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# Students' Critical Thinking and Collaborative Skills Through the Problem-Based Collaborative Learning Model

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**Abstract**: The implementation of the independent curriculum aims to maximize 21st-century skills, particularly in enhancing students' critical thinking, collaboration, communication, and creativity. Critical thinking is the effort to prove the truth of knowledge based on facts. Collaboration skills are social skills that involve exchanging ideas, opinions, or concepts with others to reach solutions. This study aims to determine the effectiveness of the problem-based collaborative learning model on students' critical thinking and collaborative skills in geometric transformation material. This study used a quasi-experimental type with a pretest-posttest control group design. The research sample consisted of 60 ninth-grade students at a private junior high school in Surabaya, divided into two groups, namely the experimental class and the control class. Data collection techniques included questions that tested critical thinking skills and collaborative skills questionnaires. Data analysis techniques included descriptive statistics and inferential statistics. The results of the study proved that (1) the problem-based collaborative learning model was effective in improving students' critical thinking skills with an average n-gain score of 79.3%, and (2) the problem-based collaborative learning model was quite effective in improving collaborative skills with an average n-gain score of 72.3%.

**Keywords**: collaborative skills; critical thinking skills; problem-based collaborative learning; 21st-century skills.

## INTRODUCTION

Education plays a fundamental role in preparing the younger generation for the future (Zuhdi et al., 2021). The quality of education is reflected in its ability to produce competent graduates. Therefore, various efforts to improve the quality of education are essential, such as curriculum development and the selection of learning strategies and models (Siahaan et al., 2023). Currently, the independent curriculum is presented with the hope of maximizing 21st-century skills, particularly in improving students' critical thinking, collaboration, creativity, and communication skills (Sartini & Mulyono, 2022). This is in line with (Mor, 2025) who stated that 21st-century skills education not only emphasizes intelligence in the field of knowledge but also requires students who are able to collaborate, think critically, communicate, and be creative.

Strong critical thinking skills help someone analyze problems and solve them more carefully and precisely. These skills contribute positively to various aspects of life, including education, employment, technology, and other fields (Dumitru & Halpern, 2023). In the educational context, mathematics is known as a subject that requires students' critical thinking skills. Furthermore, mathematics also requires reasoning, logic, creative thinking, critical thinking, problem-solving, collaboration skills, and mathematical abilities, which are taught from elementary school through university (Kusumawardani et al., 2018). However, the majority of students dislike this subject because they consider it difficult, intimidating, or even boring, resulting in suboptimal results. This issue is supported by the results of Indonesian students' mathematics studies in international competitions such as TIMSS and PISA. Indonesian students' TIMSS score in 2015 was 397 out of an international average of 500, ranking 44th out of 49 countries (Mullis et al., 2016). Meanwhile, Indonesian students' PISA score in 2022 was 388, ranking 69th out of 80 countries (OECD, 2023). These results

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illustrate that Indonesian students' mathematics studies are still far from expectations, partly due to their low critical thinking skills. This is supported by research (Fitri et al., 2023; Hasibuan et al., 2020) that shows that less than 40% of junior high school students have high critical thinking skills.

In addition to developing critical thinking skills, students also need to master collaboration skills to work well with various types of people to solve complex problems that require diverse perspectives and ideas. Collaboration skills are a crucial competency for life now and in the future. Collaboration makes students more intelligent in controlling emotions, honing good communication skills, working together to solve problems, fostering a sense of caring, respecting each other's opinions, and sharing insights and knowledge (Warsah et al., 2021). However, research (Haryani & Widajati, 2024; Maesharoh et al., 2024) shows that less than 53% of students possess collaboration skills. This occurs because the teacher's role is too dominant during learning, resulting in students tending to be passive and not fully developing their interaction and collaboration skills.

