experiences, common sense, or communication. This ability is essential for elementary school students to develop logical, systematic thinking, and problem-solving in daily life problems (Saputra & Murdani, 2023). Nowadays, the critical thinking skills of elementary school students in Indonesia are relatively low. The Programme for International Student Assessment (PISA) results from the Organization for Economic Co-operation and Development (OECD) show Indonesia was ranked 72nd out of 78 participating countries in reading, mathematics, and science categories. These results indicate that Indonesian students are still weak in high-level thinking skills, including critical thinking (OECD, 2023).

One of the factors contributing to students' critical thinking skills is the lack of innovation in the learning methods and teaching materials used. Learning is still dominated by conventional methods that tend to be teacher-centered, so it does not stimulate students to think actively and critically. Innovation in teaching materials using Electronic Student Worksheets (E-Worksheets) is a means to help facilitate teaching and learning activities so that effective interactions are formed between students and teachers. E-worksheets contain tasks carried out by students, including instructions and steps to complete a task in theory and practice (Alkautsar et al., 2023). Using E-worksheets based on contextual integration in the class point application can train students' critical thinking skills.

Furthermore, the development of integrated literacy E-worksheets can improve learning outcomes, which is the theoretical implication of this study (Asrizal et al., 2023). The E-worksheets presented contain various stages of learning, including organizing problems, organizing students to learn, and developing E-worksheets. Next, applying the Project-Based Learning (PjBL) approach, assisted by E-worksheets, can improve students' scientific literacy (Putri et al., 2022).

Using local wisdom in learning can also improve critical thinking skills (Adnan, 2023). Integrating local wisdom in the learning process encourages students to continue exploring deeper knowledge to make learning more meaningful. The perfect perception of students regarding using e-worksheets based on local wisdom makes this teaching material able to improve students' knowledge in science learning (Ria Rochmi Safitri et al., 2024). The development of E-Worksheets containing coastal local wisdom is expected to enable students to understand better the concept of sciences, which is associated with the culture of coastal communities.

The Science, Technology, Engineering, Arts, and Mathematics (STEAM) approach is believed to increase students' motivation to actively participate in effective teaching and learning processes in the classroom (Belbase et al., 2022). The STEAM approach is used in lessons because students' learning motivation can be increased by creating curiosity about the relationship between the lessons students get in school and real conditions in daily life (Adriyawati et al., 2020). To support the STEAM learning approach, a PJBL model is needed. PjBL is a teaching and learning strategy involving students working on a project for community or environmental problems

(Winarni et al., 2024). Integrating PjBL and STEM in elementary schools can improve the quality of human resources in industrialization and globalization to maintain environmental systems and meet 21st-century competencies (Winarni et al., 2022). The STEAM approach can be realized effectively and provide optimal benefits for students with the PjBL model (Indahwati et al., 2023).

In this study, researchers surveyed the effect of using E-Worksheets based on STEAM-PjBL, which was designed to cover various activities that encourage the use of digital technology. The STEAM learning method is very popular today because it facilitates students' understanding of lessons and helps them solve problems critically (Febriansari et al., 2022). In addition, students will be able to analyze data and innovate in solving existing problems. Applying technology in STEAM is useful for reducing the cognitive load (mental load and mental effort) and increasing students' learning intentions (Winarni et al., 2024).

STEAM-PjBL in the E-worksheets can encourage collaborative learning and creativity. Students can work in groups to complete projects requiring E-worksheets, thus developing their technical and essential social and communication skills (Lufri et al., 2020). Using E-worksheets based on local wisdom with the PjBL model is expected to make the learning process more interesting and increase students' interest in participating in learning activities. This study aims to fill this knowledge gap by investigating the effect of E-worksheets with coastal local wisdom content based on STEAM-PjBL on improving the critical thinking of grade V elementary school students in the subject of science. In addition, this study aims to evaluate the effectiveness of using E-Worksheets in enhancing students' critical thinking skills in the context of PjBL-based learning to solve real problems with local wisdom content.

2. Method

The type of research is quantitative, based on samples, which uses instruments in data collection, statistical data analysis, and aims to test the hypothesis set at the beginning (Winarni, 2021). This study uses a quasi-experimental method (Quasi-Experiment). The research design used is the Matching Only Pretest-Posttest Control Group Design. The study was conducted in class V SDN 09 as an experimental class with 25 students and SDN 02 Kota Bengkulu as a control class with 19 students. The determination of schools used cluster random sampling. Data collection techniques used pretest and posttest with essay questions. The data analysis techniques used are descriptive statistics, prerequisite tests, including normality and homogeneity tests, and inferential statistical tests using the Independent Sample T-test. The preparation of the question instrument is adjusted to the learning of class V science based on the Learning Outcomes (LO) on the coastal ecosystem (see Table 1).

