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Case Study of Problem-Solving Ability on Gender Through Collaborative Problem Based Learning

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Abstract

The impact of online learning that has been running for two years has resulted in students becoming less focused and couch potato to study the material provided by the teacher. Provision of stimulation that is still lacking and the lack of laboratory equipment is one of the causes of low problem-solving abilities. This study aims to see the differences and significant improvements in the experimental and control groups based on gender through problem based learning collaborative learning. The research method was quasi-experimental with nonequivalent control group design. Classical calculations of the experimental and control groups have a difference in the significance level (2-tailed) 0.02 <0.05 with the N-Gain scores being 0.71 and 0.59. The results of the different test of the experimental group based on gender were (2-tailed) 0.00 <0.05 with an N-Gain score of 0.66 and 0.72. The results of the control group's different test showed that the significance level (2-tailed) based on gender was 0.00 <0.05. The results of the control group's N-Gain test based on gender were 0.47 and 0.62. The collaborative problem-based learning model encourages the development of critical thinking, problem-solving skills, and communication. Male students have important visuospatial abilities in learning mathematics. Female students have Broca's area which is voluminous and functions to activate language skills.

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INTRODUCTION

The impact of online learning that has been running for two years has resulted in students becoming less focused and lazy in exploring the material provided by the teacher. The term "learning from home" causes students to feel bored. Therefore, in the 2022/2023 academic year the implementation of 100% face-to-face learning delete influence the way students learn. According to Faradila & Kashardi (2022), learning using conventional methods makes it difficult for students to express the ideas they have. This causes solving capabilities to be lacking and must be taken into account. Students are expected to be able to build knowledge when carrying out various activities in learning activities. The methods and strategies for active learning are that students are able to be involved in working on worksheets, working together in groups, and discussion (Pfeifer et al., 2022).

Previous research stated that male students solved a problem by re-reading the problem phenomenon, then identifying the problem with the information they had previously obtained, then solving the problem and writing it on a worksheet. The problem solving process for female students is by underlining important information found while reading a book and then immediately writing down the findings on a worksheet (Danindra & Masriyah, 2020). Male students usually prefer to reveal their answers immediately after being asked a problem, even though they may be less accurate. But over time, this practice of memorizing answers can push male students far beyond female students. On the other hand, female students give more correct answers, but tend to respond slowly to questions and have fewer questions to answer (Dorisno, 2019).

According to information from delete teachers, the lack of laboratory equipment affects students' understanding of the concepts of temperature and heat. Students find it difficult to identify problem cases in temperature and heat material because the laboratory equipment needed to prove the concept is still limited. This causes less mastery of concepts, which affects students' use and calculation of mathematical formulas. Laili, et.al (2021) stated that one of the factors in students' difficulties in studying temperature and heat material is that students fail to activate concepts related to temperature and heat. In addition, students also lack skills in operating mathematical equations and have difficulty analyzing physical quantities.

Atira, et.al (2022) show that using a collaborative learning model based on problem based learning is an effective way to develop 21st century abilities by encouraging the formation of critical thinking and problem solving, interpersonal communication, information and media literacy, cooperation, leadership and team work, innovation and creativity. Research by Faradila & Kashardi (2022) shows that the problem based learning model can increase students' learning activities and problem solving abilities. Problem based learning is an innovative learning model that can provide active learning conditions for students.

In Atira, *et.al* (2022) research combined both collaborative models and problem-solving abilities without being based on gender, while this study tested based on gender. This study combines the two models because there are students who are lacking in problem solving but are enthusiastic when collaborating. Based on the description of the problem above, a novel idea emerged by collaborating the two learning modes, namely collaborative and problem based learning into one. This case study was given to upper secondary level students based on gender by analyzing the students' problem solving abilities.

METHODS

This research method is quasi experimental with nonequivalent control group design. The research was carried out at SMA Negeri 1 Tolanghula which is on Jalan Beringin Jaya, Lakeya Village, Tolanghula District, Gorontalo Regency. Research begins in the 2022/2023 odd semester academic year. The research was conducted on students in classes XI IPA 1 and X IPA 2 who took material on temperature and heat. The subject in this research was a purposive sampling technique. Class XI IPA 2 has 29 students and XI Science 1 has 27 students. The questions were used to see students' problem solving abilities based on gender. The questions consist of a pretest and posttest.