A similar problem was also found in a private junior high school in Surabaya. Based on the researcher's observations during mathematics lessons, it was revealed that many students did not fully understand the material on geometric transformations, especially dilation. This difficulty was evident when students worked on dilation story problems, as they remained confused about the difference between dilation centered at point O (0,0) and dilation centered at point (a,b). Furthermore, determining the scale factor and the dilation process of a shape was also a challenge for some students. This is in line with research (Maulani & Setiawan, 2021) which stated that students' difficulties working on geometric transformation material were caused by a lack of understanding in describing the changes in a shape after being transformed. Dilation is a change in the size of a geometric shape, either enlarged or reduced, without changing its shape. Upon further investigation, researchers discovered that one of the causes of the lack of mastery of dilation material in this school was the monotonous mathematics learning process, dominated by lectures and individual practice exercises. Conventional learning models tend to cause students to spend a lot of time interacting outside of the subject matter and to develop fewer critical thinking skills in problem solving, as students often cheat from each other (Sun & Wu, 2016).

Furthermore, classroom learning has traditionally focused on completing subject matter as defined by the curriculum. However, the true quality of education depends heavily on how the learning process unfolds, including the delivery method and the classroom atmosphere. Monotonous learning models without variation are not only boring but also hinder the development of critical thinking and collaborative skills in students. Learning should, fundamentally, be an interactive process that prioritizes active student involvement in every learning activity and is directed toward achieving specific learning objectives.

Previous research has shown that problem-based learning (PBL) successfully improves students' critical thinking skills (Cahyaningtyas & Sutarni, 2024; Romadhoni et al., 2025; Utami & Permadi, 2025). Problem-based learning (PBL), which focuses on real-life problems, is the primary learning tool for honing students' skills such as critical thinking, problem solving, self-confidence, and expanding knowledge and conceptual understanding (Romadhoni et al., 2025). Although PBL generally involves dividing students into groups, this does not automatically improve their critical thinking skills (Nookhong & Wannapiroon, 2015). In fact, students tend to rely on individual thinking to solve problems during PBL (Hidayah et al., 2021), so this model does not specifically support the development of collaborative skills. Conversely, the collaborative learning model has been shown to improve collaboration and interaction skills through grouping students with diverse backgrounds and ability levels to achieve common goals. Classes with collaborative management also demonstrate higher levels of motivation, curiosity, a desire to help, a competitive spirit among groups, and a greater drive for independent learning (Handayani et al., 2019). However, CL implementation places greater emphasis on social interaction and idea sharing, with less emphasis on real-world problem solving.

The PBL and CL models, which focus on the active role of students as the center of learning activities, encourage them to actively solve problems collaboratively and reflect on the learning process. Specifically, CL facilitates communication that is not limited to one-way communication but rather occurs actively between students in one group, between different groups, and also between students and teachers. The combination of PBL and CL has the potential to produce complex, high-level thinking processes relevant to real-world contexts. Thus, the problem-based collaborative learning model exists by combining both models to complement each other in realizing meaningful learning (Ariyanto et al., 2019). Research related to the problem-based collaborative learning model has been previously analyzed by several researchers.

Research (Siswanto, 2025) found that the collaborative problem-based learning model can reduce anxiety and improve critical thinking skills in high school students. This finding is evidence that this learning model contributes to improving students' cognitive and affective abilities in the mathematics learning process. In line with this, research (Hendarwati, Nurlaela & Bachri, 2021) concluded that the collaborative problem-based learning model can improve collaborative skills, problem-solving skills, and critical thinking in UNESA students. The novelty of this study lies in the class comparison used. The learning model chosen for the comparison is problem-based learning. In addition, this study also focuses on the geometric transformation material taught at the junior high school level. Thus, this study aims to determine students' critical thinking skills and collaborative skills in geometric transformation material through the problem-based collaborative learning model.

## METHODS

This study applies a quantitative approach of the quasi-experimental type with a pretest-posttest control group design model that intends to measure the effectiveness of the problem-based collaborative learning model on students' critical thinking abilities and collaborative skills. The study population was all students in one of the private junior high schools in Surabaya. Two classes were directly selected as the experimental class and the control class. The sample selection was based on a purposive sampling technique, with class IX B as the experimental class consisting of 30 students and class IX A as the control class consisting of 30 students. The experimental class was taught with the problem-based collaborative learning model, while the control class was taught with the problem-based learning model.

