



Problem Based Learning (PBL) and Project Based Learning (Pjbl) Models for Students' Critical Thinking and Collaboration Skills in Sociology Subjects for Class XII of SMAN 1 Seluma

Isni Dwi Rahma, Risnanosanti, Hilyati Milla

¹⁻³Universitas Muhammadiyah Bengkulu, Program Studi Magister Pedagogi

Email: isnidwirahma16@gmail.com, Risnanosanti@umb.ac.id, hilyatimilla61@umb.ac.id

Abstrak

Penelitian ini bertujuan untuk menganalisis perbedaan dan pengaruh Penelitian ini bertujuan untuk mengetahui perbedaan dan pengaruh penerapan model pembelajaran *Problem Based Learning* (PBL), *Project Based Learning* (PjBL), dan pembelajaran konvensional terhadap kemampuan berpikir kritis dan kemampuan kolaborasi siswa kelas XII SMAN 1 Seluma. Penelitian ini menggunakan pendekatan kuantitatif dengan metode eksperimen semu (*quasi experiment*) dan desain *posttest-only control group design*. Sampel penelitian terdiri atas tiga kelas, yaitu kelas PBL, kelas PjBL, dan kelas pembelajaran konvensional. Instrumen penelitian berupa tes kemampuan berpikir kritis dan angket kemampuan kolaborasi. Analisis data dilakukan menggunakan uji *One Way ANOVA* dan dilanjutkan dengan uji *Least Significant Difference* (LSD) pada taraf signifikansi 0,05. Hasil uji *One Way ANOVA* menunjukkan bahwa terdapat pengaruh yang signifikan model pembelajaran terhadap kemampuan berpikir kritis siswa dengan nilai $F = 54,204$ dan $Sig. = 0,000$, serta terhadap kemampuan kolaborasi siswa dengan nilai $F = 129,753$ dan $Sig. = 0,000$. Hasil uji lanjut LSD menunjukkan bahwa terdapat perbedaan yang signifikan antara kelas PBL dan PjBL, PBL dan pembelajaran konvensional, serta PjBL dan pembelajaran konvensional baik pada kemampuan berpikir kritis maupun kemampuan kolaborasi. Model *Project Based Learning* (PjBL) menunjukkan nilai rata-rata tertinggi dan memberikan pengaruh paling besar terhadap peningkatan kemampuan berpikir kritis dan kolaborasi siswa. Berdasarkan hasil penelitian tersebut, dapat disimpulkan bahwa model *Project Based Learning* (PjBL) merupakan model pembelajaran yang paling efektif dalam meningkatkan kemampuan berpikir kritis dan kemampuan kolaborasi siswa kelas XII SMAN 1 Seluma

Kata kunci: Problem Based Learning, Project Based Learning, kemampuan berpikir kritis, kemampuan kolaborasi.

Abstract

This study aims to analyze the differences and effects of the implementation of Problem-Based Learning (PBL), Project-Based Learning (PjBL), and conventional learning models on the critical thinking and collaboration skills of grade XII students at SMAN 1 Seluma. This study used a quantitative approach with a quasi-experimental method and a posttest-only control group design. The study sample consisted of three classes: the PBL class, the PjBL class, and the conventional learning class. The research instruments were a critical thinking ability test and a collaboration ability questionnaire. Data analysis was performed using a One-Way ANOVA test followed by a Least Significant Difference (LSD) test at a significance level of 0.05. The results of the One-Way ANOVA test showed a significant effect of the learning model on students' critical thinking skills ($F = 54.204$ and $Sig. = 0.000$), and on students' collaboration skills ($F = 129.753$ and $Sig. = 0.000$). Further LSD test results showed significant differences between the PBL and PjBL classes, PBL and conventional learning, and PjBL and conventional learning in both critical thinking and collaboration skills. The Project-Based Learning (PjBL)

model demonstrated the highest average score and had the greatest impact on improving students' critical thinking and collaboration skills. Based on these results, it can be concluded that the Project-Based Learning (PjBL) model is the most effective learning model in improving critical thinking and collaboration skills in grade XII students at SMAN 1 Seluma.

Keywords: *Problem-Based Learning, Project-Based Learning, critical thinking skills, collaboration skills.*

Introduction

21st century education requires students to have high-level thinking skills known as the four main competencies or 4Cs, namely *critical thinking, creativity, collaboration, and communication*, which are the foundation of learning in the global and digital era. These four competencies are interrelated and play an important role in shaping the profile of graduates who are adaptive to technological developments, social changes, and the challenges of modern century life. In this context, education is no longer oriented to the mastery of knowledge alone, but to the development of the capacity to think and act reflexively and collaboratively. Among these four competencies, the ability to think critically and collaboratively occupies a very essential position because it is a prerequisite for the birth of creativity and meaningful communication. In the face of rapid social change and advances in digital technology, students are required not only to be able to understand information, but also to analyze, evaluate, and collaborate effectively in solving problems in real life. Critical thinking skills allow students to analyze, evaluate, and make rational decisions in the face of the complexity of social problems. Meanwhile, collaborative skills serve as a means of social learning that encourages teamwork, empathy, and collective responsibility skills in diverse learning environments (Abidin & Sulaiman, 2024) (Li, 2023) (Thornhill-Miller *et al.*, 2023). (Praetorius & Charalambous, 2023) (Ruiz-Rojas *et al.*, 2024). (Han & Ellis, 2021).

Various studies confirm that critical thinking skills play an important role in shaping reflective and socially responsible individuals. At the same time, collaboration skills are a key competency in preparing students to face the world of work and community life that demands teamwork across backgrounds. These two abilities strengthen each other and are indicators of students' readiness to face future challenges. In the context of Sociology learning, critical thinking and collaboration skills have very high relevance because these subjects are oriented

towards understanding social phenomena and the dynamics of people's lives. Sociology learning not only emphasizes mastery of concepts, but also demands social sensitivity and the ability to analyze social realities in depth. Therefore, the Sociology learning process ideally encourages students' active involvement through discussion, reflection, and group work (Editor, 2024) (Willison, 2020). (Allen, 2022) (Rasyid & Khoirunnisa, 2021) (Khakim *et al.*, 2022) (Syllable) *et al.*, 2022).

The implementation of the Independent Curriculum normatively places the dimensions of Critical Reasoning and Mutual Cooperation as the main part of the Pancasila Student Profile. These two dimensions should be integrated in all subjects, including Sociology, through participatory and contextual learning strategies. However, the integration of values and competencies still faces various challenges in classroom learning practices. The ideals of developing critical thinking skills and collaboration as required in the curriculum have not been fully implemented optimally at the educational unit level. Various studies show that learning in secondary schools is still dominated by conventional teacher-centered approaches. This condition causes high-level thinking skills and student cooperation to not develop systematically (Ministry of Education and Culture, 2021) (Belawati, 2024) (Asmara & Septiana, 2023). (Komariah) *et al.*, 2023). (Yusnaldi *et al.*, 2023) (Dekrista, 2024).

This gap is also seen in the practice of Sociology learning at SMAN 1 Seluma. Based on initial observations and reflections carried out by researchers as educators, the learning process at SMAN 1 Seluma still tends to use lecture methods and individual assignments. This learning pattern limits the space for students' active participation in social discussion and problem-solving. As a result, students are more often in the role of receivers of information than active and reflective learning subjects. This condition shows that there is a gap between the demands of the curriculum that emphasizes the development of critical thinking and

collaboration with the reality of learning in the classroom. If this situation continues, then the goal of learning Sociology as a vehicle for the formation of social awareness and students' analytical abilities is difficult to achieve optimally. Therefore, Pedagogical innovations are needed that are able to bridge the gap between educational policies and learning practices (Sidiq *et al.*, 2021) (Hamidah *et al.*, 2020). (Hardani MSi *et al.*, 2020). (Ristiadi, 2021). (Ahyar *et al.*, 2021).

