

Implementation of project-based learning and problem-based learning in mathematics course with students' anxiety: Is it effective?

Getut Pramesti¹, Nabila Shafa Salsabila¹

Abstrak Kecemasan terhadap matematika sering kali mengganggu keterlibatan dan pencapaian siswa, yang menyebabkan penurunan kepercayaan diri dan kemungkinan menarik diri dari proses pembelajaran. Pembelajaran berbasis proyek (PjBL), yang menekankan pada pengalaman aktif serta kolaboratif, merupakan solusi yang menjanjikan untuk masalah tersebut. Sementara itu, kemampuan pemecahan masalah menjadi krusial pada pembelajaran di masa mendatang dan pembelajaran berbasis masalah (PBL) dapat menjadi pendekatan yang dapat meningkatkan kemampuan berpikir tingkat tinggi tersebut. Penelitian ini menguji keefektifan PjBL dan PBL dalam meningkatkan domain kognitif siswa yang mengalami kecemasan matematika. Penelitian ini menggunakan pendekatan kuantitatif dengan pengambilan sampel secara acak kluster yang menargetkan siswa kelas 9 di Banyuasin, Jawa Timur, Indonesia. Data dikumpulkan melalui dokumentasi, angket, dan tes hasil belajar pada materi geometri spasial, bersama dengan pengukuran terhadap kecemasan matematika. Teknik analisis data menggunakan analisis kovariat satu arah, dengan kecemasan sebagai variabel kovariat. Hasil temuan mengindikasikan bahwa PjBL dan PBL meningkatkan hasil belajar siswa dengan kecemasan matematika secara signifikan (p -value < 0.050). Kedua pendekatan tersebut mempromosikan pembelajaran kolaboratif, tutor sebaya, dan interaksi aktif siswa, yang dapat meningkatkan kemampuan komunikasi, mengurangi kecemasan, serta memperdalam penguasaan materi pembelajaran.

Kata kunci *Kecemasan matematika, Pembelajaran berbasis proyek, Pembelajaran berbasis masalah, Hasil belajar*

Abstract Mathematics anxiety often interferes with students' engagement and achievement, leading to reduced self-confidence and the potential withdrawal from the learning process. Project-Based Learning (PjBL), which emphasizes hands-on, collaborative experiences, is a promising approach for addressing this issue. Meanwhile, problem-solving skills are essential for future learning and Problem-Based Learning (PBL) offers an effective approach to fostering these higher-order thinking skills. This study investigates the effectiveness of PjBL and PBL in enhancing the cognitive performance of students suffering from mathematics anxiety. The study employs quantitative approach with cluster random sampling by targeting 9th-grade students in Banyuasin, East Java, Indonesia. Data were collected through documentation, questionnaires, and achievement tests on spatial geometry, alongside measures of mathematics anxiety. The data was analysed using a one-way covariance (ANCOVA) analysis, treating anxiety as a covariate variable. The findings indicate that both PjBL and PBL significantly enhance students' learning outcomes despite of their mathematics anxiety (p -value < 0.050). Both approaches promote collaborative learning, peer tutoring, and active student interaction, which foster improved communication skills, reduce anxiety, and deepen mastery of the subject.

Keywords *Mathematics anxiety, Project-based learning, Problem-based learning, Learning achievement*

¹ Department of Mathematics Education, Universitas Negeri Surakarta, Indonesia, getutpramesti@staff.uns.ac.id

Introduction

Mathematics involves abstract concepts and requires engaging instructional approaches to enhance student interest and motivation. Such methods foster greater student participation and enthusiasm for learning (Supi et al., 2020). Mathematics plays a critical role in shaping graduates with a solid foundation in mathematical thinking, enabling them to solve real-life problems logically, rationally, critically, and systematically.

According to the PISA 2022 report, Indonesian students scored an average of 366 points in mathematics, ranking 6th out of 8 ASEAN countries that participated in the PISA test (OECD, 2023). This score places them at Level 1a, indicating an inability to formulate solutions to complex problems creatively. These results suggest that students' mathematics learning outcomes in Indonesia remain significantly low. Learning outcomes are key indicators of educational success and are commonly categorized into three domains: cognitive, affective, and psychomotor (Suhaida & Mardison, 2019). In mathematics, the cognitive domain is especially crucial, as it involves mental processes such as memory, reasoning, and problem-solving (Maulidya & Nugraheni, 2021). According to Bloom's taxonomy, key components of the cognitive domain include acquiring and understanding knowledge, applying it in context, analyzing and combining information, and making informed judgments (Maulidya & Nugraheni, 2021).

However, not all students share equal learning experiences, and many struggle with comprehension, which significantly impacts their academic performance. For instance, the average score of 9th-grade students on a mathematics test covering circle geometry during the 2024/2025 academic year was 65.58, with only 10 out of 34 students scoring above the Minimum Completion Criteria (MCC) of 75. This indicates that a substantial number of students failed to meet academic expectations. Beyond material mastery, student motivation and learning readiness are essential internal factors contributing to academic achievement. Meanwhile, external factors—such as the instructional strategies teachers employ—play an equally influential role.