The research began by giving a pretest of 14 multiple choice questions to the experimental group and the control group. These questions have been tested first. The experimental group was given intervention through learning using a collaborative model based on problem based learning, while the control group used a lecture and discussion model. The experimental and control student study groups were divided by gender into three groups. Group 1 is female students; group 2 is male students and group 3 is a mix of male and female students. After the intervention, the experimental and control groups were given a posttest of 14 multiple choice questions. The pretest and posttest were intended to measure problem solving abilities based on gender. The next stage was analyzing pretest and posttest data based on gender through providing intervention. The final stage was to conclude based on data analysis and discussion to answer the problem formulation.

Before the questions are used, the questions must first be validated by experts who are experienced in their field. There are three experts consisting of two lecturers and one teacher who has

a linear master's degree in their field. Validation of questions in this research uses content validation. According to Retnawati (2016), to find out the item validity agreement index, the item validity index proposed by Aiken was used.

$$V = \frac{\sum s}{n(c-1)} \quad (1)$$

The above equation describes that V was the rater agreement index regarding item validity, $\sum s$ are each rater's score minus the lowest score, n is the number of raters, and c is the categories that raters can choose from. The results of calculating the expert agreement index are shown in Table 1.

Table 1. Expert Agreement Index Calculation Results

Question item number	V
1	0.833333
2	0.75
3	0.916667
4	0.833333
5	0.916667
6	0.916667
7	0.916667
8	1
9	1
10	0.916667
11	0.916667
12	0.916667
13	0.833333
14	0.833333
15	0.916667
16	0.833333
17	0.833333
18	1

According to Retnawati (2016), if the agreement index was less than 0.4 then it was said to have low validity. An index between 0.4 – 0.8 was said to have moderate validity (mediocore) and if it was more than 0.8 it was said to be high. Based on Table 3, it can be seen that the expert validity agreement index was very high. Testing the validity of the items in this research uses the product moment correlation technique formula as follows (Arikunto, 2013).

$$r_{xy} = \frac{N\sum XY - (\sum X)(\sum Y)}{\sqrt{\{N\sum X^2 - (\sum X^2)\}\{N\sum Y^2\}}} \quad (2)$$

Where r_{xy} was the correlation coefficient X and Y, N was number of subjects studied, $\sum X$ was the sum of the scores for each question item, $\sum Y$ was the total score, $\sum X^2$ was the sum of the squares of the question item scores, $\sum Y^2$was the sum of the squares of the total score.

In this study, the respondents numbered 100 people. The error rate of 5% at the r table value is 0.195. The results of the comparison of r count with r table obtained 14 questions having r count values > 0.195 and those having r count values < 0.195 were 4 questions. This means that there are 14 valid questions and 4 invalid questions. The invalid questions are numbers 4, 11, 14 and 16. The criteria for a test instrument to be reliable or not refer to the criteria according to Sugiyono (2012)

This study uses the K-R 21 reliability test formula. According to Arikunto (2013) The K-R 21 formula is used for test items that are systematically created using multiple choice.

$$r_{1-1} = \frac{k}{k-1}\left\{1 - \frac{M(k-M)}{ks_t{}^2}\right\}, \quad (3)$$

where $r_{1-1}$was instrument reliability, k was number of items in the instrument, M was mean total score, and $s_t{}^2$ was total variance

The results of the reliability test showed a reliable value of 0.62 and was included in the high category. After being tested for validity and reliability, the questions must be tested for the level of difficulty and discrimination power. According to Arikunto (2016) The difficulty level index formula is as follows.

$$IK = \frac{nB}{n}, \quad (4)$$

Where IK was test item difficulty index, nB was the number of testees who answered, n was total number of testees

The difficulty index ranges from 0.00 to 1.00. Questions with a difficulty index of 0.00 mean that the question is too difficult, conversely, a question with a difficulty index approaching 1.00 means that it is too easy. This study uses the difficulty level index category according to Mahendra (2019)

The results of the level of difficulty of the problem-solving ability questions show that there are 14 questions that have a value of > 0.40 and 4 questions have a value of < 0.40. The 4 questions that have a value of < 0.40 and are difficult are numbers 4, 11, 14 and 16.

