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The Effectiveness of PjBL-STEAM Using GeoAI Media: Junior High School Students' Creative Thinking Skills

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ABSTRACT

The problem identified in this study stemmed from the condition of science learning, which remained limited to the learning model and media used, resulting in less effectiveness in developing creativity. Therefore, this study was conducted to test the effectiveness of the Project Based Learning (PjBL) model integrated with the Science, Technology, Engineering, Arts, and Mathematics (STEAM) approach using Geospatial Information System Artificial Intelligence (GeoAI) media in improving students' creative thinking skills. This study used a mixed-methods design with an embedded experimental model, where the data collection techniques were carried out through pre-research interviews, pretests and posttests, questionnaires, and interviews after the intervention. The research sample consisted of second-semester students from class VIII at Public Junior High School 1 Weru. We processed the data using normality tests, homogeneity tests, paired sample t-tests, independent sample t-tests, and N-Gain tests. The results showed a significant increase in creative thinking skills in the experimental class. The improvement was evidenced by the results of the average pretest score of 66.32, then the posttest increased to 90.44, with a very significant difference compared to the control class. The N-Gain test also recorded improvements, with an average score of 0.69 in the moderate category. This finding is reinforced by qualitative data from questionnaires and interviews, which showed a very positive response from students to the GeoAI-assisted PjBL-STEAM model, achieving an average score of 75.99% out of a maximum score of 100%.

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1. INTRODUCTION

The demands of the 21st century extend beyond assignments to material but also emphasize the development of creative thinking, collaboration, and communication skills (González-Pérez & Ramírez-Montoya, 2022; Thornhill-Miller et al., 2023). These skills are crucial to helping students solve complex problems and adapt to technological advances. To face these challenges, the Indonesian government faces these challenges through an independent curriculum that forms the profile of Pancasila students who have global competencies; students are able to face the complexities of the future by producing superior graduates (Stkipsubang, 2022). This is in line with the idea of Society 5.0, which urges the integration of advanced technologies such as Artificial Intelligence (AI) and Geographic Information Systems (GIS) to improve students' understanding and skills (Lee, 2023). This makes it possible to implement effective science learning. Still faces various obstacles. Previous research shows that science learning in schools often still uses conventional media, making it less effective in developing students' creative thinking skills (Yang et al., 2016; Jannah & Atmojo, 2022). This condition is strengthened by the results of pre-research interviews with science teachers at public junior high school 1 Weru. Teachers revealed that ecology and community service materials are often limited to observations in the school environment, making it difficult to answer participants' curiosity broadly regarding endemic animals and their habitats in the region as a whole.

Addressing the gap between student needs and the limitations of conventional media requires innovation in learning models. To address this issue, the Project-Based Learning (PjBL) model, combined with a Science, Technology, Engineering, Arts, and Mathematics (STEAM) approach, has proven effective as a solution (Mufida et al., 2020; Zayyinah et al., 2022). The PjBL-STEAM model directly focuses on developing skills needed in the 21st century, as stated by Indahwati et al. (2022). This model encourages more active learning and creative thinking (Chen et al., 2022), which are derived from student involvement in project work (Lu et al., 2022).

STEM Project-Based Learning (PjBL) is an interdisciplinary learning model that integrates the disciplines of Science, Technology, Engineering, and Mathematics (STEM) through a Project-Based Learning (PjBL) approach (Lou et al., 2017; Pérez Torres et al., 2023). Students work on real-life projects to solve everyday problems, develop innovative products, processes, and systems, and practice collaboration, problem-solving, and critical thinking skills.

The main concepts of STEM Project-Based Learning (PjBL) are: STEM Integration: Combining four disciplines (science, technology, engineering, and mathematics) into a holistic whole (Chistyakov et al., 2023; Sukmawati et al., 2023; Baidal-Bustamante et al., 2023). PjBL Approach: Students engage in real-life projects as the foundation of the learning process, accumulating and integrating new knowledge (Sukackė et al., 2022). Focus on Problem Solving: Students are encouraged to discover solutions to real-life problems. Skills Development: Trains students to become problem solvers and developers of innovative products, while enhancing their communication, collaboration, and critical thinking skills.

