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Implementation of the PjBL-STEM Model Utilizing Algodoo for Science Learning in Improving Cognitive Learning Outcomes, Critical Thinking Skills, and Creative Thinking Skills

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Abstract
Aims. This research aimed to determine the effect of the PjBL-STEM model using Algodoo on science learning.
Methods. This research employs a quasi-experimental design with a nonequivalent control group. The population selected was the Semester 2 Class VIII students at SMPN 1 Sumber in 2023/2024. The sample of this study comprised 25 students from classes VIII C and VIII D. Data were collected through essay tests and student response questionnaires. Data were processed using prerequisite tests, the independent-samples t-test, and the N-Gain test.
Result. The results showed an increase in average pretest and posttest scores for cognitive learning outcomes from 56 to 88 points, with an N-Gain score of 0.73, categorized as high. Meanwhile, based on critical thinking skills and creative thinking skills, each student experienced an increase in each indicator, with an average pretest score of 45.5 and 43.35 points and an average posttest score of 83.34 points and 87.75 points. Each N-Gain was 0.69 and 0.78, categorized as medium and high, respectively. Students gave a very positive response to the PjBL-STEM model using Algodoo, with an average score of 85.55%, indicating that all aspects received a very positive response.
Conclusion. The interesting aspect received the highest average score (86.82%), followed by achieving learning objectives (86.80%) and convenience (83.03%).
Implementation. These results indicate that the PjBL-STEM model, which uses Algodoo for science learning, can significantly improve students' cognitive learning outcomes, critical thinking skills, and creative thinking skills.

Keywords: PjBL-STEM, Cognitive Learning Outcomes, Critical Thinking Skills, Creative Thinking Skills

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INTRODUCTION

The use of technology to support human activities is a demand in the era of society 5.0. The use of technology is projected to address various social issues, as humans employ it to

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promote long-term, inclusive development. In the context of education, society 5.0 aims to enhance instruction and learning by integrating technology as part of an educational revolution. Furthermore, students must be able to apply and operate technology in learning activities in the society 5.0 era as a tool for understanding theories and concepts.

Science education is a process that equips students with an understanding of the universe through observation, experimentation, and drawing conclusions. Science learning is a field of science that is included in the PISA assessment. Therefore, science learning has a significant role in improving Indonesia's PISA score. Therefore, science learning must be implemented through an independent curriculum that focuses on problem- or project-based learning, which requires students to effectively tackle challenges and produce a project. Optimal science learning is learning that utilizes appropriate learning media to support the material, so that the learning process takes place interactively and can improve cognitive learning outcomes and develop the abilities needed to confront obstacles in the age of Society 5.0. However, the fact is that conventional learning models are still widely applied by educators in science learning in Indonesia, which causes students to obtain poor cognitive learning outcomes and have not been able to think critically and creatively, even though these abilities are abilities that are needed by students (Aripin & Mu'minah, 2019). This condition is evident from the PISA 2022 results, which show that Indonesia experienced a decline in average results across all fields compared to 2018 (OECD, 2022).

The PISA results reflect that Indonesia has experienced a decline caused by inequality in the implementation of the independent curriculum, which has an impact on Indonesia's PISA results. This condition can be observed in the implementation of the learning model commonly used by educators, which has not met the criteria set by the independent curriculum. In addition, the science learning model applied by educators in schools is still limited in its use of learning media to capture students' active attention and increase enthusiasm for learning, so that the learning process can run dynamically. Educators tend to use traditional learning media, such as books and pictures, which do not meet the requirements of the independent curriculum, which emphasizes the use of technology as a learning medium. Digitalization, or the implementation of technology in science learning, needs to be done as an effort to support an independent curriculum.

Dewi (2023) states that the PjBL learning model is appropriate for implementation in the Independent Curriculum because it has advantages in improving students' academic

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achievement, cognitive learning outcomes, learning motivation, and 4C (Communication, Collaboration, Creative Thinking, Critical Thinking) abilities. Based on Riskayanti's (2021) research, the PjBL learning model is effective in improving 4C skills and fostering interactive, dynamic learning.

