



Effectiveness of PjBL Worksheet Based on Local Potential to Improve Critical and Creative Thinking Skills of Phase E High School Students

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Abstract: Involving local potential as teaching material content is an effort to create more contextual learning and introduce local potential to students. This study aimed to determine the effectiveness of the PjBL-Worksheet based on the regional potential of Gandong River in improving critical and creative thinking skills. The research method is a quasi-experimental nonrandomized control class pretest-posttest design. The study was conducted in January-March 2024. The research population was students of Phase E of SMA 1 Sukomoro, Indonesia. The research sampling technique was cluster random sampling, and the research sample was students of classes Phase E.1 and E.5. The method of collecting data on critical and creative thinking skills was using a test technique. The instrument used to collect data was valid and reliable essay questions. The data were analyzed descriptively and using one-way MANOVA tests. The result of $0.00 < 0.05$ means that applying the PjBL Worksheet based on the local potential of Sungai Gandong was practical in simultaneously improving students' critical and creative thinking skills. The results of further tests showed that the treatment given had a simultaneous effect on critical thinking skills by 68.3% and creative thinking by 62.3%.

Keywords: 21st-century skills; biology learning; problem-based learning; student worksheets; teaching materials

Recommended citation: Sari, T. N. I., Rakhmawati, A., & Rakhmawati, H. R. (2025). Effectiveness of PjBL Worksheet Based on Local Potential to Improve Critical and Creative Thinking Skills of Phase E High School Students. *Journal of Innovation in Educational and Cultural Research*, 6(2), 242-252.

INTRODUCTION

The teaching and learning process in 21st-century learning must meet the standards of graduates in this century, meaning that students must be equipped with several relevant skills, one of which is the skills to think critically and creatively (Sumarni & Kadarwati, 2020). According to Retnawati et al. (2018), critical and creative thinking skills are necessary for utilizing students' knowledge. The skills to solve problems and make decisions in various areas of life are also important. Creative thinking is crucial in solving problems and generating new ideas (Suherman & Vidákovich, 2022). Critical thinking skills are the key to developing creative thinking skills, and the emergence of creative thinking is due to critically seeing phenomena, hearing, and feeling, thus requiring creative thinking. The skills to think critically and creatively are like two sides of a coin that cannot be separated, each providing meaning to the other (Evans, 2020; Thornhill-Miller et al., 2023).

It is known that thinking critically and creatively is important for students. However, several previous research results show that students' critical thinking skills are still low. Sari and Wardhani (2020) state that students' critical thinking skills are still in the low category. Junaedi et al. (2021) similarly found that the critical thinking skills of secondary school students on water pollution material are still relatively low. Mursid et al. (2022) concluded that the creative thinking skills of university students are still relatively low. In general, previous research shows that the critical and creative thinking skills of students in Indonesia are still relatively low. A research survey also reinforces this finding, showing that students' critical and creative thinking skills in the Magetan Regency are still relatively low. According to Nurhayati et al. (2022) and Ramdani et al. (2021), There are several causes of students' low thinking skills, one of which is using media and teaching materials that need to be more appropriate to students' needs and characteristics. Teachers in schools generally only use textbooks from the government and worksheets from publishers as learning resources. The needs of each student at each school are different (Latifah et al., 2020). These results are in line with the results of observations and interviews at one of the high schools in Magetan Regency. The results of observations and interviews with teachers and students in the biology learning process show that the use of media and teaching materials still uses textbooks from publishers, and teachers still need to compile the teaching materials used themselves. Apart from that, the biology learning process is predominantly carried out in theory in the classroom. Lastly, biology learning has yet to utilize the local potential of the surrounding environment. It must be understood that the skills to think critically and creatively have a crucial role in learning today. Apart from that, providing media and teaching materials that can accustom students to think critically and creatively is also a job

