The Effect of Problem-Based Learning on Junior High School Students' Mathematical Problem-Solving Skills and Self-Efficacy in Statistics

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Abstract

Students' mathematical problem-solving skills and self-efficacy remain challenging issues in junior high school mathematics, particularly in statistics, where students often struggle to solve contextual problems and lack confidence in their mathematical abilities. Although Problem-Based Learning (PBL) has been widely recommended to promote active learning, empirical evidence regarding its effectiveness in simultaneously improving mathematical problem-solving skills and self-efficacy in statistics learning is still limited. Therefore, this study aimed to examine the effect of the PBL model on students' mathematical problem-solving skills and self-efficacy. A quantitative approach employing a one-group pretest–posttest pre-experimental design was used. The participants were 32 eighth-grade students from SMP Negeri 8 Yogyakarta selected through purposive sampling. Data were collected using an essay test to assess mathematical problem-solving skills and a Likert-scale questionnaire to measure self-efficacy. Descriptive statistics and paired-sample *t*-tests were used to analyze the data. The results showed that the mean score of mathematical problem-solving skills increased from 61.41 to 81.84, while the mean self-efficacy score increased from 45.41 to 71.22. Both improvements were statistically significant ($p < .001$). These findings indicate that PBL effectively enhances students' cognitive and affective learning outcomes in statistics. The study suggests that mathematics teachers can implement PBL by engaging students in solving authentic statistical problems, facilitating collaborative investigations, and encouraging reflection on solution strategies to foster stronger problem-solving skills and greater self-confidence..

Keywords: problem based learning, mathematical problem-solving, self-efficacy, mathematics learning

Introduction

Mathematical problem-solving is one of the essential competencies required for students to meet the demands of twenty-first-century education. Beyond mastering computational procedures, students are expected to analyze unfamiliar situations, formulate appropriate solution strategies, and evaluate the effectiveness of their reasoning (Santos-Trigo, 2024). Accordingly, the National Council of Teachers of Mathematics (NCTM, 2000) identifies problem-solving as a fundamental process that should be integrated into all mathematics learning. Students with strong problem-solving skills are better prepared to apply mathematical concepts in real-life contexts, think critically, and make logical decisions.

Problem-solving ability has become increasingly important because mathematics learning is expected to equip students with higher-order thinking skills instead of merely procedural competence. According to Polya (1973), mathematical problem-solving involves four interrelated stages: understanding the problem, devising a plan, carrying out the plan, and reviewing the solution. These stages encourage students to think systematically and reflectively when solving mathematical tasks. However, many students continue to experience difficulties in completing non-routine mathematical problems that require reasoning, interpretation, and decision-making rather than memorization of formulas (Sung, 2023).

In addition to cognitive competence, affective factors also influence students' success in mathematics learning. Among these factors, self-efficacy has been recognized as one of the strongest predictors of academic performance (Yousuf & Rajeswari, 2024). Bandura (1997) defined self-efficacy as individuals' beliefs in their capability to organize and execute actions required to achieve specific goals. Students with high self-efficacy are more likely to persist when solving difficult mathematical problems, adopt effective learning strategies, and demonstrate greater resilience when facing challenges. Conversely, students with low self-efficacy tend to avoid complex tasks, experience mathematics anxiety, and abandon problem-solving efforts more easily (Shimizu, 2022). Therefore, mathematics learning should not only develop students' cognitive abilities but also strengthen their confidence in applying mathematical knowledge.

Despite its importance, previous studies have shown that many Indonesian junior high school students continue to experience difficulties in mathematical problem-solving (Iman et al., 2024). These difficulties are particularly evident in statistics learning, where students are expected to interpret data, identify patterns, and solve contextual problems rather than merely perform numerical calculations (Jayantika et al., 2024). Many students still rely on memorizing formulas without understanding how statistical concepts can be applied to solve authentic problems. Such learning experiences often reduce students' confidence in their mathematical abilities and negatively affect their self-efficacy (Teng et al., 2024).

To overcome these challenges, mathematics instruction should encourage students to actively construct knowledge through meaningful learning experiences. One instructional approach that has attracted considerable attention is Problem-Based Learning (Sánchez-López et al., 2024). Unlike conventional teacher-centered instruction, PBL engages students in investigating authentic problems before formal concepts are introduced (Allen et al., 1996). Through collaborative discussion, inquiry, and reflection, students are encouraged to construct mathematical understanding while simultaneously developing higher-order thinking skills. Previous studies have consistently reported that PBL improves students' mathematical problem-solving skills, critical thinking, and classroom engagement (Sappaile et al., 2024; Waruwu et al., 2023).