Table 1. Research Evaluation Question

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Dimensions of Critical Thinking	Material	Cognitive Level	Question Number	Score
Providing Simple Explanations (Focusing on questions)	The relationship between living things in the coastal ecosystems	Level 3 (C4-HOTS)	1	15
Building Basic Skills (Considering answers based on observations)	The relationship between living things in the coastal ecosystems	Level 3 (C5-HOTS)	2	15
Summarizing (Inducing and considering the results of induction)	The process of transformation between living things in the coastal ecosystem	Level 3 (C6-HOTS)	5	20
Providing Further Explanation (identifying assumptions)	The process of transformation between living things in the coastal ecosystem	Level 3 (C4-HOTS)	4	20
Setting Strategy and Tactics (Determining actions)	The relationship of food webs between living things in the coastal ecosystem	Level 3 (C6-HOTS)	3	30

The instrument was to see whether the questions were suitable (see Table 2). Several tests were carried out: validity test, reliability test, difficulty level, and discrimination power. The validity test results with an average calculation of 0.736, greater than the r_{table} of 0.374, so the 5 questions were declared valid. The reliability test of 5 questions that had been tested obtained a result of 0.744> 0.70. This research instrument is reliable and can be used. Based on the discriminatory power test of the 5 questions used in this study, the questions with a very good discrimination power category for 5 questions. Based on the 5 tested questions, all were valid and could be used in the study. From the difficulty level calculation data, a moderate difficulty index was obtained on questions 1, 2, 3, 4, and 5.

Table 2. The Instrument Test Results

Question	Validity		Reliability		Difficulty Level		Discriminating Power	
	Score	Result	Score	Result	Score	Result	Score	Result
1	0.754	Valid	0.744	Reliable	0.430	Middle	0.680	Very good
2	0.703	Valid			0.690	Middle	0.494	Very good
3	0.821	Valid			0.763	Middle	0.637	Very good
4	0.677	Valid			0.357	Middle	0.561	Very good
5	0.728	Valid			0.488	Middle	0.458	Very good

3. Result and Discussion

The phenomenon of low critical thinking skills also occurs in Bengkulu City. Based on initial observations and interviews with teachers at one of the Elementary Schools in Bengkulu City, it was found that (1) most students still have difficulty in analyzing information, making logical conclusions, and solving complex problems; (2) students tend to be passive in learning and are less able to ask critical questions; and (3) only

use worksheets from printed books. This shows a gap between expectations and reality in developing students' critical thinking skills.

This study aimed to determine the effect of STEAM-PjBL on the critical thinking skills of Class V elementary school students in Bengkulu City and evaluate the effects of E-worksheets with STEAM-PjBL. This study was conducted from 20 November – 07 December 2024. The study was conducted on two samples that received different treatments: the experimental group, class V A students of SDN 09 Bengkulu City, and the control group, class VA students of SDN 02 Bengkulu City. The critical thinking skills came from the pretest and posttest carried out by students in science learning.

The pretest was conducted before the experimental and control groups were given the research. The posttest was conducted after teaching students in the experimental and control classes. The experimental group was given treatment by learning using E-worksheets with STEAM-PjBL, and the control group learned using printed books. Data collection was carried out by distributing descriptive question instruments of 5 questions to 44 grade V students, including 25 students for the experimental group and 19 students for the control group.

Table 2. Pretest and Posttest in the Experimental and Control Classes

Data	*Pretest*		*Posttest*	
	Experiment	Control	Experiment	Control
Students	25	19	25	19
Highest score	77	70	100	80
Lowest score	27	35	37	25
Average	48.48	46.57	80.28	52.21
Varian	161.927	18.702	236.960	135.620

Table 2 shows that the average pretest score of the experimental class is 48.48, with the highest score of 77 and the lowest score of 27. In the control class, the average pretest score is 46.5789, with the highest score of 70 and the lowest score of 35. The average posttest score of the experimental class is 80.28, with the highest score of 100 and the lowest score of 37. In the control class, the average posttest score is 52.21, with the highest score of 80 and the lowest score of 25.