The conventional teaching model, characterized by its teacher-centered orientation, remains dominant in many Indonesian classrooms, particularly in mathematics instruction (Pila, 2023). This approach typically emphasizes one-way content delivery, limiting opportunities for student interaction, collaboration, and critical thinking (Chang et al., 2018; Ordonez, 2014). A classroom observation at a public junior high school in Banyuwangi Regency on August 3, 2024, revealed low levels of student engagement, with several students found outside the classroom during instructional time, congregating in informal areas such as the canteen and school cooperative. Interviews with the mathematics teacher confirmed that instructional routines mainly involved lectures followed by individual exercises, often resulting in disengagement and distraction among students. These conditions reflect the persistence of passive learning environments that fail to accommodate students' cognitive and emotional needs. Consequently, this instruction may hinder conceptual understanding and contribute to heightened levels of mathematics anxiety among students (Sauter et al., 2022).

Mathematics anxiety is a psychological discomfort or cognitive disruption experienced by individuals when confronted with mathematical tasks (Ashcraft, 2002). Various factors may contribute to the development of this condition, including personality traits, environmental influences, and intellectual capacities. Personality-related factors involve students' self-doubt and fear of failure, while environmental factors include the instructional methods employed by

teachers. Intellectual aspects, such as individual cognitive abilities and levels of intelligence, also play a significant role in shaping mathematics anxiety (Cavanagh & Sparrow, 2010). According to Cavanagh and Sparrow (2010), mathematics anxiety can lead to errors in calculation and hinder effective problem-solving. It typically manifests in three dimensions: cognitive, affective (attitudinal), and somatic (Sholichah & Aini, 2022). If not adequately addressed, mathematics anxiety can severely impair students' academic performance and overall learning outcomes.

Research by Dewi and Pujiastuti (2020), indicates that lower levels of anxiety can enhance students' mathematical knowledge and skills, whereas higher levels of anxiety tend to inhibit them. This finding underscores the importance of adopting instructional models that promote meaningful learning, enabling students to comprehend the material and remain actively engaged throughout the learning process. In this context, alternative pedagogical approaches such as Problem-Based Learning (PBL) and Project-Based Learning (PjBL) have shown promise in mitigating mathematics anxiety and improving academic outcomes (Prasetyo & Juandi, 2023). PBL, in particular, emphasizes the integration of real-world problems into the learning environment, allowing students to understand better, apply, and internalize mathematical concepts (Ardianti et al., 2022). This model fosters collaborative problem-solving, where students work in groups to address contextual tasks, encouraging active participation, reducing anxiety, and enhancing motivation.

Similarly, PjBL provides a contextual framework for students engaging in extended, inquiry-driven projects culminating in tangible outcomes (Nababan et al., 2023). The implementation of this model has been shown to promote critical skills such as creativity, responsibility, self-confidence, independence, and analytical thinking. Through collaborative project work, students construct knowledge incrementally, linking their tasks to curricular content and producing meaningful artifacts. PjBL encourages autonomy and deep engagement with mathematical content by shifting the focus away from teacher-centered instruction.

PBL and PjBL share core features supporting student creativity, collaboration, and reduced dependence on direct instruction. Given their theoretical and practical advantages, this study examines the effectiveness of PBL, PjBL, and conventional learning models in improving mathematical achievement among students experiencing mathematics anxiety.

Theoretical review

Mathematics anxiety

Mathematics anxiety refers to a psychological barrier that impairs an individual's ability to engage with mathematical tasks, primarily stemming from persistent feelings of fear and apprehension (Ashcraft, 2002). When left unaddressed, this form of anxiety can significantly influence students' attitudes toward mathematics, leading to avoidance behaviors and reduced academic performance. It affects students' willingness to participate in mathematical activities and undermines their confidence in tackling quantitative reasoning tasks.

The concept of mathematics anxiety is widely understood as a multidimensional construct that includes behavioral, cognitive, and affective components. These dimensions provide a comprehensive framework for analyzing how anxiety manifests in students. Behavioral symptoms may include restlessness or physical agitation, cognitive symptoms often involve disrupted concentration and intrusive thoughts or nightmares, and affective symptoms are

reflected in intense fear, worry, or emotional tension. This perspective aligns with previous research that emphasizes the complexity of mathematics anxiety as more than a single emotional response (Stuart, 2004; Asrifa et al., 2021). In the present study, these three dimensions serve as the primary indicators for assessing the presence and severity of mathematics anxiety among students.

Learning achievement

Learning achievement is a measurable indicator of students' comprehension and mastery of the subject matter delivered during instruction. It provides insight into the extent to which educational objectives have been achieved. As noted by Hamalik (2014), learning outcomes are not limited to academic performance but also represent observable changes in students' behavior, indicating a transition from not knowing to knowing, and from misunderstanding to understanding. These outcomes reflect the effectiveness of teaching strategies and the level of student engagement throughout the learning process.

Moore, as cited in Suhaida and Mardison (2019) classifies learning outcomes into three key domains: cognitive, affective, and psychomotor. Each domain captures different aspects of student development, from intellectual capabilities to emotional and physical skills. The present study focuses on the cognitive domain, which includes fundamental thinking processes such as recall, comprehension, application, analysis, and evaluation. These cognitive indicators offer a structured framework for assessing the depth of student understanding and the effectiveness of the instructional methods.

Conventional learning model

The conventional learning model is a widely used instructional approach, typically characterized by lecture-based delivery (Djamarah, 2010). However, this model is often perceived as monotonous and not well-aligned with the nature of the material being taught (Magdalena, 2018). Key characteristics of conventional learning include students acting as passive recipients of information, emphasizing individual learning, and minimal interaction between teachers and students. The instructional sequence follows several stages: preparation, presentation, discussion, conclusion, and evaluation (Purnomo et al., 2022).