This study involved two types of instruments, namely tests and questionnaires. The test instrument was a descriptive test consisting of 4 questions. The test questions were designed based on indicators of critical thinking skills, which include 1) interpretation; 2) analysis; 3) evaluation; and 4) inference. Meanwhile, the questionnaire instrument was a closed questionnaire consisting of 30 positive and negative statements arranged based on indicators of collaborative skills. The indicators of collaborative skills are 1) being responsible in completing tasks; 2) working productively and positive interdependence; 3) time management; 4) adapting to various roles in a group; 5) flexibility and compromise in a group; and 6) working together to accept suggestions and make joint decisions.

The data collection techniques used included a pretest and posttest of critical thinking skills on geometric transformations and a pretest and posttest questionnaire on collaborative skills. The pretest and posttest questions on critical thinking skills were designed differently to avoid memorization effects. The statements in the pretest and posttest questionnaire on collaborative skills were structured similarly to ensure researchers accurately measured each indicator. Before being used on the research sample, both instruments underwent validity and reliability testing.

Testing the validity of the test instrument was carried out in two stages, namely content validity and construct validity. The number of questions on the validated critical thinking ability test instrument was 6 questions. The results of expert validation showed that there were four questions that were declared valid for research with major revision notes and obtained a validation value of 102 out of 150. Furthermore, construct validity was carried out in class IX at Dr. Soetomo Middle School Surabaya involving 60 students. The test instrument was declared valid if it obtained a significance level value of < 0,01. The results of the validity test at this school obtained a significance value of questions number 1 to 4 of 0,000 < 0,01. Therefore, it was concluded that the test instrument for questions number 1, 2, 3, and 4 was declared valid. After the validity test was fulfilled, the questions were then tested for reliability. Questions were considered reliable if they had a Cronbach alpha value of > 0,70. The results of the reliability test obtained a Cronbach alpha value of 0,827 > 0,70. Therefore, it was concluded that the critical thinking ability questions met the criteria and were declared reliable. The validation of the collaborative skills questionnaire involved only one stage, expert validation. Thirty questionnaire items were validated. The expert validation results concluded that the questionnaire was generally sound, meeting all indicators, and feasible, with a validation score of 138 out of 150. Therefore, the critical thinking skills test and collaborative skills questionnaire were suitable for use in research.

The research hypothesis is divided into two, namely (1) there is effectiveness of the problem-based collaborative learning model on students' critical thinking skills in geometric transformation material, and (2) there is effectiveness of the problem-based collaborative learning model on students' collaborative skills in geometric transformation material. To test the hypothesis, field data is needed. The data obtained is then analyzed using two methods, namely descriptive statistics and inferential statistics. Descriptive statistics aim to describe the data more concisely, including the mean, maximum value, minimum value, and standard deviation. The inferential statistic chosen is the independent sample t-test. Before the test is carried out, a prerequisite test is first carried out, which includes a normality test and a homogeneity test. After the normality and homogeneity requirements are met, an independent sample t-test is continued in order to determine whether there is a difference in the pretest-posttest of critical thinking skills and collaborative skills of students in the experimental class and the control class. The final step to measure the level of effectiveness of the learning model for both classes uses the n-gain test. The average results of the n-gain test are categorized based on the following table (Hake, 1998).