for all stakeholders because teaching materials play a crucial role in ensuring the effectiveness of teaching and learning activities (Hartini et al., 2020). One effort to be made is to present a PjBL worksheet based on the local potential of the Gandong River. PjBL worksheet means that the worksheet will be carried out based on the Project-based Learning (PjBL) learning syntax. PjBL worksheet is integrated with local potential in environmental problems. The PjBL worksheet, based on local potential, will guide students in solving problems presented by the project learning syntax packaged in the worksheet. The study or discussion material in the worksheet is based on local potential regarding the local potential of the Gandong River, Magetan Regency. Local potential in learning makes learning more meaningful through students' activities in discovering concepts (Amsikan & Deda, 2018) and helps students process and learn independently (Setyorini, 2023). Teachers can develop materials based on local potential in fun learning activities, which are expected to foster students' attitudes and character, such as tolerance, coordination, and caring (Haka et al., 2020). The integration of local potential in the learning process is expected to be able to shape students' character through the noble values of local culture (Ismiyanti & Afandi, 2022), raise awareness of environmental conservation (Setyorini, 2023), and increase students' sense of love and sensitivity to the enormous potential of the environment in which they live (Busyairi et al., 2022). Apart from the PjBL worksheet based on the local potential of the Gandong River, the use of the PBL worksheet can also empower students' critical and creative thinking skills. The research results of the PBL learning model are also effective in improving critical thinking skills (Xu et al., 2023) and creative thinking (Simangunsong et al., 2023). PBL and PjBL both use constructivist learning theory (Radjawane, 2023; Suryati et al., 2023), and these two learning models use actual problems as the main focus of learning (Anazifa & Djukri, 2017; Simbolon & Koeswanti, 2020). PjBL emphasizes that students produce a final product, and PBL produces something theoretical. A similar opinion was expressed by Musaad and Suparman (2023) and Srirahmawati et al. (2023). These learning models are considered the best methods for teaching and training students in developing and improving the 21st-century skills required by today's industry. Several research results regarding the application of the PjBL learning model are effective in improving students' critical thinking skills (Firda & Sunarti, 2022; Pantiwati et al., 2022) and creative thinking skills (Firda & Sunarti, 2022; Yamin et al., 2020).

The description shows that using the PjBL Worksheet and involving local potential in learning have positively influenced critical and creative thinking skills. There have been many studies involving local potential in education. However, minimal research still utilizes local potential in Magetan Regency (Sari, 2023). Based on the geographical location, Magetan Regency has abundant natural resources and local wisdom. However, not many studies have examined the local potential of Magetan Regency as a source of learning. Learning must be able to introduce students to the importance of the surrounding environment, and students must be able to implement the results of the learning process in everyday life; learning alone is not enough if it can only provide knowledge. Therefore, this study aims to determine the effectiveness of the PjBL Worksheet based on the local potential of the Gandong River on water pollution material to improve the critical and creative thinking skills of phase E students.

METHODS

This research is quasi-experimental with a nonrandomized control class pretest-posttest design (Lavery, 2018; Li et al., 2018). The research was carried out in January-March 2024. The study was conducted at SMA 1 Sukomoro, Magetan Regency, Indonesia. The independent variables in the study are the PjBL worksheet based on the local potential of the Gandong River and the PBL worksheet. Meanwhile, the dependent variable in this research is critical thinking skills (Y1) and creative thinking skills (Y2).

Table 1. Experimental Research Design

Treatment	Pre-Test	Post-Test
PJBL worksheet based on the local potential of the Gandong River	Y1	Y2
PBL worksheet	Y1	Y2

The population of this study was phase E class students at Senior High School 1 Sukomoro. The research sample was students from Phase E.1 and Phase E.5. Two classes were taken randomly using cluster random sampling.

Table 2. Research Sample

Class	Treatment Class	The number of students	
Phase E.1	Experiment	Man	13
		Woman	20
Phase E.5	Control	Man	9
		Woman	20

The data collection technique in this research was using tests. The test data collection technique obtains data on students' critical and creative thinking skills in phase E. The test data collection technique uses an essay question instrument. The critical thinking essay questions totaled seven valid questions with real skills of 0.74, while the creative thinking questions totaled seven valid questions with real skills of 0.79 (Sari & Rakhmawati, 2024). Research conducted in the experimental and control classes used different worksheets. Still, based on previous research literature reviews, the treatment given to the experimental and control classes could improve students' critical and creative thinking skills. The PjBL worksheet based on local potential was previously tested in the experimental class on the feasibility and practicality of learning media and material experts (Table 3). In contrast, the practicality was carried out on Biology Teachers and high school students (Table 3). Validation was carried out for the control class PBL worksheet, using expert lecturers' opinions regarding suggestions and input as considerations for improving the PBL worksheet. This shows that there is no difference in the use of learning scenarios in the experimental and control classes, so both the control and experimental classes receive the same treatment, or the learning scenarios used have the potential to develop students' critical thinking skills and creative thinking.