Although this method facilitates fast and structured delivery of material, its weaknesses include a lack of critical thinking, the assumption that all students have the same learning style, and less emphasis on meaningful learning process skills (Purnomo et al., 2022). Based on these characteristics, the conventional learning model is considered teacher-centered, with one-way communication and a predominant focus on content mastery rather than developing broader student skills.

Problem-based learning model

Problem-Based Learning (PBL) engages students in critical thinking by involving them in solving real-world problems (Ardianti et al., 2022). This model encourages learners to search for information, identify problems, and formulate solutions independently. Grounded in Piaget's theory of cognitive development, PBL aligns with students' developmental stages, enabling them to construct understanding through active learning experiences (Jayantika et al., 2020). The main characteristics of PBL include using authentic, real-life problems, interdisciplinary

connections, inquiry-based investigations, and collaborative problem-solving among students (Arends, 2012).

PBL typically includes identifying problems, during which the teacher introduces a relevant and contextual issue; organizing students into groups to facilitate collaborative discussion; conducting investigations, where students seek information and analyze the problem; presenting the results of their work; proposing possible solutions; and concluding with reflection and evaluation conducted by both students and the teacher. These stages collectively foster the development of critical thinking skills, teamwork, and scientific problem-solving abilities. Project-Based Learning (PBL) is a student-centered approach that effectively promotes critical thinking, creativity, and collaboration by integrating real-world problems. Although it presents challenges—such as requiring more time, consistent student participation, and careful implementation—PBL has been shown to improve learning outcomes when applied appropriately significantly (Muharlisiani et al., 2023; Nofiarida, 2023). Therefore, despite its limitations, PBL remains a valuable pedagogical strategy for fostering academic and soft skills in diverse educational settings.

Project-based learning model

Project-Based Learning (PjBL) begins with presenting real-world problems, which serve as a foundation for students to gather and integrate knowledge based on their experiences (Laela, 2021). This model enables students to explore, evaluate, and acquire information through structured project activities. The key characteristics of PjBL include student decision-making within a defined framework, engagement with project-based challenges, collaborative problem-solving, periodic evaluations, and reflective learning processes (Sutrisna et al., 2020). According to Wajdi (Dewi, 2022), the steps of PjBL involve several phases: posing initial questions to stimulate students' curiosity; planning the project by developing strategies and dividing tasks; determining schedules and setting implementation timelines. Throughout the process, students work independently with ongoing guidance from the teacher. After the project, the teacher evaluates students' competency achievements, assesses the quality of the project outcomes, and provides constructive feedback on both the product and the learning process.

The benefits of PjBL include enhanced motivation, improved critical thinking, strengthened collaboration and communication skills, and learning experiences that are closely aligned with real-world contexts (Daryanto & Mulyo, 2012). However, the model also presents challenges, such as extended implementation time, higher resource demands, and the risk of unequal participation within student groups. Despite these limitations, PjBL has improved students' problem-solving, collaboration, and creative thinking abilities. To overcome its challenges, effective time management and readily available resources are essential strategies for successful implementation.

Methods

A quantitative approach employing a quasi-experimental design was adopted in this study. The research design incorporates a dependent variable (learning achievement), an independent variable (learning models), and a covariate variable (mathematics anxiety), which collectively justify the use of One-Way Analysis of Covariance (ANCOVA). Prior to conducting the

ANCOVA, several assumption tests were performed, including tests of normality, homogeneity, group balance, linearity, and one-way analysis of variance (Kutner et al., 2005). Based on these assumptions, the following linear model was used to describe the relationships among the dependent, independent, and covariate variables

$$Y_{ij} = \mu + \tau_i + \gamma(X_{ij} - \bar{X}) + \epsilon_{ij}$$

where

- Y_{ij} : Score of mathematics learning achievement obtained by the j -th student under the i -th learning model
- μ : Overall mean
- τ_i : Effects of the i -th learning model
- γ : Regression coefficient of Y_{ij} on X_{ij}
- ϵ_{ij} : Error term associated with the j -th student in the i -th learning model; assumed to be independent, identically distributed, and follow a normal distribution with $N(0, \sigma^2)$
- X_{ij} : Mathematics anxiety score of the j -th student in the i -th learning model
- \bar{X} : The mean of mathematics anxiety scores
- i : 1, 2, and 3; where $i = 1$ is conventional learning model, $i = 2$ is PjBL, while $i = 3$ is PBL
- j : 1, 2, 3, ... N , where N is number of students.

The sampling method employed in this study was cluster random sampling, a technique in which naturally formed groups (clusters) serve as the sampling units, and samples are randomly selected from within these clusters. The study targeted 9th-grade students from a public junior high school in Banyuasin, East Java. Based on students' mathematics achievement scores, one class was randomly selected from a group of available classes. Then, three classes were assigned to different treatment groups: one experimental class applying Problem-Based Learning (PBL), another applying Project-Based Learning (PjBL), and one control class using the Conventional model. Each group consisted of 30 students.