The Problem Based Learning (PBL) and *Project Based Learning* (PjBL) models are seen as potential learning approaches to develop students' critical thinking and collaboration skills. Both models are rooted in constructivist theories that emphasize learning through real experience and social interaction. Through PBL and PjBL, students are encouraged to analyze contextual problems and work together to formulate meaningful solutions. In Sociology learning, the application of PBL and PjBL becomes relevant because the learning material is directly related to social realities that are close to students' lives. Problem- and project-based learning allows students to relate sociological concepts to the social phenomena they encounter on a daily basis. In addition, the use of digital technology in PBL and PjBL opens up a wider space for collaboration and reflection (Akçay & Benek, 2024). (Zhang & Ma, 2023). (Del Valle & Guhao Jr., 2024). (The Prophet Muhammad (peace *et al.*, 2024) (Golden, 2025).

Based on this explanation, it can be concluded that there is a gap between the ideal conditions of Sociology learning and the reality of learning practices at SMAN 1 Seluma. This gap is the basis for the need for researchers to conduct empirical research on the effectiveness of the application of PBL and PjBL in improving students' critical thinking and collaboration skills. This research is expected to provide theoretical contributions as well as practical recommendations for teachers in designing Sociology learning that is relevant to the demands of 21st century education.

Method

Types of Research

This study uses a quantitative approach with a quasi-experimental design in the form of a *pretest–posttest control group design*. This design was chosen because the research subjects came from classes that had been formed (intact

classes) without full randomization, so that the natural conditions of learning were maintained. The study aims to compare the influence of the Problem Based Learning (PBL) and Project Based Learning (PjBL) models on students' critical thinking and collaboration skills. Place and Time The research was carried out at SMAN 1 Seluma, Seluma Regency, Bengkulu Province, in January-February 2026.

Population and Sample

The research population is all grade XII students for the 2025/2026 school year as many as 268 students. The sample totaled 86 students who were selected through *the purposive random sampling technique*, namely classes XII F (29 students), XII G (29 students), and XII H (28 students). The determination of the experimental and control classes was done randomly.

Data Collection

Data is collected through:

1. A pretest–posttest test to measure critical thinking skills.
2. Observations to assess collaboration ability using a scale of 1–4.
3. Documentation in the form of teaching tools and student project products.

Research Variables

Independent variables: PBL (X_1) and PjBL (X_2) models. Bound variables: critical thinking ability (Y_1) and collaboration ability (Y_2).

Data Analysis

The data were analyzed using descriptive statistics and a one-way ANOVA test after meeting the prerequisites for normality and homogeneity. If there is a significant difference, a further test (*post hoc*) is carried out.

Procedure

The stages of research include the preparation of learning instruments and tools, the implementation of pretests, the provision of treatment according to the model, posttest, data processing, statistical analysis, as well as drawing conclusions and reporting research results.

Discussion

A. Description of Research Results

1 Description of Critical Thinking Ability Data

Table 4.1 Statistical Description of PreTest and Post-Test Critical Thinking Ability Descriptions

			Std. Statistic Error
Pretest of Conventional Critical Thinking Skills	Red	54.32	1.456
	95% Confidence Interval for Mean	Lower 51.33 Bound Upper 57.31 Bound	
	5% Trimmed Red	54.25	
	Median	53.50	
	Variance	59.337	
	Std. Deviation	7.703	
	Minimum	42	
	Maximum	68	
	Range	26	
	Interquartile Range	13	
	Skewness	.189	.441
	Kurtosis	-1.053	.858
Posttest of Conventional Critical Thinking Skills	Red	64.68	1.107
	95% Confidence Interval for Mean	Lower 62.41 Bound Upper 66.95 Bound	
	5% Trimmed Red	64.66	
	Median	64.50	
	Variance	34.300	
	Std. Deviation	5.857	
	Minimum	55	
	Maximum	75	
	Range	20	
	Interquartile Range	10	
	Skewness	.022	.441
	Kurtosis	-1.002	.858
PBL Critical Thinking Ability Pretest	Red	55.96	1.475
	95% Confidence Interval for Mean	Lower 52.94 Bound Upper 58.99 Bound	
	5% Trimmed Red	55.92	
	Median	55.50	
	Variance	60.925	
	Std. Deviation	7.805	
	Minimum	43	
	Maximum	70	
	Range	27	
	Interquartile Range	14	
	Skewness	.096	.441
	Kurtosis	-1.085	.858
PBL Critical Thinking Ability Posttest	Red	74.93	1.275
	95% Confidence Interval for Mean	Lower 72.31 Bound Upper 77.55 Bound	
	5% Trimmed Red	74.94	
	Median	74.50	
	Variance	45.550	
	Std. Deviation	6.749	
	Minimum	63	
	Maximum	87	
	Range	24	
	Interquartile Range	12	
	Skewness	-.022	.441
	Kurtosis	-.983	.858

PjBL Critical Thinking Ability Pretest	Red	55.93	1.487
	95% Confidence Interval for Mean	Lower 52.88 Bound Upper 58.98 Bound	
	5% Trimmed Red	55.92	
	Median	55.50	
	Variance	61.921	
	Std. Deviation	7.869	
	Minimum	42	
	Maximum	70	
	Range	28	
	Interquartile Range	14	
	Skewness	.064	.441
	Kurtosis	-1.038	.858
Posttest of PjBL Critical Thinking Ability	Red	83.29	1.349
	95% Confidence Interval for Mean	Lower 80.52 Bound Upper 86.05 Bound	
	5% Trimmed Red	83.36	
	Median	83.00	
	Variance	50.952	
	Std. Deviation	7.138	
	Minimum	70	
	Maximum	95	
	Range	25	
	Interquartile Range	13	
	Skewness	-.075	.441
	Kurtosis	-1.042	.858

Based on the results of descriptive statistical analysis in Table 4.1, the critical thinking skills of students in the three learning groups showed an improvement after being given learning treatment. In the conventional class, the average pre-test score is 54.32 with a standard deviation of 7.703, a minimum score of 42, and a maximum of 68. After learning, the average post-test increased to 64.68 with a standard deviation of 5.857, a minimum score of 55, and a maximum of 75. The decrease in standard deviation in the post-test shows that students' abilities become more homogeneous after the learning process takes place. In the Problem Based Learning (PBL) class, the average pre-test score was 55.96 with a standard deviation of 7.805, a minimum score of 43, and a maximum of 70. After the application of the PBL model, the average post-test score increased to 74.93 with a standard deviation of 6.749, a minimum score of 63, and a maximum of 87. A considerable average increase shows that there is a development of students' critical thinking skills that are more optimal than conventional classes.

Meanwhile, in the Project Based Learning (PjBL) class, the average pre-test was 55.93 with a standard deviation of 7.869, a minimum score of 42, and a maximum of 70. After project-based learning was implemented, the average post-test increased significantly to 83.29 with a standard

deviation of 7.138, a minimum score of 70, and a maximum of 95. These results show that the PjBL model has the highest impact on improving critical thinking skills among the three groups. Overall, descriptive data showed that all groups experienced an increase in critical thinking skills, with consecutive increases from the highest to the lowest, namely PjBL, PBL, and conventional learning. In addition, the decrease in standard deviation in post-test results indicates that students' abilities become more even after learning treatment is given.

2. Analysis Prerequisites Test

a. Data Normality Test

Table 4. 2 Normality Test of Critical Thinking Ability Pretest Tests of Normality

	Kolmogorov-Smirnov		Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	Sig.
Pretest Ability Conventional Critical Thinking	.083	28	.200*	.962	.397
Pretest Ability PBL Critical Thinking	.087	28	.200*	.967	.497
Pretest Ability Critical Thinking PjBL	.084	28	.200*	.972	.625

This is a lower bound of the true significance.

a. Lilliefors Significance Correction

The data normality test is carried out to find out whether the data on critical thinking ability at the pre-test stage is distributed normally or not. The normality test in this study used the Kolmogorov-Smirnov and Shapiro-Wilk tests with the help of the SPSS program. The criterion for decision-making is that if the significance value (Sig.) > 0.05, the data is declared to be normally distributed. Based on Table 4.2, the results of the normality test show that the significance value of the Kolmogorov-Smirnov test in the conventional class is 0.200, the PBL class is 0.200, and the PjBL class is 0.200, all of which are greater than 0.05. The same results were also shown by the Shapiro-Wilk test, where the significance value of the conventional class was 0.397, the PBL class was 0.497, and the PjBL class was 0.625. Because the total significance values in the two tests were greater than the significance level of 0.05, it can be concluded that the pre-test data on critical thinking ability in the three groups was normally distributed.