Algodoo is an electronic platform that can serve as an alternative educational tool. Algodoo is a simulation software that provides various menus that can be used to create a learning simulation that can be made from start to finish based on user creativity (Resmiyanto, 2017). The use of Algodoo is an implementation of PjBL-STEM learning that can stimulate students to develop new innovations to support the project-creation process. The expectation is that employing the PjBL-STEM model, along with Algodoo as a learning tool, will enhance cognitive learning outcomes and critical and creative thinking abilities.

The PjBL-STEM model, which utilizes Algodoo, can help overcome challenges in 21st-century learning and serves as an implementation of an independent curriculum (Riyasni et al., 2023). The PjBL-STEM learning model that uses Algodoo can also encourage students to improve cognitive, critical, and creative learning outcomes. Research conducted by Afifah, Ilmiyanti, and Toto (2019) indicates a notable improvement in the mastery of critical thinking skills and concepts in the high and medium categories due to the application of the PjBL-STEM approach. In addition, research by Amin and Sholihah (2024) found that students' creative thinking ability increased due to the application of the PjBL-STEM approach to learning biology in class XII SMA. Research conducted by Fitriyah and Ramadani (2021) also produced similar findings, that the PjBL-STEM model was effective in improving students' creativity and critical thinking skills.

From the various problems described, the researcher formulates several problems, among others: How does the PjBL-STEM model utilizing Algodoo improve science learning outcomes, including cognitive learning outcomes, critical thinking skills, and creative thinking skills? How are students responding to the PjBL-STEM model using Algodoo? The research aims to examine the effects of the PjBL-STEM model using Algodoo on science learning, including cognitive learning outcomes, critical thinking skills, and creative thinking skills, and to examine students' responses to the PjBL-STEM model using Algodoo.

METHODS

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Research using a quasi-experimental design is Experimental research that is used due to the difficulty in obtaining a control class that is useful for controlling external variables that have an impact on research (Zonyfar et al., 2022). In this research, the selected design was a Nonequivalent Control Group Design utilizing a Pretest-Posttest method to compare the results before and after the treatment (Oktafadilla, Wijaya, and Arsyah 2024). A pretest was administered to assess initial competencies before the intervention. Following this, the Experimental group received treatment through the PjBL-STEM learning model with Algodoo, whereas the control group received treatment through the PjBL learning model. Subsequently, a posttest was administered to both the Experimental and control groups to measure final competencies following the implementation of the learning. The posttest outcomes for both classes were examined to identify differences between the Experimental group, which received treatment with the PjBL-STEM learning model using Algodoo, and the control group, which received the PjBL model treatment (Abdillah, Riyana, and Alinawati 2018). Below is the representation of the research design outlined in Table 1.

Table 1. Nonequivalent Group Control Design

Clas	***Pretest***	**Treatment**	***Posttest***
Eksperimental	O_1	X_1	O_2
Control	O_3	X_2	O_4

Description :

O1: Experimental Class Pre-Treatment Test

O2: Experimental Class Post-Treatment Test

O3: Control Class Pre-Treatment Test

O4: Control Class Post-Treatment Test

X1: Receiving PjBL- STEM Model Treatment Utilizing Algodoo

X2: Receiving PjBL Model Treatment

The selected population was Semester 2 students of Class VIII at SMPN 1 Sumber in 2023/2024. The sample of this study comprised 25 students from class VIII C and VIII D. The research instruments were an essay test comprising 30 questions and a student response questionnaire comprising 20 statements. Essay tests were used to assess cognitive learning

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outcomes, critical thinking skills, and creative thinking skills. Meanwhile, the response questionnaire was used to collect data on students' responses after receiving learning treatment with the PjBL-STEM model utilizing Algodoo. Data processing methods use prerequisite tests, independent of sample t tests and N-Gain tests. Implemented from January 10, 2024, to February 12, 2024. The research was conducted at SMPN 1 Sumber, Cirebon Regency, West Java Province.