Independent Sample t-Test was conducted to see the differences between the experimental class and the control class. According to Nuryadi, *et.al* (2017) Independent Sample t-Test to determine the difference in the average of two independent populations or data groups. The Independent Sample T-test formula is as follows.

$$t_{hit} = \frac{M_1 - M_2}{\sqrt{\frac{SS_1 + SS_2}{n_1 + n_2 - 2}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}} \quad (5)$$

Information M_1 was average score of group 1, M_2 was average of group 2, SS_1 was *sum of square* group 1, SS_2 was *sum of square* group 2, n_1 was number of subjects/samples group 1, n_2 was number of subjects/samples group 2

In this study, the data normality test uses the SPPS 16 application which aims to see whether the data population is normally distributed or not. If the data is normally distributed, a parametric statistical test can be used. Data is normally distributed if the sig value was > 0.05. This study uses the Shapiro-Wilk data normality test type. This is because the number of respondents from the experimental and control groups is less than 50 people. Table 2 is a data normality test for problem-solving ability questions.

Table 2. Data Normality Test

Class	Shapiro-Wilk Significance	Information
Pretest Experiment	0,193	Normally
Posttest Experiment	0,110	Normally
Pretest Control	0,063	Normally
Posttest Control	0,070	Normally

According to Setyawan (2021) Homogeneity test is conducted to determine whether the data in variables X and Y are homogeneous or not. If the significance value (P-value) <0.05 then it can be concluded that "the variance of two or more data groups is not the same (not homogeneous)". If the significance value (P-value) >0.05 then it can be concluded that "the variance of two or more data groups is the same (homogeneous)". The results of the homogeneity test can be seen in Table 3.

Table 3. Homogeneity Test Results

Sig. Value	Information
0,541	Homogeneous
0,553	Homogeneous
0,553	Homogeneous
0,543	Homogeneous

Hypothesis analysis in improving students' problem solving abilities based on gender using the *N-Gain* test. According to Nirmalasari, *et.al* (2016) *Gain* is the difference between the pretest and posttest values. To find out the N-gain, the following formula is used.

$$N\text{-}Gain = \frac{score\ posttest - score\ pretest}{100 - score\ pretest} \quad (6)$$

The average $N\text{-}gain$ score category according to Waldrip, *et.al* (2014) can be seen in Table 4.

Table 4. Category Average Score $N\text{-}Gain$

Skor *N-Gain*	Kriteria
N-Gain $\geq \mathbf{0,65}$	High
$\mathbf{0,45} \leq$ *N-Gain* $< \mathbf{0,65}$	Upper Medium
$\mathbf{0,25} \leq$ *N-Gain* $< \mathbf{0,45}$	Lower Medium
N-Gain $< \mathbf{0,25}$	Low

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RESULTS AND DISCUSSION

The *pretest* results for each problem-solving ability indicator for the experimental and control groups can be seen in Figure 1.