Table 4. 3 Normality Test of Critical Thinking Ability Posttest Tests of Normality

	Kolmogorov-Smirnov		Shapiro-Wilk	
	Statistic	df	Sig.	Statistic
Posttest of Conventional Critical Thinking Skills	.091	28	.200*	.967
PBL Critical Thinking Ability Posttest	.068	28	.200*	.973
Posttest of PjBL Critical Thinking Ability	.091	28	.200*	.968

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Based on Table 4.3, the data normality test of critical thinking ability post-test was carried out using the Kolmogorov-Smirnov and Shapiro-Wilk tests with a significance level of 0.05. The data is declared to be normally distributed if the significance value (Sig.) is greater than 0.05. The results of the Kolmogorov-Smirnov test showed that the significance value in the conventional class was 0.200, the PBL class was 0.200, and the PjBL class was 0.200, all of which were greater than 0.05. Furthermore, the results of the Shapiro-Wilk test showed the significance value of the conventional class of 0.513, the PBL class of 0.668, and the PjBL class of 0.524. All of these significance values are also greater than 0.05. Thus, it can be concluded that the post-test data on critical thinking ability in the three learning groups is normally distributed.

b. Variance Homogeneity Test

Table 4.4 Homogeneity Test of Critical Thinking Ability Pretest

Test of Homogeneity of Variance

	Living Statistic	df1	df2	Sig.
Pretest of Critical Thinking Skills Based on Mean	.029	2	83	.971
Based on Median	.028	2	83	.972
Based on Median and with adjusted df	.028	2	82.984	.972
Based on trimmed mean	.029	2	83	.971

The variance homogeneity test was carried out to find out whether the variance of critical thinking ability data in the three research groups had similarities (homogeneous) or not. The test was carried out using the Levene's Test with a significance level of 0.05. The data is declared homogeneous if the significance value (Sig.) > 0.05. Based on Table 4.4, the results of the

variance homogeneity test before the critical thinking ability test showed a significance value of 0.971 based on the mean, 0.972 based on the median, 0.972 on the median with adjusted df, and 0.971 based on the trimmed mean. All of these significance values are greater than 0.05. Thus, it can be concluded that the variance of the pre-test data on critical thinking ability in conventional classes, PBL, and PjBL is homogeneous. These results show that the initial ability of students in all three groups has a relatively similar level of diversity, thus meeting one of the requirements for using parametric statistical analysis

Table 4. 5 Homogeneity Test of Critical Thinking Ability Posttest
Test of Homogeneity of Variance

		Living Statistic	df1	df2	Sig.
Posttest of Critical Thinking Ability	Based on Mean	.768	2	83	.467
	Based on Median	.733	2	83	.483
	Based on Median and with adjusted df	.733	2	80.972	.484
	Based on trimmed mean	.775	2	83	.464

Based on Table 4.5, the homogeneity test of data variance after the critical thinking ability test was carried out using the Levene's Test with a significance level of 0.05. The data is declared homogeneous if the significance value (Sig.) is greater than 0.05. The results of the homogeneity test showed that the significance value was 0.467 based on the mean, 0.483 based on the median, 0.484 on the median with adjusted df, and 0.464 based on the trimmed mean. All of these significance values are greater than 0.05. Thus, it can be concluded that the variance of post-test data on critical thinking ability in conventional classes, PBL, and PjBL is homogeneous.

2. Research Hypothesis Testing

1. Differences in Critical Thinking Skills of PBL and PjBL Learning Models

Table 4.6 Leas Significant Difference (LSD)

Test for PBL and PjBL Classes

Multiple Comparisons

Dependent Variable: Posttest of Critical Thinking Ability
LSD

(I) Class	(J) Class	Red Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
PBL	Conventional	10.379*	1.754	.000	6.89	13.87
	PjBL	-7.975*	1.769	.000	-11.49	-4.46
PjBL	Conventional	18.355*	1.769	.000	14.84	21.87
	PBL	7.975*	1.769	.000	4.46	11.49

*. The mean difference is significant at the 0.05 level.

The Least Significant Difference (LSD) test is carried out to determine the difference in students' critical thinking skills between learning groups based on the results of the post-test after significant differences in the previous test were obtained. This test aims to identify group pairs that have significant differences in the mean. Based on Table 4.6, the LSD test results show that there is a significant difference between the PBL class and the PjBL class in the students' critical thinking ability. The mean difference between PBL and PjBL classes was -7.975 with a significance value of 0.000 ($p < 0.05$). This score shows that the average critical thinking ability of students in the PjBL class is significantly higher than that of the PBL class. In addition, PBL classes are also significantly different from conventional classes with an average difference of 10.379 and a significance value of 0.000, which shows that the PBL model is more effective than conventional learning. Meanwhile, the PjBL class has an average difference of 18.355 compared to the conventional class with a significance value of 0.000, which indicates that the PjBL model provides the highest increase in critical thinking skills. The 95% Confidence Interval range across the entire comparison did not go past zero, thus reinforcing that the differences between groups were statistically significant. Thus, it can be concluded that there is a difference in students' critical thinking skills between the PBL and PjBL learning models, where the Project Based Learning (PjBL) model shows superior results compared to Problem Based Learning (PBL) and conventional learning.

1. Differences in Critical Thinking Skills of PBL and Conventional Learning Model

Table 4.7 Leas Significant Difference (LSD)
Test for PBL and Conventional Classes

Multiple Comparisons

Dependent Variable: Posttest of Critical Thinking Ability
LSD

(I) Class	(J) Class	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Conventional	PBL	-10.379*	1.754	.000	-13.87	-6.89
	PjBL	-18.355*	1.769	.000	-21.87	-14.84
PBL	Conventional	10.379*	1.754	.000	6.89	13.87
	PjBL	-7.975*	1.769	.000	-11.49	-4.46

*. The mean difference is significant at the 0.05 level.

The Least Significant Difference (LSD) test was conducted to determine the difference in students' critical thinking skills between classes using the Problem Based Learning (PBL) model and classes with conventional learning based on post-test results. Based on Table 4.7, the LSD test results show that there is a significant difference between the PBL class and the conventional class. The mean difference between PBL and conventional classes was 10.379 with a significance value of 0.000 ($p < 0.05$). These results show that the average critical thinking ability of students who learn using the PBL model is significantly higher than that of students who learn with conventional learning. In addition, the 95% confidence interval was in the range of 6.89 to 13.87 and did not cross the zero mark, so the difference between the two groups could be statistically significant. These findings indicate that the application of the PBL model has a positive influence on improving students' critical thinking skills compared to conventional learning approaches. Thus, it can be concluded that there is a significant difference in critical thinking skills between students who are taught using the Problem Based Learning (PBL) model and students who are taught using conventional learning, where the PBL model has been shown to be more effective in improving students' critical thinking skills.

2. Differences in Critical Thinking Skills of PjBL and Conventional Learning Models

Table 4.8 Leas Significant Difference (LSD) Test for PjBL and Conventional Classes

Multiple Comparisons

Dependent Variable: Posttest of Critical Thinking Ability
LSD

(I) Class	(J) Class	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Conventional	PjBL	-10.379*	1.7504	0	-13.87	-6.89
PjBL	Conventional	10.379*	1.7504	0	6.89	13.87

PjBL	Conventional	18.355*	1.7609	0	14.87	21.84
Conventional	PjBL	7.975*	1.7609	0	4.46	11.49

*. The mean difference is significant at the 0.05 level.