DISCUSSION

Prior to assessing the impact of the PjBL-STEM learning model using Algodoo on science education, prerequisite tests were conducted, including normality and homogeneity tests, to identify the appropriate statistical analyses. The normality test checks if the collected data follows a normal distribution, which is essential for conducting parametric tests. When the data do not follow a normal distribution, nonparametric tests are used instead. For the homogeneity test, before comparing two groups in this study, it is important to ensure that the observed differences are not due to differences in the primary data (inhomogeneity) (Fatihatussa'adah et al., 2024). Data that exhibit normality and homogeneity will be analyzed using the independent samples t-test and the N-Gain test. In contrast, data that do not conform to a normal distribution will be assessed using the Mann-Whitney test. For this study, the Shapiro-Wilk normality test was employed, which is considered suitable for small sample sizes. Normality and homogeneity tests were performed on the collected data from both research groups as a prerequisite for the analysis. Samples are deemed normally distributed if the significance level is ≥ 0.05. Likewise, the homogeneity test is considered valid if the significance level is ≥ 0.05.

Testing Cognitive Learning Outcome Scores

Learning outcomes in the cognitive domain play an important role because they encompass aspects of knowledge and thinking, including Bloom's taxonomy (Nurlindayani, 2021). Bloom's taxonomy categorizes cognitive levels, beginning with the operational terms: recall (C1), comprehend (C2), apply (C3), analyze (C4), evaluate (C5), and create (C6) (Ihzani & Wulandrai, 2022). The cognitive learning outcome scores gathered from both the control and Experimental groups will be evaluated to gauge the impact of the PjBL-STEM model utilizing

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Algodoo on cognitive learning outcomes. Table 2 displays the results of the normality test for cognitive learning outcome scores.

Table 2. Results of the Normality Test

Score	Class	Statistic	*Df*	Sig.
Pretest	Control	0.910	25	0.073
	Experiment	0.932	25	0.173
Posttest	Control	0.905	25	0.052
	Experiment	0.939	25	0.240

According to Table 2, which shows the results of the normality test, the significance score was≥0.05. This indicates that the data are normally distributed. The subsequent step involves conducting a homogeneity test, with the cognitive learning outcomes detailed in Table 3.

Table 3. Results of the Homogeneity Test

Score	*Levene Statistic*	*Df 1*	*Df 2*	*Sig.*
Pretest	3.450	1	48	0.069
Posttest	1.740	1	48	0.195

According to Table 3, which presents the results of the homogeneity test, the significance score is≥ 0.05. So this result can be interpreted as indicating that the data are homogeneous. The next step was to conduct the independent-samples t-test, as shown in Table 4.

Table 4. Results of The Independent Sample T-Test

Score	*F*	*Sig.*	*Df*	*Sig. (2-tailed)*

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Posttest of Control Class and Experimental Class	1.737	0.195	48	0.023

Referring to Table 4, which displays the findings of the independent sample t-test, a significance score (2-tailed) of 0.023 was recorded. Since the significance score is 0.023, which is less than or equal to 0.05, we can conclude that H0 is rejected and H1 is accepted. This indicates that the PjBL-STEM learning model using Algodoo positively impacts students' cognitive learning outcomes.

Critical Thinking Skills Score Testing

Students must master critical thinking skills to address the challenges of the era of society 5.0. Critical thinking skills must be trained and familiarized during learning activities through communication between students and educators to improve students' critical thinking skills and other skills, thereby realizing an ideal education (Susanti et al., 2022). Scores for critical thinking skills gathered from both the control and experimental classes will be analyzed to evaluate the effectiveness of the PjBL-STEM model with Algodoo in enhancing critical thinking abilities. Table 5 presents the results of the normality assessment for students' critical thinking abilities.