The implementation of STEM Project-Based Learning (PjBL) generally involves several stages (Diana & Sukma, 2021; Retno et al., 2025): 1. Reflection: Brings students into the context of the problem and inspires them to conduct investigations. 2. Research: Facilitates students in researching science concepts, searching for relevant information, and collecting data. 3. Discovery: Students discover the learning process, identify unknown knowledge, and design project steps. 4. Application: Students create problem-solving models, test the models, and can return to previous steps if necessary. 5.

Communication: Students present models and solutions to develop communication and collaboration skills and receive feedback.

As an innovation in the PjBL-STEAM learning model, the medium used is Geospatial Artificial Intelligence (GeoAI), which is the application of Artificial Intelligence to Geospatial data (Usery et al., 2022). GeoAI media allows students to analyze and visualize biodiversity from various regions in an interactive manner, thus overcoming the limitations of learning in a school environment (Lee, 2023). Geospatial artificial intelligence (GeoAI) is the application of artificial intelligence (AI) combined with geospatial data, science, and technology to accelerate real-world understanding of business opportunities, environmental impacts, and operational risks (VoPham et al., 2018; Janowicz et al., 2020). Various organizations are modernizing operations to operate at scale through automated data generation and accessible spatial tools and algorithms.

Building upon the explanation above, researchers are interested in conducting further research on the PjBL-STEAM learning model using GeoAI media on the topic of Indonesian ecology and biodiversity. This is to improve the creative thinking skills of seventh-grade students. Creative thinking skills are the ability to generate new ideas and unique solutions to problems, involving abilities such as flexible thinking, imagination, fluency, originality, and the ability to elaborate or detail those ideas. These skills are crucial in various areas of life, not just the arts, and can be cultivated through practices such as submitting proposals. These skills encompass fluency, flexibility, and originality and are essential for developing self-confidence and responsibility as active citizens. Therefore, this study was conducted to test the effectiveness of the Project-Based Learning (PjBL) model integrated with the Science, Technology, Engineering, Arts, and Mathematics (STEAM) approach using Geospatial Information System Artificial Intelligence (GeoAI) media in improving students' creative thinking skills. This research is needed to fill this gap.

2. METHOD

This study employs an embedded experimental mixed-methods design, as described by Creswell and Creswell (2017), to simultaneously obtain both quantitative and qualitative data during the learning process that utilizes the PjBL-STEAM model supported by GeoAI Media, focusing on biodiversity material in Indonesia. The selected research sample consisted of second-semester students from class VIII at Public Junior High School 1 Weru. In selecting the sample using purposive sampling, two classes were chosen as the control class and the experimental class (Cohen et al., 2017). The following is the embedded experimental mixed-methods design model in Figure 1.