Table 3. Average PjBL-Worksheet Based on Local Potential of Gandong River Assessment Results

Expert/Practitioner	Average Assessment Result	Description
Media and teaching materials expert	79%	Very Worthy
Material expert	81%	Worthy
Teacher Practitioner	85%	Very Practical
Student Practitioner	81%	Very Practical

The research procedures in the experimental and control classes had almost the same procedures. In both the experimental and control classes before and after learning, a pre-test was carried out to measure students' critical thinking and creative thinking skills before learning, and a post-test measured students' critical thinking and creative thinking skills after learning. The experimental class was taught three times (Table 4). The first meeting worksheet contains project learning steps: 1) setting basic questions, 2) designing a project plan, and 3) designing a project schedule. The second meeting worksheet contains project learning steps: 1) monitoring project activities and 2) studying local potential. The third meeting worksheet tests the results and evaluates the experience. Furthermore, in the control class, learning with worksheets was carried out twice (Table 3). The first meeting worksheet contains 1) orienting students to the problem, 2) coordinating students to learn, and 3) fostering individual or group research. Meanwhile, the second meeting worksheet includes 1) optimizing and displaying results and 2) analyzing and evaluating the problem-solving process.

Table 4. Learning Scenarios in Experimental and Control Classes

PjBL worksheet based on the local potential of the Gandong River	Skills		PBL worksheet	Skills	
	Critical thinking	Creative thinking		Critical thinking	Creative thinking
Start with the big questions (Worksheet 1)	Give a simple explanation	Fluency	Orienting students to the problem (Worksheet 1)	Give a simple explanation	Fluency
Designing a project plan (Worksheet 1)	Create estimates and integrations	Authenticity Elaboration	Coordinating students to learn (Worksheet 1)	Create estimates and integrations	Fluency Flexibility
Prepare a project schedule (Worksheet 1)	Determine the basis for decision-making	Fluency	Fostering individual or group research (Worksheet 1)	Determine the basis for decision-making	Elaboration
Project implementation and monitoring (Worksheet 2)	Create estimates and integrations	Elaboration Flexibility	Optimizing and displaying results (Worksheet 2)	Create estimates and integrations Make further explanations	Fluency Elaboration Flexibility
Testing the results (Worksheet 3)	Make further explanations	Elaboration	Analyzing and evaluating the problem-solving process (Worksheet 2)	Menarik Draw a conclusion	Elaboration
Evaluation and Reflection on Experience (Worksheet 3)	Draw a conclusion	Elaboration			

Data on the critical and creative thinking skills of phase E students in the experimental and control classes were analyzed descriptively to determine the average differences in students' critical and creative thinking skills in the two classes. Next, the data was analyzed using one-way MANOVA to determine the effectiveness of the PjBL worksheet based on local potential in Sugai Gandong with the help of IBM SPSS 27 software. In the one-way MANOVA test, several prerequisite assumptions must be met, namely 1) the data comes from a distributed population, multivariate normal, 2) homogeneity of variance-covariance matrix, and 3) multicollinearity (Sutadji et al., 2022). If the prerequisite test assumptions are met, then the research data is analyzed using the one-way MANOVA test. If the prerequisites are unmet, the data is analyzed using non-parametric tests, such as the Mann-Whitney test.

Table 5. MANOVA Hypothesis Test

Decisions	Hypothesis
Sig > 0.05	The PjBL worksheet based on the Gandong River's local potential is ineffective in improving the critical and creative thinking skills of phase E students with students who study not using the PjBL worksheet based on the local potential of the Gandong River on water pollution material.
Sig < 0.05	At least the PjBL worksheet based on the local potential of the Gandong River is effective in improving the critical and creative thinking skills of phase E students with students who study not using the PjBL worksheet based on the local potential of the Gandong River on water pollution material.