Table 5. Results of the Normality Test

Score	Class	Statistic	*Df*	Sig.
Pretest	Control	0.912	25	0.093
	Experimental	0.934	25	0.182
Posttest	Control	0.914	25	0.063
	Experimental	0.915	25	0.256

According to the findings in Table 5, which presents the normality test results, the significance score was≥ 0.05. This indicates that the data are normally distributed. The following step involved conducting a homogeneity test, with critical thinking skills outlined in Table 6.

Table 6. Results of the Homogeneity Test

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Score	*Levene Statistic*	*df1*	*df2*	*Sig.*
Pretest	3.380	1	48	0.063
Posttest	1.840	1	48	0.235

According to Table 6, which presents the results of the homogeneity test, a significance score≥ 0.05 was obtained. So this result can be interpreted as indicating that the data are homogeneous. The next step was to conduct the independent-samples t-test, as shown in Table 7.

Table 7. Results of The Independent Sample T-Test

Score	*F*	*Sig.*	*Df*	*Sig. (2-tailed)*
Posttest of the Control Class and the Experimental Class.	1.824	0.213	48	0.047

Referring to Table 7, which displays the findings of the independent sample t-test, a significance score (2-tailed) of 0.047 was recorded. Since this score, 0.047, is less than or equal to 0.05, we can conclude that H0 is rejected and H1 is accepted. This suggests that the PjBL-STEM learning model employing Algodoo positively influences students' critical thinking skills.

Testing of Creative Thinking Skills Scores

One of the skills needed in the Society 5.0 era is creative thinking skills. Creative thinking is an individual's skill in generating new concepts and opinions by drawing on sound fundamental principles and personal intuition (Mahfud, 2019). Mastery of creative thinking skills helps students implement new ideas and concepts. The measurement of creative thinking skills is assessed using an essay test instrument. The creative thinking scores obtained from the control and experimental classes will be tested to determine the effectiveness of the PjBL-STEM model utilizing Algodoo in improving creative thinking skills. Table 8 presents the results of the normality test related to students' creative thinking skills.

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Table 8. Results of the Normality Test

Score	Class	Statistic	*Df*	Sig.
Pretest	Control	0.928	25	0.093
	Experimental	0.946	25	0.196
Posttest	Control	0.915	25	0.067
	Experimental	0.933	25	0.222

According to the data in Table 8 on the normality test, the significance score was≥0.05. This result suggests that the data follows a normal distribution. The next step is to perform the homogeneity test, using the critical thinking skills detailed in Table 9.

Table 9. Results of the Homogeneity Test

Score	*Levene Statistic*	*df1*	*df2*	*Sig.*
Pretest	3.380	1	48	0.063
Posttest	1.840	1	48	0.235

Referring to Table 9, which outlines the findings of the homogeneity test, a significance score≥ 0.05 was observed. This indicates that the data is homogeneous. The next step was to perform the independent sample t-test, as illustrated in Table 10.

Table 10. Results of The Independent Sample T-Test

Skor	*F*	*Sig.*	*Df*	*Sig. (2-tailed)*
Posttest of the Control Class and the Experimental Class.	1.783	0.187	48	0.019

According to the results shown in Table 10, the independent sample t-test yielded a significance score (2-tailed) of 0.019. Since this score of 0.019 is less than or equal to 0.05, we can conclude that H0 is rejected and H1 is accepted. This indicates that the PjBL-STEM learning model incorporating Algodoo positively affects students' creative thinking skills.

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Improvement of Students' Cognitive Learning Outcomes

The enhancement of cognitive learning outcomes can be assessed using the N-Gain test, which is based on scores from the pre- and posttests. These scores are taken from formative assessments. The N-Gain values, calculated from the average pretest and posttest results, are presented in Table 11.

Table 11. Average Cognitive Learning Outcomes

Class	**Average Score**		***N-Gain***
Control	51	77	0.54
Experimental	56	88	0.73

Referring to Table 11, which displays the results from the N-Gain test, the control group achieved an average score of 0.54, classified as moderate. In contrast, the experimental group obtained an average score of 0.73, categorized as high. These findings indicate a positive enhancement in students' cognitive learning outcomes following the implementation of the PjBL-STEM learning model with Algodoo. A detailed breakdown of this data for each cognitive learning outcome indicator is provided in Table 12.

