JPPIPA 11(5) (2025)

Jurnal Penelitian Pendidikan IPA

http://jppipa.unram.ac.id/index.php/jppipa/index

Effectiveness of Collaborative Project-Based Learning to Improve Critical Thinking Science in Elementary School

Salsadilla Maryan Ningsih[1*], Ana Fitrotun Nisa[1], Akbar Al Masjid[1], Banun Havifah Khosiyono[1], Berliana Henu Cahyani[1]

[1]Master of Elementary Education, Directorate of Postgraduate Education, Universitas Sarjanawiyata Tamansiswa, Yogyakarta, Indonesia.

Received: January 10, 2025
Revised: March 22, 2025
Accepted: May 25, 2025
Published: May 31, 2025

Corresponding Author:
Salsadilla Maryan Ningsih
Salsadillamaryanningsih@gmail.com

DOI: 10.29303/jppipa.v11i5.10949

Abstract: The use of project-based collaborative models in learning can hone critical thinking skills in learning. The purpose of this study is to determine the implementation of collaborative project-based learning model innovations on the critical thinking skills of elementary school students in science lessons. The research method is a quasi-experiment with one-group pretest-posttest design. The data collection tool uses observation sheets for the implementation of learning models and critical thinking description tests. Indicators of critical thinking are inference, explanation, interpretation, and metacognition. The results of the research obtained in the form of a collaborative project-based learning model ran very well in phase one 92% and phase two 100%. There was an increase in the average pretest score of 56.73 and posttest of 91.57. The results of the effect size test (cohen'd) showed a very high category of 5.94, in the very high category. It can be concluded that collaborative project-based learning models are very effective in improving critical thinking in elementary school science.

Keywords: Collaborative; Critical thinking; Project-based learning

Introduction

Science that studies the human environment in a complex and structured manner. Puspita et al. (2023) argues that living things, the appearance of nature, and all natural phenomena that occur around humans are the scope of science. Science in elementary school is the main focus at the elementary school levels, because students' knowledge of the surrounding environment affects sympathy and empathy to contribute to the surrounding nature (Rorimpandey & Modeong, 2024). The basic concept of science must spur students to think critically through problem-solving activities both individually and in groups (Suciati et al., 2023). Science and technology learning in elementary schools seeks to optimize students' knowledge of the environment, as well as train critical thinking that can be applied in daily life (Awang et al., 2020).

The concept of teaching and learning must have a reciprocal relationship that occurs between teachers and students. Teachers' skills that must be honed in the 21st century can choose a learning model that is based on characteristics, meaningful, in-depth, and beneficial to the environment (Thao et al., 2024). This is in line with Dewi & Arifin (2024) the application of the project-based learning collaborative learning model can create meaningful and beneficial learning for the surrounding environment. Collaborative learning project-based learning will foster confidence, critical thinking, social attitudes and being able to provide real experiences that will be remembered and applied in daily life related to the surrounding nature (Susanti et al., 2023). The importance of a collaborative learning model of project-based learning to develop critical thinking skills in elementary school science (Hasan et al., 2023).

How to Cite:
Ningsih, salsadilla M., Nisa, A. F., Al Masjid, A., Khosiyono, B. H., & Cahyani, B. H. (2025). Effectiveness of Collaborative Project-Based Learning to Improve Critical Thinking Science in Elementary School. *Jurnal Penelitian Pendidikan IPA*, *11*(5), 749-760. https://doi.org/10.29303/jppipa.v11i5.10949

Critical thinking is the ability to analyze the information received, understand, explain and provide solutions. These aspects of critical thinking include inference, explanation, interpretation and metacognition (Dafit et al., 2024). Inference is the ability to draw conclusions, explanation is the ability to articulate reasoning and structured thought processes, interpretation is the ability to explain information, and metacognition is the ability to evaluate one's own knowledge (Wahidin & Romli, 2020). The 21st century learning model also requires the skills that must be achieved are innovative thinking skills, active roles, critical, free to interact and cooperate (Lidyasari, 2023). The ability to inference, explanation, interpretation and metacognition can be trained by applying a collaborative learning model of project-based learning, especially in elementary school science (Suratmi & Sopandi, 2022).

There have been previous studies that have examined the effects of project-based learning during the teaching and learning process. This research was conducted by Wedasuwari et al. (2024). Project-based learning can enhance the critical thinking of 21st-century students. Studies conducted by Azmi (2023) prove that the project-based learning model has succeeded in improving students' 4C skills, and research conducted by Winarni (2023) that Project-based learning has been shown to increase creativity in creating creative writing in elementary school.

Collaborative learning project-based learning means a student-centered learning model, making students productive, collaborative, imaginative, and able to solve problems through work in the form of products that are done collaboratively (Anggriani et al., 2024). Collaborative project-based learning makes students actors in learning that focuses on inference, explanation, interpretation, and metacognition (Yanti & Rahmad, 2023). This research focuses on efforts to hone students' critical thinking through elementary science teaching materials, a collaborative project-based learning approach.

Learning activities with collaborative project-based learning in its implementation focus on aspects of critical thinking in science (Rupavijetra et al., 2022). Collaborative components that are integrated into the project-based learning syntax include communication, community learning, discussion, and problem-solving (Suradika et al., 2023). The collaborative component integrated with project-based learning will hone students' science critical thinking skills for inference, explanation, interpretation, and metacognition (Mursalim et al., 2023).

The collaborative implementation of project-based learning is very important, but this learning model has not been optimally applied in the learning process. In line with Isa & Azid (2021) that the learning model applied in elementary schools is still in the form of traditional learning in the form of assignments, teacher centers, and taking notes. Traditional learning creates a monotonous learning atmosphere and does not make students think critically to develop their intelligence and skills to collaborate (Wulandari & Rohaeti, 2024). The teaching and learning process in school still requires students to take notes, work on evaluation questions, and remember what the teacher explains (Purwaningsih et al., 2020). This problem was further strengthened through the results of an interview with a teacher of SD Negeri 007 Bukit Kemuning that the learning model that is often applied is the traditional model, where the teacher provides video-assisted learning topics as well as explaining the material and in the end, students are given evaluations. The teacher is still the model in learning, engaging students only during the question and answer process and presentation.