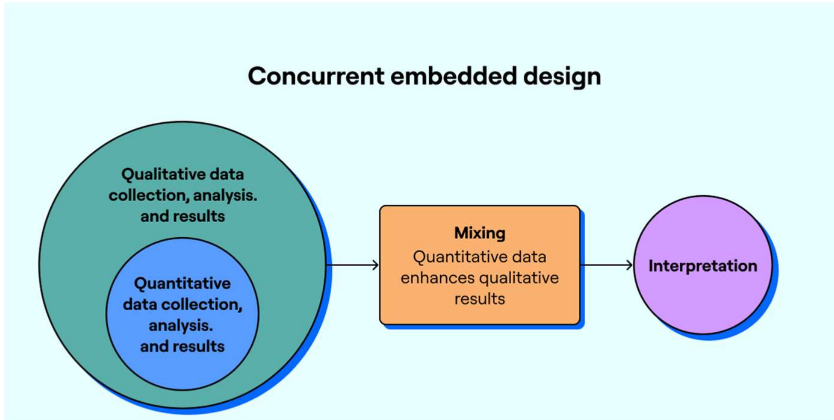

Figure 1. Embedded Experimental Mixed Methods Design

The steps of the "Embedded Experimental Mixed Method" approach involve research planning, quantitative data collection as the primary focus, and concurrent qualitative data collection embedded within it to explain or complement the quantitative data. This is followed by data analysis, both quantitative and qualitative, and the integration of the two to gain comprehensive insights. Finally, the results are interpreted and reported.

The selection of two classes as the control and experimental classes was based on the criteria of having homogeneous academic abilities and not yet receiving ecology and biodiversity material. This criterion was used to ensure the effectiveness of the GeoAI-assisted PjBL-STEAM model. Data collection criteria included pre-research needs interviews to identify real-world problems in schools (Braun & Clarke, 2021). Pretests and posttests, among others, were used to gauge the students' creative thinking skills. Student response questionnaires are utilized to gauge students' reactions to the learning process. We conduct student response interviews to gather qualitative data that complements the results of the questionnaires.

3. RESULTS AND DISCUSSION

Results

The effectiveness of the PjBL-STEAM model using GeoAI to improve creative thinking skills was analyzed by examining the pretest and posttest data from both the control and experimental classes, which included determining the number of participants, minimum value, maximum value, mean, and standard deviation.

Table 1. Pretest and Posttest Results of the Control Class and Experimental Class

	N	Minimum	Maximum	Mean	Std. Deviation
Control Pretest	34	50	85	66.18	9.460
Control Posttest	34	65	90	75.74	6.977
Pretest Experiment	34	50	85	66.32	9.638
Experiment Posttest	34	80	100	90.44	5.555
Valid N (listwise)	34				

Table 1 shows the minimum value of the control class pretest is 50 and the posttest is 65, while the minimum value of the experimental class pretest is 50 and the posttest is 80. The maximum value of the control class pretest is 85 and the posttest is 90, while the maximum value of the experimental class pretest is 85 and the posttest is 100. This result indicates that the learning intervention carried out by the researcher in the experimental class is more effective compared to the control class. The following is an illustration of the data from Table 1 in Figure 2.

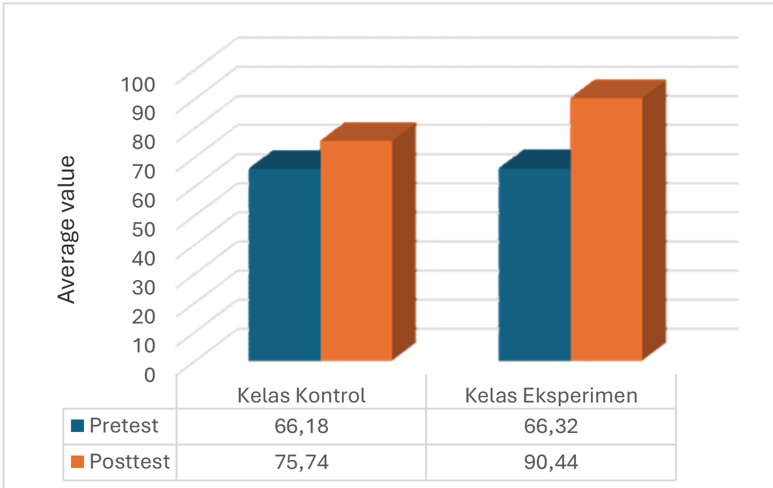

Figure 2. Pretest and posttest results for the control class and experimental class

According to the analysis in Figure 1, the average posttest score was higher than the pretest score, and the posttest score for the experimental class was higher than the posttest score for the control class. This data is visual evidence that can support the statement indicating that the intervention carried out by the researcher in the experimental class regarding the effectiveness of learning using PjBL integrated with STEAM was more effective than the control class. This hypothesis will be proven by the results of the normality test, homogeneity test, paired sample test, independent sample t-test, N-Gain test, and analysis of student interviews after the intervention.