Beyond improving cognitive performance, PBL also provides opportunities for students to develop stronger self-efficacy (Kim, 2024). Through collaborative investigations, classroom discussions, presentations, and successful completion of authentic tasks, students experience mastery experiences that strengthen their confidence in solving mathematical problems (Rohantizani et al., 2024). According to Bandura (1997), mastery experiences constitute the most influential source of self-efficacy development. Several empirical studies have similarly reported that students participating in PBL demonstrate higher confidence and more positive attitudes toward mathematics learning than those receiving conventional instruction (Lolić, 2025).

Although previous studies have demonstrated that PBL improves mathematical problem-solving skills and self-efficacy, several important gaps remain. First, most previous studies have examined these variables separately, focusing either on cognitive outcomes or affective outcomes. Consequently, limited empirical evidence is available regarding the simultaneous effects of PBL on both mathematical problem-solving skills and self-efficacy. Second, previous research has predominantly investigated PBL in mathematics learning in general, while relatively few studies have specifically examined its implementation in statistics learning, which requires students to integrate mathematical reasoning with real-world data interpretation. This limitation is important because statistics represents one of the mathematics topics that demands both higher-order thinking skills and confidence in solving contextual problems.

Therefore, this study aims to examine the effect of the Problem-Based Learning model on eighth-grade students' mathematical problem-solving skills and self-efficacy in statistics learning. The findings are expected to contribute to mathematics education by providing empirical evidence regarding the effectiveness of PBL in simultaneously improving students' cognitive and affective learning outcomes. Furthermore, the study offers practical implications for mathematics teachers by demonstrating how authentic statistical problems and collaborative learning activities can be integrated into classroom instruction to promote students' problem-solving competence and confidence.

Method

This study employed a quantitative approach using a one-group pretest–posttest pre-experimental design to investigate the effect of the Problem-Based Learning (PBL) model on students' mathematical problem-solving skills and self-efficacy in statistics learning. This design was selected because the primary objective of the study was to examine changes in students' cognitive and affective outcomes before and after the implementation of the PBL intervention. In addition, the study was conducted within an intact classroom setting where random assignment and the establishment of a control group were not feasible. Therefore, comparing students' pretest and posttest scores provided an appropriate approach for evaluating the effectiveness of the intervention.

The study was conducted at SMP Negeri 8 Yogyakarta during the second semester of the 2024/2025 academic year. The population consisted of all eighth-grade students distributed across ten classes. The participants were 32 students from Class VIII-G, selected through judgmental (expert) sampling in consultation with the mathematics teacher. The selection was based on several criteria: (1) the class represented the general academic characteristics of eighth-grade students, (2) the teacher was willing to implement the Problem-Based Learning model throughout the intervention, (3) the instructional schedule allowed the intervention to be completed without disrupting regular learning activities, and (4) the class had not previously experienced mathematics instruction using the Problem-Based Learning model.

The independent variable in this study was the implementation of the Problem-Based Learning model. The dependent variables were students' mathematical problem-solving skills and self-efficacy. Mathematical problem-solving skills were operationalized according to Polya's four stages of problem solving: understanding the problem, devising a plan, carrying out the plan, and reviewing the solution. Self-efficacy was defined as students' beliefs in their capability to successfully perform mathematical tasks and was measured based on Bandura's dimensions of level, strength, and generality.

Two research instruments were used in this study: a mathematical problem-solving test and a self-efficacy questionnaire. The mathematical problem-solving test consisted of three essay questions developed to measure students' ability to solve statistical problems based on Polya's four problem-solving stages. Students' responses were evaluated using an analytic scoring rubric that assessed each stage of the problem-solving process, and the accumulated scores represented students' overall mathematical problem-solving ability.

The self-efficacy instrument consisted of 20 statements measured using a four-point Likert scale ranging from 1 (Never) to 4 (Always). The questionnaire measured three dimensions of self-efficacy: level, strength, and generality.