The critical thinking component in elementary school still needs guidance. Critical thinking in elementary school students in science subjects is still low and requires guidance in the aspects of inference and metacognition (Suastra et al., 2021). Based on the results of interviews with teachers of SD Negeri 007 Bukit Kemuning regarding critical thinking skills, students are not able to infer well at the end of learning. This lack of inferential ability means that the critical thinking indicators in this study have not been met. The low level of critical thinking is due to the selection of a learning model that does not focus on the ability to think critically about science (Astra et al., 2024). From the results of the interviews, it is necessary to innovate the collaborative model of project-based learning to optimize the critical thinking of science in elementary school students.

The solution that can be done to overcome the problem of students' low critical thinking skills is to apply a project-based learning model with a collaborative approach. Collaborative approaches that are integrated with project-based learning complement and blend in creating the ability for inference, explanation, interpretation, and metacognition (Rahayu et al., 2025). In its implementation, students are trained to communicate, discuss, learn and solve problems collaboratively. These habits can affect the way they think in the context of elementary school science.

Method

This type of research is quantitative with a quasi-experimental method. Design one group pretest-posttest by providing tests at the beginning before being given treatment and tests at the end after being given treatment (Cohen et al., 2007). The sample of this study amounted to 23 students of class VI A as an experimental group. The design of this study is presented in Table 1.

Table 1. One group pretest-posttest (Sugiyono, 2016)

Group	Pretest	Treatment	Posttest
experiment	0_1	X	0_2

Information:
0_1 : Pretest value before treatment is given
X : Treatment with a collaborative project-based learning model
0_2 : Posttest value after treatment

This research instrument consists of observation sheets on the implementation of collaborative project-based learning models and descriptive tests used to measure students' critical thinking skills. The acquisition of pretest-posttest data will be statistically tested with Prerequisite Tests, namely, Normality Test (Shapiro-Wilk), Homogeneity Test (Levene) and Hypothesis Test (Paired Sample t-test) with the help of Jamovi software 2.3.28.

Result and Discussion

This study was conducted with the aim of measuring the effectiveness of the collaborative project-based learning model on the critical thinking skills of elementary school science. This study was conducted at SDN 007 Bukit Kemuning with a focus on the material on the form of matter and its changes. This study was conducted in two face-to-face meetings in the 2024/2025 academic year.

Implementation of Collaborative Project-Based Learning in the First Meeting

In the first meeting, students worked on a project to create a poster of a triangle about changes in the state of an object. In this work, students were free to divide tasks, work on projects, and determine the time used to create the poster. Poster materials had been prepared before the meeting. So, in this first meeting, students started working and collaborating with their group members to create a poster. Students used textbooks, worksheets, learning videos, and pictures shown by the teacher. The poster consisted of pictures of changes in the state of an object and their meaning. Students were asked to match and create their posters together with their group members collaboratively. If there was material that was not understood, they were allowed to reread the material in the book and watch the learning video about changes in the state of an object. After the poster was finished, students were asked to present their work in front of their group members. Other students who did not present were asked to give appreciation, suggestions, and correct the work of other group members.

In this first meeting, there were some students who did not understand what sublimation and crystallization were, and examples of them in everyday life. The two changes in the state of an object were reviewed and reflected on together with the help of learning videos displayed using a projector, making it easier for students to understand the material and for teachers to deliver the learning topic.

Implementation of Collaborative Project-Based Learning in the Second Meeting

At the second meeting, students made simple ice cream with their group members. Each group consisted of four students, the tools and materials had been agreed upon at the first meeting. Students were free to collaborate to determine the design, strategy, how to make and complete the making of their simple ice cream. For the ice cream flavor, powdered milk was used according to the agreement of each group. Students collaborated with their group members to make ice cream with guidance and direction from the teacher. Students who still lacked tools and materials were allowed to ask the group that was still available. After successfully making simple ice cream, students were asked to explain their experience in making ice cream.

Based on the results of the presentation, it was found that students still did not understand the addition of salt when making simple ice cream. The more salt is used, the colder the ice cubes around the can will be and make the ice cream spin faster. The rotation of the rocks in the same direction makes the ice cream soft in texture, while the rotation of the can that is not in the same direction makes the ice cream texture a little rough. At this second meeting, students already know the changes in form that occur after making simple ice cream. Students can already mention what melting, condensing, freezing and crystallizing are along with examples because they have conducted experiments in working on a simple ice cream project in the second meeting.

In the learning process, project-based learning and collaboration teach students that learning is not a competition, but cooperation, respect, attitude and action (Muhibbin & Khoirunisa, 2023). With project-based learning integrated with this collaborative component, students can learn through experience, knowledge, and insights that their friends have as learning resources, because learning resources are not only from teachers (Wibowo et al., 2024).

Collaborative project-based learning in science the learning steps refer to the collaborative syntax of project-based learning whose components are communication, discussion, learning community, and problem solving. Student activities in the collaborative syntax of project-based learning can hone students' critical thinking skills,

namely inference, explanation, interpretation and metacognision. Student and teacher activities during the implementation of collaborative project-based learning are presented in Table 2.

Table 2. Steps of the collaborative project-based learning model

Steps of the collaborative project-based learning model	Collaborative components	Teacher activities	Student activities	Critical thinking indicators
Students are given trigger/basic questions	Communication, discussion, problem-solving	Teachers give quizzes/triggering questions to measure students' understanding	Students answer questions presented based on prior knowledge	Interpretation, students are able to understand and explain the various types of changes in the state of objects.
Students collaborate to design project designs	communication, community learning, discussion, problem-solving	teachers monitor students in group formation, and guide them in the division of tasks	Students and group friends construct their knowledge collaboratively preparing strategies, tools, and materials to solve the problems presented	Metacognition, students are able to monitor, evaluate and search for information to develop their projects on the state of matter and its changes.
Students collaborate to create a project timeline	Communication, community learning, discussion, problem solving,	Teachers actively involve students to agree on the time and stages of working on the project	Students collaborate with their group friends to arrange stages and times to be agreed upon	Explanation, students are able to design poster work and make ice cream rolls so that they can be completed on time
Teachers Monitor Students' Work	Communication, community learning, discussion, problem solving,	Teachers monitor students while collaborating on projects	Students collaborate with their group friends to work on projects based on agreed Steps and times	Metacognition, students are able to work collaboratively to complete their projects within the agreed time
Assess the results of student collaboration	Communication, community learning, discussion, problem solving,	The teacher guides students in presenting the work	Students and their group friends present the results of the project in front of their friends	Inference, students are able to present the results of their group work on the form of matter and its changes
Evaluate the knowledge of project results	Communication, community learning, discussion	The teacher guides the presentation, assesses the project results with other students, and provides reflection	Students convey obstacles to the work on the project that has been completed	Interpretation, students already understand the types, causes, and triangles of changes in state and are able to make ice cream based on the results of their own thinking.