Normality Test

The normality test was conducted to ensure that the data from the control and experimental classes were normally distributed before further testing. The following is a normality test for the pretest data for the control and experimental classes.

Table 2. Results of the Normality Test

	Class	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Learning Outcomes	Control	.157	34	.033	.940	34	.063
	Experiment	.149	34	.055	.949	34	.113

The analysis of the normality test on the pretest data, the significance value in the Shapiro-Wilk test for the control class obtained a value of .063 or 0.063 while the experimental class obtained a value of .113 or equivalent to 0.113. The data for both classes were stated to be normally distributed. The normality assumption is met because the significance value in the Shapiro-Wilk test for the control and experimental classes is more than 0.05.

Homogeneity Test

The homogeneity test was conducted to ensure that the data variance between the control and experimental classes was homogeneous in the initial stages of the study.

Table 3. Results of Homogeneity Test

		Levene Statistic	df1	df2	Sig.
Learning Outcomes	Based on Mean	.012	1	66	.912
	Based on Median	.012	1	66	.914
	Based on Median and with adjusted df	.012	1	65.992	.914
	Based on trimmed mean	.012	1	66	.912

The results of the homogeneity test analysis conducted on the pretest data showed that the variance of the two groups was homogeneous with a significance value of 0.912. Based on this statement, it proves that there is no significant difference in variance between the control class and the experimental class in the initial stage before the experimental class was intervened. The homogeneity assumption is met if the significance value in the statistical Levene test is greater than 0.05.

Paired Sample T-Test

The paired sample t-test was used to measure the effectiveness of the learning intervention in the experimental class by comparing the average pretest and posttest scores.

Table 4. Paired Sample Test Results

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Experiment – Experiment	-24.118	8.570	1.470	-27.108	-21.128	-16.410	33	0.000

The results of the Paired Samples T-Test analysis conducted on the experimental class produced a t-value of -16.410 and a significance level (2-tailed) of 0.000. Because the significance value is less than 0.05, it indicates a very significant increase in learning outcomes between the pretest and posttest. The average difference value of 24.118 indicates a very significant increase in learning outcomes after the intervention. The results of the paired t-test found a significant average difference between the pretest and posttest with a significance value of $p < 0.05$.

Independent Sample T-Test

The independent sample t-test is used to compare learning outcomes between the control and experimental classes after an intervention. The aim is to determine whether there are significant differences.

Table 5. Independent Samples Test Results

		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	95% Confidence Interval of the Difference	
							Lower	Upper
Post-Test Score	Equal variances assumed	3.115	0.082	-9.614	66	0.000	-17.760	-11.652
	Equal variances not assumed			-9.614	62.844	0.000	-17.763	-11.649

The results of the Independent Samples T-Test for the posttest scores between the control and experimental classes showed a significance value (2-tailed) of 0.000 and a calculated t-value of -9.614, a value of -9.614 less than 0.05. This value indicates a very significant difference between the posttest scores of the two classes, with the experimental class obtaining a posttest score that was statistically higher than the control class.

N-Gain Test

The Normalized Gain Test is used to calculate the improvement in students' creative thinking skills after learning intervention.