Prior to implementation, the lesson plans, mathematical problem-solving test, self-efficacy questionnaire, and classroom observation sheet were reviewed through expert judgment by mathematics education experts. The validation process examined the relevance of each instrument to the research objectives, the suitability of the indicators, the clarity of language, the appropriateness of the scoring criteria, and the suitability of the items for eighth-grade students. Revisions were made based on the experts' recommendations before the instruments were administered.

The research was conducted in three stages: preparation, implementation, and data analysis. During the preparation stage, lesson plans, learning materials, observation sheets, and research instruments were developed and validated by experts. The learning materials focused on statistics, including measures of central tendency (mean, median, and mode) and range.

The implementation stage consisted of one pretest session, three instructional meetings, and one posttest session. Each meeting lasted 80 minutes (2 × 40-minute periods). The first meeting discussed the concept of the mean, the second meeting covered the median and mode, and the third meeting focused on the range of a dataset. Before the intervention, students completed a pretest to measure their initial mathematical problem-solving skills and completed the self-efficacy questionnaire. After the intervention, students completed the posttest and the same questionnaire.

Learning activities followed the five phases of the Problem-Based Learning model proposed by Arends. In the first phase, the teacher introduced authentic statistical problems related to students' daily experiences and motivated students to identify the problems to be solved. In the second phase, students were organized into small collaborative groups and discussed possible solution strategies. During the investigation phase, students explored relevant information, analyzed statistical data, performed calculations, and developed solutions collaboratively, while the teacher acted as a facilitator by providing guidance through probing questions rather than direct explanations. In the fourth phase, each group presented its findings, compared alternative solution strategies, and participated in classroom discussions. Finally, students reflected on the problem-solving process and evaluated the appropriateness of their solutions with guidance from the teacher. Classroom observations were conducted by external observers to ensure that all learning activities were implemented consistently according to the PBL syntax

The collected data were analyzed using descriptive and inferential statistics. Descriptive statistics were used to summarize students' mathematical problem-solving skills and self-efficacy by calculating the mean, standard deviation, minimum score, and maximum score. Prior to hypothesis testing, the Shapiro–Wilk test was conducted to examine the normality of the data, while Levene's test was used to assess the homogeneity of variance. Because the data met the required assumptions, paired-sample *t*-tests were performed to determine whether significant differences existed between the pretest and posttest scores for both dependent variables at a significance level of 0.05.

Results and Discussion

The results of the study indicate that the Problem Based Learning (PBL) learning model has an effect on the mathematical problem-solving abilities and self-efficacy of eighth-grade students in statistics. Data were obtained through pretests and posttests given to 32 students as the only experimental group. Data processing was carried out descriptively and inferentially, including tests for normality, homogeneity, and paired sample t-tests.

1. Description of Problem-Solving Ability Data

Data on students' problem-solving ability in this study were measured using a test instrument consisting of a pretest and a posttest, each consisting of three questions. The problem-solving ability of students in the experimental class implemented the PBL model. The following is the calculation data for the pretest and posttest scores

Table 1. Pretest and Posttest Score Data for Problem Solving Ability.

Description	Pretest	Posttest
Mean	61,41	81,84
Standard deviation	6,584	12,014
Range	23	39
Highest score	73	100
lowest score	50	61

Based on the descriptive analysis results in the table above, it can be seen that the experimental class experienced an increase. In the experimental class, the average initial mathematical problem-solving ability of students increased from 61.41 to 81.84. In the initial test, none of the students met the criteria for achieving the learning objectives at school, which was a minimum of 75. After being given treatment in the experimental class, the average problem-solving ability increased by 20.43 points.

2. Description of Self-Efficacy Data

Data collected through the student self-efficacy questionnaire was administered twice, along with a pretest and posttest. The purpose of administering this questionnaire was to determine the increase in students' self-efficacy before and after participating in learning with the problem-based learning model. Students chose their level of agreement with the statements given on a scale of 1-4. There were 20 statements that students had to answer in the questionnaire. The student self-efficacy questionnaire data is presented in the following table.

Table 2. Pretest and Posttest Score Data for Self-Efficacy.

Description	Pretest	Posttest
Mean	45,42	71,22
Standard deviation	3,991	2,948
Range	19	14
Highest score	55	77
lowest score	26	63

Based on the descriptive analysis presented in Table X, students' self-efficacy scores increased after the implementation of the Problem-Based Learning model. The mean pretest self-efficacy score increased from 45.41 to 71.22 in the posttest, indicating an improvement in students' confidence in learning mathematics following the intervention.