In its implementation, the collaborative project-based learning model in science lesson materials changes due to heat is qualified in Table 3.

Table 3. Qualifications collaborative project-based learning

Model feasibility (%)	Qualification
$X < 60$	Very less
$60 \leq X < 70$	Less
$70 \leq X < 80$	Enough
$80 \leq X < 90$	Good
$90 \leq X$	Excellent

The results of the research related to the implementation of the collaborative project-based learning model in the science lesson of the material on the change in the shape of objects due to heat can be seen in the diagram presented in Figure 1.

The implementation of collaborative project-based learning model, it can be concluded that the percentage of implementation of collaborative project-based learning model in the first and second stages of science learning is done very well because the percentage is above 90%. The percentage of implementation of learning model in the first stage is 92% and the second stage is 100%. The learning syntax applied is arranged

according to the steps of project-based learning integrated with a collaborative approach.

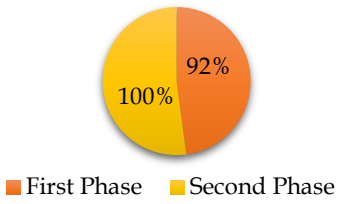

Figure 1. The results of implementation of collaborative project-based learning

The implementation of a collaborative project-based learning model encourages students to collaborate, collaborate, and interact directly with the problems presented in the learning process (Anggraito et al., 2023). Activities where students design projects and present the results of their work in front of their group of friends will train them how to communicate and be confident (Sajidan et al., 2022). Students' freedom to gather, create, and work in groups to complete projects will have an impact on their application in everyday life (Saputra et al., 2023). Collaborative project-based learning makes learning less monotonous but will create an active learning atmosphere that makes students become models and will train critical thinking in solving problems faced every day (Khairani & Tressyalina, 2020).

The implementation of collaborative project-based learning in the learning process can train their communication, cooperation, discussion, and attitudes in solving problems (Biantoro & Pertiwi, 2024). The classification of collaborative project-based learning implementation is very good, this is because all steps are carried out well. A good learning model is a learning model that activates students to interact directly with the problems presented (Subiyantoro, 2024). Actively involving students in making projects will train their time management, social attitudes, and way of thinking (Mahulae et al., 2023). Students who are involved and active during learning will easily remember the material they are studying and can motivate students to think critically (Hidayatullah et al., 2022). Students' ability to take on roles in their environment is one of the goals of implementing a collaborative project-based learning model.

Critical Thinking of Students After the Implementation of the Collaborative Project-Based Learning Model in Science and Science Learning

Critical thinking IPAS is calculated based on four indicators developed following research needs. The test used is a description or essay test which of course is used and developed according to research needs. This description test is very appropriate to measure students' critical thinking because it can maximize the way children think as much as possible and pour it into the form of writing, which of course they stringing together words until they become the correct answer according to the topic presented in the question (Yuliarti et al., 2023).

Testing the validity of a question is indispensable before conducting research. The validity test is useful to ensure the feasibility of the measuring instrument used (Umam & Susandi, 2022). The validity test helps ensure that the measuring instrument used is exactly as it will be measured (Sawji et al., 2024).

Before the critical thinking indicator test is used in research, it must be ensured that the essay test questions are valid and reliable to accurately and appropriately measure students' critical thinking. The validity test was carried out by testing the correlation formula of the moment product with a significance of 5% presented in Table 4.

Table 4. Testing the validity of pretest and posttest critical thinking questions

Indicators of critical thinking	Question numbers with critical thinking indicators	Significance table value 5%	Test the validity of post-test questions	Validity test of the post-test questions	Information
Able to provide a brief explanation of the change in the shape of objects due to heat with their group friends	1	0.433	0.644	0.690	Valid
	2		0.566	0.578	Valid
Able to provide a complete and structured explanation of the causes and consequences of changes in the form of objects due to heat	3		0.880	0.890	Valid
	4		0.670	0.787	Valid
Able to give conclusions about the effect of heat can change the shape and shape of objects	5		0.640	0.550	Valid
	6		0.550	0.765	Valid
Able to make decisions and solutions to solve problems related to changes in the form of objects due to heat	7		0.540	0.580	Valid

Based on the results of the question validity test presented in Table 4, it shows that all question items are confirmed to be valid. The critical thinking indicators used in this study amounted to four points which were developed into seven questions. The first question indicator can measure critical thinking for inference. The

second question indicator can measure critical thinking with explanation. The third question indicator can measure the ability to interpret, and the fourth question indicator measures the ability to metacognition.

All questions with critical thinking indicators are proven to be valid. The determination of the validity of the questions was carried out with the Jamovi 2.3.28 application with R_{table} 0.433. The validity test of the question is above the value of the R_{table} or above 0.433 which is used as a reference in determining the validity of the question. A validity value above 0.433 states that the critical thinking question items to be used are valid and feasible.

After analyzing the validity of the question items, the question can be used to measure the improvement of students' critical thinking. The results of the students' pretest and posttest critical thinking scores are presented in Figure 2.

