ISSN 2715-7458
E-ISSN 2715-7466

Journal of Mathematical Pedagogy
Volume 7, No. 1, December 2025, pp. 54-61

Collaborative Problem Based Learning and Students' Anxiety: An Experimental Study in Algebra Learning

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Abstract

Mathematical skills and ability are indispensable in the 21st century, especially in the development of modern technology. Thus, an understanding of mathematics is necessary to face future challenges. Unfortunately, math is often perceived as a big challenge by students, especially in affective aspects such as math anxiety. This anxiety is known to have a negative impact on students' performance, working memory, and mathematical ability. Therefore, this study aims to determine how much influence Collaborative Problem Based Learning has in reducing math anxiety. Through post-test data, this study uses quantitative, quasi-experimental methodology. The population is class 10 students in a high school in Gresik Regency (N = 320). By purposive sampling, two classes (64 students) studying Two-Variable Inequality System material were selected, which were divided into experimental groups with CPBL treatment and control groups with conventional learning. This research instrument was modified from Sadia Mahmood and Tahira Khatoon's Mathematics Anxiety Development Instrumen (14 items). The results showed that the application of the CPBL learning model did not have a significant effect on reducing student anxiety. This may be due to the short implementation period (two meetings), inconsistent group collaboration, and and a lot of students are hesitant to seek clarification when they are having trouble understanding algebra.

Keywords: *algebra, collaborative problem-based learning, conventional learning, mathematic anxiety, system of linear inequalities in two variables*

Abstrak

Keterampilan dan kemampuan matematika sangat penting di abad ke-21, terutama dalam pengembangan teknologi modern. Oleh karena itu, pemahaman matematika diperlukan untuk menghadapi tantangan di masa depan. Sayangnya, matematika sering dianggap sebagai tantangan besar oleh siswa, terutama dalam aspek afektif seperti kecemasan matematika. Kecemasan ini diketahui memiliki dampak negatif pada kinerja siswa, memori kerja, dan kemampuan matematika mereka. Oleh karena itu, penelitian ini bertujuan untuk menentukan sejauh mana pengaruh Collaborative Problem Based Learning (CPBL) dalam mengurangi kecemasan matematika. Melalui data post-test, penelitian ini menggunakan metodologi kuantitatif quasi-eksperimental. Populasi penelitian adalah siswa kelas 10 di sebuah sekolah menengah atas di Kabupaten Gresik (N = 320). Melalui sampling purposif, dua kelas (64 siswa) yang mempelajari materi Sistem Pertidaksamaan Dua Variabel dipilih, yang dibagi menjadi kelompok eksperimen dengan perlakuan CPBL dan kelompok kontrol dengan pembelajaran konvensional. Instrumen yang digunakan dalam penelitian ini dimodifikasi dari pengembangan instrumen kecemasan matematika oleh Sadia Mahmood dan Tahira Khatoon (14 item). Hasil penelitian menunjukkan bahwa penerapan model pembelajaran CPBL tidak memiliki efek signifikan dalam mengurangi kecemasan siswa. Hal ini mungkin disebabkan oleh periode implementasi yang cukup singkat (dua pertemuan), kolaborasi kelompok yang tidak konsisten, dan tidak sedikit siswa yang enggan bertanya ketika menghadapi kesulitan dalam memahami aljabar.

Kata kunci: *aljabar, kecemasan matematika, pembelajaran berbasis masalah secara kolaboratif, pembelajaran konvensional, sistem pertidaksamaan linear dua variabel*

How to Cite: Putri, A.E. & Sari, Y.M. (2025). Collaborative Problem Based Learning and Students' Anxiety: An Experimental Study in Algebra Learning. *Journal of Mathematical Pedagogy, 7* (1), 54-61.

Introduction

In this era of globalization and rapid technological advancement, mathematical ability has become a key skill that supports innovation in various fields (Gestiardi et al., 2025). Mathematics is no longer merely the foundation of science, but rather a key component in the development of modern technology.