RESULT AND DISCUSSION

The research results in Figure 2 show that the average pre-test score for critical thinking skills in the experimental class was 50, and the post-test score was 85. Meanwhile, the average pre-test score for students' critical thinking skills in the control class was 48, and the post-test average was 75. It can be said that there is a difference in students' average critical thinking scores before and after the learning process in either the experimental or control classes. However, the difference in the average critical thinking score of students who took part in learning using the PjBL worksheet based on the local potential of the Gandong River was higher than that of students who took part in the learning process in the control class.

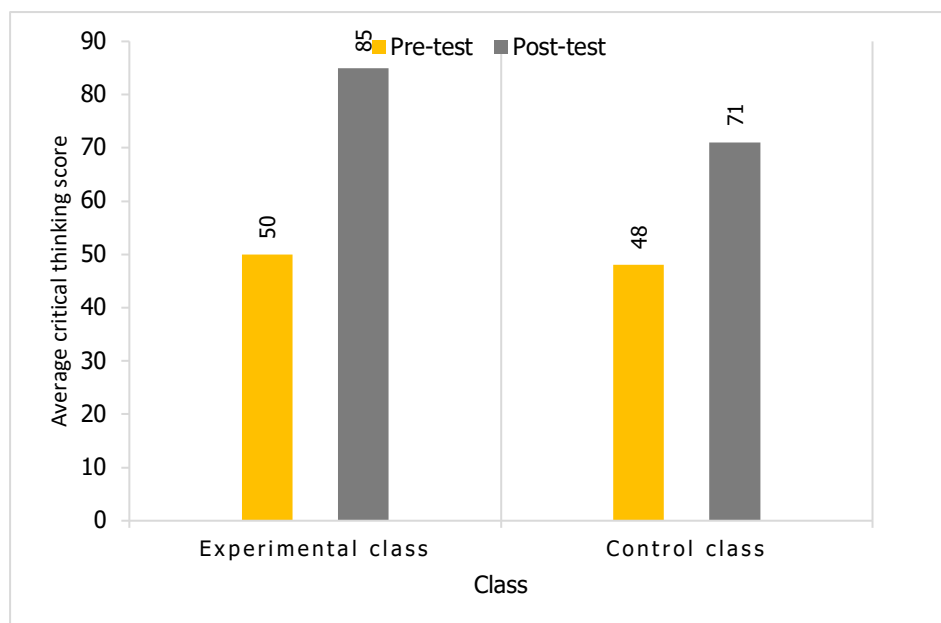


Figure 1 . Comparison of the Average Increase in Pre-test and Post-test Critical Thinking Skills Scores for Experimental and Control Classes

The results of the average of the creative thinking skills of phase E students stated that there was a difference between the average value of the experimental class and the control class. Figure 3 shows that the experimental class's average pre-test score for creative thinking skills was 47, and the post-test score was 86. Meanwhile, the average pre-test score for the creative thinking skills students in the control class was 46, and the average post-test score was 73. It can be stated that there is a difference in the average value of students' creative thinking skills before and after the learning process in both the experimental class and the control class.

However, the difference in the average creative thinking score of students in the phase class with the PjBL worksheet based on the local potential of the Gandong River is higher than that of students who took part in learning in the control class.