Table 12. Recapitulation of Learning Outcome Scores in Each Cognitive Domain

Cognitive Domain	**Control**		***N-Gain***	**Desc.**	**Experimental**		***N-Gain***	**Desc.**
C1	70	90	0.67	Moderate	75	93	0.72	High
C2	60	85	0.63	Moderate	63	92	0.78	High
C3	53	78	0.53	Moderate	55	85	0.67	Moderate
C4	45	64	0.35	Low	52	88	0.75	High
C5	40	75	0.58	Moderate	46	78	0.59	Moderate
C6	39	70	0.51	Moderate	42	94	0.90	High
Average	**51**	**77**	**0.54**	**Moderate**	**56**	**88**	**0.73**	**High**

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According to Table 12, which presents the score data for learning outcomes in each cognitive domain from the Experimental class and the control class. The control class obtained pretest results with an average score of 51 points, a posttest score of 77 points, and an N-Gain of 0.54, categorized as moderate. Meanwhile, the Experimental class achieved higher results than the control class, with pretest scores averaging 56 points, posttest scores of 88 points, and an N-Gain of 0.73, categorized as high. These results indicate that the Experimental class achieved greater improvement in cognitive learning outcomes than the control class. Furthermore, in terms of increases across cognitive domains, the Experimental class scored higher than the control class in all domains from C1 to C6. The cognitive domains with great improvement were C1, C2, C4, and C6, with respective N-Gain scores of 0.72, 0.78, 0.75, and 0.90. In contrast, the cognitive domains categorized as moderate were C3 and C5, with N-Gain scores of 0.67 and 0.59, respectively.

The findings of this study align with the research by Faidah, Listiawati, and Yamin (2023), which indicates that the application of the PjBL-STEM model using Algodoo positively influences students' cognitive learning outcomes. The PjBL-STEM model utilizing Algodoo is a learning model that integrates four fields of study: Science, Technology, Engineering, and Mathematics, aimed at enhancing problem-solving skills and critical thinking by using Algodoo as a learning medium (Aini et al., 2023). This underscores that educational approaches that combine four different disciplines and incorporate technology as a teaching tool can significantly improve student learning results. Learning through the implementation of technology facilitates students' comprehension of material on lenses and optics, as the PjBL-STEM model uses Algodoo to provide a learning system that integrates technology through simulations for lenses and optics.

By integrating four fields of study and technology into the learning system in this research, students are enabled to think more broadly or openly about the material on lenses and optics. The use of Algodoo simulations for the material on lenses and optics makes it easier for students to understand the concepts. Students will grasp the material through Algodoo simulations that present engaging scenarios, accompanied by explanations from educators, allowing them to understand the material more deeply. Furthermore, the use of Algodoo enables students to independently create simulations related to lenses and optics, which will

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hone their higher-order thinking skills and align them with the material, making students more interested in learning.

The study conducted by Liadiana, Gunawan, and Taufik (2018) revealed that utilizing virtual laboratory learning media (PhET) significantly enhances students' cognitive learning outcomes, especially within the cognitive levels of C1, C2, and C6. Furthermore, research by Simbolon (2015) examining the impact of virtual laboratory media demonstrated that the experimental group achieved a higher N-Gain score than the control group, with N-Gain scores across the cognitive domains C1, C2, C3, C4, C5, and C6 being 0.31, 0.40, 0.74, 0.75, 0.75, and 0.68, respectively. The most substantial improvements were noted in the cognitive domains C3, C4, C5, and C6. These findings are aligned with the results of the current study, which also indicated a marked enhancement in students' cognitive learning outcomes, with N-Gain scores in the cognitive domains C1, C2, C3, C4, C5, and C6 recorded at 0.72, 0.78, 0.67, 0.75, 0.59, and 0.90, respectively. The greatest advancements were observed in the cognitive domains C1, C2, C3, C4, and C6.