Table 6. N-Gain Test Results

Creative Thinking Indicators	Average value		N-Gain	
	Pretest	Posttest		Information
Fluency	63.88	90.27	0.73	High
Flexibility	63.42	86.57	0.63	Medium
Originality	60	83.88	0.60	Medium
Elaboration	63.49	84.12	0.57	Medium
Average	62.69	72.35	0,69	Medium

The results of quantitative data analysis showed a significant increase in the experimental class in students' creative thinking skills after participating in learning using the PjBL-STEAM model with the help of GeoAI media. The average N-Gain value for students' creative thinking skills in the experimental class was 0.69. In the pretest, the average score of creative thinking skills was 62.69; after intervention or learning treatment with the PjBL learning model integrated with STEAM and using GeoAI media, The average posttest score increased to 72.35, which is included in the "Medium" category. However, when viewed from the Masihng-Masihng indicators, it shows variations in the increase. The fluency indicator showed a high increase with an N-Gain value of 0.73, which indicates that students' ability to generate various relevant ideas increased significantly. Meanwhile, the indicators of flexibility, originality, and elaboration of each have N-Gain values of 0.63, 0.60, and 0.57, which lead to a moderate increase. The improvement in creative thinking skills can be seen in Figure 3.

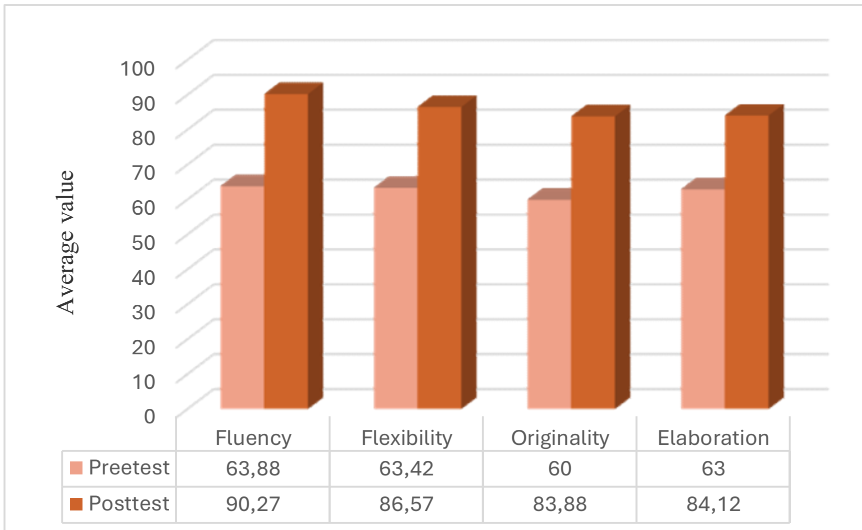

Figure 3. Results of the N-Gain Test of Creative Thinking Skills Indicators

Figure 3 shows that the average posttest score is higher than the average pretest score for each indicator of students' creative thinking skills. Figure 3 clearly shows that fluency is the indicator with the highest score, indicating that fluency is the foundation of creativity. Improvements in creative thinking skills are not only seen through quantitative data but also supported by qualitative data from student responses through interviews. Many students felt they were more active because this learning method encouraged them to generate ideas and create works. Here are some statements from students:

"*I feel my creative thinking skills have improved. For example, learning about endemic animals, such as the bird of paradise from Papua, and creating a digital map directly using a computer has given me many new ideas*."

"*I feel my skills have improved, and I've become more active in learning, such as searching for infographic map references, searching for flora and fauna classification data, and creating digital maps*."

According to excerpts from student interviews, project-based learning, such as creating digital maps and infographics using GeoAI, can develop skills in identifying, processing, and visualizing. This information is still available. Therefore, it can be concluded that the learning model shows that students are starting to be able to create original ideas and develop their details better. This improvement proves that the learning model and media used are effective in facilitating the improvement of students' creative thinking skills.

The implementation of PjBL-STEAM, assisted by GeoAI, in this study has been proven to facilitate students in integrating various disciplines, such as science, technology, engineering, art, and mathematics, in creating projects, which is the core of creative thinking. The interactivity and visualization in GeoAI media also contribute to arousing curiosity and motivating students to think outside the box.

Student Responses

Student responses were used to explore perspectives, measure student responses in depth, and holistically validate both quantitative and qualitative data.