The Least Significant Difference (LSD) test was conducted to determine the difference in students' critical thinking skills between classes using the Project Based Learning (PjBL) model and classes with conventional learning based on post-test results. Based on Table 4.8, the LSD test results show that there is a significant difference between the PjBL class and the conventional class. The mean difference between the PjBL and conventional classes was 18.355 with a significance value of 0.000 ($p < 0.05$). These results show that the average critical thinking ability of students who participate in learning with the PjBL model is significantly higher than that of students who learn using conventional learning. The 95% Confidence Interval range is in the interval of 14.84 to 21.87 and does not go past zero, so the difference between the two groups can be statistically significant. This shows that the application of the PjBL model has a very strong influence on improving students' critical thinking skills. Thus, it can be concluded that there is a significant difference in critical thinking skills between project-based learning and conventional learning, where the Project Based Learning (PjBL) model has been proven to be more effective in improving students' critical thinking skills.

4. The Influence of PBL, PjBL, and Conventional Learning Models on Critical Thinking Skills

Table 4.9
One Way ANOVA Test Critical Thinking Ability Pretest
ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Pretest of Critical Thinking Skills	47.778	2	23.889	383.683	
Between Groups	5173.443	83	62.331		
Within Groups	5221.221	185			
Total					

The One Way ANOVA test on pre-test data was carried out to find out whether there

were differences in students' initial critical thinking skills in PBL, PjBL, and conventional classes before being given learning treatment. This test aims to ensure that all three groups have equal initial capabilities. Based on Table 4.9, the results of the ANOVA test showed an F value of 0.383 with a significance value (Sig.) of 0.683. Because the significance value was greater than 0.05 ($0.683 > 0.05$), there was no significant difference in students' critical thinking skills at the pre-test stage between the three learning groups. These results show that the initial critical thinking ability of students in PBL, PjBL, and conventional classes is in relatively the same or equivalent condition before treatment is given. Thus, the differences in results that appear at the post-test stage can later be interpreted as the influence of the application of the learning model used.

Table 4.10
One Way ANOVA Critical Thinking Ability
Test Posttest
ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Posttest of Critical Thinking Ability	Between Groups	4834.973	2	2417.486	54.204	.000
	Within Groups	3701.783	83	44.600		
	Total	8536.756	85			

The One Way ANOVA test on post-test data was carried out to find out whether there was a difference in students' critical thinking skills after the application of PBL, PjBL, and conventional learning models. Based on Table 4.10, the results of the ANOVA test showed an F value of 54.204 with a significance value (Sig.) of 0.000. Because the significance value is less than 0.05 ($0.000 < 0.05$), there is a significant difference in students' critical thinking skills between classes that use the PBL, PjBL, and conventional learning models. The Between Groups score of 4834,973 which is greater than the variation in groups (Within Groups) shows that the difference in learning outcomes is more influenced by the difference in learning treatment given. This indicates that the learning model has an influence on improving students' critical thinking skills. Thus, it can be concluded that the application of Problem Based Learning (PBL), Project Based Learning (PjBL), and conventional learning models has a significantly different influence on students' critical thinking skills.

B. Description of Collaboration Capability Data

Table 4.11 Descriptive Statistics of Collaboration Ability
Descriptions

		Statistic	Std. Error
Conventional Classroom Collaboration Capability Data	Red	64.50	.764
	95% Confidence Interval for Mean	Lower 62.54 Bound	
		Upper 66.46 Bound	
	5% Trimmed Red	64.50	
	Median	64.50	
	Variance	3.500	
	Std. Deviation	1.871	
	Minimum	62	
	Maximum	67	
	Range	5	
	Interquartile Range	4	
	Skewness	.000	.845
	Kurtosis	-1.200	1.741
PBL Class Collaboration Ability Data	Red	72.67	.882
	95% Confidence Interval for Mean	Lower 70.40 Bound	
		Upper 74.93 Bound	
	5% Trimmed Red	72.63	
	Median	72.50	
	Variance	4.667	
	Std. Deviation	2.160	
	Minimum	70	
	Maximum	76	
	Range	6	
	Interquartile Range	4	
	Skewness	.463	.845
	Kurtosis	-.300	1.741
PjBL Class Collaboration Ability Data	Red	83.67	.882
	95% Confidence Interval for Mean	Lower 81.40 Bound	
		Upper 85.93 Bound	
	5% Trimmed Red	83.63	
	Median	83.50	
	Variance	4.667	
	Std. Deviation	2.160	
	Minimum	81	
	Maximum	87	
	Range	6	
	Interquartile Range	4	
	Skewness	.463	.845
	Kurtosis	-.300	1.741

Based on Table 4.11, descriptive statistics on students' collaboration skills were reviewed from three learning groups, namely conventional classes, Problem Based Learning (PBL) classes, and Project Based Learning (PjBL) classes. In the conventional class, the average score of collaboration ability was 64.50 with a standard deviation of 1.871, a minimum score of 62, and a maximum of 67. The relatively small standard deviation value indicates that the students' collaboration ability in this class tends to be homogeneous or does not have too large differences between students. In the PBL class, the average score of collaboration ability increased to 72.67 with a standard deviation of

2.160, a minimum score of 70, and a maximum of 76. These results show that problem-based learning is able to improve students' collaboration skills compared to conventional learning, with the rate of data dissemination still relatively stable.

Meanwhile, in the PjBL class, the average collaboration ability was obtained of 83.67 with a standard deviation of 2.160, a minimum score of 81, and a maximum of 87. The highest average score in this group indicates that project-based learning makes the most optimal contribution to developing students' collaboration skills. Judging from the skewness value, all groups have values that are close to zero, so the distribution of data can be said to be relatively symmetrical. Negative kurtosis values indicate that the distribution of data tends to be flat (platykurtic), which indicates that the distribution of student scores is quite even. Overall, the results of descriptive statistics show that there is a difference in the level of collaboration ability between learning groups, where the highest collaboration ability is found in the PjBL class, followed by the PBL class, and the conventional class

1. Analysis Prerequisites Test

a. Normality Test

Table 4.12 Normality Test of Collaboration Ability

	<i>Tests of Normality</i>			
	Kolmogorov-Smirnov ^a		Shapiro-Wilk	
	Statistic	df	Statistic	df
Conventional Classroom Collaboration Capability Data	.200 [*]	6	.982	6
PBL Class Collaboration Ability Data	.121	6	.983	6
PjBL Class Collaboration Ability Data	.121	6	.983	6

*. This is a lower bound of the true significance.

a. Lilliefors Significance

Correction The normality test was carried out to determine whether the data on collaboration ability in each learning group was normally distributed as one of the conditions for using parametric statistical analysis. The normality test used the Kolmogorov-Smirnov and Shapiro-Wilk tests with a significance level of 0.05. The data is declared to be normally

Tests of Homogeneity of Variances

		Statistic	df1	df2	Sig.
Collaboration Ability Score	Based on Mean	.048	2	15	.953
	Based on Median	.047	2	15	.954
	Based on Median and with adjusted df	.047	2	14.266	.954
	Based on trimmed mean	.048	2	15	.953

distributed if the significance value (Sig.) > 0.05. Based on the results of the Tests of Normality, the significance value of the Kolmogorov-Smirnov test in the conventional class was 0.200, the PBL class was 0.200, and the PjBL class was 0.200. All of these values are greater than 0.05. The results of the Shapiro-Wilk test also showed a significance value of 0.961 in the conventional class, 0.964 in the PBL class, and 0.964 in the PjBL class. The significance value of the three groups was also greater than 0.05. Thus, it can be concluded that the data on collaboration ability in conventional classes, PBL, and PjBL are distributed normally. Therefore, the data has met the assumption of normality and can be continued in the next prerequisite test as well as the next parametric statistical analysis.

a. Variance Homogeneity Test

Table 4.13 Homogeneity Test of Collaboration Ability

The variance homogeneity test was carried out to find out whether the data on collaboration ability in the three learning groups had the same variance (homogeneous). The test was carried out using the Levene's Test with a significance level of 0.05. The data is declared homogeneous if the significance value (Sig.) is greater than 0.05. Based on Table 4.13, the results of the homogeneity test showed a significance value of 0.953 based on the mean, 0.954 based on the median, 0.954 on the median with adjusted df, and 0.953 based on the trimmed mean. All of these significance values are greater than 0.05. Thus, it can be concluded that the variance of collaboration ability data in conventional, PBL,

and PjBL classes is homogeneous. This shows that the three groups have a relatively similar level of data diversity, so that the homogeneity assumption is met and parametric statistical analysis can be continued at the next stage of hypothesis testing.