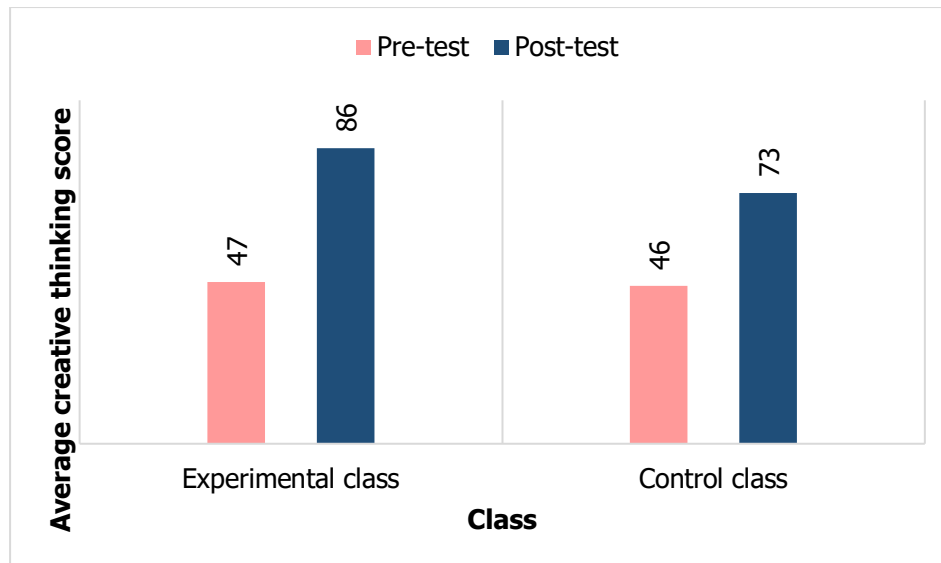


Figure 2. Comparison of the Average Increase in Pre-test and Post-test Scores for Creative Thinking Skills in Experimental and Control Classes

The results of the multivariate normality test in the experimental and control classes obtained a sig value of $0.00 < 0.05$, meaning that the critical thinking and creative thinking skills data from the experimental and control classes came from a normally distributed population (Table 6).

Table 6. Qi Value and Mahalanobis Distance

Mahalanobis Distance			Qi
Mahalanobis Distance	Pearson Correlation	1	.985**
	Sig. (2-tailed)		.000
	N	62	62
Qi	Pearson Correlation	.985**	1
	Sig. (2-tailed)	.000	
	N	62	62

In addition to the normality test, the following prerequisite is the homogeneity test. The homogeneity test results of the variance-covariance matrix in Table 7 Box's M show a significance value of the homogeneity test of $0.075 > 0.05$, meaning that the population variance-covariance matrix is the same or homogeneous.

Table 7. Variance-Covariance Matrix Homogeneity Test Results

Box'M	F	df1	df2	Sig
7,180	2,307	3	1476717.965	0,075

The last prerequisite test is the multicollinearity test. The results of the multicollinearity test of critical thinking skills in Table 8 show a tolerance value of $0.650 > 0.10$ and a VIF value of $1.537 < 10.00$, meaning there is no multicollinearity of the critical thinking skills variable in the regression model. Furthermore, the results of the multicollinearity test of creative thinking skills in Table 8 show a tolerance value of $0.650 > 0.10$ and a VIF value of $1.537 < 10.00$, meaning that there is no multicollinearity of the creative thinking skills variable in the regression model.

Table 8. Multicollinearity Test Results

Variable	t	Sig.	Collinearity Statistics Tolerance	VIF
Critical thinking	-8.133	.000	.650	1.537
Creative thinking	-6.796	.000	.650	1.537

The results of the multivariate prerequisite test on the research data are generally met; namely, the data is usually distributed and homogeneous, and there is no multicollinearity in the regression model. Therefore, the research data can be continued to the hypothesis testing stage with the one-way MANOVA test. The results of the one-way MANOVA test in Table 9 obtained a sig value of $0.00 < 0.05$, meaning that the implementation of the PjBL worksheet based on the local potential of the Gandong River in the experimental class effectively increased students' critical and creative thinking skills compared to the control class simultaneously. In addition, Table 9 shows that the partial eta squared value of 0.822 means that implementing the PjBL worksheet based on the local potential of the Gandong River contributed to increasing critical and creative thinking skills by 0.822 (significant effect).

Table 9. Multivariate One-Way MANOVA Test Results

Effect	Sig.	Partial eta squared
Hotelling's Trace	0.000	0,822

The results of the advanced test results in Table 10 on the critical thinking skills of phase E students, when learning was applied with the PjBL worksheet based on the local potential of the Gandong River with the PBL worksheet (on the other hand), obtained a sig value of $0.00 < 0.05$, meaning that the application of the PjBL worksheet was based on the local potential of the Gandong River is effective in improving students' critical thinking skills. Finally, there is a further test of creative thinking skills. The results of pairwise comparisons of creative thinking skills have a sig value of $0.00 < 0.05$ that the implementation of the PjBL worksheet based on the local potential of the Gandong River is effective in increasing students' creative thinking skills.