Improvement of Students' Critical Thinking Skills

The enhancement of critical thinking skills can be assessed using the N-Gain test, calculated from the pretest and posttest scores. The N-Gain values, determined from the average scores of these tests, are presented in Table 13.

Table 13. Results of the N-Gain Test

Class	**Average Score**		***N-Gain***
Control	47	73	0,60
Experimental	45.4	83.4	0.69

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According to Table 13, which showcases the results from the N-Gain test, the control group received an average score of 0.60 points, classified as moderate. In contrast, the experimental group attained an average score of 0.69 points, which is similarly classified as moderate. For a more detailed examination of the enhancement in students' critical thinking skills in the experimental group across various indicators, refer to Table 14.

Table 14. Improvement of Critical Thinking Skills

Indicators of Critical Thinking	**Average Score**		***N-Gain***
Elementary Clarification	52	86	0,71
Basic Support	48	82	0.65
Inferring	45	80	0.64
Advance Clarification	42	76	0.59
Strategies and Tactics	40	93	0.88
Average	**45.4**	**83.4**	**0.69**

Table 14 illustrates that performance across each indicator of critical thinking skills has improved, with an average posttest score of 83.4 points, exceeding the average pretest score of 45.4 points, resulting in an N-Gain of 0.69 points, classified as moderate. The strategies and tactics indicator showed the most significant average score increase, with a mean difference of 53 points and an N-Gain of 0.88 points, categorized as high. Next is the elementary clarification indicator, which demonstrated an average score increase of 34 points, resulting in an N-Gain of 0.71 points, categorized as high. Furthermore, the basic support indicator showed an average score increase of 34 points, yielding an N-Gain of 0.65, classified as moderate. The inferring indicator exhibited the smallest average score increase of 35 points, with an N-Gain of 0.64 points, also categorized as moderate. This was followed by the advanced clarification indicator, which recorded an average score increase of 34 points and an N-Gain of 0.59 points, likewise categorized as moderate. Figure 1 illustrates the progression in critical thinking skills, clearly showing these improvements.

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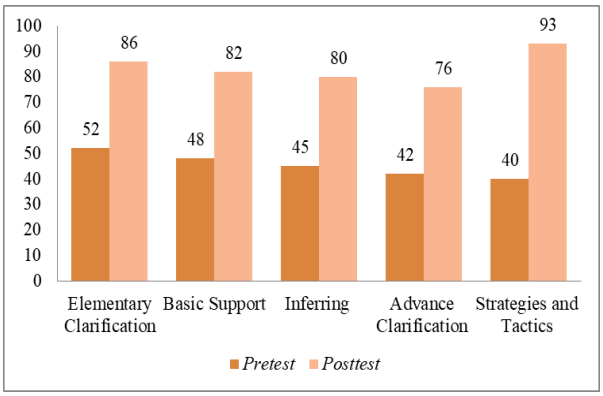


Figure 1. Average Scores of Critical Thinking Skills

Based on Figure 1, which shows average posttest scores higher than average pretest scores for each indicator of critical thinking skills, each indicator achieved an average score of 73.4 points. The average scores for each indicator are as follows: elementary clarification, 86 points; basic support, 82 points; inference, 80 points; advanced clarification, 76 points; and strategies and tactics, 93 points. This aligns with the research conducted by Khoiriyyah et al. (2022), which reported an average critical thinking score of 62.73 points, with the following average scores for each indicator: elementary carification scored 60 points, basic support scored 46.4 points, inferring scored 71.8 points, advanced clarification scored 68.2 points, and strategies and tactics scored 67.3 points. Additionally, another study conducted by Allanta and Puspita (2021) reported an average critical thinking score of 81.2 points, with the average scores for each indicator as follows: elementary carification scored 85.28 points, basic support scored 78.4 points, inferring scored 95.2 points, advanced clarification scored 70.4 points, and strategies and tactics scored 76.8 points. Furthermore, the average N-Gain score attained was 0.60 points, classified as moderate for each critical thinking skill. This aligns with the results from the study by Istiqomah et al. (2022), which reported an average N-Gain score of 0.62 points, also categorized as moderate. This suggests a notable improvement across all indicators. Consequently, it can be concluded that the PjBL-STEM model utilizing Algodoo effectively improves students' critical thinking skills, especially in the strategies and tactics indicator and the elementary clarification indicator.