**Table 1. N-Gain Effectiveness Interpretation Category**

| Percentage (%) | Interpretation |
|---|---|
| < 40 | Ineffective |
| 40 - 50 | Less Effective |
| 56 – 75 | Quite Effective |
| > 76 | Effective |

## RESULTS AND DISCUSSION

This study began by providing test questions and questionnaires to determine the initial critical thinking skills and collaborative skills of students from both classes. Next, different learning models were taught to both classes. The experimental class with the problem-based collaborative learning model was implemented through the following steps: (1) The teacher introduced real-life dilation problems; (2) students were divided into 6 heterogeneous groups to collaborate in solving the problems; (3) students discussed collaboratively in groups; (4) each group presented the results of the discussion; and (5) evaluation of the discussion results was carried out by each group, other groups, and the teacher. Meanwhile, the control class with the problem-based learning model was implemented through the following steps: (1) Orientation of students to real-life dilation problems; (2) Students were divided into 6 groups with homogeneous abilities to solve dilation problems; (3) Students discussed in groups with teacher guidance; (4) Presentation of the results of the group discussions; and (5) Evaluation of the results of the discussions. In the final stage, both classes were given a post-test with questions and questionnaires to determine whether there were any changes in students' critical thinking and collaborative skills. The following presents the results of the data obtained during the study.

- Effectiveness of the Problem Based Collaborative Learning Model on Critical Thinking Skills

This research data analysis involved two methods: descriptive statistics and inferential statistics. If the mean value is greater than the standard deviation, the data distribution is relatively uniform or tends to be around the mean. The following table presents descriptive statistics from the pretest to posttest for students' critical thinking skills:

**Table 2. Results of Descriptive Statistical Analysis of Critical Thinking Ability**

| **Description** | **Experimental Class** *Problem-Based Collaborative Learning* | | **Control Class** *Problem-Based Learning* | |
|---|---|---|---|---|
| | ***Pretest*** | ***Posttest*** | ***Pretest*** | ***Posttest*** |
| Number of students | 30 | 30 | 30 | 30 |
| Mean | 33,2333 | 85,7667 | 38,4667 | 77,8333 |
| Minimum | 13,00 | 63,00 | 14,00 | 53,00 |
| Maximum | 67,00 | 100,00 | 75,00 | 94,00 |
| Standard Deviation | 15,02339 | 9,02366 | 17,85716 | 11,40805 |

Based on Table 2, the pretest data of critical thinking skills of experimental class students who were taught using the PBCL model obtained a mean value of 33,2333 with a standard deviation of 15,0239. Meanwhile, the posttest data showed a mean value of 85,7667 with a standard deviation of 9,02366. The increase in the mean from pretest to posttest was seen at 52,5334. Referring to the results of the standard deviation of the experimental class, it means that the distribution of pretest data is more diverse than the posttest data.

The pretest data of critical thinking ability of control class students who were taught with the PBL model obtained a mean value of 38,4667 with a standard deviation of 17,85716. Meanwhile, the posttest data showed a mean value of 77,8333 with a standard deviation of 11,40805. The mean increase from pretest to posttest was seen at 39,3666. Referring to the results of the standard deviation of the control class, it means that the distribution of pretest data is more diverse than posttest data.

Although the mean pretest score for the control class appears to be higher than that for the experimental class, the posttest results show a higher increase in students' critical thinking skills in the experimental class. Based on the standard deviation, the distribution of data for the control class is more varied than for the experimental class. Furthermore, a Shapiro-Wilk normality test was conducted because the sample size for each class was <50. This test aims to determine whether the data is normally distributed. Data are considered normally distributed if a significance value of > 0,05 is obtained. The following are the results of the pretest and posttest normality test for students' critical thinking skills:

**Tabl3 3. Results of the Normality Test of Critical Thinking Ability**

| Description | Data | Statistic | Sig. | Criteria |
|---|---|---|---|---|
| Experimental Class | *Pretest* | 0,939 | 0,088 | Normal |
| *Problem Based Collaborative Learning* | *Posttest* | 0,940 | 0,093 | Normal |
| Control Class | *Pretest* | 0,937 | 0,076 | Normal |
| *Problem Based Learning* | *Posttest* | 0,938 | 0,080 | Normal |

Based on the results of the normality test for students' critical thinking skills, the significance value of the pretest and posttest data for both classes is normally distributed. The homogeneity test aims to determine whether the variance of the two data groups is homogeneous. The Levene statistic test is used because it involves two class samples. Data is considered homogeneous if a significance value of > 0,05 is obtained. The results of the homogeneity test for students' pretest and posttest critical thinking skills are presented in the following table 4.