Data were collected using three instruments: a questionnaire to assess mathematics anxiety, a written test to measure students' mathematics learning achievement, and documentation to gather information on students' prior academic abilities. The construct of mathematics anxiety in this study was based on the framework proposed by Gail W. Stuart (2004), which includes three dimensions: cognitive, affective, and behavioral (see Table 1). The study emphasized the cognitive dimension, focusing on symptoms such as decreased concentration and reduced productivity in learning mathematics.

Table 1. The mathematics anxiety grid

No	Dimension	Indicator	Sub-indicator	Statement	Item	Number of items	
				type	numbers		
				Positive	Negative		
1	Cognitive	Self-ability	Students' ability to recall mathematical material	1, 2	3, 4	4	
		Self-confidence	Confidence in attempting to solve mathematical problems	5, 6, 7	8, 9, 10	6	
		Difficulty concentrating	Difficulty focusing during exams	11, 12	13, 14	4	
		Fear	Anxiety about potential failure in mathematics	15, 16	17, 18, 30	5	
2	Affective	Nervousness	Feeling nervous and unsure while solving problems	19	20	2	
		Enjoyment	Enjoyment in solving mathematical problems	21, 22	23, 24	4	
		Anxiety	Worry when unable to understand mathematical material	25, 26	27, 35	4	
3	Somatic	Nausea	Feeling nauseous when under pressure to solve problems	28	29	2	
		Normal body temperature	Comfort comes when you successfully work on math problems.		31, 32	2	
		Heart rate	Increased heart rate when struggling with math tasks		33	1	
		Headache	Experiencing headaches when asked to solve problems	34		1	

As stated by Benjamin Bloom in (Sudjana, 2017), the cognitive domain encompasses six aspects of learning outcomes: knowledge, comprehension, application, analysis, creation, and evaluation. Table 2 displays a grid of learning achievements for cognitive aspects.

The statistical analysis in this study was conducted using One-Way ANCOVA and performed with IBM SPSS Statistics 27 software. Before conducting the ANCOVA, several key assumptions were tested, including normality, homogeneity, independence, and identical distribution of the sample. Linear regression analysis further assumes that residuals are normally distributed and homoscedastic (Kutner, 2005). Additionally, it is assumed that the covariate variable is not influenced by the treatment conditions (Montgomery, 2017). Based on these assumptions, the research hypothesis posited that implementing PBL and PjBL learning models significantly influences the academic performance of students experiencing mathematics anxiety. The p -value generated from the SPSS output is subsequently compared to the 0.050 significance level to evaluate whether the adjusted mean differences between groups are statistically significant.

Table 2. Learning achievement grids

Cognitive level	Sub-indicator	Item indicator	Item number
Knowledge	Representing and retrieving information	Students solve problems involving cones and state their surface area and volume.	1
Understanding	Comprehending and applying formulas correctly	Students calculate the surface area of a cone based on a visual representation.	2
Application	Applying concepts in new contexts	Students solve word problems involving a cone and hemisphere combination.	3
Analysis	Classifying and analyzing problems	Students analyze word problems involving volume and related financial scenarios.	4
Evaluation	Evaluating and justifying solutions	Students calculate surface areas for birthday hats and evaluate whether they match available cardboard dimensions.	5
Creating	Integrating and synthesizing mathematical knowledge	Students find relationships between the volume of a cylinder and a cone.	6

Findings

Before analyzing the inferential statistics of the research variables, the descriptive statistics for mathematics learning achievement are presented in [Table 3](#) and [Figure 1](#).

Table 3. Descriptive statistics of mathematics achievements across the learning groups

Learning model	N	Mean	Std. Error
Conventional	30	56.73	2.946
PBL	30	64.23	2.538
PjBL	30	77.23	2.091

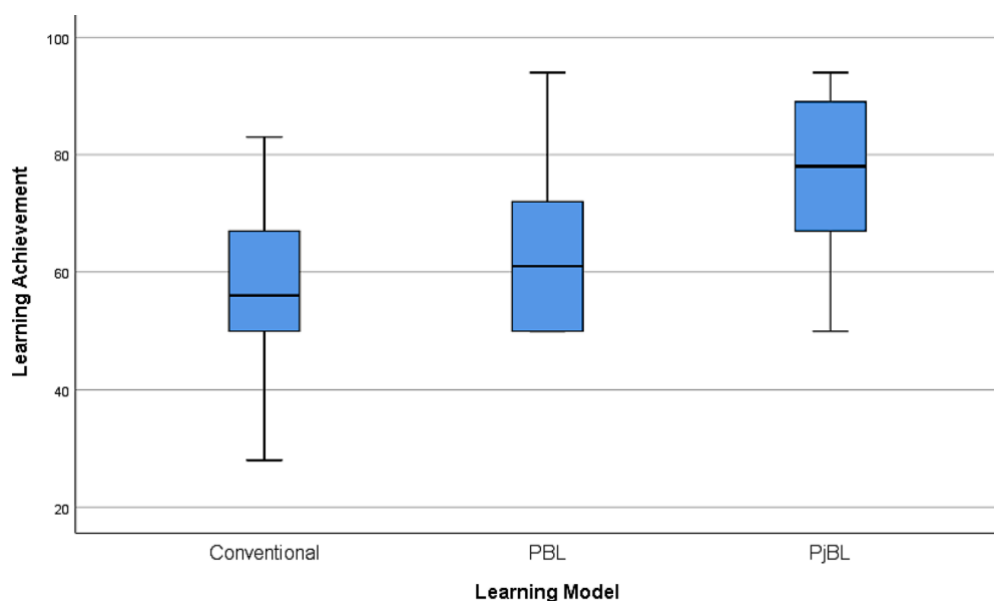


Figure 1. Learning achievement across the learning model

Table 3 and Figure 1 show that the PjBL group achieved the highest mean score (77.23) with the lowest variability (2.091), while the Conventional group recorded the lowest mean score (56.73) and the highest variability (2.946). These results suggest a wider distribution of scores in the conventional class, indicating a less consistent achievement level than the PjBL and PBL groups.