Table 10. Advanced Test Results

Variable	(I) Class	(J) Class	Mean Difference (I-J)	Std. Error	Sig. ^b	95% Confidence Interval for Difference ^b	
						Lower Bound	Upper Bound
Critical thinking	Experiment	Control	27.444*	2.412	.000	22.620	32.269
	Control	Experiment	-27.444*	2.412	.000	-32.269	-22.620
Creative thinking	Experiment	Control	23.311*	2.340	.000	18.631	27.992
	Control	Experiment	-23.311*	2.340	.000	-27.992	-18.631

Lastly are the results of the effect size test, the research results in Table 11 of partial critical thinking skills obtained an eta squared value of 0.683 with a sig value of $0.00 < 0.05$, meaning that the implementation of PjBL worksheet based on local potential Gandong River is effective in increasing students' critical thinking skills with the contribution of PjBL worksheet based on the local potential of the Gandong River on students' critical thinking skills was 68.3%. Meanwhile, the results of the effect size test for creative thinking skills in Table 11 obtained a partial eta squared value of 0.623 with a sig value of $0.00 < 0.05$, which means that the implementation of the PjBL worksheet based on local potential in the River is effective in increasing students' creative skills with the contribution of PjBL worksheet based on local potential Gandong River on creative thinking skills was 62.3%.

Table 11. Effect Size Test Results

Source	Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Class	Critical thinking	11626.000	1	11626.000	129.489	.000	.683
	Creative thinking	8387.893	1	8387.893	99.263	.000	.623

This study aims to determine the effectiveness of implementing the PjBL Worksheet based on the Gandong River's local potential to improve phase E students' critical and creative thinking skills on water pollution material. Learning in the experimental and control classes was carried out for 1 month. The local potential studied in this study was the Gandong River. The Gandong River is one of the longest rivers in the Magetan Regency. In the last few decades, this river has experienced a crucial problem, namely being a place to dispose of irresponsible leather industry waste; as a result, several points of the Gandong River have experienced water pollution. Several previous research results regarding water quality in the Gandong River also reinforce the findings regarding water pollution (Fenani et al., 2022; Ni'mah et al., 2021). Later, the Worksheet will present some data from water quality research on the Gandong River. The PjBL Worksheet based on the local potential of the Gandong River will guide students in project activities. This project activity is an effort by students to

solve the water pollution problem in the river environment. Students are free to convey their ideas, which will later be used as ideas for implementing project activities with the Worksheet. The output of project learning in the experimental class is the creation of a simple water filter.

The first finding is that the PjBL Worksheet, based on the local potential of the Gandong River, is efficacious in improving critical thinking skills with a significant influence of 68.3%. This finding is relevant to previous studies that the implementation of the PjBL Worksheet is effective in optimizing the critical thinking skills of high school students through the project learning process steps contained in the Worksheet (Efriansyah & Wahyuni, 2021; Kartika et al., 2019; Widiyawati et al., 2020) and the integration of local potential or local wisdom in the learning process has a positive impact on critical thinking skills (Haliq et al., 2023; Ramdani et al., 2021; Susanto et al., 2021). Worksheets generally contain tables, tasks, directions, or stages that help students complete their work. Its implementation must clearly express essential skills that must be achieved. Worksheet supports and facilitates learning process activities, which allow effective relationships between students and teachers and increase student activities to improve academic achievement (Dwijayanti et al., 2022). In this study, the steps of activities used as a reference for students are project learning steps. The project learning scenario in Worksheets is packaged into directions that students carrying out project activities must carry out. Their projects are integrated by involving the local potential of the Gandong River.