**Table 4. Results of the Homogeneity Test of Critical Thinking Skills**

| Data | *Levene Statistic* | df2 | Sig. | Criteria |
|---|---|---|---|---|
| *Pretest* | 0,854 | 58 | 0,359 | Homogen |
| *Posttest* | 2,405 | 58 | 0,126 | Homogen |

The results of the pretest homogeneity test of the Levene statistic for the critical thinking ability of second-grade students obtained a significance value of 0,359 > 0,05. Meanwhile, the posttest homogeneity test obtained a significance value of 0,126 > 0,05. Thus, it was concluded that the variance of the pretest and posttest data for critical thinking ability was homogeneous.

After the data was normally distributed and homogeneous, the hypothesis was tested using the assumed equal variances. The chosen hypothesis was the independent sample t-test, with the aim of determining whether there was a difference between the pretest and posttest of critical thinking skills of students in the experimental and control classes. The results of the independent sample t-test pretest-posttest of students' critical thinking skills are presented in the following table 5.

**Table 5. Results of the Independent Sample t-test on Students' Critical Thinking Skills**

| Data | T | df2 | Sig.(2-tailed) | Criteria |
|---|---|---|---|---|
| *Pretest* | -1,228 | 58 | 0,224 | There is no difference |
| *Posttest* | 2,987 | 58 | 0,004 | There are difference |

The results of the independent sample t test pretest of critical thinking skills of both classes obtained a significance value of 0,224 > 0,05. This indicates that there is no difference in students' critical thinking skills between the experimental and control classes. Thus, it was concluded that the initial conditions of the two groups had the same critical thinking skills, so the study continued by providing learning model treatment to both groups.

Furthermore, the results of the independent sample t test posttest of the critical thinking skills of both classes obtained a significance value of 0,004 < 0,05. This shows a difference in the critical thinking skills of students in both classes. Therefore, it means that the final condition of the two groups has different critical thinking skills. Then, to assess the level of effectiveness of the learning model taught to both groups, an n-gain test was conducted. The n-gain test aims to measure the effectiveness of both learning models on students' critical thinking skills. The results of the n-gain test are presented in the following table 6.

**Table 6. N-Gain Test Results of Critical Thinking Ability**

| Group | *Mean* | Minimum | Maximum | Category |
|---|---|---|---|---|
| PBCL Experimental Class | 79,2871 | 55,42 | 100,00 | Effective |
| PBL Control Class | 65,2315 | 39,34 | 88,00 | Quite Effective |

The results of the n-gain test for critical thinking skills in the experimental class showed a mean of 79,2871 or 79,3%, which is categorized as effective. Meanwhile, the control class obtained a mean of 65,2315 or 65,2%, which is categorized as quite effective. This shows that the experimental class with the problem based collaborative learning model obtained a higher score than the control class with the problem-based learning model.

In the problem orientation stage, almost all students in the experimental class were able to understand the problem of dilation integrated into real life. Some of them even provided examples of dilation material they frequently encountered. Meanwhile, in the control class, some students were also seen to have mastered and understood the material of dilation integrated into real life. Furthermore, in the second stage, students in the experimental and control classes were divided into six groups of five students. At this stage, the experimental class consisted of students with different abilities, while the control class had students with the same abilities in each group.