An assumption test was initially conducted using one-way ANOVA and regression analysis, which included evaluations of normality, homogeneity of variance, group balance, linearity, and covariate independence, in preparation for the one-way ANCOVA. These procedures are described in detail below. Table 4 presents the results of the normality and homogeneity tests, which show significance values (p -value) are greater than 0.050, indicating that the data satisfy the required assumptions. Therefore, it can be concluded that the learning achievement variable is normally distributed and exhibits homogeneity of variance across the learning model groups.

Table 4. Normality and Homogeneity of variance tests of learning achievements

Learning model	Normality	Homogeneity
Conventional	0.090	0.418
PBL	0.052	0.418
PjBL	0.050	0.418

In Table 5 the normality and homogeneity of variance of mathematics anxiety across the three learning model groups were examined. As seen the p -values are greater than 0.050 which indicate that the data for mathematics anxiety in the PBL, PjBL, and conventional groups meet the assumption of normal distribution as well as homogeneous variance across the groups.

Table 5. Normality and Homogeneity of variance of math anxiety

Learning model	Normality	Homogeneity
Conventional	0.125	0.401
PBL	0.200	0.401
PjBL	0.200	0.401

An initial ability balance test was conducted to ensure that the three class groups were in comparable conditions before further analysis. Before performing the balance test, the assumptions of normality and homogeneity of variance were examined. As displayed in Table 6, the normality test results for the initial ability variable showed significance values (p -value) greater than 0.050, indicating that the data are normally distributed. Meanwhile, the homogeneity test revealed that the variances were also homogeneous across the groups.

Table 6. Normality and Homogeneity of variance of initial ability

Learning model	Normality	Homogeneity
Conventional	0.200	0.161
PBL	0.200	0.161
PjBL	0.101	0.161

The balance test was then conducted using students' initial ability scores derived from their daily mathematics test results on the circle geometry sub-topic. The test yielded a significance value of 0.161 (see Table 7), which exceeds the standard threshold of 0.050. This result indicates that the initial ability levels of students across the three learning model groups are statistically

equivalent, thereby supporting the assumption of group equivalence and confirming that the sample population is balanced.

Table 7. Balance test on initial skill data

Variable	Significance (<i>p</i> -value)
Initial ability	0.161

Before conducting the linearity test, it is necessary to perform a residual analysis to ensure that the regression model satisfies the required assumptions. This includes testing the normality and homogeneity of residuals. As presented in [Table 8](#), the results show significance values greater than 0.050 for the normality and homogeneity tests, indicating that the residuals are normally distributed and exhibit homogeneity of variance.

Furthermore, the linearity test between mathematics anxiety and learning achievement produced a significance value 0.000, below the accepted threshold of 0.050. This result confirms a linear relationship between mathematics anxiety and students' learning achievement.

Table 8. Math anxiety and learning achievements test

Test	Significance (<i>p</i> -value)
Normality	0.200
Homogeneity	1.000
Linearity	0.000

Following the linearity test, the next step was to assess the independence of mathematics anxiety from the treatment variable, namely the learning model. As shown in [Table 9](#), the significance value exceeds the 0.050 threshold, indicating that the learning model does not have a statistically significant effect on students' mathematics anxiety. This result supports the assumption that mathematics anxiety is independent of the treatment, fulfilling one of the key requirements for conducting ANCOVA.

Table 9. One-way ANOVA

Variables	F	Significance (<i>p</i> -value)
Math anxiety	1.848	0.164

Table 10. One-way ANCOVA

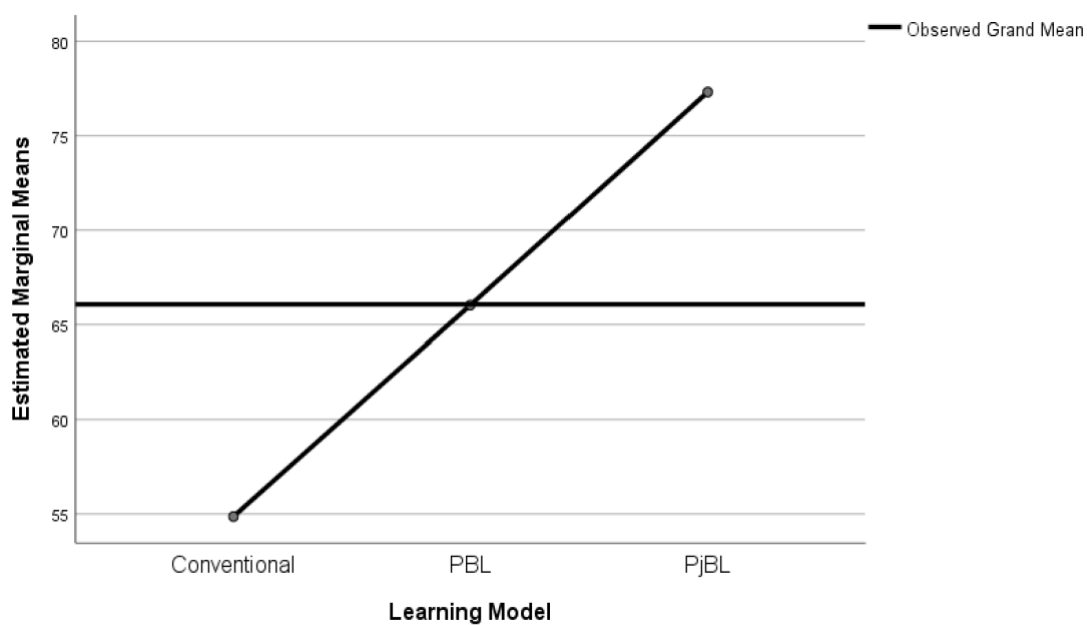
Source of variance	Significance (<i>p</i> -value)
Math anxiety	0.000
Learning model	0.000