The continuous development of mathematical skills is also recognized as a major factor underlying a country's economic progress and has a significant impact on society at large (Živković et al., 2023). Therefore, a strong understanding of mathematics is essential to address the challenges of the future.

However, learning mathematics is still often considered a major challenge for students, especially in affective aspects such as anxiety. Mathematical anxiety can be experienced by various age groups (Commodari & La Rosa, 2021). This can hinder conceptual understanding, reduce learning motivation, and have a negative impact on students' academic achievement. This situation is supported by research showing that the drop in math learning outcomes among students is still a consistent and serious issue (Cuder et al., 2023). According to a report by the Programme for International Student Assessment (PISA), many children struggle with mathematics. The 2018 PISA report indicates that 30% of students experience anxiety or despair when solving math problems, which causes their performance to fall below expectations. This condition is supported by the results of the 2022 PISA survey, which indicates that the mathematical proficiency of Indonesian students is still comparatively low. The average mathematics score of Indonesian students is far behind the OECD average of 472, with Indonesia ranking 65th out of 81 countries. This fact underscores the need for immediate efforts to improve the quality of mathematics education, taking into account both the cognitive and affective aspects of students.

One affective aspect that needs to be considered is anxiety. Numerous studies have shown the existence of anxiety, particularly mathematical anxiety. Mathematical anxiety can be defined as a form of fear, anxiety, worry, or discomfort that students often experience when faced with mathematical tasks (Wahyuni et al., 2025; Yarkwah et al., 2024). Mathematics anxiety can have a negative impact on students' cognitive abilities and performance in solving problems, such as test anxiety, which often causes cognitive impairment. This can arise from a fear of failure. In line with this, it has been found that low mastery combined with high anxiety in mathematics classes can lead to lower test performance (Putwain & Wood, 2023). In addition, these concerns also extend to working memory, as there is a strong inverse relationship between working memory and math anxiety (Finell et al., 2022). Thus, it can be concluded that anxiety not only affects math performance but also disrupts students' working memory. This can be one of the reasons students feel stressed and tend to avoid math, thereby impacting their math abilities.

This condition can be even more pronounced in certain mathematical topics, especially complex and abstract material such as algebra (Haji et al., 2017). Most students feel stressed when faced with symbols to solve a problem (Díaz et al., 2024), especially if assignments are done individually and focus on procedural learning, such as conventional teacher-centered learning, where students tend to be more passive and simply follow the teacher's instructions, which can lead to learning becoming meaningless (Alfina & Sutirna, 2022).

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Given the many challenges, there is a need for a learning approach that not only reduces students' anxiety levels toward mathematics but also enhances meaningful understanding of mathematical concepts, particularly algebra. One model that has the potential to address these issues is Collaborative Problem-Based Learning. This model uses problem-based learning integrated with collaboration skills. Collaboration is an important skill to teach students because it is believed to help them develop mathematical skills (Díaz et al., 2024). In line with this research, Problem Based Learning can also help students improve their cognitive abilities in solving mathematical problems. Classes using the

conventional approach and those using the PBL model differ greatly in their capacity to resolve mathematical story issues (Ardianik et al., 2022). It was found that the application of PBL has a positive effect on students' mathematical connection abilities and is considered capable of activating students' thinking processes, increasing deep and meaningful understanding compared to other models (Aisyah et al., 2022). Through the CPBL model, students are not only guided to develop their independence and creativity in learning but are also required to solve problems in groups (Ariyanto et al., 2019), directing students to conduct investigations, integrate theory and practice, and apply the knowledge and skills they possess to enhance their problem-solving skills (Hidayatullah R. S., Ariyanto S. R., Muhaji & Yohannes, 2020).