Critical Thinking Skills

The aspect of critical thinking in providing a simple explanation (see Figure 1), the pretest value was 10.36, and the posttest value in the experiment class was 12.88, so there was an increase of 2.52 (16.8%). In the aspect of building basic skills, the pretest value was 11.64, and the posttest was 14.6 in the experiment class, so there was an increase of 2.96 (19.73%). In conclusion aspect, the pretest value of the experiment was 7, and the posttest value was 19, so there was an increase of 12 (60%). The pretest value was 7.28, and the posttest value was 16.2, so there was an increase of 8.92 (44.6%) in the experiment class. Regarding arranging strategies and tactics, the pretest value was 12.2, and the posttest value was 17.6 in the experiment class, so there was an increase of 5.4 (18%). It can be seen that the highest score gain occurred in the aspect of concluding was 12 (60%), and the lowest score gain in providing simple explanations was 2.52 (16.8%).

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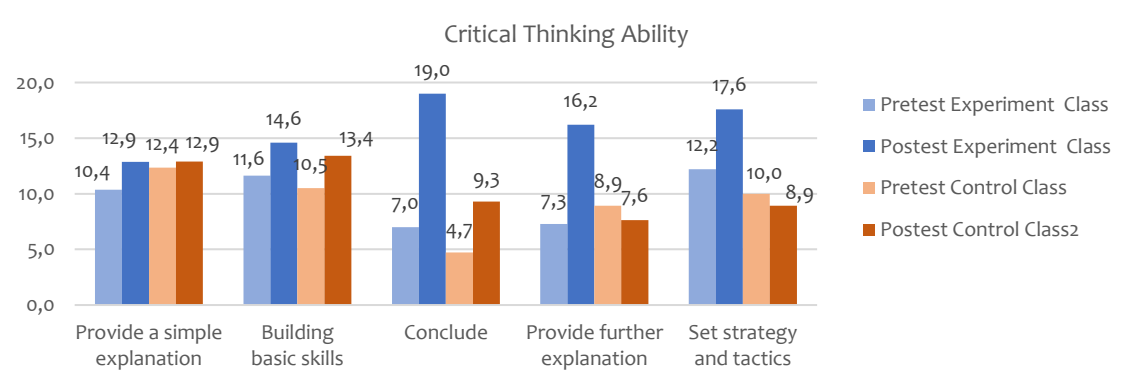

Figure 1. The Average Score of Critical Thinking Ability

Based on Figure 1, in the aspect of providing a simple explanation, the control class shows a pretest value of 12.36 and a posttest value of 12.89, so there is an increase of 0.53 (3.53%). In the aspect of building basic skills, the control value is 10.52, and the posttest value is 13.42, so there is an increase of 2.9 (19.33%). In the aspect of concluding, the pretest value is 4.73, and the posttest value is 9.31, so there is an increase of 4.58 (22.9%). In the aspect of providing further explanation, the pretest value is 8.94, and the posttest value is 7.63, so there is a decrease of 1.31 (-6.55%). Regarding arranging strategies and tactics, the pretest value is 10, and posttest is 8.94 in the control class, so there is a decrease of 1.06 (-3.53%). It can be seen that the highest average score occurred in the aspect of concluding, namely (22.9%), and the lowest score gain occurred in the aspect of providing a simple explanation, namely 0.53 (3.53%).

It can be concluded that critical thinking skills in the experimental class are better than those in the control class. The experimental class implemented E-worksheets with STEAM-PjBL, significantly influencing students' critical thinking skills compared to the control class, which used conventional models and books. Next, the normality test with the sample size was less than 50 (>50), so the Shapiro-Wilk test was conducted using IBM SPSS Statistics software version 22 with a significance level of 0.05. If the significance value is > (0.05), then the research data is normally distributed and vice versa.

Table 3. Results of the Normality Test

Class		Shapiro-Wilk			Result
		Statistics	df	Sig.	
Critical Thinking Ability	Pretest in Experiment Class	0,967	25	0,574	Normal
	Posttest in Experiment Class	0,926	25	0,072	Normal
	Pretest in Control Class	0,936	19	0,225	Normal
	Posttest in Control Class	0,929	19	0,165	Normal

Table 3 shows that the normality test results for the experimental and control classes obtained results of 0.574 and 0.225 with a sig value > (0.05). It can be concluded that the experimental and control classes are normally distributed. The homogeneity test results for the experimental and control classes obtained a significant level (0.05) used in the experimental class, which was 0.072 > 0.05, and

the control class, which was 0.263 > 0.05. Then, the posttest data for the experimental and control classes are normally distributed.