[Table 10](#) shows that the three learning models are statistically different having adjusted for mathematics anxiety for each group as indicated by $p\text{-value} = 0.000 < 0.050$. This is further supported by the outcomes in [Table 11](#).

Table 11. Pairwise comparisons of the learning model

Model	Model	Mean difference	Significance (p-value)
Conventional	PBL	-7.500	0.040
	PjBL	-20.500	0.000
PBL	Conventional	7.500	0.040
	PjBL	-13.000	0.001
PjBL	Conventional	20.500	0.000
	PBL	13.000	0.001

Based on [Table 11](#), it can be concluded that there are statistically significant differences in learning achievement among the three learning models. Moreover, as seen in [Figure 2](#), the conventional learning model resulted in the lowest learning achievement, whereas the Project-Based Learning (PBL) model yielded the highest. The figure also shows that the estimated marginal mean for the conventional model falls below the overall grand mean. In contrast, the PjBL model is positioned above the grand mean, further confirming the superior effectiveness of the PjBL approach in enhancing student achievement.



Covariates appearing in the model are evaluated at the following values: Mathematics Anxiety = 88.58

Figure 2. Estimated marginal means of learning achievement

Discussion

PjBL model encourages students to experiment with their learning styles and collaborative skills, enabling them to construct new knowledge and gain meaningful, practical experience. Students must generate ideas, analyze information, gain insights, draw conclusions, and apply concepts to real-world problems throughout this learning process.

The first follow-up test results indicated that PjBL outperformed the Problem-Based Learning (PBL) model. This finding is supported by Ratri and Nurfalah (2023), who reported significant differences in mathematics achievement between PBL and PjBL classes, particularly on spatial structure topics related to prisms, as evidenced by average posttest scores.

In contrast, the conventional learning model, which typically involves one-way communication and positions the teacher as the central authority, tends to limit student engagement. Learning activities within this model are often perceived as preparatory rather than fostering immediate skill development. The second follow-up test revealed that PjBL produced significantly better outcomes than the conventional approach. This is consistent with findings from Rahayuningsih et al. (2022) who, at a 95% confidence level, confirmed that students taught using the PjBL model demonstrated superior mathematics learning achievement compared to those in conventional classrooms.

Meanwhile, the PBL model promotes critical thinking by encouraging students to collect and analyze information using various media and tools. This process strengthens their ability to solve problems related to cone-shaped spatial material, as students work through contextualized worksheets. Findings from the third follow-up test showed that PBL was more effective than the conventional model. This is further validated by a study conducted by Laksanawati and Rofiroh (2020) which found a statistically significant improvement in students' mathematical problem-solving skills using the PBL model, based on an independent samples t-test result ($p\text{-value} = 0.000 < 0.005$).

Among the three learning models examined, PjBL consistently yielded the highest learning outcomes in mathematics. This can be attributed to the model's emphasis on peer collaboration, where students assist and motivate one another, often acting as peer tutors. Such interaction enhances group success and fosters deeper understanding of the material. The PjBL approach also reduces students' fear and anxiety toward mathematics, as students become more confident in expressing their ideas and engaging actively in learning.

However, some challenges were observed during the implementation of PBL. A few students showed low interest, enthusiasm, and curiosity toward mathematics. During group discussions, certain students adopted passive roles, relying heavily on more dominant group members and participating only when prompted by the teacher. Despite these issues, most students could contribute actively, particularly while working on student worksheets. This helped them enhance their cognitive abilities, apply mathematical concepts related to cone geometry to real-life situations, and reduce their overall anxiety toward the subject.

Statistical analysis revealed that mathematics anxiety did not significantly differ across the three learning models, as indicated by the one-way ANOVA results. This suggests that the learning model employed does not influence students' mathematics anxiety level. However, a linear relationship was found between mathematics anxiety and mathematics achievement, indicating that higher levels of anxiety are associated with lower achievement. In the conventional learning group, many students appeared reluctant to participate, especially in activities such as solving problems on the board or asking questions. In contrast, anxiety levels were notably lower among students in the PjBL and PBL groups.

These findings are further supported by the linearity test, which produced a significance value of 0.000, confirming the presence of a strong linear relationship between the learning model, mathematics anxiety, and student achievement. This aligns with research that found that the PBL model fosters a more relaxed learning environment, reduces avoidance behaviors, and effectively alleviates mathematics anxiety.