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Improvement of Students' Creative Thinking Skills

The improvement in creative thinking skills can be calculated using the N-Gain test, which is derived from pre- and posttest scores. The N-Gain scores, based on the average pretest and posttest scores, are shown in Table 15.

Table 15. Results of the N-Gain Test

Class	**Average Score**		***N-Gain***
Control	45	72	0.48
Experimental	56	88	0.78

According to Table 15, which presents the data obtained from the N-Gain test, the control class achieved an average score of 0.48 points, categorized as moderate. Meanwhile, the Experimental class obtained an average score of 0.78 points, categorized as high. In more detail, to understand the improvement in students' creative thinking skills in the Experimental class for each indicator, see Table 16.

Table 16. Improvement of Creative Thinking Skills

Indicators of Critical Thinking	**Average Score**		***N-Gain***
	Pretest	***Posttest***	
Fluency	50	90	0.80
Flexibility	48	87	0.75
Originality	40	82	0.70
Elaboration	35	92	0.88
Average	**43.35**	**87.75**	**0.78**

According to Table 16, it shows that the achievement of each indicator of creative thinking skills has improved, as evidenced by the average posttest score of 87.75 points, which

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is greater than the average pretest score of 43.35 points, and an N-Gain of 0.78 points, categorized as high. The elaboration indicator showed the most significant average score increase, with a mean difference of 57 points and an N-Gain of 0.88 points, categorized as high. This is followed by the fluency indicator, which showed an average score increase of 40 points and an N-Gain of 0.80 points, also categorized as high. Next, the flexibility indicator showed an average score increase of 39 points and an N-Gain of 0.75 points, categorized as high; the originality indicator, which followed, showed an average score increase of 42 points and an N-Gain of 0.70 points, categorized as high. All indicators of creative thinking skills demonstrated improvement that is categorized as high. This is illustrated in Figure 2, which clearly shows the diagram of the improvement in creative thinking skills.

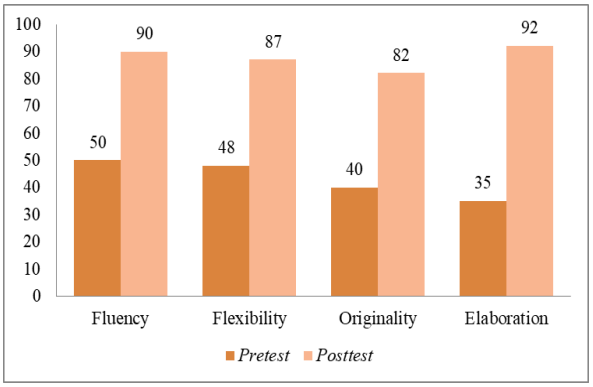


Figure 2. Average Scores of Creative Thinking Skills Indicators

Figure 2 shows that the average posttest scores are higher than the average pretest scores for each indicator of creative thinking skills. Each indicator of creative thinking skills received an average score of 87.75 points. The average scores for each indicator are as follows: fluency at 90 points, flexibility at 87 points, originality at 82 points, and elaboration at 92 points. This is in line with the research conducted by Wanggi, Santoso, and Lestari (2023), which reported an average score of 76.5 points for creative thinking skills, with the average scores for each indicator as follows: fluency at 89.5 points, flexibility at 55.5 points, originality at 73.5 points, and elaboration at 88 points. Additionally, another study conducted by Ningrum, Rahman, and Riandi (2022) found an average score of 74.25 points for creative thinking skills, with the average scores for each indicator as follows: fluency at 83 points, flexibility at 81

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points, originality at 71 points, and elaboration at 62 points. Moreover, the average N-Gain score was 0.55 points, categorized as moderate for each creative thinking skill. This is consistent with the findings of Rinto et al. (2022) and Ningrum, Rahman, and Riandi (2022), which reported average N-Gain scores of 0.59 and 0.57, respectively, both categorized as moderate. Therefore, it can be concluded that the use of the PjBL-STEM model utilizing Algodoo can significantly enhance students' creative thinking skills, particularly in the indicators of elaboration and fluency.