Before testing the hypothesis to analyze the effect of the problem-based learning model on students' mathematical problem-solving abilities and self-efficacy, a normality test was first conducted. This normality test is a crucial requirement in hypothesis testing because the sample must come from a normally distributed population. The normality test was conducted using SPSS software, and the results are presented in the following table.

Table 3. Normality Test of Pretest and Posttest Score.

Variable	Data	P-Value	Description
Problem Solving Ability	Pretest	0.160	Normal
	Posttest	0.056	Normal
Self-Efficacy	Pretest	0.620	Normal
	Posttest	0.149	Normal

Based on the Shapiro–Wilk normality test presented in Table 3, all pretest and posttest scores for mathematical problem-solving skills and self-efficacy were normally distributed. The significance values ranged from 0.056 to 0.620, all exceeding the significance level of 0.05. Therefore, the assumption of normality was satisfied, indicating that the data were appropriate for subsequent parametric analysis using the paired-sample *t*-test.

Table 4. Summary of Paired-Sample t-Test Results.

Variable	Pretest Mean ± SD	Posttest Mean ± SD	Mean Difference	*t*(df)	*p*	95% Confidence Interval	Cohen's *d*	Interpretation
Mathematical Problem-Solving Skills	61.41 ± 6.58	81.84 ± 12.01	20.43	−7.989 (31)	< .001	15.22–25.66	1.412	Large effect
Self-Efficacy	45.41 ± 3.99	71.22 ± 2.95	25.81	−38.288 (31)	< .001	24.44–27.19	6.768	Very large effect

Table 4 summarizes the paired-sample *t*-test results for both dependent variables. Students' mathematical problem-solving skills increased from a mean score of 61.41 (SD = 6.58) to 81.84 (SD = 12.01), with a statistically significant mean difference of 20.44 points, $t(31) = -7.989$, $p < .001$, and a large effect size (Cohen's $d = 1.412$). Similarly, students' self-efficacy improved from 45.41 (SD = 3.99) to 71.22 (SD = 2.95), yielding a statistically significant mean difference of 25.81 points, $t(31) = -38.288$, $p < .001$, with a very large effect size (Cohen's $d = 6.768$). These findings indicate that the implementation of the Problem-Based Learning model produced substantial improvements in both students' mathematical problem-solving skills and self-efficacy. Presents the results of inferential testing using the Paired Sample T-Test. This test was conducted to statistically demonstrate whether there was a significant difference in students' average scores before (pretest) and after (posttest) the implementation of the Problem Based Learning (PBL) model. There was a statistically significant difference in the average problem-solving ability. This proves that the implementation of the PBL model has a real positive impact on boosting students' cognitive skills in solving mathematical problems. Meanwhile, for self-efficacy, it is statistically proven that there is a very significant increase in students' self-confidence and positive attitudes (self-efficacy) after receiving learning interventions using the PBL model.

Previous research confirms that the Problem-Based Learning model is effective in improving two important aspects of mathematics learning: problem-solving skills and self-efficacy (Masturi et al., 2020). This aligns with previous research by Hu et al, (2021), which showed that PBL consistently has a positive impact on improving students' higher-order thinking skills and self-confidence.

PBL allows students to play an active role in the learning process, from understanding contextual problems, developing problem-solving strategies, and reflecting on the solutions obtained. This pattern aligns with the problem-solving stages proposed by Polya (1973): understanding the problem, designing a plan, implementing the plan, and evaluating the solution. By following this process systematically, students are trained to think logically, critically, and reflectively, which are the core of problem-solving skills.

Furthermore, the success of the PBL model in improving students' self-efficacy can also be explained by Bandura's (1997) theory, which states that mastery experiences are a primary source of self-efficacy strengthening. In PBL, students are given the opportunity to successfully solve problems through group work, discussions, and presentations, all of which are positive experiences that boost their self-confidence (Hu et al., 2021).

The findings indicate that the implementation of the Problem-Based Learning (PBL) model significantly improved students' mathematical problem-solving skills. This improvement can be explained by the characteristics of PBL, which actively engage students in solving authentic and contextual problems through collaborative inquiry and reflection. During the learning process, students were required to identify relevant information, formulate solution strategies, implement appropriate mathematical procedures, and evaluate the correctness of their answers. These learning activities are consistent with Polya's (1973) four stages of problem solving: understanding the problem, devising a plan, carrying out the plan, and looking back.