Conclusion

PjBL is highly effective in enhancing students' mathematics achievement, particularly for those experiencing high levels of mathematics anxiety. Compared to PBL and conventional model, it provides greater opportunities for active student engagement through collaborative, real-world projects. This model fosters essential skills such as critical thinking, problem-solving, and knowledge application, while also helping students reduce anxiety and build confidence. Although PBL also supports anxiety reduction through structured inquiry and reflective learning, PjBL offers more substantial cognitive and affective advantages. Both models serve as effective instructional strategies for improving mathematics learning outcomes while addressing emotional challenges commonly faced by students. Additionally, PBL remains a valuable approach in managing mathematics anxiety by promoting active inquiry and engagement. In conclusion, PjBL and PBL present viable alternatives for educators seeking to enhance student performance and reduce anxiety in mathematics education.

Acknowledgment

My gratitude to everyone who has supported the implementation of this research. A special thanks to the school, teachers, and students for their active involvement in data collection and the execution of this research. I hope this research contributes to the advancement of knowledge. Further, Thanks to LPPM UNS for the research scheme PKGR-UNS A Grant Number 371/UN27.22/PT.01.03/2025.

References

- Ardianti, R., Sujarwanto, E. & Surahman, E. (2022). Problem-based learning: Apa dan bagaimana? *Diffraction*, 3(1), 27–35. <https://doi.org/10.37058/diffraction.v3i1.4416>
- Arends, R. I. (2012). *Learning to teach*. New York: McGraw-Hill Irwin.
- Ashcraft, M. H. (2002). Math anxiety: Personal, educational, and cognitive consequences. *Current Directions in Psychological Science*, 11(5), 181–185. <https://doi.org/10.1111/1467-8721.00196>
- Asrifa, N. D., Nurmala, M. D. & Prabowo, A. S. (2021). Hubungan dukungan orang tua dengan kecemasan pada mahasiswa Fakultas Keguruan dan Ilmu Pendidikan Universitas Sultan Ageng Tirtayasa angkatan 2017 yang sedang menyusun skripsi. *Jurnal Al-Shifa Bimbingan Konseling Islam*, 2(1), 39–51. <https://doi.org/10.32678/alshifa.v2i1.4696>
- Cavanagh, R. & Sparrow, L. (2010). Measuring mathematics anxiety: Paper 2—Constructing and validating the measure. In *AARE 2010 Conference Proceedings*. Australian Association for Research in Education.
- Chang, Y., Song, A. & Fang, R. (2018). Integrating ARCS model of motivation and PBL in flipped classroom: A case study on a programming language. *Eurasia Journal of Mathematics, Science and Technology Education*, 14(12), 1 – 15. <https://doi.org/10.29333/ejmste/97187>
- Daryanto & Mulyo, R. (2012). *Model pembelajaran inovatif*. Yogyakarta: Gava Media.
- Dewi, F. K. M. & Pujiastuti, H. (2020). Pengaruh tingkat kecemasan terhadap hasil belajar matematika siswa: Studi kasus pada siswa SMPN 2 Balaraja. *Suska Journal of Mathematics Education*, 6(2), 145–155. <https://doi.org/10.24014/sjme.v6i2.9440>
- Dewi, M. R. (2022). Kelebihan dan kekurangan project-based learning untuk penguatan profil pelajar Pancasila kurikulum merdeka. *Inovasi Kurikulum*, 19(2), 213–226. <https://doi.org/10.17509/jik.v19i2.44226>
- Djamarah, S. B. (2010). *Strategi belajar mengajar*. Jakarta: Rineka Cipta.
- Hamalik, O. (2014). *Proses belajar mengajar*. Jakarta: Bumi Aksara.
- Kutner, M. H., Nachtsheim, C.J., Neter, J. & Li, W. (Eds.). (2005). *Applied linear statistical models* (5th edition). New York: McGraw-Hill Irwin.