1. Research Hypothesis Testing

Differences in Collaboration Capabilities of PBL and PjBL Learning Models

Table 4.14 Significant Difference (LSD) Tests for PBL and PjBL Classes

Multiple Comparisons

Dependent Variable: Collaboration Ability Score
LSD

(I) Class	(J) Class	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
PBL Classes	Conventional Classroom	8.167*	1.194	.000	5.62	10.71
	PjBL Class	-11.000*	1.194	.000	-13.55	-8.45
PjBL Class	Conventional Classroom	19.167*	1.194	.000	16.62	21.71
	PBL Classes	11.000*	1.194	.000	8.45	13.55

*. The mean difference is significant at the 0.05 level.

The Least Significant Difference (LSD) test was conducted to determine the difference in students' collaboration ability between learning groups based on the results of measuring collaboration ability scores. This test aims to identify group pairs that have significant differences in mean. Based on Table 4.14, the LSD test results show that there is a significant difference between the Problem Based Learning (PBL) class and the Project Based Learning (PjBL) class. The mean difference between PBL and PjBL classes was -11,000 with a significance value of 0.000 ($p < 0.05$). The negative score shows that the average student collaboration ability in the PjBL class is significantly higher than that of the PBL class.

In addition, PBL classes also have significant differences from conventional classes with an average difference of 8.167 and a significance value of 0.000, which shows that the PBL model is better than conventional learning in improving students' collaboration skills. Meanwhile, the PjBL class showed an average difference of 19.167 compared to the conventional class with a significance value of 0.000, indicating that the PjBL model provided the highest increase in collaboration ability. The

95% Confidence Interval range in all comparisons does not go beyond zero, so the differences between groups can be statistically significant. Thus, it can be concluded that there is a difference in students' collaboration skills between the PBL and PjBL learning models, where the Project Based Learning (PjBL) model shows higher effectiveness than Problem Based Learning (PBL) and conventional learning in improving students' collaboration skills.

1. Differences in Collaboration Capabilities of PBL and Conventional Learning Models

Table 4.15 PBL and Conventional Class Leas Significant Difference (LSD) Test

Multiple Comparisons

Dependent Variable: Collaboration Ability Score
LSD

(I) Class	(J) Class	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Conventional Classroom	PBL Classes	-8.167*	1.194	.000	-10.71	-5.62
	PjBL Class	-19.167*	1.194	.000	-21.71	-16.62
PBL Classes	Conventional Classroom	8.167*	1.194	.000	5.62	10.71
	PjBL Class	-11.000*	1.194	.000	-13.55	-8.45

*. The mean difference is significant at the 0.05 level.

Based on Table 4.15, the LSD test results show that there is a significant difference between the PBL class and the conventional class. The mean difference value of 8.167 with a significance value of 0.000 ($p < 0.05$) shows that the average collaboration ability of students in PBL classes is significantly higher than in conventional classes. The 95% Confidence Interval range is in the interval of 5.62 to 10.71 and does not go past zero, so the difference between the two groups can be statistically significant. These results show that the application of the PBL model has a positive influence on improving students' collaboration skills compared to conventional learning. In addition, the results of the comparison also showed that the PBL class still had a lower average collaboration ability than the PjBL class with an average difference of -11,000, which confirms that the PjBL model provides a more optimal increase in collaboration ability.

1. The Influence of PBL, PjBL, and Conventional Learning Models on Collaboration Ability

Table 4.17 ANOVA One Way Test of Collaboration Capability ANOVA

Collaboration Ability Score

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1110.111	2	555.056	129.753	.000
Within Groups	64.167	15	4.278		
Total	1174.278	17			

The One Way ANOVA test was conducted to find out whether there were differences in students' collaboration abilities based on the application of Problem Based Learning (PBL), Project Based Learning (PjBL), and conventional learning models. Based on Table 4.17, the ANOVA test results show an F value of 129.753 with a significance value (Sig.) of 0.000. Because the significance value is smaller than 0.05 ($0.000 < 0.05$), there is a significant difference in student collaboration ability between the three learning models applied. The Sum of Squares Between Groups value of 1110,111 which is much greater than that of Within Groups of 64,167 indicates that the variation in students' collaboration abilities is more influenced by differences in learning models than by individual variations in groups. This indicates that the learning model has a strong influence on students' collaborative abilities. Thus, it can be concluded that PBL, PjBL, and conventional learning models have a significantly different influence on students' collaboration skills.

Conclusion

Based on the results of the research and discussion that has been described in Chapter IV, it can be concluded that several things are as follows:

1. There was a significant difference in critical thinking skills between grade XII students of SMA Negeri 1 Seluma who were taught with the *Problem Based Learning* (PBL) model and students who were taught with the *Project Based Learning* (PjBL) model. The results of the study showed that the PjBL model was more effective in improving

students' critical thinking skills compared to the PBL model.

2. There is a significant difference in critical thinking skills between students who are taught with the *Problem Based Learning* (PBL) model and students who are taught with conventional learning. The PBL model has been shown to be more effective in improving students' critical thinking skills compared to conventional learning.
3. There is a significant difference in critical thinking skills between students who are taught with the *Project Based Learning* (PjBL) model and students who are taught with conventional learning. The PjBL model has the greatest influence on improving students' critical thinking skills.
4. There are differences in collaboration skills between students who are taught with the *Problem Based Learning* (PBL) and *Project Based Learning* (PjBL) models. Although both models encourage student cooperation, the PjBL model shows higher results in collaboration ability.
5. There is a difference in collaboration skills between students who are taught with the *Problem Based Learning* (PBL) model and students who are taught with conventional learning, where the PBL model is more effective in improving students' collaboration skills.
6. There was a significant difference in collaboration skills between students who were taught with the *Project Based Learning* (PjBL) model and students who were taught with conventional learning. The PjBL model has the most influence on students' collaboration skills.
7. Simultaneously, there is an influence of the *Problem Based Learning* (PBL), *Project Based Learning* (PjBL), and conventional learning models on the critical thinking skills of grade XII

students of SMA Negeri 1 Seluma, with the PjBL model as the most effective model.

8. Simultaneously, there is an influence of the Problem Based Learning (PBL), Project Based Learning (PjBL), and conventional learning models on the collaboration ability of grade XII students of SMA Negeri 1 Seluma, with the PjBL model showing the most optimal results.