Next, the experimental class engaged in collaborative problem-solving. In the third stage, each group appointed one student to be the group leader, and each member was then assigned a task tailored to their expertise. This division of tasks aimed to ensure each student felt responsible and actively participated in their group. After each member completed their assignment, they proceeded to a discussion session. During the discussion, several groups demonstrated an atmosphere of mutual support and cooperation. They exchanged ideas and concepts, enabling lower-ability students to understand the material and solutions through explanations from their groupmates. In this process, the teacher's role was not merely as a facilitator but also as a guide and motivator. The teacher presented each group with a problem, leaving the rest to students to discuss collaboratively to identify solutions. These results align with research (Widowati et al., 2023), which explains that the collaborative problem-based learning model impacts student active engagement, interaction, and collaboration in learning the material.

The collaborative problem-based learning model also fosters high interest, motivation, and mutual discussion, receiving input from diverse perspectives. This allows students' critical thinking skills to gradually improve. By collaborating in groups, students can independently find solutions to problems, freely exploring them until they find the right solution. In the third stage, for the control class using the problem-based learning model, the teacher was tasked with guiding individual and group investigations. However, it was found that some groups were not yet able to discuss independently and still needed guidance from the teacher. Furthermore, the distribution of tasks within the groups was uneven, so students with greater mastery of the material felt disadvantaged because they had to complete the tasks themselves, while other members contributed less. Thus, this model failed to optimize students' discussion skills.

In the fourth stage, both classes presented the results of their discussions. In the experimental class, each group member appeared capable of conveying the results of their discussions accurately. Furthermore, they were able to explain the problem solution in detail, from interpreting the information in the problem, analyzing the formula for solving the problem, evaluating it appropriately, and drawing accurate conclusions. Meanwhile, in the control class, several groups presented themselves and appeared less capable of interpreting the information in the problem. They tended to directly use the formula to solve the problem, without first explaining what was known and what was being asked in the problem. As a result, the conclusions they reached were less accurate.

The fifth stage is evaluating the discussion results. In the experimental class, other groups that did not present actively provided feedback. Meanwhile, in the control class, only a few groups were able to provide evaluations. Thus, the problem-based collaborative learning model not only positively impacts students' academic abilities but also develops interpersonal skills such as communication, interaction with others, and fostering empathy for others.

This research aligns with research by (Hendarwati, Nurlaela, & Bachri, 2021), which concluded that the collaborative problem-based learning model can improve students' critical thinking skills. This is because students play an active role in planning and solving problems through discussion activities, cooperation, sharing tasks, collaboration, interacting with each other to share knowledge, and presenting and evaluating discussion results with other groups. Based on research by (Siswanto, 2025), students' critical thinking skills can be improved through the application of the collaborative problem-based learning model. This learning model supports students in working together in teams, discussing, sharing ideas and exchanging opinions, and helping each other in their groups. Therefore, this study can conclude that the problem-based collaborative learning model is effective in improving students' critical thinking skills in geometric transformation material.

- Effectiveness of Problem Based Collaborative Learning Model on Collaborative Skills

This research data analysis involved two methods: descriptive statistics and inferential statistics. If the mean value is greater than the standard deviation, the data distribution is relatively uniform or tends to be around the mean. The following table presents descriptive statistics from the pretest and posttest for students' collaborative skills.

**Table 7. Results of Descriptive Statistical Analysis of Collaborative Skills**

| **Description** | **Experimental Class** *Problem Based Collaborative Learning* | | **Control Class** *Problem Based Learning* | |
|---|---|---|---|---|
| | ***Pretest*** | ***Posttest*** | ***Pretest*** | ***Posttest*** |
| Number of students | 30 | 30 | 30 | 30 |
| Mean | 64,0333 | 126,5000 | 65,2667 | 119,8667 |
| Minimum | 48,00 | 104,00 | 34,00 | 92,00 |
| Maximum | 84,00 | 146,00 | 81,00 | 135,00 |
| Standard Deviation | 8,75129 | 10,73425 | 11,70008 | 10,07124 |

Based on table 7, the pretest data of collaborative skills of experimental class students who were taught with the problem-based collaborative learning model obtained a mean value of 64,0333 with a standard deviation of 8,75129. Meanwhile, the posttest data showed a mean value of 126,5000 with a standard deviation of 10,73425. The increase in the mean from pretest to posttest was seen at 62,4667. Referring to the results of the standard deviation of the experimental class, it means that the distribution of posttest data is more diverse than the pretest data.