- Laela, K. (2021). Peningkatan hasil belajar peserta didik dengan menggunakan model pembelajaran project-based learning di kelas 2 SDN 2 Setu Kulon. *Pinisi: Journal of Teacher Professional*, 2(3), 404 – 412. <https://ojs.unm.ac.id/TPJ/article/view/26057>
- Laksanawati, E. K. & Rofiroh, R. (2020). Perbandingan metode problem-based learning dengan metode konvensional terhadap kemampuan pemecahan masalah dan self-efficacy matematis mahasiswa pada mata kuliah matematika teknik. *Jurnal Pendidikan Matematika (Jupitek)*, 3(2), 81–87. <https://doi.org/10.30598/jupitekvol3iss2pp81-87>
- Sholichah, F. M., & Aini, A. N. (2022). Math anxiety siswa: Level dan aspek kecemasan serta penyebabnya. *Journal of Mathematics Learning Innovation (JMLI)*, 1(2), 125–134. <https://doi.org/10.35905/jmlipare.v1i2.4374>
- Magdalena, M. (2018). Kesenjangan pendekatan model pembelajaran conventional dengan model pembelajaran kontekstual terhadap hasil belajar Pancasila di Program Studi Teknika Akademi Maritim Indonesia – Medan. *Jurnal Warta Dharmawangsa*, 58, 1 – 19. <https://jurnal.dharmawangsa.ac.id/index.php/juwarta/article/view/389>
- Maulidya, N. S., & Nugraheni, E. A. (2021). Analisis hasil belajar matematika peserta didik ditinjau dari self-confidence. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, 5(3), 2584–2593. <https://doi.org/10.31004/cendekia.v5i3.903>
- Montgomery, D. C. (2017). *Design and analysis of experiments* (9th edition). New York: John Wiley & Sons.
- Nababan, D., Marpaung, A. K., & Koresy, A. (2023). Strategi pembelajaran project-based learning (PjBL). *Jurnal Pendidikan Sosial dan Humaniora*, 2(2), 706–719. <https://publisherqu.com/index.php/pediaqu/article/view/178>
- Muharlisiani, L., Wisnujati, S., Purwati, T., Marzuki, K., Nasution, B. & Santosa, T. (2023). Systematic literature review and meta-analysis: the effectiveness of project-based learning in science learning. *Jurnal Penelitian Pendidikan IPA*, 9(12), 1385-1393. <https://doi.org/10.29303/jppipa.v9i12.5544>
- Nofiarida, N. (2023). Implementation of the project-based learning (pjbl) model as an attempt to improve the third-grade students' critical thinking skills at SDN 004 Rantau Kopar. *Primary: Jurnal Pendidikan Guru Sekolah Dasar*, 12(2), 534 – 541. <http://dx.doi.org/10.33578/jpkip.v12i2.9674>
- OECD. (2023). *PISA 2022 results (Volume I): The state of learning and equity in education*. <https://doi.org/10.1787/53f23881-en>
- Ordonez, B. (2014). Competency-based education: Changing the traditional college degree—Power, policy, and practice. *New Horizons in Adult Education and Human Resource Development*, 26(4), 47–53. <https://doi.org/10.1002/nha3.20085>
- Pila, A. (2023). Will artificial intelligence overcome teachers that just address content? *Concilium*, 23(14), 393–405. <https://doi.org/10.53660/clm-1590-23j20>
- Prasetyo, F., & Juandi, D. (2023). Systematic literature review identifikasi penerapan model pembelajaran terhadap kecemasan matematika siswa. *Elips: Jurnal Pendidikan Matematika*, 4(1), 28–47. <https://journal.unpacti.ac.id/ELIPS/article/view/779>
- Purnomo, A., Kanusta, M., Fitriyah, S. A., Guntur, M., Siregar, R. A., Ritongan, S. & Listantia, N. (Eds.). (2022). *Pengantar model pembelajaran*. Pringgarata, Lombok Tengah: Yayasan Hamjah Diha.
- Rahayuningsih, S., Nurasrawati, N. & Nurhusain, M. (2022). Komparasi efektivitas model pembelajaran project-based learning (PjBL) dan konvensional: Studi pada siswa menengah pertama. *Kognitif: Jurnal Riset HOTS Pendidikan Matematika*, 2(2), 118–129. <https://doi.org/10.51574/kognitif.v2i2.654>
- Ratri, I. R. & Nurfalah, E. (2023). Studi komparasi model problem-based learning (Pbl) dan project-based learning (Pjbl) terhadap hasil belajar matematika siswa kelas VIII SMP Negeri 4 Tuban tahun pelajaran 2022/2023. *Innovative: Journal Of Social Science Research*, 3(3), 10985–11001. <https://j-innovative.org/index.php/Innovative/article/view/3454>
- Sauter, T., Bintener, T., Kishk, A., Presta, L., Prohaska, T., Guignard, D., ... & Pacheco, M. (2022). Project-based learning course on metabolic network modelling in computational systems biology. *PLOS Computational Biology*, 18(1), e1009711. <https://doi.org/10.1371/journal.pcbi.1009711>
- Stuart, G. W. (2004). Behavioral, cognitive, and affective dimensions of math anxiety. *Journal of Educational Measurement*, 41(2), 123–138. <https://doi.org/10.1000/jem.v41i2.1234>
- Sudjana. (2017). *Penilaian hasil proses belajar mengajar*. Bandung: PT Remaja Rosdakarya.

- Suhaida, P. & Mardison, S. (2019). Pengaruh teman sebaya terhadap konsep diri siswa kelas VIII di MTsN Lembah Gumanti Kabupaten Solok. *Jurnal Al-Taujih*, 5(1), 25–36. <https://doi.org/10.15548/atj.v5i1.752>
- Supi, V., Tupen, S. N. & Seto, S. B. (2020). Pengaruh pembelajaran kooperatif tipe jigsaw terhadap hasil belajar matematika materi relasi dan fungsi. *JUPIKA: Jurnal Pendidikan Matematika*, 3(2), 131–140. <https://doi.org/10.37478/jupika.v3i2.679>
- Sutrisna, G. B. B., Sujana, I. W. & Ganing, N. N. (2020). Pengaruh model project-based learning berlandaskan Tri Hita Karana terhadap kompetensi pengetahuan IPS. *Jurnal Adat dan Budaya Indonesia*, 1(2), 84–93. <https://doi.org/10.23887/jabi.v2i2.28898>
- Jayantika, I. G. A. N. T., Parmithi, N. & Purwaningsih, D. N. D. (2020). Pengaruh model pembelajaran problem-based learning terhadap kecemasan dan hasil belajar matematika. *Jurnal Emasains: Jurnal Edukasi Matematika dan Sains*, IX(2), 276 – 287. <https://doi.org/10.5281/zenodo.4362651>