Prior research has demonstrated that problem-based and collaborative learning enhance students' cognitive capabilities and mathematical problem-solving skills (Saadati & Reyes, 2019). Several studies suggest that a collaborative learning environment may reduce math anxiety (Jatisunda et al., 2020). However, the majority of research still concentrates on cognitive characteristics, and there are still few empirical studies that specifically look at how collaborative problem-based learning affects students' math anxiety, especially in algebra at the high school level. This study aims to address this gap by empirically investigate the impact of CPBL on math anxiety.

Based on these objectives, this study examines whether there is a difference in the level of mathematics anxiety between students who learn using the CPBL model and students who learn using conventional learning methods. Thus, the hypothesis proposed is that CPBL can significantly reduce students' mathematics anxiety compared to conventional learning. The results of this study are expected to contribute theoretically to the development of mathematics education studies and practically serve as a reference for teachers in designing learning strategies that are sensitive to student anxiety.

Method

This study uses a quantitative, with a quasi-experimental approach. Posttest data were utilized in this study to examine how well collaborative problem-based learning models reduce math anxiety. The study population consists of students aged 14–16 years, specifically all 10th grade students at a public high school in Gresik Regency ($N = 320$). The sampling technique used was purposive sampling, focusing on classes studying the material on Two-Variable Inequality Systems, with two classes (64 students) selected and divided into an experimental group and a control group. The main instrument in this research was a mathematics anxiety questionnaire with 14 statements on a 5-point Likert scale that was modified from Sadia Mahmood and Tahira Khatoon's Mathematics Anxiety Development Instrument (Ko & Yi, 2011). This questionnaire will be presented to both the experimental and control groups following their receipt of conventional learning for the control group and collaborative problem-based learning for the experimental group.

In the control class, conventional learning was applied with a teacher-centered approach. The teacher took charge of the learning process by explaining algebraic concepts, followed by problem instances and individual exercises. As information recipients, students' primary tasks included listening to explanations, taking notes, and solving problems in accordance with the teacher's shown techniques. Students engaged in problem-solving exercises on their own, with little to no interaction among them.

In contrast to the experimental class, learning was conducted using the Collaborative Problem-Based Learning (CPBL) model, which consists of five steps. In the first step, the teacher presented contextual problems related to algebra material, commonly known as problem orientation. Students are divided into small groups for the second step, organizing, which involves identifying issues and formulating solutions. Students then collaborate in groups to collect data, exchange ideas, and create answers to the challenges at hand during the collaborative problem-solving stage. Each group presents their answers and has a conversation with other groups during the presentation and discussion phase

that follows. Evaluation is the last phase, during which instructors and students evaluate the learning process and the solutions generated.

Descriptive statistical tests (mean and standard deviation) will be used to assess the study's data and characterize its features, then an independent samples t-test using Levene's homogeneity test and Shapiro-Wilk normality test to make sure the data is normally distributed using SPSS software version 26. There are several criteria in data analysis, including the decision criteria in the Shapiro-Wilk normality test, where if the sig p value > 0.05, the data is normally distributed. Conversely, if the sig p value < 0.05, the data is not normally distributed.

Table 1. Decision Criteria for *Shapiro-Wilk Normality Test*

P-Value	**Decision Criteria**
p > 0,05	Normally distributed data
p < 0,05	Data is not normally distributed

The decision criteria in the homogeneity test are not much different from the decision criteria in the Shapiro-Wilk Normality test, namely when the p-value in the Levene test is < 0.05, then the data variance is not homogeneous or the assumption of homogeneity is not met. Conversely, if the p-value in the Levene test is > 0.05, then the data variance is homogeneous or the assumption of homogeneity is met.

Table 2. Decision Criteria for Levene's Homogeneity

P-Value	**Decision Criteria**
p > 0,05	Homogeneous data variance
p < 0,05	The data variance is not homogeneous

When the data has been confirmed to be normally distributed and the data variance is homogeneous, an independent t-test will be conducted to determine the difference in the level of math anxiety experienced by students between the Collaborative Problem Based Learning group and the control group. The testing criteria in the independent sample t-test is when the p value < 0.05, then there is a significant difference between the two variables. However, if the p value > 0.05, then there is no significant difference between the two variables.