The pretest data of collaborative skills of control class students who were taught with the PBL model obtained a mean value of 65,2667 with a standard deviation of 11,70008. Meanwhile, the posttest data showed a mean value of 119,8667 with a standard deviation of

10,07124. The mean increase from pretest to posttest was seen at 54,6. Referring to the results of the standard deviation of the control class, it means that the distribution of pretest data is more diverse than the posttest data.

Although the mean pretest score for the control class appears to be higher than that for the experimental class, the posttest results indicate that the experimental class has a higher impact on collaborative skills. Furthermore, based on the standard deviation, the distribution of data for the experimental class is more varied than that for the experimental class. Furthermore, a Shapiro Wilk normality test was conducted because the sample size for each class was <50. This test aims to determine whether the data is normally distributed. Data is considered normally distributed if a significance value of >0,05 is obtained. The following are the results of the pretest and posttest normality test for students' collaborative skills:

**Table 7. Collaborative Skills Normality Test Results**

| Description | Data | Statistic | Sig. | Criteria |
|---|---|---|---|---|
| Experimental Class | *Pretest* | 0,941 | 0,098 | Normal |
| *Problem Based Collaborative Learning* | *Posttest* | 0,966 | 0,426 | Normal |
| Control Class | *Pretest* | 0,945 | 0,122 | Normal |
| *Problem Based Learning* | *Posttest* | 0,956 | 0,242 | Normal |

Based on the results table 8 that the normality test for students' collaborative skills, the significance value of the pretest and posttest data for both classes is normally distributed. The homogeneity test aims to determine whether the variance of the two data groups is homogeneous. The Levene statistic test is used because it involves two class samples. Data is considered homogeneous if a significance value of > 0,05 is obtained. The results of the homogeneity test for the pretest and posttest for students' collaborative skills are presented in the following table 9.

**Table 8. Collaborative Skills Homogeneity Test Results**

| Data | *Levene Statistic* | df2 | Sig. | Criteria |
|---|---|---|---|---|
| *Pretest* | 3,015 | 58 | 0,088 | Homogen |
| *Posttest* | 0,485 | 58 | 0,489 | Homogen |

The results of the Levene statistical homogeneity test for the pretest collaborative skills of students in both classes obtained a significance value of 0,088 > 0,05. Meanwhile, the Levene statistical homogeneity test for the posttest obtained a significance value of 0,489>0,05. Thus, it was concluded that the variance of the pretest and posttest collaborative skills data was homogeneous.

After the data is normally distributed and homogeneous, the next step is to test the hypothesis using the assumed equal variances. The chosen hypothesis is the independent sample t test, with the aim of determining whether there is a difference between the pretest and posttest of collaborative skills of students in the experimental and control classes. The results of the independent sample t test pretest posttest of students' collaborative skills are presented in the following table 10.

**Table 9. Results of the Independent Sample t-test on Students' Collaborative Skills**

| Data | t | df2 | Sig.(2-tailed) | Criteria |
|---|---|---|---|---|
| *Pretest* | -0,462 | 58 | 0,646 | There is no difference |
| *Posttest* | 2,468 | 58 | 0,017 | There are difference |

The results of the independent sample t test pretest for collaborative skills in both classes obtained a significance value of 0,646 > 0,05. This shows that there is no difference in the collaborative skills of students in the experimental and control classes. Thus, it was concluded that the initial conditions of the two groups had the same collaborative skills, so the study continued by providing learning model treatments to both groups.

Furthermore, the results of the independent sample t test posttest of the collaborative skills of both classes obtained a significance value of 0,017 < 0,05. This shows a difference in the collaborative skills of students from both classes. Therefore, it means that the final condition of the two groups has different collaborative skills. Then, to assess the level of effectiveness of the learning model taught to both groups, an n-gain test was conducted. The n-gain test aims to measure the effectiveness of both learning models on students' collaborative skills. The results of the n-gain test are shown in the following table 11.