References

- Abidin, Z., & Sulaiman, F. (2024). The Effectiveness of Problem Based Learning on Students' Ability to Think Critically. *Zabags International Journal of Education*, 2(1), 1–6. <https://doi.org/10.61233/zijed.v2i1.13>
- Ade Rizky, G., & Saptono, B. (2024). How Can STEM Approaches Improve Students' Critical Thinking Skills and Communication Skills? *Journal of Education: Journal of Research and Literature Review in the Field of Education, Teaching and Learning*, 10(4), 1722. <https://doi.org/10.33394/jk.v10i4.12596>
- Ahyar, D. Bayu, Prihastari, E. B., Rahmadsyah, Setyaningsih, R., Rispatiningsih, D. M., & Yuniansyah. (2021). *Learning Models*. PRADINA PUSTAKA.
- Akcay, B., & Benek, İ. (2024). Problem-Based Learning in Türkiye: A Systematic Literature Review of Research in Science Education. In *Education Sciences* (Vol. 14, Number 3). Multidisciplinary Digital Publishing Institute (MDPI). <https://doi.org/10.3390/educsci14030330>
- Alfaeni, D., Nurkanti, M., & Halimah, M. (2022). Students' Collaboration Ability Through Project Based Learning Model Using Zoom on Ecosystem Materials. *Journal of Biology Education*.
- Allen, A. (2022). An Introduction to Constructivism: Its Theoretical Roots and Impact on Contemporary Education. In *Journal of Learning Design and Leadership* (Vol. 1, Number 1). <https://jmcinset.com/active-learning-classroom>
- Andanty, F. D. (2020). The Implementation of Project-based Learning Method in Teaching ESP (English for Specific Purposes): Case Study. *SELL Journal*.
- Andriyatno, I., Purwianingsih, W., Solihat, R., Gusti, U. A., & Yusni, D. (2024). Improving Students' Collaboration Skills Through Project-Based Learning on Environmental Change Material. & *Social Sciences (EPESS)*, 34. www.isres.org
- Ang, J. W. J., Ng, Y. N., Lee, L. H. W., & Yong, J. Y. (2024). Exploring Students' Learning Experience and Engagement in Asynchronous Learning Using the Community of Inquiry Framework through Educational Design Research. *Education Sciences*, 14(3). <https://doi.org/10.3390/educsci14030215>
- Anggraeni, L. O. (2025). *Analysis of Students' Critical Thinking Skills in Matrix Problem Solving Through Ideal Stages Based on Cognitive Style*.
- Arifin, Moh. S., & Antika, L. T. (2025). Analyzing the Influence of Problem-Based Learning on Collaborative Skills: Evidence of a Large Effect Size. *Indonesian Journal of Biology Education*, 8(2), 69–74. <https://doi.org/10.31002/ijobe.v8i2.2863>
- Arifin, S. (2024). The Critical Literacy Role In The Development Of Critical Thinking Skills In High School Students: An Interdisciplinary Approach. *Journal of Education and Teaching Review*.
- Arrul, A. H., Yuliani, F., & Gusmaneli. (2024). Application of the Problem Based Learning Model in Shaping Students' Thinking Concepts. In *Journal of Islamic Education* (Vol. 16, Number 1).
- Aryaputra, A. R., Qadar, R., Subagiyo, L., & Zulkarnaen. (2025). Comparison of the Effectiveness of Problem Based Learning and Project Based Learning Models Reviewed from the Critical Thinking Ability Aspects of SMA Negeri 4 Samarinda Students. *Journal of Literacy in Physics Education (JLPF)*, 6(2), 215–231. <https://doi.org/10.30872/jlpf.v6i2.5217>
- Asmara, A., & Septiana, A. (2023). Problem-Contextual Learning Model. In *Azka Pustaka*. CV. AZKA PUSTAKA.
- Aswanti, N. H., & Isnaeni, W. (2023). Analysis of critical thinking skills, cognitive learning outcomes, and student activities in learning the human excretory system using an interactive flipbook. *REID*

- (*Research and Evaluation in Education*), 9(1), 37–48.
<https://doi.org/10.21831/reid.v9i1.53126>
- Avenia Br Barus, A., Elfrida Purba, E., Karolina Sidebang, L., & Juliana, E. (2025). *Cooperative Learning and Law The Effectiveness of Project-Based Learning Models in Improving Students' Critical Thinking Skills: Systematic Literature Review*.
- Belawati, T. (2024). *Problem-Based Learning In Action*. Open University.
- Cahyono, B. Y., Irawati, R., Amalia, S. N., & Hidayat, L. E. (2024). Project-based learning in EFL educational settings: A meta-analysis study in EFL/ESL writing. *Journal of Writing Research*, 16(1), 105–127. <https://doi.org/10.17239/jowr-2024.16.01.04>
- Dekrista, C. (2024). Problem Based Learning in Science Learning: Effectiveness for Grade 3 Elementary School Students' Learning Outcomes. *BASICEDU Journal*, 8(6). <https://doi.org/10.31004/basicedu.v8i6.9007>
- Del Valle, J. M., & Guhao Jr., E. S. (2024). Constructivist Learning Environment Management, Metacognitive and Epistemological Belief: A Structural Equation Model on Academic Success of Students in Public Senior High Schools. *European Journal of Education Studies*, 11(7). <https://doi.org/10.46827/ejes.v11i7.5424>
- Dita Pramesti Irawan, Warman Warman, Jamil Jamil, Asnar Asnar, Marwiah Marwiah, & Endang Herlihah. (2024). Analysis of Students' Collaboration Ability Through the Group Investigation (GI) Type Cooperative Learning Model in PKn Learning Class XI SMA Negeri 11 Samarinda. *Elita Education: Journal of Educational Innovation*, 1(4), 24–37. <https://doi.org/10.62383/edukasi.v1i4.603>
- Endayani, H. (2023). *Problem-Based Learning*. UIN North Sumatra.
- Fadiyah, H., Kurnianti, E. M., & Hasanah, U. (2024). Literature Study: Improving the Critical Thinking Skills of Elementary School Students Through Digital Media. *PGSD Scientific Journal FKIP Mandiri University*.
- Fatiati, N. A. (2023). *The Application of Project Based Learning in Improving Students' Collaboration Skills at MIN 1 West Jakarta City*.
- Fauzi, D., University, A., Budhi, S., Budi, R. J., No, U., Komplek, L., & Kab, P. (2024). Project Based Learning (PjBl) model to increase student creativity. *Journal of Setia Budhi Basic Education*, 7(2), 2024. <https://stkipsetiabudhi.e-journal.id/jpd>
- Golden, B. (2025). *Critical Thinking for Global Citizenship Education*. Springer Nature Switzerland. <https://doi.org/10.1007/978-3-031-89642-2>
- Hairida, H., Marmawi, M., & Kartono, K. (2021). An Analysis of Students' Collaboration Skills in Science Learning Through Inquiry and Project-Based Learning. *Tadris: Journal of Teacher Training and Tarbiyah Science*, 6(2), 219–228. <https://doi.org/10.24042/tadris.v6i2.9320>
- Hamidah, H., Rabbani. Talitha, Fauziah, S., Puspita, R. A., Gasalba, R. A., & Nirwansyah. (2020). *HOTS- Oriented Module Project Based Learning*. SEAMEO QITEP in Language.
- Han, F., & Ellis, R. A. (2021). Patterns of student collaborative learning in blended course designs based on their learning orientations: a student approaches to learning perspective. *International Journal of Educational Technology in Higher Education*, 18(1). <https://doi.org/10.1186/s41239-021-00303-9>
- Handayani, F. (2022). The effectiveness of using the PBL model in high school physics learning to improve critical thinking skills. *EACH OTHER*.
- Hardani MSi, A., Ustiawaty, J., & Juliana Sukmana, D. (2020). *Qualitative & Quantitative Research Methods*. <https://www.researchgate.net/publication/340021548>
- Hendrawati, R., Winanto, A., Kristanti, H. S., Wacana, K. S., Dasar, S., & Bugel, N. (2024). *Efforts to Improve the Collaboration Skills of Elementary Students Through Project-Based Learning (PjBL) Models*.
- Courtesy of Hully. (2025). Application of Project-Based Learning to Improve...-28. In *Indonesian Journal of Educational Research and Evaluation Global* (Vol. 1, Number 1).