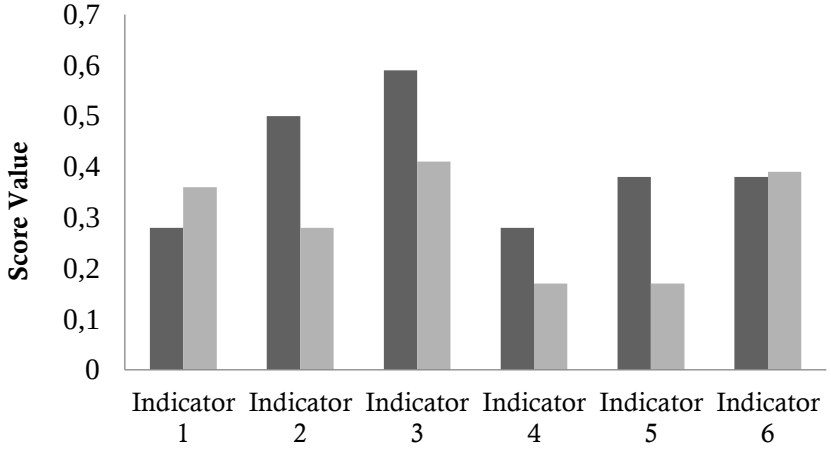

Figure 1. Pretest Results for Experimental and Control Groups

Figure 1 shows that the indicator of identifying problems (1) in the control group has a value of 0.35, higher than the experimental group which has a value of 0.27. In the indicator of reviewing and discussing (6), the control group is superior with 0.38 and the experimental group has a value of 0.37. The experimental group is superior in the indicators of diagnosing problems (2), making a solution plan (3), collecting several solution solutions (4), and implementing the solution plan (5).

The posttest results of the experimental and control groups can be seen in Figure 1.2. The posttest was conducted after the provision of a learning model. The experimental group used a collaborative model based on problem-based learning. The control group used a lecture and discussion model.

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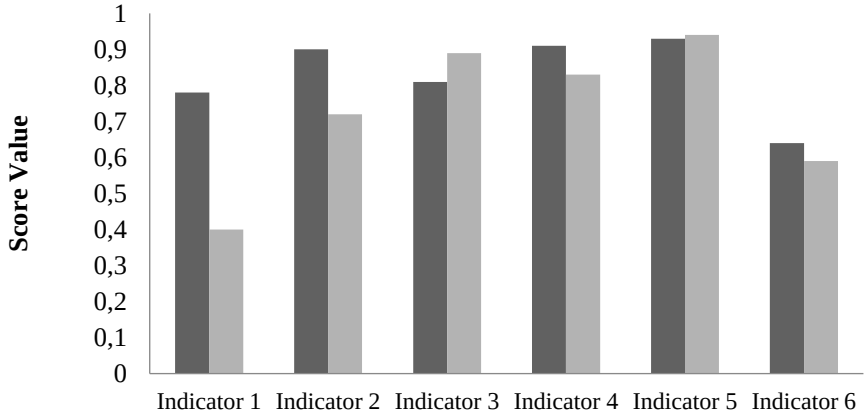

Figure 2. Posttest Results for Experimental and Control Groups

It can be seen from the indicators of making a problem-solving plan (3) and implementing problem-solving (5), namely the control group is superior, while in the indicators of identifying problems (1), diagnosing problems (2), collecting several problem-solving solutions (4), and reviewing and discussing (6), namely the experimental group is superior. This is because the collaborative model based on problem-based learning has a learning stage, namely the investigation stage. At this investigation stage, students must choose a problem-solving strategy by discussing with group members so that collaboration is created.

Table 5. Results of Independent Sample t-Test for Experimental and Control Groups

Group	Sig. (*2-tailed*)
Experiment	0,02
Control	0,02

Based on the results of the Independent t-Test test, the sig. (2-tailed) value is 0.02 <0.05 for the experimental and control groups, meaning that there is a significant difference between the experimental and control groups. The results of the Independent t-Test test for the experimental and control groups can be seen in Table 5.

The N-Gain test shows a statistical value for the experimental group of 0.71 high criteria compared to the control group with a statistical value of 0.59 medium upper criteria. Based on these results, it can be concluded that there is a significant increase when using a collaborative model based on problem based learning. This is also supported by Atira, *et.al* (2022) that there was a significant increase after using a collaborative problem-based learning model on students' problem-solving abilities. The results of the classical N-Gain test can be seen in Table 6.