Table 3. *Decision Criteria For Independent Sample T-test*

P-Value	**Decision Criteria**
p > 0,05	There is no significant difference between the two groups (H_0)
p < 0,05	There is a significant difference between the two groups (H_1)

Result and Discussion

This study is motivated by problems in learning mathematics, namely the low level of student understanding of algebraic material which is often accompanied by high levels of anxiety. This anxiety is further exacerbated by the difficulties that students have felt before when dealing with abstract symbols and problems in algebraic material, as well as conventional learning that is considered less meaningful and tends to be passive making it difficult for students to better understand the concepts learned (Isfayani, 2023). Therefore, the Collaborative Problem Based Learning model was chosen in the hope that it could be a solution to these problems. It is hoped that through the application of the CPBL learning model can increase students' contribution to learning through group discussions, so as

to reduce students' anxiety about math, and improve understanding of algebraic concepts, especially the Two-Variable Linear Inequality System.

Sociodemographic Conditions

Table 4. *Sociodemographics*

Characteristics	Category	Frequency	Percentage(%)
Gender	Female	48	70,6
	Male	20	29,4
Age	15	23	33,8
	16	31	45,5
	17	14	20,5

Based on table 4, the results of the analysis of socio-demographic characteristics consisting of 68 subjects show that of these, 48 subjects or around (70.6%) are female, while 20 other subjects or around (29.4%) are male. From these data, it can be concluded that most of the responses obtained came from female student subjects. Meanwhile, in terms of age, the subjects of this study are divided into three age groups including, 15 years old as many as 23 students or around (33.8%), 16 years old as many as 31 students or around (45.5%), and 17 years old as many as 14 students or around (20.5%).

Descriptive analysis of the two groups

Table 5. *Descriptive analysis*

Characteristics	Group	N	Mean	Std. Deviation	Std. Error Mean
Anxiety score	Control group	34	40.40	11.670	1.973
	Experimental group	34	41.97	12.705	2.179

Based on table 5, descriptive analysis shows that the math anxiety score in the experimental group that gets Collaborative Problem Based Learning has an average anxiety score of 41.97 with Standard Deviation 12.70, this value is not much different from the average anxiety of the control class which is 40.40 with Standard deviation 11.67. To find out whether there is a significant difference, it is necessary to conduct further statistical tests, namely the Independent t-test.

Test of Normality

Table 6. *Test of Normality Shapiro-Wilk*

Characteristics	Statistic	df	Sig.
Experiment	.939	34	.056
Control	.954	34	.162

Based on the Shapiro-Wilk normality test on table 6, the significance value (p-value) > 0.05 is obtained, which is 0.056 for the experimental group and 0.162 for the control group. This shows that the distribution of data from these two groups can be said to be normal.

Test of Homogeneity

Table 7. *Test of Homogeneity of Variance*

Characteristics		Levene Statistic	df1	df2	Sig.
Anxiety score	Based on Mean	.756	1	67	.388

Based on Median	.766	1	67	.385
Based on Median and with adjusted df	.766	1	66.971	.385
Based on trimmed mean	.758	1	67	.387

Based on the homogeneity test (Levene's test) on table 7), the variance between the experimental and control groups was homogeneous, with a significant value of 0.388 ($p > 0.05$). As a result, an independent t-test might be run. The data satisfied the assumption of normality, hence Levene's mean-based homogeneity of variance test was selected.