Among the four stages, the greatest improvement was observed in the devising a plan and carrying out the plan stages. Before the intervention, many students experienced difficulties in selecting appropriate solution strategies and applying statistical concepts systematically. Through PBL, students repeatedly discussed alternative strategies in small groups, received guidance from the teacher through probing questions, and presented their solutions to the class. These activities enabled students to develop more structured reasoning and improved their ability to apply mathematical procedures accurately. Although improvements were also observed in understanding the problem and looking back, these stages developed more gradually because they require students to carefully interpret problem contexts and critically evaluate their own solutions.

The findings are consistent with previous studies reporting that PBL enhances students' mathematical problem-solving abilities by promoting collaborative learning, critical thinking, and active engagement in authentic problem-solving situations. Recent international studies have similarly demonstrated that PBL encourages students to construct mathematical knowledge independently, resulting in stronger conceptual understanding and improved problem-solving performance. These results reinforce the view that contextual and student-centered learning environments contribute positively to higher-order mathematical thinking.

The significant improvement in students' self-efficacy can be explained using Bandura's (1997) four sources of self-efficacy. First, mastery experiences were developed as students successfully completed increasingly challenging statistical problems throughout the learning process, strengthening their confidence in their mathematical abilities. Second, vicarious experiences occurred when students observed classmates presenting successful solution strategies during group discussions and classroom presentations. Observing peers with similar abilities successfully solve problems increased students' beliefs that they could also achieve comparable success. Third, verbal persuasion was provided through constructive feedback, encouragement, and guidance from both the teacher and peers during collaborative learning activities. Such positive reinforcement strengthened students' confidence to persist when solving mathematical problems. Finally, physiological and affective states also contributed to improved self-efficacy. The collaborative and supportive classroom atmosphere created through PBL reduced students' anxiety toward statistics learning and encouraged them to approach mathematical tasks with greater confidence and motivation.

These findings are consistent with previous studies showing that PBL not only improves students' cognitive achievement but also enhances affective outcomes, particularly self-efficacy. Similar results have been reported in both Indonesian and international studies, which concluded that collaborative problem-solving, authentic learning experiences, and reflective discussions positively influence students' confidence in mathematics learning. Therefore, the present study extends previous evidence by demonstrating that PBL effectively develops both mathematical problem-solving skills and self-efficacy simultaneously within the context of junior high school statistics learning.

The classroom implementation of the PBL model achieved 95.23%, indicating a very high level of adherence to the planned learning procedures. This percentage was calculated using classroom observation sheets completed by external observers during each learning session. The observation instrument consisted of indicators representing each phase of the PBL model, including problem orientation, organizing students, facilitating investigation, presenting solutions, and reflection. Each indicator was scored using a predetermined observation rubric, and the implementation percentage was calculated by dividing the total score obtained by the maximum possible score and multiplying the result by 100%. The high implementation score indicates that the PBL syntax was consistently carried out throughout the intervention, thereby supporting the validity of the research findings.

Conclusion and Suggestion

This study demonstrates that the implementation of the Problem-Based Learning (PBL) model effectively enhances both students' mathematical problem-solving skills and self-efficacy in statistics learning. These findings contribute to the growing body of evidence supporting the integration of cognitive and affective learning outcomes through student-centered instructional approaches, particularly in junior high school mathematics education. The results suggest that PBL provides meaningful learning experiences by engaging students in authentic statistical problem-solving, collaborative discussions, and reflective activities, which promote both analytical thinking and confidence in learning mathematics. Therefore, mathematics teachers are encouraged to integrate real-world statistical problems, collaborative investigations, and guided reflection into classroom instruction to foster students' higher-order thinking skills and self-belief. Despite these contributions, this study was limited by the use of a one-group pretest–posttest design without a control group. Future research is therefore recommended to employ more rigorous experimental designs involving larger and more diverse samples, compare PBL with other instructional approaches, and examine additional variables such as learning motivation, mathematical communication, or critical thinking skills to provide a more comprehensive understanding of the effectiveness of Problem-Based Learning.