Table 6. Results of the N-Gain Test for the Experimental and Control Groups

Group	Statistik
Experiment	0,71
Control	0,59

The pretest results for each experimental group indicator based on gender can be seen in

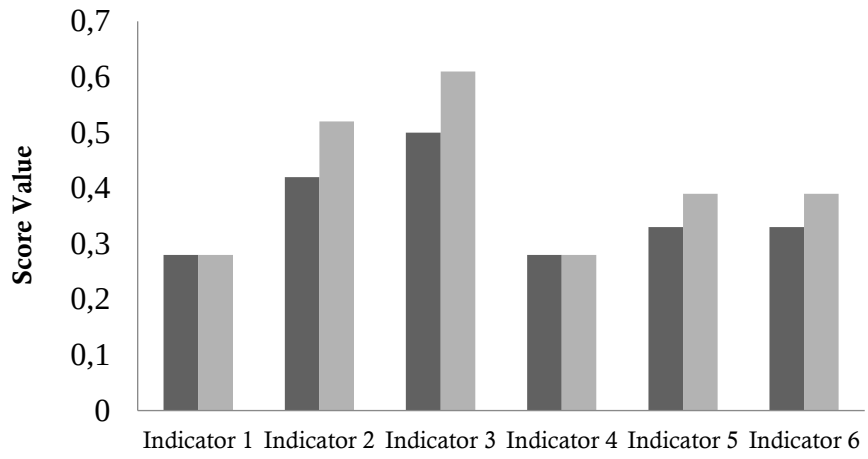

Figure 3. Results of the Experimental Group Pretest Based on Gender

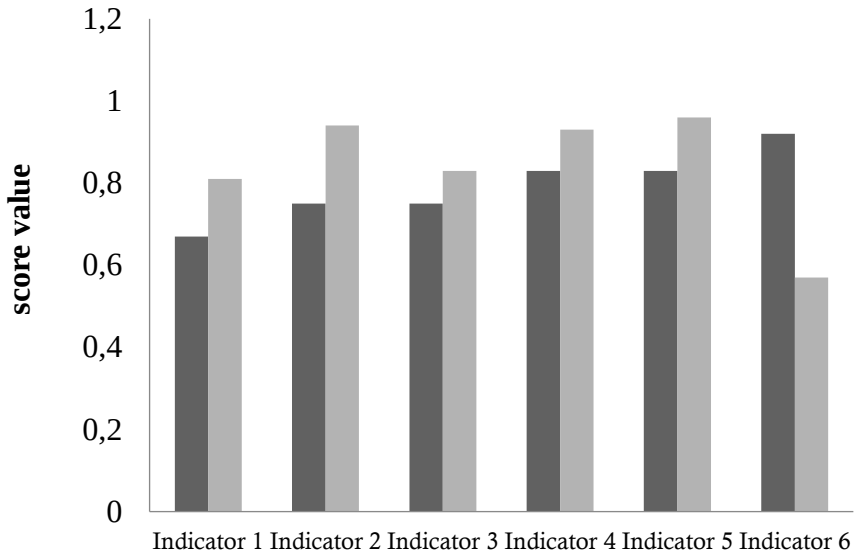

Figure 4. Posttest Results of Experimental Group Based on Gender

The diagram of the average pretest value for each indicator shows that male and female students have the same average value for the indicators of identifying problems (1) and collecting several solutions (4), namely 0.28. Female students are superior in the indicators of diagnosing problems (2), making a solution plan (3), implementing a solution plan (5), reviewing and discussing (6). This is because female students are more diligent in working on questions. According to Santrock (2008) female students want to study more diligently than male students. So in making a strategy for problem-solving plans, female students are superior when given questions whose material has never been taught by the teacher.

After the intervention is implemented, students work on post-test questions to see the final abilities they have after the learning process. The post-test results can be seen in Figure 4.

Male students have an average score of 0.92 on the reviewing and discussing indicator (6) compared to the average score of female students, which is 0.57. According to Dorisno (2019) male students have the ability to practice remembering answers. This is what makes male students superior in the review indicator (6) compared to female students.

Female students have higher average scores on the indicators of identifying problems (1), diagnosing problems (2), making a solution plan (3), collecting several solution plans (4), and implementing the solution plan (5) compared to male students. This is supported by Wardani & Kurniawan (2014) that female students are more thorough in solving problems compared to male students. Santrock (2008) has explained that female students pay more attention to lessons in class, are more diligent in studying, and participate more than male students.