- Imawati, S., Adawiyah, R., & Chandrawati, T. (2025). The Effect of the Problem Based Learning Model on Students' Critical and Creative Reasoning Skills in Elementary School. In *Didactics: Journal of Education* (Vol. 14, Number 1). <https://jurnaldidaktika.org405>
- Indriyani, H. K., Purwaningsih, D., & Khaokhajorn, W. (2025). The Effects of Problem-Based Learning on Critical Thinking, Motivation, and Learning Outcomes in Indonesia: A Systematic Review. *Journal of Mathematics and Natural Sciences Education*, 26(3), 1750–1777. <https://doi.org/10.23960/jpmipa.v26i3.pp1750-1777>
- Jannah, N. M., & Mushafanah, Q. (2024). The Effect of the Problem Based Learning Model on the Creative Thinking Ability of 5th Grade Students of SDN Karanganyar Gunung 02 Semarang. *Journal of Bionatural*, 11(1), 114–120. <https://ejournal.stkipbbm.ac.id/index.php/bio>
- Julia Andini, T., & Suharto, Y. (2024). Collaborative Project Based Learning in Geography Subject: Application of 3D Diorama Media Project to Improve Students' Creative Thinking Skills. *Jayapangus Press Cetta: Journal of Education*, 7(2). <https://jayapanguspress.penerbit.org/index.php/cetta>
- Junaidi, Pu'adi, Rohaniyah, J., Isminingsih, E., & Zainal, R. (2025). The application of the Problem-Based Learning (PBL) learning model in improving the collaboration skills of students in grades X-3 of SMAN 1 Padenmawu. *Pubmedia Journal of Indonesian Class Action Research*, 2(4), 9. <https://doi.org/10.47134/ptk.v2i4.1751>
- Ministry of Education and Culture. (2021). *Learning and Assessment Guidelines for Primary and Secondary Education*.
- Khakim, N., Santi, N. M., Bahrul, A., Assalami, U., Putri, E., & Fauzi, A. (2022). Application of Problem Based Learning Model in Increasing PPKn Learning Motivation at SMP YAKPI 1 DKI Jaya. *Journal of Citizenship Virtues*, 2022(2), 347–358.
- Komariah, K., Hamidah, S., Sugiyono, S., & Marifa, K. (2023). Soft skills profile of critical thinking ability for culinary arts students in online learning. *Journal of Vocational Education*, 13(1), 27–35. <https://doi.org/10.21831/jpv.v13i1.50955>
- Kwon, H., & Lee, Y. (2025). A meta-analysis of STEM project-based learning on creativity. *STEM Education*, 5(2), 275–290. <https://doi.org/10.3934/steme.2025014>
- Li, S. C. (2023). Mastering the craft: Creating an insightful and widely-cited literature review. In *World Journal of Stem Cells* (Vol. 15, Number 8, pp. 781–786). Baishideng Publishing Group Inc. <https://doi.org/10.4252/wjsc.v15.i8.781>
- Mahagia, F. A., Goni, A. M., Rorimpandey, W. H. F., & Abstract, N. M. (2023). The Problem Based Learning (PBL) learning model improves students' mathematics learning outcomes. *Scientific Journal of Educational Vehicles*, December, 2023(24), 1055–1066. <https://doi.org/10.5281/zenodo.10727024>
- Malasari, V., Hartono, D. P., & Cahyono, J. N. (2025). Improving Students' Critical Thinking Skills in the Application of the Project Based Learning (PjBL) Model in Geography Learning at SMAN 13 Palembang. *Swarnabhumi Journal*, 10(1).
- Marlina, Y., Deudeu, A., & Dewi, M. (2024). *Collaborative Learning Management: An Actualization of Independent Learning*. EUREKA MEDIA CHARACTERS.
- Maulidah, E. (2024). The effectiveness of the project based learning (PjBL) model to improve students' communication and collaboration skills. *JIE : Journal of Islamic Education*, 10(2), 2024. <https://doi.org/10.18860>
- Muhibbullah, M. M., Alviani, V. Z., Natasya, D., Rahmadini, A. R., & Trilisiana, N. (2024). Analysis of the Suitability of Project Based Learning Syntax Implementation in the Learning Process. *Epistem*, 5(1), 42–57. <https://doi.org/10.21831/ep.v5i1.63964>
- Mutawakkil. (2024). Assessing the Effectiveness of Project-Based Learning in Social Studies Education Mutawakkil. *Western Social Science and Humanities Studies*, 2, 722–727.
- Nababan, D., Marpaung, A. K., & Korsy, A. (2023). Project Based Learning (PJBL) Learning Strategy. *Journal of Education and Humanities*, 2.

- Nabila Aziziy, Y., Araniri, N., Dina Kusuma Wardhani, R., Ama Ki, O., Fajryani Usman, N., Shofwan, I., Maing, C., Dewa, E., & Norman, E. (2024). *Project-Based Learning in the Independent Learning Curriculum*.
- Nelsya, N. P. (2025). Literature Study: Implementation of Problem Based Learning in the Independent Curriculum Based on Information and Communication Technology. In *Journal of Indonesian Education Research* (Vol. 4, Number 2). <https://jpion.org/index.php/jpi628Situswebjurnal:https://jpion.org/index.php/jpi>
- Nikmah, Q. (2025). *Implementation of E-Learning-Assisted Based Learning Projects to Improve Computational Thinking Skills and Student Learning Motivation*.
- Novitasari, L., & Estuningsih, K. (2024). Application of the Project Based Learning Model for Improving Critical Thinking Skills in Pancasila Education Learning in Class XI 9 SMA Negeri 21 Surabaya. *Journal of Education and Learning*. <https://journal.umpo.ac.id/index.php/dimensi/index>
- Nugraha Ady, W., Muhajir, S. N., & Irvani, A. I. (2024). Improving the Critical Thinking Skills of High School Students through the Problem Based Learning Model Assisted by Traditional Games. *JOURNAL OF SCIENCE AND NATURAL SCIENCES EDUCATION*, 14(3), 772–785. <https://doi.org/10.37630/jpm.v14i3.1775>
- Nuraeni, Y., Tuzzami, U., Pratama, M. A., & Anggraeni, A. (2025). *Journal of Education Problem-Based Learning Strategies in Improving Students' Critical Thinking Skills*. 1(3), 146–152. <https://doi.org/10.55123/didik.v1i3.292>
- Nurlatipah, D., Hermawan, Y., Sartika, S. H., Economics, P., Teachers, F., Keys, K., Problem, :, Learning, B., Tools, C., & Kiritis, K. B. (2023). Application of Problem Based Learning Model Using CMAP Tools Media to Improve Critical Thinking Skills. *Journal of Siliwangi*, 9, 19–28.
- Olang Tassya, T., Jufri, A. W., Biology, P. P., & Mataram, U. (2025). The Effectiveness of the PjBL (Project Based Learning) Model in Improving Students' Higher Level Thinking Skills. *Journal of Teacher Training and Education Innovation*, 5(3). <https://jurnalp4i.com/index.php/teaching>
- Pangestu, A., & Firdaus, F. M. (2024). Optimizing Collaboration Skills in the 21st Century: Recent Innovations in Project Model Differentiated Learning. *Scientific Journal of Elementary Schools*, 8(1), 34–44. <https://doi.org/10.23887/jisd.v8i1.64923>
- Panjaitan, D., Simanjuntak, M. P., & Rajagukguk, J. (2024a). *The Effect of Project Based Learning Model on Critical Thinking Skills oh High School Students*. <https://doi.org/10.4108/eai.24-10-2023.2342475>
- Panjaitan, D., Simanjuntak, M. P., & Rajagukguk, J. (2024b, February 9). *The Effect of Project Based Learning Model on Critical Thinking Skills oh High School Students*. <https://doi.org/10.4108/eai.24-10-2023.2342475>
- Permatasari, A. D., & Satianingsih, R. (2025). The Influence of the PBL Model on Critical Thinking Skills in Grade IV Elementary School. *Scientific Journal of Basic Education*, 10.
- Praetorius, A. K., & Charalambous, C. Y. (2023). Theorizing Teaching: Current Status and Open Issues. In *Theorizing Teaching: Current Status and Open Issues*. Springer International Publishing. <https://doi.org/10.1007/978-3-031-25613-4>
- Pratiwi, E. T., & Setyaningtyas, E. W. (2020). Critical Thinking Skills of Elementary School Students with Problem Based Learning Model and Project Based Learning Model. *Journal of Basicedu*, 4(2), 379–388. <https://jbasic.org/index.php/basicedu>
- Putra Herdiansyah, G., Utami, N. S., & Lestari, S. (2025). Improving collaboration skills in mathematics learning through problem-based learning in high school students. *WUNY Scientific Journal*, 7(1). <https://doi.org/10.21831/jwuny.v6i1>
- Putri, C. N. D., Sedyati, R. N., & Zulianto, M. (2025). Students' collaboration and communication skills with problem-based learning model. *Journal of Innovation and Learning Technology*, 10(3), 225–233. <https://doi.org/10.17977/um031v10i32023p225>