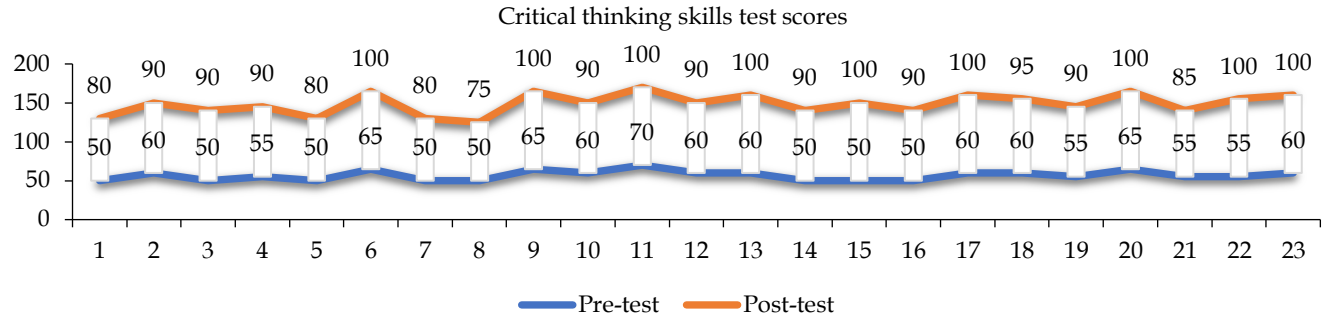

Figure 2. Pretest-posttest scores for students

From the results of obtaining pretest and posttest critical thinking scores, all students increased and got scores above average. The highest score was achieved by the numbers fifteen and twenty-two. The two students had the highest difference in pretest and posttest scores compared to other students. The increase is with a difference of 45-50 points in the pretest score. Based on the students' post-test scores, can provide a clear picture and conclusion that students' critical thinking has increased entirely.

The increase in the pretest and posttest scores occurred due to the implementation of collaborative project-based learning in science, and material changes in the form of objects due to heat. The learning model is carried out very well, involving active and collaborative students during learning. Students are able to give simple and complex explanations about the change in the shape of objects due to heat, are able to give conclusions, and are able to solve problems that occur related to changes in the shape of objects due to heat/heat. The abilities obtained by the students are a reference indicator of critical thinking which is used as a benchmark in answering research hypotheses.

Based on the pretest and posttest critical thinking scores, all students obtained scores above average. The collaborative project-based learning model that is implemented very well can hone students' critical thinking. An increase in critical thinking scores can occur because learning is investigating, presenting problems, and making structured conclusions (Wibowo et al., 2024). This is in line with Khoiri et al. (2023) that a collaborative learning model will definitely develop critical thinking skills in solving the problems faced. The collaborative project-based learning model has been proven to improve students' critical thinking, as evidenced by the increase in all student scores.

To find out the category of student scores, a data descriptive test was carried out to find the mean, median, mode and standard of defiance of students' pretest and posttest scores. The table of test results is presented in Table 5.

Table 5. Mean, median, mode, and standard deviation values of pretest and posttest scores

Descriptive test	Pretest	Posttest
Mean	56.73	91.95
Median	55	90
Modus	50	100
Defiance standards	6.14	7.94

Table 6. Categorization based on mean values and defibrillation standards

Categorize	Formula
High	> M + 1 Sdi
Medium	Between M-1 to M + 1 Sdi
Low	< M–1 Sdi

Description:

High : all samples that obtained a score of the same mean score plus one standard of defiance and above.

Medium : all samples obtained between an average of minus one standard deviation and an average score of plus one standard deviation.

Low : all samples that obtained a score lower than the average score minus one standard deviation of defiance.

Based on the descriptive test of critical thinking posttest data presented in Table 5, it can be concluded that there is an increase in critical thinking posttest. Starting from the pretest mean which was initially 56.73 to 91.95, there was an increase of 35.22. The pretest mode to posttest increased from 50 to 100. To categorize student scores in the high, medium or low categories, it is done using the formula presented in Table 6.

With the acquisition of pretest and posttest critical thinking scores of students of class IV A SDN 007 Bukit Kemuning, the researcher described the data into three groups, namely high, medium, and low. This classification aims to find out what category students' abilities are in so that it can be an evaluation for teachers. The results of the grouping are presented in Figure 3.

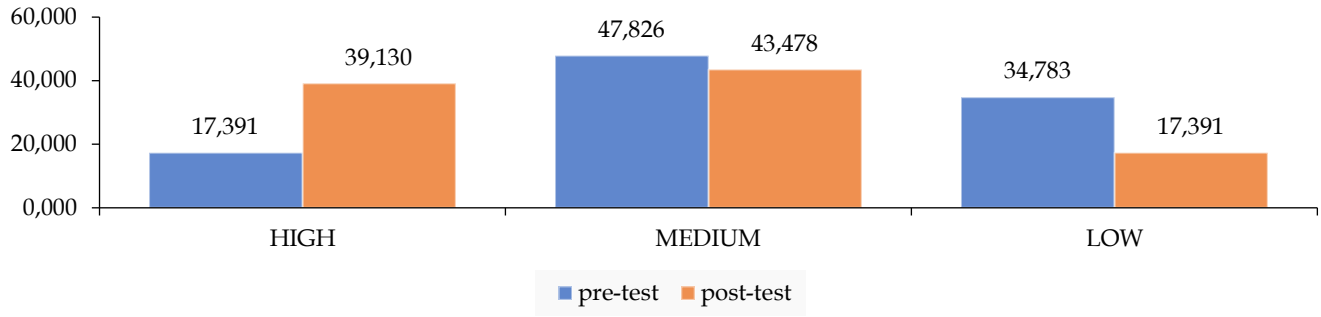

Figure 3. Value groups pretest-posttest critical thinking IPAS

The group of pretest and posttest critical thinking scores of IPAS in Figure 3 shows that the acquisition of pretest to posttest scores in the high group has increased and, conversely, there is a decrease in the pretest to posttest scores in the low group. In the pretest, the score in the group was low at 34.783, but the collaborative project-based learning model managed to reduce it to 17.391 during the post-test, which means that it managed to reduce by 17.392. An increase in the high group also occurred, which initially at the pretest was only 17.391, increased far to 39.130 after the posttest, which means an increase of 21.739. The distribution of student scores is the highest in the medium group, both pretest and posttest.