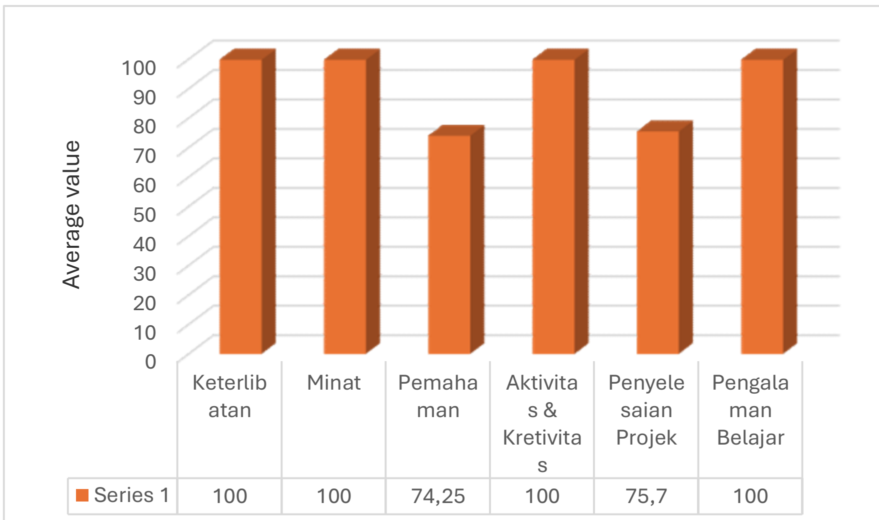

Figure 4. Results of student response questionnaire indicators

The results of the figure 4 analysis, visualizing the questionnaire responses given to students, show an average score of 75.99 out of a maximum score of 100. Based on the diagram, it is clear that several indicators achieved a perfect score of 100%. These are: student engagement, who felt highly involved in the learning process; Interest: All students showed very high interest in PjBL-STEAM learning using GeoAI media; Activity and Creativity: Students felt very active, and their creativity was truly motivated. The learning experience was truly new and different for them. Other indicators also showed quite high positive values, such as Understanding at 74.25%, indicating that most students felt they understood the material better, and Project Completion at 75.7%, proving that the majority of students successfully completed the project.

This visual presentation diagram of the response indicators aims to confirm that aspects of them, such as engagement, interest, understanding, activity, creativity, project completion, and student learning experience, achieved maximum results. This indicates that students responded positively to the GeoAI-assisted PjBL-STEAM learning model. The above conclusion is supported by qualitative data from student interviews regarding their responses to each questionnaire indicator. Students' enthusiasm for the project, related to engagement, interest, activity, and creativity, stated that project learning was very enjoyable due to its practical and collaborative nature. The following are excerpts from interviews with several respondents:

"Yes, I like it because it's fun and engaging." (Respondent CP)
"I really like it because we can discuss things together, and I understand the project better." (Respondent FS)
"Yes, I like learning to create projects like this because I can directly see how to create them." (Respondent AN)

This supports why the "Engagement," "Interest," and "Activity and Creativity" indicators reached 100% in the questionnaire diagram. Furthermore, other respondents also provided positive feedback regarding their understanding of ecology and biodiversity materials and their learning experiences using the PjBL learning model integrated with STEAM and assisted by GeoAI. The digital map and infographic map projects were considered very engaging because they were new and different from conventional learning methods. The following statements from respondents support this statement:

"Yes, it's very interesting because I've never tried it before." (Respondent CP)
"Yes, it's very interesting. Because we can learn with computers, which is different from other methods." (Respondent AN)
"Creating projects like this is very exciting. Students can learn about endemic flora and fauna in Indonesia and can utilize modern technology. Yes, I really like it." (Respondent SNA)

This explains why "Learning Experience" reached 100% and "Understanding" also achieved a high score, as this medium facilitates a more visual and practical learning experience. Most respondents responded with high scores related to increased creative thinking skills in the activity, creativity, and project completion indicators, especially in creating the final product.