The female student's brain has a fairly large Broca area. This Broca area has an important role in activating language processes including the ability to write and read (Takizawa & Kobayashi, 2022). Female students are superior in the indicator of collecting several solutions because female students are more careful in reading each teaching material and book distributed by the teacher. If they do not find what they are looking for in the book, they look for information via cellphone. Writing and reading skills can help female students in collecting information and can be a solution to problems so that problem-solving planning can be completed properly.

The one sample t-Test is used to see the difference in one paired group. Based on the results of the one sample t-Test where male and female students have a sig. (2-tailed) value of 0.00 <0.05, meaning that there is a significant difference between male and female students in the experimental group. The One Sample t-Test of the experimental group based on gender can be seen in Table 7.

Table 7. Results of One Sample t-Test for Experimental Group

Students	Sig. (2-tailed)
Male	0,00
Female	0,00

The results of the N-Gain test of the experimental group showed an N-Gain Score for male students of 0.66 and 0.72 for female students with the same criteria, namely high. Based on these results, it can be concluded that there is a significant increase in problem-solving ability based on gender in the experimental group. The results of the N-Gain test of the experimental group based on gender can be seen in Table 8

Table 8. Results of the Experimental Group N-Gain Test Based on Gender

Students	Statistics
Male	0,66
Female	0,72

Through Figure 5, each indicator of problem-solving ability of control group students can be seen based on gender before the learning process. In the pretest results, male students had higher average scores on the indicators of problem diagnosis (2), implementing a solution plan (5), reviewing and discussing (6), compared to female students. Female students had superior scores on the indicators of identifying problems (1), making a solution plan (3), and collecting several solution solutions (4)

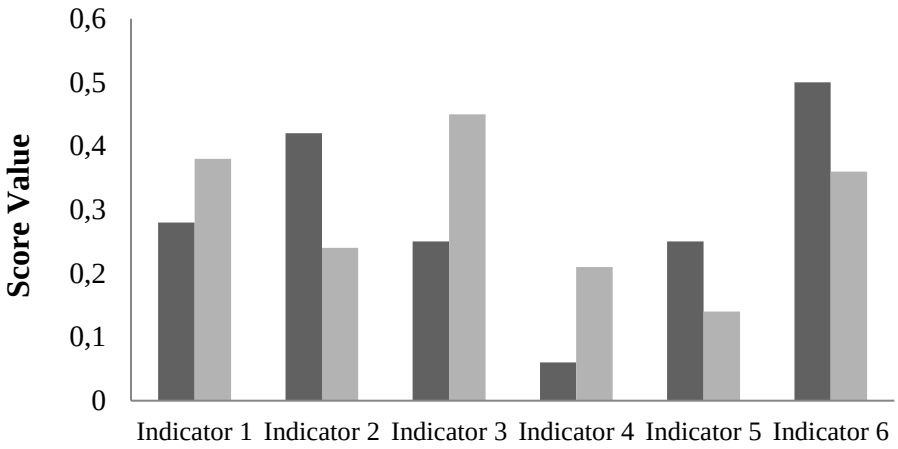

Figure 5. Results of the Control Group Pretest Based on Gender

According to Santrock (2008) Male students have visuospatial abilities. This visuospatial ability includes the ability to mentally rotate objects and know what the object looks like. This ability is important in mathematics lessons. Therefore, male students excel in the indicators of implementing problem-solving plans (5), and reviewing (6) compared to female students. Takizawa & Kobayashi (2022) stated that male students have a higher interest in mathematical problems than female students. Wardani & Kurniawan (2014) stated that female students were more thorough in solving problems compared to male students. It can be seen from the indicators of identifying problems (1), making a solution plan (3), and collecting several solution solutions (4), female students had a

higher average score. After the learning process was completed, the control group students were given questions in the form of a posttest. The results of the control group posttest based on gender can be seen in Figure 6.