The homogeneity test with the One-Way ANOVA test was carried out. Based on the basic decision-making provisions, if the significance value is > (0.05), then the data is homogeneous and vice versa. Table 4 shows that the results of the homogeneity test of the pretest data of the experimental and control classes, with a significance level of 0.05, obtained the result sig (0.796) > 0.05. As for the results of the homogeneity test of the posttest data of the experimental and control classes with a significance level of 0.05, the result sig (0.311) > (0.05). Both pretest and posttest in the experimental and control classes have homogeneous data.

Table 4. The Results of Homogeneity Test

Data	*Lavene Statistic*	*Df1*	*Df2*	*Sig. Homogeneity*	Result
Pretest	0,068	1	42	0,796	Homogenous
Posttest	1,050	1	42	0,311	Homogenous

Hypothesis testing is conducted after normality and homogeneity tests. Hypothesis testing on pretest and posttest data uses an independent sample T-test. This test aims to determine whether there is a significant difference between pretest and posttest data in the experimental and control classes. The conclusion of the hypothesis test is as follows: If, Sig. (2-tailed) < (0.05), then Ho is rejected, and if Sig. (2-tailed) > (0.05), Ho is accepted.

Table 4 Data Results of Independent Sample T-test Pretest

Data	Pretest		Posttest	
	Experiment	Control	Experiment	Control
Average	48,48	46,57	80,28	52,21
Varian	161,927	180,702	236.960	135.620
N	25	19	25	19
Df	42		42	
Sig. (2-tailed)	0,634		0,000	
Conclusion	Sig. (2-tailed) > 0,05 H_0 accepted, H_a rejected		Sig. (2-tailed) < 0,05 H_a accepted, H_0 rejected	

Table 4 shows the pretest results of both groups obtained a Sig. (2-tailed) value of 0.634 > 0.05, so it can be concluded that Ho is accepted. There is no significant difference between the pretest experimental and control classes. This shows that the initial abilities of students are equivalent between the experimental and control classes before treatment. Furthermore, the hypothesis test with the independent sample T-test of the posttest data of both groups obtained a Sig. (2-tailed) value of 0.00 <0.05, so it can be concluded that Ho is rejected. There is a significant difference in the posttest from the experimental and control classes. It can be concluded that E-worksheets with STEAM-PjBL can improve students' high-level thinking skills in the experimental class.

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The Elements of Science, Technology and Mathematics

In science learning, preparation for the learning process is carried out concretely by asking several questions or preparing reading materials. At this stage, the teacher can provide E-worksheets with STEAM-PjBL related to the material being taught and ask questions to arouse students' curiosity. The preparation of learning process greatly determines learning outcomes. Thorough preparation will produce good results. At the beginning of learning, students were seen to be enthusiastic and enthusiastic because they received an explanation that they would carry out learning using the E-worksheets. After making preparations, students were given several basic questions displayed, and they understood and thought about the answers. These basic questions aim to explore students' initial knowledge.

In answering questions, students actively find answers using Chromebook to access the Website and QR Code video material provided in the E-worksheets. Students, in determining answers, actively convey their opinions through student thinking activities and answer questions about the coastal ecosystem so that it has an impact on students' critical thinking skills. When given basic questions, the subject's activeness increases in answering questions and expressing opinions. This is evidenced by the increase in indicators providing simple explanations focusing on questions and indicators of building basic skills by considering whether the source is reliable.

Designing Project Planning, Scheduling, and Monitoring Project Progress with Technology Elements

The second step is forming groups and observing the learning videos in the E-worksheets with STEAM-PjBL. The use of learning videos affects students' understanding of concepts. Students interact in groups by discussing with the group and then concluding what will happen if one of the components in the ecosystem is lost so that it can train students' critical thinking skills. Discussions in learning aim to involve students as system components, stimulate and motivate them, and teach them to be critical in analyzing and developing their ability to work together.

Figure 2. Students Plan and Present Poster Projects

The third step is planning and discussing related to the poster project to be made. Then, students and their groups work on the project. Students cooperatively plan a project to be right in planning, and then information related to the question is

collected. Due to time constraints, students continue working on the poster project at home.