"I feel more creative when creating products, for example, digital maps and infographics." (Respondent FS) "Yes, like creating digital maps and studying rare flora and fauna in Indonesia." (Respondent AN) "Yes, I think my skills and creative ideas come to the fore, and I can provide creative ideas. For example, I can provide photos of unique flora or fauna." (Respondent KA) This feeling supports the high scores in the "Activity & Creativity" and "Project Completion" indicators.

Although the responses were predominantly positive, some students identified challenges, such as difficulties using computers ("Yes, I don't understand how to use a computer"—Respondent CP; "Using a computer or laptop"—Respondent KA) or MyMaps ("Yes, part of using My Maps in Google Chrome"—Respondent SNA). This explains why the "low" percentage of 50-51.4% appeared for negative statements such as "I found it difficult to understand the material when using GeoAI" or "I had difficulty completing the project," indicating that some students did indeed experience initial challenges. Suggestions such as "Provide instruction on how to use a computer" (Respondent CP) or "This time's learning is better. It is used more often" (Respondent S) indicates a desire to deepen the use of technology and extend learning duration.

The very positive student responses, both from the questionnaire and interviews, clearly indicate that the implementation of the GeoAI-assisted PjBL-STEAM learning model was very well received. The indicator percentage diagram visually reinforces that key aspects such as student engagement, interest, activity & creativity, and learning experience are reaching optimal levels.

Discussion

This study aimed to evaluate the efficacy of the Project Based Learning (PjBL) model, integrated with the Science, Technology, Engineering, Arts, and Mathematics (STEAM) approach, utilizing Geospatial Information System Artificial Intelligence (GeoAI) media to enhance students' creative thinking abilities. The research findings indicate that the minimum score for the control class pretest is 50 and the posttest is 65, but the minimum score for the experimental class pretest is 50 and the posttest is 80. The control class has a maximum pretest score of 85 and a posttest score of 90, whereas the experimental class has a maximum pretest score of 85 and a posttest score of 100. This outcome demonstrates that the learning intervention implemented by the researcher in the experimental group is more efficacious than that in the control group. This data serves as visual proof supporting the assertion that the researcher's intervention in the experimental class, utilizing PjBL combined with STEAM, was more effective than that in the control class. The hypothesis will be substantiated by the outcomes of the normalcy test, homogeneity test, paired sample test, independent sample t-test, N-Gain test, and the analysis of student interviews following the intervention.

The normality test examination of the pretest data revealed a significant value of 0.063 for the control class and 0.113 for the experimental class in the Shapiro-Wilk test. The results for both classes were reported to follow a normal distribution. de Souza et al. (2023) asserts that the normal assumption is satisfied, as the significance value in the Shapiro-Wilk test for both the control and experimental groups exceeds 0.05. The homogeneity test analysis of the pretest data indicated that the variance of the two groups was homogeneous, with a significance value of 0.912. This statement demonstrates that there is no substantial variance difference between the control class and the experimental class prior to the intervention in the experimental class. de Souza et al. (2023) asserts that the homogeneity assumption is satisfied when the significance value in the Levene test exceeds 0.05.

The Paired Samples T-Test analysis of the experimental class yielded a t-value of -16.410 and a two-tailed significance level of 0.000. The significance value, being less than 0.05, implies a highly significant enhancement in learning outcomes between the pretest and posttest. The mean difference of 24.118 signifies a substantial enhancement in learning outcomes post-intervention. This conclusion is corroborated by Afifah et al. (2022), who reported that the paired t-test revealed a significant average difference between the pretest and posttest, with a significance value of $p < 0.05$. The Independent Samples T-Test findings for the posttest scores between the control and experimental classes indicated a significance value (2-tailed) of 0.000 and a computed t-value of -9.614, which is less than 0.05. This figure signifies a substantial disparity between the posttest results of the two classes, with the experimental class achieving a statistically superior posttest score compared to the control class.