**Tabel 10. Collaborative Skills N-Gain Test Results**

| Group | *Mean* | Minimum | Maximum | Category |
|---|---|---|---|---|
| PBCL Experimental Class | 72,2960 | 49,45 | 95,60 | Quite Effective |
| PBL Control Class | 63,8624 | 19,44 | 82,47 | Quite Effective |

The results of the n-gain test of collaborative skills of students in the experimental class obtained a mean of 72,2960 or 72,3%, which is categorized as quite effective. Meanwhile, the control class obtained a mean of 63,8624 or 63,9%, which is categorized as quite effective. This shows that the experimental class with the problem based collaborative learning model obtained a higher questionnaire score than the control class with the problem based learning model.

The implementation of the problem-based collaborative learning model is quite effective in improving students' collaborative skills due to several factors. The first factor is the lack of adequate time allocation during the research. According to research (Mustika et al., 2022; Sejarah et al., 2025), implementing problem-based learning and collaborative learning in the classroom context requires a significant amount of time. Collaborative learning, in particular, plays a crucial role in developing students' collaborative skills. In this regard, teachers must ensure that each student understands their assignments, plays an active role, and makes a maximum contribution. Therefore, if this learning model is optimally planned and facilitated, it has great potential to improve learning outcomes and develop 21st-century skills (Rofiudin et al., 2024). The second factor is the diverse abilities of students. Although teachers have grouped students with different abilities to encourage the effective exchange of ideas and collaboration, high-ability students often dominate discussions and assignment completion. As a result, other students become less active and feel excluded, even choosing to work independently rather than in groups, because group assignments have already been completed by high-ability students. Therefore, a more mature approach and preparation are needed to encourage involvement and contribution within groups. This is in line with (Utami, Putri & Wandini, 2023) who stated that teachers need to be sensitive to understanding each student's abilities and grasp of the material and also to pay more attention to groups that are perceived as lacking.

The third factor is that teachers have not been able to optimally maintain student focus and cooperation. This is in line with (Syauqi & Rafianti, 2024), who stated that many students have difficulty thinking contextually during learning, which leads to a lack of engagement in group discussions. The fourth factor is the environment. In this case, the environment also plays a role that is no less important than other factors. Students with low social skills, both at home and at school, often experience obstacles in group work. Their readiness for school is greatly influenced by parental support in teaching communication and collaboration. By achieving an environment that fosters collaboration, students can learn from each other and interact well with their peers (Utami, Putri & Wandini, 2023).

The implementation of the problem based learning model is quite effective in improving students’ collaborative skills due to several factors. The first factor is the limited time during the research. According to research (Mustika et al., 2022), implementing the problem based learning model requires a long duration. The second factor is the problem based learning model's excessive focus on problem solving, while paying insufficient attention to the problem-solving process (Hidayah et al., 2021). The third factor is the environment. Similar to the problem based collaborative learning model, the problem based learning model also requires a supportive environment (Iseu Laelasari & Rahmawati, 2020).

This research is relevant to research by (Agistian et al., 2025), which explains that collaborative problem based learning models have benefits for improving students’ collaborative skills through group communication, task sharing, and agreements. Furthermore, research by (Nurdin et al., 2024) states that collaborative models can develop collaborative skills because students can solve problems quickly and accurately through group discussions, cooperation, and active participation. Therefore, this study concludes that the problem based collaborative learning model is quite effective in improving students' collaborative skills.

## CONCLUSION

Based on the problems, objectives, research results, and discussions, the following conclusions were obtained: (1) There is effectiveness of the problem-based collaborative learning model on students' critical thinking skills in geometric transformation material with an n-gain test score of 79.3% which is categorized as effective, (2) there is effectiveness of the problem-based collaborative learning model on collaborative skills with an n-gain test score of 72.3% which is categorized as quite effective.

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