The acquisition of scores in the high category has increased when given a posttest, which means that the collaborative project-based learning model has succeeded in providing a learning experience that maximizes critical thinking (Wahyudi et al., 2024). Before the implementation of the collaborative project-based learning model, high groups were still small, while after being given the high group acquisition model, it increased dramatically. Critical thinking is a student's ability that needs to be honed and developed because, through this ability, they can act and take a role in the problems that occur around them (Astawan et al., 2023).

The decrease and increase that occurred in the pretest and posttest critical thinking of students was due to the application of the collaborative project-based learning model which was carried out very well. Based on the descriptive statistical test, it can be concluded that the student's scores are in the medium group. The explanation of the student's abilities in the medium category is also evidenced by the analysis of the results of the students' post-test work.

The results of the analysis of question items can strengthen decision-making. Children with moderate critical thinking still need guidance and supervision in what matters, so that educators can provide learning and direction according to the characteristics of students (Tereshchuk et al., 2023). Critical thinking questions must be made based on indicators that have been developed according to research needs (Ting et al., 2025). The results of the analysis of question items with critical thinking indicators are presented in Table 7.

Table 7 provides an explanation that based on the work on the critical thinking posttest questions, the lowest score obtained by students is in the indicator of metacognition. In this case, of course, it can give a conclusion that students still need detailed guidance to be able to make decisions and provide solutions in order to solve the problems that occur around them related to changes in the form of objects due to heat.

Ability critical thinking It is characterized by still needing guidance to solve problems by providing solutions or appropriate actions related to the problems that occur around it (Zetriuslita et al., 2016). The ability to think critically means that in giving conclusions, it still requires detailed guidance to provide the right solution or action related to the problems that occur around it (Tanti et al., 2020). The analysis is taken from the critical thinking indicator questions that have previously been analyzed in Table 7.

Table 7. Critical thinking indicators and posttest data of students after the implementation of collaborative project-based learning

Variable	Critical thinking indicators	Indicators of critical thinking questions	Question numbers with critical thinking indicators	Average post-test score indicator	Number of students
Critical thinking	Inference	Able to provide a brief explanation of the change in the shape of objects due to heat with their group friends	1	60	23
			2	56	23
	Explanation	Able to provide a complete and structured explanation of the causes and consequences of changes in the form of objects due to heat	3	62	23
			4	61	23
	Interpretation	Able to give conclusions about the effect of heat can change the shape and shape of objects	5	60	23
			6	62	23
	Metacognition	Able to make decisions and solutions to solve problems related to changes in the form of objects due to heat	7	50	23

Analysis of achievement indicators of students' critical thinking questions showed that the average score was high. Students already have the ability to inference, explanation, interpretation, and metacognition in analyzing changes in the form of objects that occur around them (Danil et al., 2023). Students are presented with a description of the change in shape of objects due to heat and are asked to name and find out the cause and effect, and the students are shown to be capable. Students' abilities are due to the application of a collaborative project-based learning model because in stages one and two, students themselves learn under the supervision of teachers. The lowest indicator obtained was metacognition ability. This means that students still need guidance and direction from teachers to determine solutions to the problem of changing the shape of objects in daily life (Kawuryan et al., 2022). Based on the analysis of questions with critical thinking indicators, it is proven that all indicators have been achieved, which means that students' critical thinking has been honed.

The Effectiveness of the Collaborative Project-Based Learning Model in Learning Science and Science Materials for Changes in the Form of Objects Due to Heat

Testing the effectiveness of the collaborative project-based learning model in science lessons is carried out by testing the prerequisites for analysis. The proof is through normality and homogeneity, hypothesis tests are carried out first before testing the effectiveness after the data is distributed normally and homogeneously, then look at the effect size score to conclude that the collaborative project-based learning model has succeeded in maximizing critical thinking of social science students in class IV A SDN 007 Bukit Kemuning.

The normality test was carried out by the Shapiro-Wilk test with a significance of 0.05. The homogeneity test with Levene significance level used was 0.05 and the hypothesis test using the T-test, namely the paired sample T-test. This study wants to reveal how effective collaborative project-based learning is on students' critical thinking, then it is seen that the cohen'd score is obtained with the provisions of 0.2, 0.5 and 0.8. The results of the jamovi 2.3.28 assisted data test is presented in Table 8.

Based on Table 8, the results of normality, homogeneity, and hypothesis tests can be drawn from the conclusion that the pretest and posttest data are distributed normally and homogeneously. To state that the collaborative project-based learning model has succeeded in improving the critical thinking of classroom students, it can be seen from the effect size (cohen'd) value. Based on the data obtained, 5.94 is very large. The results of the acquisition of effect size (cohen'd) values can answer the research hypothesis, which means that the collaborative project-based learning model is successful in raising the critical thinking of science students in grade IV A SDN 007 Bukit Kemuning. In line with Mutakinati & Anwari (2018) a very effective learning model is usually student center, able to involve students to be imaginative, critical, collaborative, and able to meet the learning outcomes to be achieved.

Table 8. Test normal, homogeneous, and hypothetical data

Prerequisite Test	Conditions	Test Results	Information
Normality	> 0.05	0.93	Normal data
Homogeneity	> 0.05	0.245	Homogeneous Data
Hypothesis	< 0.05	< .001	There are significant differences
Effect Size (Cohen'd)	0.2 0.5 0.8	5.94	Very large

Collaborative project-based learning can optimize critical thinking in IPAS class IVA. Research in line with this research has proven that project-based learning is appropriately applied to elementary school students. Studies and research by Wicaksono et al. (2021) prove that collaborative project-based learning can maximize critical thinking skills in the 21st century. Research by Azmi (2023) proves that collaborative project-based learning is able to sharpen students' 4C skills, and a research study Winarni (2023) shows that collaborative project-based learning has been shown to increase creativity in creating creative writing at the elementary school level. This research complements previous research, namely by implementing a collaborative learning model that is proven to be able to improve critical thinking of science in elementary school students.

Conclusion

The implementation of the collaborative project-based learning model is well implemented. The collaborative learning model of project-based learning is well implemented and appropriate to be applied at the elementary level because it can hone students' critical thinking. Critical thinking increased after the implementation of collaborative project-based learning, as evidenced by the increase in the results of the critical thinking test used in the research. It is proven that students are capable of inference, explanation, interpretation and metacognition related to the problem of changing the form of objects in daily life. This proves that the collaborative project-based learning model has succeeded in increasing scientific critical thinking on changes in the shape of objects due to heat in class IVA SDN 007 Bukit Kemuning.