Independent Sample t-test

Table 8. *Independent Sample t-test*

Levene's Test for Equality Variances						**95% Confidence interval of the difference**	
		F	**t**	**df**	**Sig. (2-tailed)**	**Lower**	**Upper**
Anxiety score	Equal variances assumed	.756	-.535	67	.594	-7.430	4.289
	Equal variances not assumed		-.534	66.139	.595	-7.439	4.297

Table 8 shows that the application of the Collaborative Problem Based Learning (CPBL) model does not have a significant effect in reducing students' math anxiety. Based on the results of the analysis using an independent sample t-test between the experimental group (CPBL) and the control group (conventional learning), there was no statistically significant difference in students' anxiety scores, with a significance value of $0.594 > \alpha$ (0.05). This finding even contradicts the initial hypothesis, which assumed that CPBL could reduce individual pressure through a supportive learning environment. This indicates that the CPBL model cannot significantly reduce math anxiety in the study, so H_0 is accepted.

One of the possible reasons for the discrepancy between the research objectives and the final research findings is the brief deployment period of CPBL Learning and the lack of student adaption. Although the problem-based learning model is designed to help students develop cognitive skills through mathematical problem solving using learning sequences, the benefits of adopting this model will not be completely realized if students are unfamiliar with it. Students therefore require time to become acquainted with the used approach. If students are only exposed to CPBL occasionally and for small periods of time, they might not have enough opportunities to understand the process of collaborative work and adaptation to different learning styles. Due to a lack of adaptation, the potential for psychological support in a collaborative environment, which should reduce math anxiety, has not been fully realized. The Anthropology of Didactic Theory (ATD) states that mathematical activities created by teachers in the classroom produce mathematical objects themselves (Bosch et al., 2017; ; Chevallard & Bosch, 2020b). This means that the effectiveness of a learning model is largely determined by how it is practiced or implemented, how students interact with "praxeologies," which include tasks, strategies, technology, and theories offered. The process of transforming scientific knowledge into knowledge that can be learned and taught by students is called didactic transposition. If the duration of CPBL implementation is only brief, then didactic transposition may not be realized. Second, some students did not participate in problem-solving activities. It was found that group discussions did not run optimally, hindering the collaborative learning applied from functioning

effectively. The researcher observed that only a few groups were actively involved in discussions when facing group problems, while other groups appeared more passive in their discussions, and only a few students demonstrated dominance when facing group difficulties. This can be due to the diverse personalities among the students. For example, forcing introverted students to participate in group discussions may make them feel pressured. If this continues to happen in the research, the anxiety-reducing benefits of CPBL in the learning process will not be fully realized. This is because different students benefit from teamwork in different ways. Therefore, to motivate the less engaged students to be more active in classwork and feel valued, future researchers may interact with them. Third, students' inability to understand algebra may cause them difficulties during this learning process. Although CPBL is believed to improve students' understanding of mathematics, researchers must ensure that all students can understand the context of the given problems. This needs to be done because the researcher acts as a teacher during its implementation and must facilitate learning well.

Therefore, it can be said that the learning model is not the only main strategy to overcome fear instantly. Further research that can focus on some of the alternatives mentioned above as well as other psychological and social aspects is needed to make the research work as well as.

Conclusion

The study's findings suggest that CPBL has no discernible impact on lowering student anxiety. This may be due to several factors. First, it was only implemented for a short period of time (two meetings), which apparently prevented students from fully adapting to the new learning model. Second, collaboration among students did not run optimally. Based on the researcher's observations, only a few students were dominant in the group, which certainly prevented all students from feeling the impact of collaborative learning. Third, students' difficulty in understanding algebra; not all students dare to ask questions, especially if they have an introverted personality. The researcher, who acted as a teacher in the study, must provide the best facilities for students by ensuring that all students understand the context being studied and providing guidance for those who are struggling.

Thus, it can be concluded that the learning model is not the sole primary solution for instantly addressing math anxiety. Further research is needed that can more closely examine the above possibilities along with other factors, such as psychological and social factors, to ensure that the research conducted can proceed optimally.

Acknowledgement

Without the assistance of various parties, especially the participation of respondents, this quantitative research using experimental methods would not have been possible. Therefore, the author sincerely thanks all parties who have helped and supported this research.

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