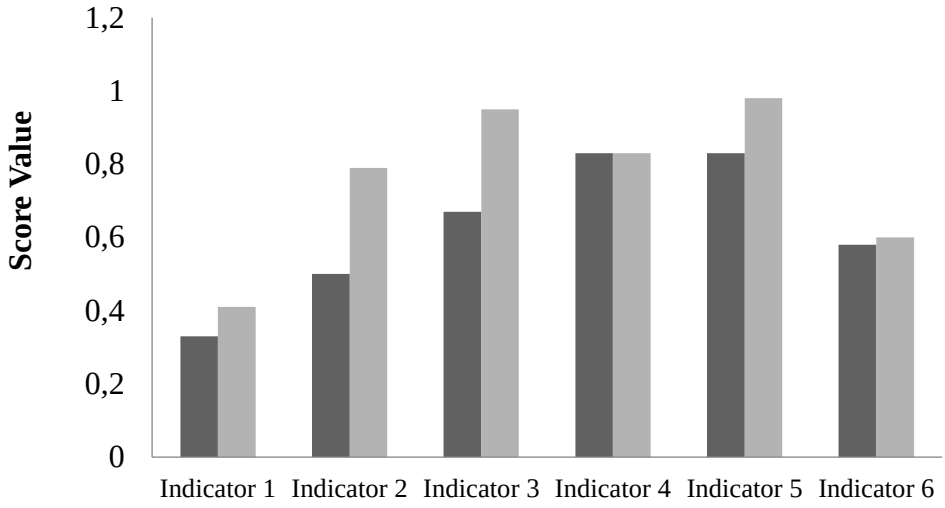

Figure 6. Posttest Results of Control Group Based on Gender

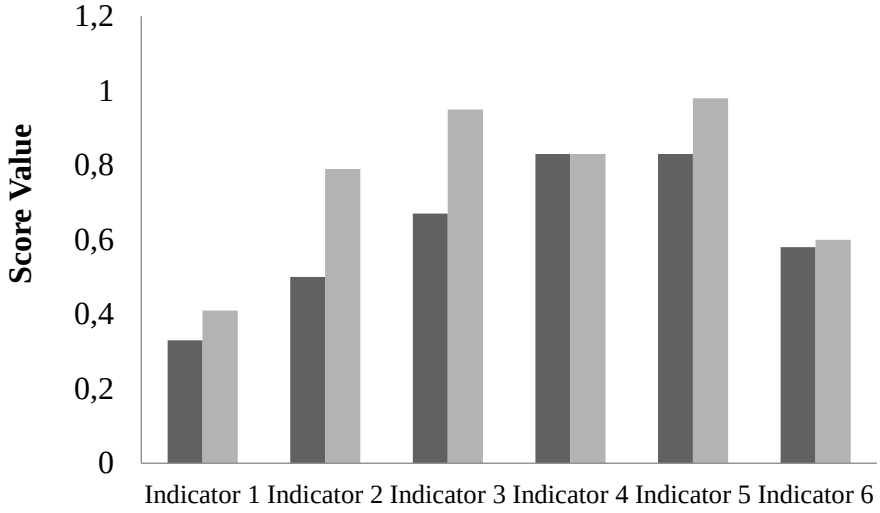

Figure 7. Posttest Results of Control Group Based on Gender

Table 9. Results of One Sample t-Test Control Group Based on Gender

Students	*Sig. (2-tailed)*
Male	0,00
Female	0,00

Figure 6 shows that male and female students have the same average score on the indicator of collecting several solution solutions (4). Female students have a higher average score than male students on the indicators of identifying problems (1), diagnosing problems (2), making a solution plan (3), implementing a solution plan (5), reviewing and discussing (6). The results of the One Sample t-Test of the control group based on gender can be seen in Table 9.

Table 9 shows that the sig. value (2-tailed) between male and female students is 0.00 < 0.05. Based on this, there is a significant difference between male and female students in the control group. The results of the N-Gain test of the control group based on gender can be seen in Table 9. Table 9 shows that the statistical values of male and female students are 0.47 and 0.62 with the upper medium criteria.

Table 10. Results of the N-Gain Test for the Control Group Based on Gender

Students	Statistik
Male	0,47
Female	0,62

Table 11. One Sample t-Test Results of Control Group Based on Gender

Students	*Sig. (2-tailed)*
Male	0,00
Female	0,00

Table 10 shows that male and female students have the same average score on the indicator of collecting several solution solutions (4). Female students have a higher average score than male students on the indicators of identifying problems (1), diagnosing problems (2), making a solution plan (3), implementing a solution plan (5), reviewing and discussing (6). The results of the One Sample t-Test of the control group based on gender can be seen in Table 11.