According to Rahmi et al. (2023), involving local potential in the science learning process optimizes students' critical thinking skills because it provides a direct experience to pursue understanding and provide in-depth knowledge. Integrating local potential in knowledge and practice in educational science presents something more relevant and contextual to the student's learning environment. This practice is also applied in this study, and involving the local potential of Gandong River can create more contextual learning. In addition, it is essential to involve local potential in learning to introduce students to recognize the potential and wisdom of the surrounding environment. A similar opinion was expressed by Verawati and Wahyudi (2024) involving local wisdom, potential, and culture in science learning supports the development of critical skills and solving students' problems because it provides promising opportunities for students to overcome current challenges by connecting scientific knowledge and traditional exploration. Therefore, the PjBL Worksheet, based on the local potential of Gandong River, is effective as a forum for students to get used to thinking critically. In completing project activities in Worksheet, students must first be able to identify problems, formulate hypotheses, analyze, and communicate results.

The second finding is that the PjBL Worksheet is based on the local potential of Gandong River for students' creative thinking, with a significant influence of 62.3%. This finding is relevant to Siregar et al. (2023) and Tasya et al. (2023). The high school students' creative thinking increased after learning with worksheets based on project learning. According to Yusnidar et al. (2023), with PjBL Worksheet, students are more motivated to develop a deeper understanding of the subject matter because they have to apply their knowledge in the context of real projects. Ramadianti et al. (2021) state that the project-based learning process model emphasizes the learning process that uses project activities as its media. Students can build their knowledge by creating experiences from their activities in each project in the Worksheet, and learning objectives will be achieved by providing meaningful experiences to students. Students will conduct assessments, synthesis, exploration, interpretation, and understanding with project activities to create several learning outcomes to design artifacts (Astra et al., 2019). In addition to the PjBL Worksheet, this teaching material is also based on the local potential of the Gandong River. Tamimiya and Suryadarma (2019) state that implementing an integrated PjBL Worksheet with Gunung Kawi's local potential positively influences students' creative thinking in science learning. Wati et al. (2023) show that integrating local potential in science learning positively impacts critical thinking skills and student creative thinking. By involving local potential with PjBL, students feel more involved in decision-making, solving problems, and collaborating with peers. According to Suwarno et al. (2020) and Zhang and Ma (2023). The project learning scenario emphasizes student activity in solving a problem by applying skills in conducting research, analysis, creating, and producing a work or product. Thus, students are emphasized as active and independent in the project learning process (Yuliyana et al., 2022).

In general, the results of the study indicate that using the PjBL Worksheet based on the local potential of the Gandong River is efficacious in improving students' critical and creative thinking skills. This finding shows that involving local potential can be used as an innovation in learning to enhance the quality of education. Involving local potential can also be used as a forum to preserve each region's potential and local wisdom. The Gandong River, as a local potential, must be maintained to continue to be utilized for the benefit of the community; the local potential is a specific resource owned by a region, including natural and cultural resources (Destiara, 2020). Learning based on the local potential of the Gandong River as an effort in the field of education to play a role in maintaining the environmental balance of the Gandong River and in supporting the demands of the independent curriculum to utilize local potential can shape students' understanding of the advantages and wisdom of the area where they live and make the learning process more applicable and meaningful (Khairani et al., 2023).

CONCLUSION

The results of the one-way MANOVA test, which had a significance level of 5%, showed that the PjBL Worksheet, based on the local potential of Gandong River, effectively improved students' critical and creative thinking skills. This result is also reinforced by the average pre-test and post-test scores of students' critical and creative thinking skills, which showed that in the experimental class, the average was superior to the control class. In general, this study's results indicate that using the PjBL Worksheet based on the local potential of Gandong River contributes more to improving students' critical and creative thinking skills. These results suggest that the PjBL Worksheet, based on the local potential of Gandong River, can be used as an alternative to empower students' critical and creative thinking skills, especially since these two skills are essential for students. In addition to empowering students' critical and creative thinking skills, involving local potential in learning creates more contextual understanding, and the more important point is to introduce students to the surrounding environment. Regardless of the study's results, these results effectively improve students' critical and creative thinking skills with a significance level of 5%; therefore, for further research, a significance level other than 5% can be used to determine the effectiveness of the treatment given. In addition, in this study, the effectiveness test was still carried out in limited schools; for further research, it can be applied on a broader scale with several different school categories so that the effectiveness of this product can be known in a more complex way.

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