Student Responses to the PjBL-STEM Model Utilizing Algodoo

The percentage of student responses can be calculated using the N-Gain test based on the scores from the response questionnaire. The N-Gain scores obtained are based on the percentage of student responses to the PjBL-STEM model utilizing Algodoo, as presented in Table 17.

Table 17. Results of Student Response Questionnaire

F	Response Percentage	Criteria
20	80% ≤ RP ≥ 100%	Very Positive
5	60% ≤ RP ≥ 80%	Positive
0	40% ≤ RP ≥ 60%	Fairly Positive
0	20% ≤ RP ≥ 40%	Less Positive
0	RP < 20%	Very Little Positive

According to Table 17, 20 students provided response percentages ranging from 80% to 100%, which fall under the very positive criterion. Meanwhile, 5 other students provided response percentages between 60% and 80%, categorized as positive. The results obtained are consistent with those of Supriyatin et al. (2022), Lestari (2021), and Erlinawati, Bektiarso, and Matyani (2019), who found response percentages above 60% with a positive criterion. Table 18 presents the analysis results of the response questionnaire aspects and indicators.

Table 18. Results of the Percentage of Aspects and Indicators of the Response Questionnaire

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Aspect	Indicator	Response (%)	Average (%)
Intersting	Clarity of Learning Media	88.25	86.82
	Suitability of Learning Media	87.75	
	Attractiveness of Learning Media	85.38	
Ease	Use of Learning Media	80.25	83.03
	Operation of Learning Media	86.53	
	Function of Learning Media	82.30	
Achievement of Learning Objectives	Relevance to Learning Material	81.65	86.80
	Level of Learning Achievement	84.50	
	Creating a Project	89.10	

According to Table 19, each aspect displays an average percentage score of 85.55%, reflecting very favorable responses across all areas. The aspect of attractiveness has the highest average score at 86.82%, followed by learning objective achievement at 86.80%, and ease at 83.03%. These results align with the findings of Ardiyansah, Rinto, and Fatnah (2024), in which students showed very positive responses to the PjBL-STEM model using Algodoo, with an average score of 84.13% across all aspects. The attractiveness aspect received an average score of 88.75%, the learning objective achievement aspect scored 83.33%, and the ease aspect scored 80.31%. Additionally, research conducted by Putra, Russitta, and Wulandari (2023) and Supriyatin et al. (2022) showed a response percentage of 80%. Therefore, it can be concluded that the use of the PjBL-STEM model with Algodoo increases student engagement, is easy to use, and enhances learning outcomes.

CONCLUSION

The results of the study show an increase in average pretest and posttest scores for cognitive learning, rising from 56 to 88 points, with an N-Gain score of 0.73, categorized as high. In terms of critical and creative thinking skills, each student improved across all indicators, with average pretest scores of 45.5 and 43.35 points, and average posttest scores of

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83.34 and 87.75 points, respectively. The N-Gain scores for these were 0.69 and 0.78, categorized as moderate and high, respectively.

Students provided very positive responses to the PjBL-STEM model using Algodoo, with an average score of 85.55%, indicating that all aspects received very positive responses from the students. The aspect of attractiveness had the highest average score at 86.82%, followed by the aspect of learning objective achievement at 86.80%, and the ease aspect at 83.03%. These results demonstrate that the PjBL-STEM model, using Algodoo in science education, can significantly improve students' cognitive learning outcomes, critical thinking skills, and creative thinking skills.

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