The Evaluation of Art Elements

Students present the group poster project after receiving awards and reinforcement of the subject matter from the teacher. Presenting the group discussions in front of class trains students to be confident and think, especially in argumentation. The analysis can show this, and good answers are given by students to questions according to their abilities. Delivering arguments is easy verbally but difficult if you don't think according to expectations. Learning in the project model with the STEM approach can be said to improve students' skills, especially critical thinking skills. This is found in students' learning to present the results of the projects they have made. Applying the PjBL-STEAM model enables students to build skills in the real world: working together, making decisions, initiative, communication, problem-solving, and self-management. It can improve students' critical thinking skills. This is evidenced by the increase in indicators providing further explanations by defining terms and considering definitions in three dimensions, as well as indicators of organizing strategies and tactics with determining actions.

Based on the statistical test analysis, the experimental class that uses E-worksheets with STEAM-PjBL is superior to the control class that uses traditional books. This is because students are more interested in the experimental class. After all, they are directly involved in learning. It can be concluded that E-worksheets with STEAM-PjBL are effective and efficient to use to facilitate student understanding in learning, and critical thinking. It has shown that STEAM with PjBL can develop students' creative and critical thinking (Nuraini et al., 2023; Rr Tasya Noor Nabila & Agus Kamaludin, 2023; Salhuteru et al., 2025; Sigit et al., 2022). Furthermore, the integrated E-worksheets also can improve students creative thinking (Suprapto et al., 2023). E-worksheets can be used because it can help students understand the material (Lufri et al., 2020; Marthin et al., 2024; Subekti & Prahmana, 2021). The E-worksheets have a great influence on critical thinking skills because its use will have an impact on more enjoyable student learning activities. Students with critical thinking skills and joining learning activities will have broad problem-solving thoughts (Alifteria et al., 2023; Alkhabra et al., 2023; Alsaleh, 2020; Canale et al., 2022).

The results show that average score in the experimental class is higher than that of the control class. The developed STEAM-PjBL integrated student worksheets are effective in the high category based on the calculation value on the pretest and posttest results in the experiment class. Based on this, it can be concluded that the E-worksheets with STEAM and PjBL can assist students in learning. This research implies that the E-worksheets that have been developed can increase students' motivation and thinking skills to improve the critical thinking skills of fifth-grade elementary school students.

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4. Conclusion

Based on data analysis and discussion, it can be concluded that E-worksheets with STEAM and PjBL can influence the critical thinking skills of fifth-grade students from state elementary schools in Bengkulu City. This is indicated by the results of the increase in the average posttest score in the experimental class, which is higher than that of the control class. This can be seen from the average posttest score in the experimental class of 80.28, while in the control class, it is 52.21. The experimental class significantly increased because students were assisted using E-worksheets with STEAM and PjBL. This can make students actively discuss to attract students' interest and enthusiasm for learning, which will positively impact students' high-level thinking skills. This research developed E-worksheets that can improve the critical thinking skills of fifth-grade elementary school students

This research is limited to the material of coastal ecosystem. Recommendation for further research is the development of E-worksheet for other materials. Furthermore, future research can be suggested to determine the effectiveness of developed E-worksheets on learning outcomes in the classroom.

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Short Profile

Endang Widi Winarni is a professor at the Department of Primary Education, Graduate School, University of Bengkulu. She received her Bachelor of Science degree from the Department of Science at the State University of Yogyakarta and her Master of Science degree at the University of Malang's Department of Science. Located in Malang. Her research interests are primary education, disaster risk education, and science education. Email: endangwidi@unib.ac.id.

Debi Heryanto was graduated from Department of Primary Education, University of Bengkulu.

Yusnia is an assistant professor at the Department of Primary Education, University of Bengkulu. She received her Bachelor and Master degree from the Department of Primary Education, University of Bengkulu.

Neza Agusdianita is an assistant professor at the Department of Primary Education, University of Bengkulu. She received her Bachelor, Master and Doctoral degree from the Department of Primary Education, University of Bengkulu.

Endina Putri Purwandari is an associate professor at the Information System Department at the University of Bengkulu. She received her bachelor's degree from the Informatics Department at the University of Bengkulu. Furthermore, she graduated with a Master and a Doctoral degree from the Faculty of Computer Science, Universitas Indonesia. Her research interests include e-learning, mobile learning, learning application, and smart learning systems.

Andang Wijanarko is an assistant professor at the Information System Department at the University of Bengkulu. He received her Bachelor and Master degree from the Department of Information System, AMIKOM Yogyakarta.

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