Quantitative data analysis demonstrated that the experimental class's creative thinking skills improved after studying with the PjBL-STEAM paradigm and GeoAI media. Creative thinking N-Gain averaged 0.69 in the experimental class. The average pretest creative thinking score was 62.69; after intervention or learning treatment with the PjBL learning model combined with STEAM and GeoAI media, the average posttest score was 72.35, which is "medium." Masihng-Masihng indicators reveal variances in the increase. The fluency indicator grew dramatically with an N-Gain value of 0.73, indicating that pupils could generate more relevant thoughts. Flexibility, creativity, and elaboration demonstrate moderate increases with N-Gain values of 0.63, 0.60, and 0.57.

Student interviews show that project-based learning, such as producing digital maps and infographics with GeoAI, can improve identification, processing, and visualization. This info is still available. Thus, the learning model reveals that pupils are improving their creativity and detail. This improvement shows that the learning methodology and media help pupils develop innovative thinking.

Ardiyansah et al. (2024) found that the PjBL-STEAM model improves creative thinking. This study found that PjBL-STEAM, helped by GeoAI, helps students integrate science, technology, engineering, art, and mathematics into project-based learning, which is essential to creative thinking. GeoAI media's interactivity and visualization spark curiosity and encourage creative thinking.

The study of student questionnaire replies shows an average score of 75.99 out of 100. The figure shows that multiple indicators scored 100%. These are student engagement, who felt strongly involved in the learning process; interest: all students exhibited great interest in PjBL-STEAM learning utilizing GeoAI media; and activity and creativity: students felt fully active and driven. Their learning experience was unique. Understanding, at 74.25%, showed that most students understood the content better, while Project Completion, at 75.7%, demonstrated that most students completed the project. The results of this study are supported by previous studies which stated that the Project Based Learning (PjBL) model integrated with the Science, Technology, Engineering, Arts, and Mathematics (STEAM) approach media in improving students' creative thinking skills (Mufida et al., 2020; Indahwati et al., 2022; Zayyinah et al., 2022).

This response indicating the visual presentation diagram confirms that engagement, interest, knowledge, activity, creativity, project completion, and student learning experience were maximized. This suggests pupils liked the GeoAI-assisted PjBL-STEAM learning paradigm. Qualitative student interviews on questionnaire indication responses confirm the stated conclusion.

4. CONCLUSION

Overall, this study indicates that the PjBL-STEAM model using GeoAI media is effective in improving students' creative thinking skills on ecology and biodiversity materials. This effectiveness is proven by the results of quantitative and qualitative data analysis. Based on the quantitative data analysis, there was a significant increase in students' learning outcomes after the intervention, as evidenced by the results of the paired sample t-test with a significant value of 0.000 $p < 0.05$ and an average posttest score of 90.44, which is much higher than the pretest of 66.32. Significant differences were also found in the learning outcomes of the control class and the experimental class in the independent sample t-test with a significant value of 0.000 $p < 0.05$. This increase was also measured through the N-Gain Test with an average score of 0.69, which is in the moderate category. These quantitative findings are reinforced by qualitative data from questionnaires and student interviews, which showed a very positive response. Students expressed a sense of increased activity, motivation, and creativity during the creation of digital maps and infographic projects. They found this learning experience engaging, exciting, and different from conventional methods. Therefore, it can be concluded that the integration of the PjBL-STEAM model and GeoAI media is effective in facilitating active learning and encouraging students' creative thinking skills.

As a recommendation, teachers can implement the PjBL-STEAM learning model using GeoAI media to improve junior high school students' creative thinking skills. This research can serve as a reference for developing innovative and effective learning media to enhance students' creative thinking skills. Further research can be conducted to develop more effective STEAM-based learning models to enhance students' creative thinking skills. Furthermore, further research can be conducted to develop interactive learning media using GeoAI technology to enhance students' creative thinking skills.

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