Acknowledgments
The researcher would like to express his deepest gratitude for all the blessings and mercy from Allah SWT so that he can complete this research article well. Not to be missed, gratitude was also conveyed to the lecturers of the University of Sarjanawiyata Tamansiswa, the principal and teachers of the class of SDN 007 Bukit Kemuning, and, the Ministry of Education, Culture, Research and Technology of the Republic of Indonesia for their assistance in conducting research.

Author Contributions
This research article involves lecturers and all actively contribute. A.F.N., A.A.M., B.H.K., and B.H.C. are responsible for reviewing the work on the research article. S.M.N. is responsible for completing and analyzing research data. The researcher completed this research article by the rules of data collection, data processing, and scientific publication.

Funding
This study does not receive external funding.

Conflicts of Interest
The researcher stated that there was no conflict

References

Anggraito, Y. U., Ridlo, S., & Harahap, F. (2023). STEM-PjBL Learning: The Impacts on Students' Critical Thinking, Creative Thinking, Communication, and Collaboration Skills. *Jurnal Penelitian Pendidikan IPA*, *9*(7), 1–9. https://doi.org/10.29303/jppipa.v9i7.2985

Anggriani, M. D., Intansari, I., & Indrianii, L. (2024). Project-Based Learning: Cultivating Collaborative Skills in Science Education. *Jurnal Pendidikan Guru Sekolah Dasar*, *13*(5), 184–190. http://dx.doi.org/10.33578/jpfkip-v13i5.p184-190

Astawan, I. G., Suarjana, I. M., Werang, B. R., Asaloei, S. I., Sianturi, M., & Elele, E. C. (2023). STEM-Based Scientific Learning and Its Impact on Students' Critical and Creative Thinking Skills: An Empirical Study. *Jurnal Pendidikan IPA Indonesia*, *12*(3), 482–492. https://doi.org/10.15294/jpii.v12i3.46882

Astra, I. M., Khoirulloh, H., & Rahayu, Y. (2024). The Implementation of Problem Based Learning (PBL) Assisted by Video on Momentum and Impuls Material to Improve Students Critical Thinking Abilities. *Jurnal Penelitian Pendidikan IPA*, *10*(2), 704–713. https://doi.org/10.29303/jppipa.v10i2.6230

Awang, Z., Yakob, N., Hamzah, A., Talling, M. M., & Steam, F. R. (2020). Exploring STEAM Teaching in Preschool Using Fred Rogers Approach. *International Journal of Evaluation and Research in Education*, *9*(4), 1071–1078. https://doi.org/10.11591/ijere.v9i4.20674

Azmi, N. (2023). Meta Analysis: The Influence of Instrument Assessment on Project-Based Learning Models to Improve 4C Skills. *Jurnal Penelitian Pendidikan IPA*, *9*(4), 2184–2190. https://doi.org/10.29303/jppipa.v9i4.2606

Biantoro, P. P., & Pertiwi, K. R. (2024). Development of IBSC (Investigation Based Science Collaborative) Based Student Worksheet on Human Respiratory System to Improve Science Literacy and Collaboration Skills of Grade XI Students. *Jurnal Penelitian Pendidikan IPA*, *10*(9), 6473–6489. https://doi.org/10.29303/jppipa.v10i9.8560

Cohen, L., Manion, L., & Morrison, K. (2007). Research Methods in Education. In *Research Methods in Education*. USA and Canada: Taylor & Francis e-Library. https://doi.org/10.4324/9780203029053

Dafit, F., Gurning, R. F., Anggriani, & Dwi, M. (2024). 4C Abilities (Critical Thinking, Communication, Collaboration, Creativity) of Elementary School Students in Learning the Indonesian Language. *Jurnal Pendidikan Guru Sekolah Dasar*, *13*(5), 191–200.

Retrieved from https://repository.uir.ac.id/24729/

Danil, M., Corebima, A. D., Mahanal, S., & Ibrohim, I. (2023). The Connection between Students' Retention and Critical Thinking Skills in Diverse Academic Skills in Biology Learning. *Jurnal Pendidikan IPA Indonesia*, *12*(2), 241–251. https://doi.org/10.15294/jpii.v12i2.39983

Dewi, M. R., & Arifin, Z. (2024). Analysis of 21 st Century Skills in the Implementation of Project Based Learning in Biology Learning Merdeka Curriculum. *Jurnal Penelitian Pendidikan IPA*, *10*(4), 2118–2127. https://doi.org/10.29303/jppipa.v10i4.5941

Hasan, M., Arisah, N., S, R., Ahmad, M. I. S., & Miranda, M. (2023). Experiential Learning Model for the Development of Collaborative Skills through Project Based Learning Practicum. *Jurnal Pendidikan Indonesia*, *12*(2), 340–349. https://doi.org/10.23887/jpiundiksha.v12i2.57376

Hidayatullah, A. R., Yamtinah, S., & Masykuri, M. (2022). Development of A Two-Tier Multiple-Choice Instrument Based on Higher Order Thinking Skills (HOTS) on Acids, Bases, and Salts. *Jurnal Penelitian Pendidikan IPA*, *8*(2), 932–938. https://doi.org/10.29303/jppipa.v8i2.1423

Isa, Z. C., & Azid, N. (2021). Embracing TVET Education: The Effectiveness of Project Based Learning on Secondary School Students' Achievement. *IJERE*, *10*(3), 1072–1079. https://doi.org/10.11591/ijere.v10i3.21392

Kawuryan, S. P., & Sayuti, S. A., & Aman, A. (2022). Critical Thinking Among Fourth Grade Elementary Schol Students: A Gender Perspective. *Cakrawala Pendidikan*, *41*(1), 211–224. Retrieved from https://discovery.researcher.life/download/article/dd6a49715df13c978d327921cdb9ddd2/full-text

Khairani, D., & Tressyalina, T. (2020). The Influence of Project Based Learning Model on Student Writing Skills. *Advances in Social Science, Education and Humanities Research*, *464*, 48-51. https://doi.org/10.2991/assehr.k.200824.012