Table 11 shows that the sig. value (2-tailed) between male and female students is 0.00 < 0.05. Based on this, there is a significant difference between male and female students in the control group. The results of the N-Gain test of the control group based on gender can be seen in Table 12. Table 11 shows that the statistical values of male and female students are 0.47 and 0.62 with the upper medium criteria.

Table 12. Results of the N-Gain Test for the Control Group Based on Gender

Students	Statistics
Male	0,47
Female	0,62

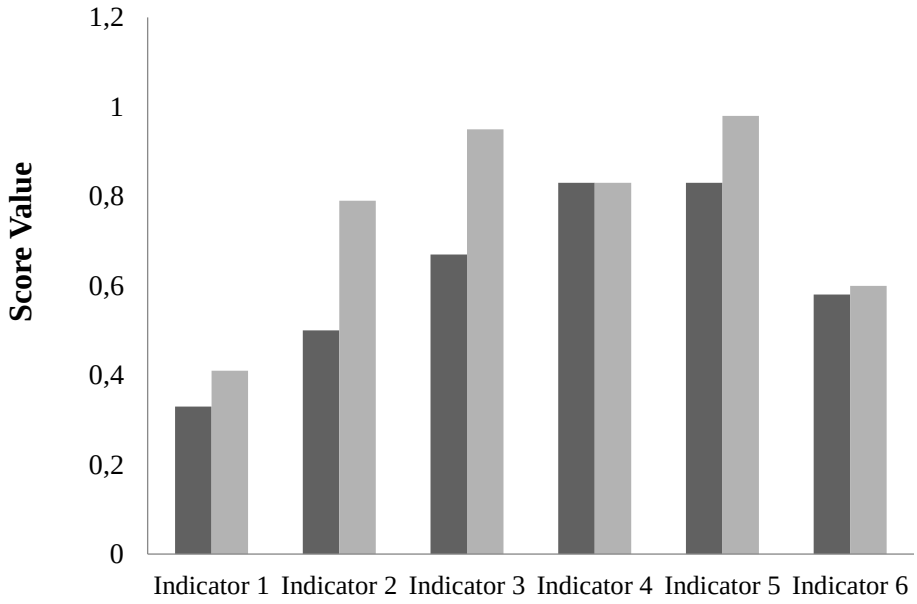

Figure 8. Posttest Results of Control Group Based on Gender

Figure 8 shows that male and female students have the same average score on the indicator of collecting several solution solutions (4). Female students have a higher average score than male students on the indicators of identifying problems (1), diagnosing problems (2), making a solution plan (3), implementing a solution plan (5), reviewing and discussing (6). The results of the One Sample t-Test of the control group based on gender can be seen in Table 13.

Table 13. Results of One Sample t-Test Control Group Based on Gender

Students	*Sig. (2-tailed)*
Male	0,00
Female	0,00

Table 13 shows that the sig. value (2-tailed) between male and female students is 0.00 < 0.05. Based on this, there is a significant difference

between male and female students in the control group. The results of the N-Gain test of the control group based on gender can be seen in Table 14. Table 14 shows that the statistical values of male and female students are 0.47 and 0.62 with the upper medium criteria.

Table 14. Results of the N-Gain Test for the Control Group Based on Gender

Students	Statistics
Male	0,47
Female	0,62

CONCLUSION

The results of the classical N-Gain test show that the collaborative model based on problem based learning is good for use in the learning process. Classes that use this model have a high N-Gain Score compared to classes that use lecture and discussion models. The collaborative model based on problem based learning encourages the development of critical thinking, problem-solving skills, and communication. Male students have visuospatial abilities that are important in mathematical learning. While female students have a Broca area that is voluminous and functions to activate language skills.

Based on the research, the problem found is about time allocation. The investigation stage in the collaborative model based on problem based learning requires quite a long time. This is because students have to design experimental tools and need time to understand the LKS well. The researcher's suggestion is that teachers are expected to be able to process and provide more time for the investigation stage.

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