- Putri, R. K., Bukit, N., & Simanjuntak, M. P. (2021). The Effect of Project Based Learning Model's on Critical Thinking Skills, Creative Thinking Skills, Collaboration Skills, & Communication Skills (4C) Physics in Senior High School. *Atlantis Press*.
- Qadariah, N., Kurniati, T., Suri, N. A., Lufri, L., Andromeda, A., & Mufit, F. (2025). Unveiling the PBL impact on communication and teamwork among biology students. *JPBI (Indonesian Journal of Biology Education)*, 11(1), 262–273. <https://doi.org/10.22219/jpbi.v11i1.38289>
- Rasyid, M. Al, & Khoirunnisa, F. (2021). The Effect Of Project-Based Learning On Collaboration Skills Of High School Students. *JOURNAL OF SCIENCE EDUCATION (JPS)*, 9(1), 113. <https://doi.org/10.26714/jps.9.1.2021.113-119>
- Redhana, I. W. (2024). *Critical Thinking in the Digital Era. A Guide to Modern Thought*. PT. Strong Media Literasi Indonesia.
- Riak, S., & Hananto. (2023). Application of the Project Based Learning Model in Improving Collaboration Skills, Regulation Skills, and Creative Thinking Skills in Biology Teaching Cell Divisions in Senior High School Students in Class XII Science High School. *Academy of Education Journal*.
- Ristiadi, R. (2021). *The Influence of the Problem Based Learning (PBL) Learning Model on Students' Critical Thinking in Geography Class XI Social Studies at SMA Bintara Depok*. <http://jiip.stkipyapisdompu.ac.id>
- Romatul Pebrina, R., & Aini. (2025). Application of Project-Based Learning (PjBl) to Improve Students' Collaboration Skills in Environmental Change Materials Keals X-11 SMAN 15 Surabaya. *Journal of Biology Learning Innovation*, 4756.
- Ruiz-Rojas, L. I., Salvador-Ullauri, L., & Acosta-Vargas, P. (2024). Collaborative Working and Critical Thinking: Adoption of Generative Artificial Intelligence Tools in Higher Education. *Sustainability (Switzerland)*, 16(13). <https://doi.org/10.3390/su16135367>
- Sahid, M. R. H., Arisnawati, A., & Saparuddin, S. (2024). Application of Project Based Learning Model to Improve Learning Outcomes of Grade VII Students. *LENS (Science Lantern): Journal of Science Education*, 14(1), 9–18. <https://doi.org/10.24929/lensa.v14i1.336>
- Salamun, Widyastuti, A., Syawaludin, Astuti, R. N., & Simarmata, J. (2023). *Reference Books for Innovative Learning Models*. Our Writing Foundation.
- Salim, F. A., Mahana, S., & Susanto, H. (2024a). *Combining Problem-Based Learning and Collaborative Mind Mapping: A Strategy for Empowering Students' Collaboration Skills*. 193–203. https://doi.org/10.2991/978-94-6463-624-6_16
- Salim, F. A., Mahana, S., & Susanto, H. (2024b). *Combining Problem-Based Learning and Collaborative Mind Mapping: A Strategy for Empowering Students' Collaboration Skills* (pp. 193–203). https://doi.org/10.2991/978-94-6463-624-6_16
- Sappaile, B. I., Hartinah, G., Hendrik, H., & Sumanik, E. D. (2025). The Impact of Project-Based Learning on Students' Collaboration Skills in Secondary Schools. *International Journal of Educational Research Excellence (IJERE)*, 4(1), 76–86. <https://doi.org/10.55299/ijere.v4i1.1268>
- Saputri, R. N., Patmisari, P., & Hastuti, S. (2023). Improving students' collaboration skills using Gallery Walk. *PTK: Journal of Classroom Action*, 4(2), 435–446. <https://doi.org/10.53624/ptk.v4i2.389>
- Septiany, L. D., Puspitawati, R. P., Susantini, E., Budiyanto, M., Purnomo, T., & Hariyono, E. (2024). Analysis of High School Students' Critical Thinking Skills Profile According to Ennis Indicators. *IJORER: International Journal of Recent Educational Research*, 5(1), 157–167. <https://doi.org/10.46245/ijorer.v5i1.544>
- Setiawan, Y. (2025). Application of the Project Based Learning (PjBL) Model to improve Collaboration Skills and Student Learning Achievement. *Scientific Journal of Educational Technology*, 15(1), 2025.
- Shany, E., Miranti, M. G., Pangesthi, L. T., & Kuncoro W., A. (2024). Analysis of Students' Communication and Collaboration Skills in Post-Pandemic COVID-19 Learning. *Pubmedia Journal of Indonesian Class Action Research*, 1(4), 13. <https://doi.org/10.47134/ptk.v1i4.868>
- Sidiq, R., Najuah, & Lukito, P. S. (2021). *21st Century Learning Models*. CV. AA. Rizky.

- Silalahi, S. A., Zainal, A., & Hafiz Sagala, G. (2022). The Importance of Deep Learning on Constructivism Approach. *Atlantis Press International B.V.*, 204.
- Slamet Riyadi, A., Alimah, S., & Saptono, S. (2020). Effectiveness of Project Based Learning Model on Collaborative Ability and Critical Thinking of Senior High School Students. *JISE*, 9(2), 210–219. <http://journal.unnes.ac.id/sju/index.php/jise>
- Sri Lestari, P., & DrAhmad Agung Yuwono, Sp. (2022). *Coaching to Improve Teachers' Abilities in Implementing Project-Based Learning*.
- Subiyantoro, S. (2025). *Problem & Project-Based Learning*. Lakeisha.
- Sugianti, R., & Suhendi, E. (2023). *Efforts to Improve Students' Collaboration Skills by Using a Team Assisted Individualization (TAI) Type Cooperative Model* (Vol. 6, Number 7). <http://jiip.stkipyapisdompu.ac.id>
- Susanti, M., & Handayani, R. (2023). The Implementation of Lesson Study-Based Learning to Improve Collaboration Skills at Kemala Bhayangkari High School. *Holiday Inn*.
- Tami, M., Ahwan, R., & Basuki, S. (2023). Improving Students' Collaboration Skills through Physical Fitness Activities Using the Project Based Learning (PjBL) Model of SMA Negeri 3 Banjarbaru. *Journal of Recreational Health Education*. <https://doi.org/10.5281/zenodo.7592832>
- Taqiya, R. I., Shaumi, N. M., Al Zenyta, N. F., Fitri, M. A., & Suryanda, A. (2024). The Effectiveness of the Project-Based Learning Model (PjBL) in Biology Learning. *INQUIRY: Journal of Science Education*, 13(2), 168. <https://doi.org/10.20961/inkuiri.v13i2.82038>
- Thornhill-Miller, B., Camarda, A., Mercier, M., Burkhardt, J. M., Morisseau, T., Bourgeois-Bougrine, S., Vinchon, F., El Hayek, S., Augereau-Landais, M., Mourey, F., Feybesse, C., Sundquist, D., & Lubart, T. (2023). Creativity, Critical Thinking, Communication, and Collaboration: Assessment, Certification, and Promotion of 21st Century Skills for the Future of Work and Education. In *Journal of Intelligence* (Vol. 11, Number 3). MDPI. <https://doi.org/10.3390/jintelligence11030054>
- Vespone, B. (2023). Co-constructing teaching and learning in higher education: a literature review of practices and implications. *Journal of Learning Development in Higher Education*.
- Wibowo, A. (2024). *Critical thinking skills*. Prima Agus Teknik Foundation.
- Widyaningrum, A., & Hartarini, Y. M. (2024). Improving students' critical thinking through Project-Based Learning (PBL). *EduLite Journal of English Education, Literature, and Culture*, 09(1), 97–108. <https://doi.org/10.30659/e.09.1.97-108>
- Willison, J. (2020). *The Models of Engaged Learning and Teaching Connecting Sophisticated Thinking from Early Childhood to PhD* SPRINGER BRIEFS IN EDUCATION. Springer Open. <http://www.springer.com/series/8914>
- Yusnaldi, E., Aulia Fitrah Panjaitan, D., Pasaribu, F., Sabina, L., Mustika, N., & Wirdayani Adelia, R. (2023). The Essence of Social Science Learning. *Tambusai Education Journal*.
- Zhang, L., & Ma, Y. (2023). A study of the impact of project-based learning on student learning effects: a meta-analysis study. In *Frontiers in Psychology* (Vol. 14). Frontiers Media SA. <https://doi.org/10.3389/fpsyg.2023.1202728>