Khoiri, N., Ristanto, S., & Kurniawan, A. F. (2023). Project-Based Learning Via Traditional Game in Physics Learning: Its Impact on Critical Thinking, Creative Thinking, and Collaborative Skills. *Jurnal Pendidikan IPA Indonesia*, *12*(2), 286–292. https://doi.org/10.15294/jpii.v12i2.43198

Lidyasari, A. T. (2023). Project-Based Learning (PjBL) Learning Model in Improving Critical Thinking Abilities in Elementary Schools to Support 21st Century Learning. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 1165–1170. https://doi.org/10.29303/jppipa.v9i11.4776

Mahulae, P. S., Makahinda, T., Silangen, P. M., & Rampengan, A. M. (2023). Effectiveness of Project Based Learning Model in Learning Evaluation Course in Physics Education Study Programme. *Jurnal Penelitian Pendidikan IPA*, *9*(SpecialIssue), 1077–1082. https://doi.org/10.29303/jppipa.v9ispecialissue.5891

Muhibbin, A., & Khoirunisa, R. I. (2023). Strengthening Project Profile Pancasila Students for Developing Students' Collaborative Skills. *Jurnal Penelitian Pendidikan IPA*, *9*(SpecialIssue), 859–864. https://doi.org/10.29303/jppipa.v9ispecialissue.6171

Mursalim, S., Rukman, W. Y., & Wajdi, M. (2023). The Effect of Project-Based Learning Model on Students' Cognitive Learning Outcomes and Collaborative Skill of Excretion System Concept. *Jurnal Penelitian Pendidikan IPA*, *9*(5), 2533–2540. https://doi.org/10.29303/jppipa.v9i5.2392

Mutakinati, L., & Anwari, I. (2018). Analysis of Students Critical Thinking Skill of Middle School Through STEM Education Project-Based Learning. *Jurnal Pendidikan IPA Indonesia*, *7*(1), 54–65. https://doi.org/10.15294/jpii.v7i1.10495

Purwaningsih, E., Sari, S. P., Sari, A. M., & Suryadi, A. (2020). The Effect of STEM-PjBL and Discovery Learning on Improving Students' Problem-Solving Skills of the Impulse and Momentum Topic. *Jurnal Pendidikan IPA Indonesia*, *9*(4), 465–476. https://doi.org/10.15294/jpii.v9i4.26432

Puspita, A. D., Maryani, I., & Sukma, H. H. (2023). Problem-Based Science Learning in Elementary Schools: A Bibliometric Analysis. *Journal of Education and Learning*, *17*(2), 285–293. https://doi.org/10.11591/edulearn.v17i2.20856

Rahayu, A. H., Widodo, A., Saud, U. S., & Muslim, M. (2025). Transforming TPACK of Elementary School Teachers: The Role of Training Based on Collaboration, Practice, and Reflection. *Jurnal Pendidikan Guru Sekolah Dasar*, *14*(1), 59–70. https://doi.org/10.33578/jpfkip-v14i1.p59-70

Rorimpandey, W. H. F., & Modeong, I. (2024). The Effect of the STEM Learning Model on IPA Learning Outcomes of Grade 4 Students at SD Negeri 2 Kotabunan. *Jurnal Mimbar Sekolah Dasar*, *11*(1), 210–221. https://doi.org/10.53400/mimbar-sd.v11i1.63061

Rupavijetra, P., Nilsook, P., Jitsupa, J., & Nopparit, T. (2022). Collaborative Project - Based Learning to Train Students for Conducting the Training Project for Older Adults. *International Journal of Evaluation and Research in Education (IJERE)*, *11*(4), 2039–2048. https://doi.org/10.11591/ijere.v11i4.22888

Sajidan, S., Suranto, S., Atmojo, I. R. W., & Saputri, D. Y. (2022). Problem-Based Learning-Collaboration (Pbl-C) Model in Elementary School Science Learning in the Industrial Revolution Era 4.0 and Indonesia

Society 5.0. *Jurnal Pendidikan IPA Indonesia*, *11*(3), 477–488. https://doi.org/10.15294/jpii.v11i3.30631

Saputra, H., Firmansyah, J., & Ihsan, A. (2023). Inquiry Project Laboratory: The Collaborative Problem Solving and Critical Thinking on Laboratory. *Jurnal Penelitian Pendidikan IPA*, *9*(9), 704–711. https://doi.org/10.29303/jppipa.v9i9.5038

Sawji, H., Murtini, W., Akbarini, N. R., Permansah, S., & Rusmana, D. (2024). Exploratory Factor Analysis-Instrument for Self-Assessment of Computation Thinking Skills and Collaboration Skills. *International Journal of Evaluation and Research in Education*, *13*(2). https://doi.org/10.11591/ijere.v13i2.25734

Suastra, I. W., Rapi, N. K., Yasa, P., & Arjana, I. G. (2021). Elaborating Indigenous Science Content into Science Learning Process: A New Science Instructional Model to Develop Students' Local Wisdom-Based Characters and Higher Order Thinking Skills. *Jurnal Pendidikan Indonesia*, *10*(3), 516–524. https://doi.org/10.23887/jpi-undiksha.v10i3.31176

Subiyantoro, S. (2024). Evaluating Students' Experiences with Project-Based Learning in Online Educational Contexts. *Edukasia: Jurnal Pendidikan dan Pembelajaran*, *5*(1), 619–624. https://doi.org/10.62775/edukasia.v5i1.812

Suciati, S., Silvita, S., Prasetyo, O., Fauziah, M. D., Santika, K. D., Norawi, A. M., & Rahman, H. T. (2023). Problem-Based Learning Models: Their Effectiveness in Improving Creative Thinking Skills of Students with Different Academic Skills in Science Learning. *Jurnal Pendidikan IPA Indonesia*, *12*(4), 672–683. https://doi.org/10.15294/jpii.v12i4.44752

Sugiyono, S. (2016). *Metode Penelitian Kualitatif, Kuantitatif dan, R&D* (19th ed.). Bandung: Alfabeta.

Suradika, A., Dewi, H. I., & Nasution, M. I. (2023). Project-Based Learning and Problem-Based Learning Models in Critical and Creative Students. *Jurnal Pendidikan IPA Indonesia*, *12*(1), 153–167. https://doi.org/10.15294/jpii.v12i1.39713

Suratmi, S., & Sopandi, W. (2022). Knowledge, Skills, and Attitudes of Teachers in Training Critical Thinking of Elementary School Students. *Journal of Education and Learning (EduLearn)*, *16*(3), 291–298. https://doi.org/10.11591/edulearn.v16i3.20493

Susanti, M., Suyanto, S., Jailani, J., & Retnawati, H. (2023). Problem-Based Learning for Improving Problem-Solving and Critical Thinking Skills: A Case on Probability Theory Course. *Journal of Education and Learning*, *17*(4), 507–525. https://doi.org/10.11591/edulearn.v17i4.20866

Tanti, T., Kurniawan, D. A., Kuswanto, K., Utami, W., & Wardhana, I. (2020). Science Process Skills and Critical Thinking in Science: Urban and Rural Disparity. *Jurnal Pendidikan IPA Indonesia*, *9*(4), 489–498. https://doi.org/10.15294/jpii.v9i4.24139

Tereshchuk, S., Sharov, S., Tereshchuk, A., Kolmakova, V., & Sharova, T. (2023). Critical Thinking and Hypothetic-Deductive Scheme for Studying the Elements of Quantum Theory. *International Journal of Evaluation and Research in Education*, *12*(3). https://doi.org/10.11591/ijere.v12i3.25249

Thao, N. P., Huong, L. T. T., Dinh, N. V., Hang, N. T. T., Quyen, C. V., Cuong, L. M., & Thao, T. T. P. (2024). Current Situation of Primary School Teachers' Integrated STEM Teaching Competence: An Exploratory Study in the Northern Mountainous Provinces of Vietnam. *Jurnal Pendidikan IPA Indonesia*, *13*(1), 64–75. https://doi.org/10.15294/jpii.v13i1.49636

Ting, K. S., Talib, O., Fauzi, A., Ayub, M., Zolkepli, M., & Yee, C. C. (2025). Rasch Model Assessment of Algebraic Word Problem Among Year 8 Malaysian Students. *International Journal of Evaluation and Research in Education*, *13*(2), 1088–1099. https://doi.org/10.11591/ijere.v13i2.25721

Umam, K., & Susandi, A. D. (2022). Critical Thinking Skills: Error Identifications on Students' with APOS Theory. *International Journal of Evaluation and Research in Education*, *11*(1), 182–192. https://doi.org/10.11591/ijere.v11i1.21171

Wahidin, D., & Romli, L. A. M. (2020). The National Scinces And Mathematics in Competition in Indonesia: A Descriptive Study. *Jurnal Pendidikan IPA Indonesia*, *9*(1), 106–116. https://doi.org/10.15294/jpii.v9i1.22240

Wahyudi, A. B. E., Salimi, M., Hidayah, R., Zainnuri, H., & Fajari, L. E. W. (2024). The Improvement of Students' Creative and Collaborative Thinking Skills by Applying STEAM-Integrated Project-Based Learning. *Jurnal Iqra': Kajian Ilmu Pendidikan*, *9*(1), 16–29. https://doi.org/10.25217/ji.v9i1.4438

Wedasuwari, I. A. M., Susrawan, I. N. A., Putra, I. K. W., Laksmi, N. N. A. T., & Pinatih, N. L. E. P. (2024). Digital-Based Literary Appreciation Teaching Materials to Strengthen Students' Communicative and Collaborative Character. *Jurnal Pendidikan Indonesia*, *13*(2), 249–257. https://doi.org/10.23887/jpiundiksha.v13i2.75908

Wibowo, A. M., Utaya, S., Wahjoedi, W., Zubaidah, S., Amin, S., & Prasad, R. R. (2024). Critical Thinking and Collaboration Skills on Environmental Awareness in Project-Based Science Learning. *Jurnal Pendidikan IPA Indonesia*, *13*(1), 103–115. https://doi.org/10.15294/jpii.v13i1.48561

Wicaksono, S. R., Lubis, M. S. A., Suprapto, E., Khasanah, K., & Ulimaz, A. (2021). Improvisation of Project Based Learning with Combination of

Collaborative Learning as a Rapid Response to Pandemic Learning. *Jurnal Iqra': Kajian Ilmu Pendidikan*, *6*(2), 215–224. https://doi.org/10.25217/ji.v6i2.1408

Winarni, R. (2023). The Effect of Project Based Learning on Creative Writing Skills in Elementary School Students: Multivariate Analysis of Variance on Themes, Diction, Imagination. *Jurnal Iqra' Kajian Ilmu Pendidikan*, *8*(2), 120–129. https://doi.org/10.25217/ji.v8i2.2826

Wulandari, T., & Rohaeti, E. (2024). Research-Oriented Collaborative Inquiry Learning (REORCILEA) Model: Improvement of Students' Critical Thinking Ability and Collaborative Skills in Thermochemistry of Materials. *Jurnal Penelitian Pendidikan IPA*, *10*(9), 6809–6814. https://doi.org/10.29303/jppipa.v10i9.8355

Yanti, N., & Rahmad, M. (2023). Application of PjBL (Project Based Learning) Based Physics Learning Model to Improve Collaboration Skills and Creative Thinking Ability of Students. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 9973–9978. https://doi.org/10.29303/jppipa.v9i11.5275

Yuliarti, Y., Marlina, L., Siahaan, S. M., Fathurohman, A., & Sudirman, S. (2023). Profile of High School Students' Critical Thinking Skills About Renewable Energy Materials. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 10151–10160. https://doi.org/10.29303/jppipa.v9i11.5418

Zetriuslita, Z., Ariawan, R., & Nufus, H. (2016). Analisis Kemampuan Berpikir Kritis Matematis Mahasiswa dalam Menyelesaikan Soal Uraian Kalkulus Integral Berdasarkan Level Kemampuan Mahasiswa. *Infinity Journal*, *5*(1), 56. https://doi.org/10.22460/infinity.v5i1.p56-66