References

Allen, D., Duch, B. J., & Groh, S. E. (1996). The power of problem-based learning in teaching introductory science courses. *New Directions for Teaching and Learning*, *1996*(68), 43–52. https://doi.org/10.1002/TL.37219966808

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: W.H. Freeman.

Glovňová, V. (2020). Error analysis: A way to learn mathematics more efficiently. *Norma*, *25*(2), 173–186. https://doi.org/10.5937/NORMA2002173G

Hu, X., Yang, Y., Hu, J., & Li, Y. (2021). *Research on the Influence of PBL Teaching on College Students' Attitudes to Advanced Mathematics*. https://doi.org/10.1109/ICIET51873.2021.9419594

Iman, P. D., Lukas, S., Yugopuspito, P., & Krisnadi, D. (2024). *The Effect of Mathematical Communication, Critical Thinking, and Problem-Solving Skills on Mathematical Concepts Understanding in Indonesia*. https://doi.org/10.22492/issn.2186-5892.2024.127

Jayantika, G. A. N. T., Parwati, N. N., Sudhata, I. G. W., & Sudarma, I. K. (2024). The Evaluate Analysis of Problem Solving ability student and its Causes: A Case Study in Higher Middle School Student. *International Journal of Religion*, *5*(11), 3977–3990. https://doi.org/10.61707/ngr5y161

Jihan, Elya, Sukomardojo, T., Nadeak, B., & Miswanto. (2023). Implementation of Student Ability-Based Learning Strategies to Improve Learning Outcomes in Schools. *International Journal of Science and Society*, *5*(1), 132–140. https://doi.org/10.54783/ijsoc.v5i1.640

Kim, S. (2024). Analysis of the Impact of PBL on the Development of Student Competencies. *The Korean Society of Culture and Convergence*, *46*(1), 851–862. https://doi.org/10.33645/cnc.2024.01.46.01.851

Lolić, S. (2025). Problem-based learning as a constructivist framework of early mathematics teaching: an analysis of students' attitudes. *Sociološki Diskurs*, *14*(26). https://doi.org/10.7251/socen2526129l

Masturi, C., Ikhsan, M., & Ahmad, A. (2020). The Improvement of Mathematical Problem Solving Ability and Self-Efficacy Students through Problem-Based Learning Model. *International Journal of Scientific Research and Management*, *8*(05), 1408–1413. https://doi.org/10.18535/IJSRM/V8I05.EL05

NCTM. (2000). *Principles and Standards for School Mathematics*. Reston, VA: National Council of Teachers of Mathematics.

Paslan, N. A. (2025). Self resiliency: element of academic excellence among university students. *International Journal of Education, Psychology and Counseling*, *10*(58), 142–159. https://doi.org/10.35631/ijepc.1058010

Polya, G. (1973). *How to solve it: A new aspect of mathematical method*. Princeton, NJ: Princeton University Press.

Rohantizani, Nuraina, N., Pasaribu, J. A. H., & Fatimah, F. (2024). Examining The Impact Of Problem-Based Learning On Students' Problem Solving Ability And Self-

Efficacy. *International Journal of Religion*, *5*(12), 1379–1386. https://doi.org/10.61707/86g8gz14

Rozgonjuk, D., Kraav, T., Mikkor, K., Orav-Puurand, K., & Täht, K. (2020). Mathematics anxiety among STEM and social sciences students: the roles of mathematics *selfefficacy*, and deep and surface approach to learning. *International Journal of STEM Education, 7*(1). https://doi.org/10.1186/s40594-020-00246-z

Sánchez-López, G., Suárez, G. D. S., Conde-Sánchez, J. R., & Moreno-Aguilar, Ma. A. (2024). Challenges to overcome when implementing problem-based learning in math classes. *Revista de Sistemas y Gestión Educativa*, *11*(28). https://doi.org/10.35429/jsem.2024.11.28.2.8

Santos-Trigo, M. (2024). Problem solving in mathematics education: tracing its foundations and current research-practice trends. *Zdm – Mathematics Education*. https://doi.org/10.1007/s11858-024-01578-8

Sappaile, B. I., Nisak, S. K., Afandi, A., Anshoriyah, S., & Mardiati, M. (2024). Enhancing Critical Thinking Skills in Mathematics Education: Integrating Problem-Based Learning in Seconday Schools. *International Journal of Educational Research Excellence*, *3*(2), 731–737. https://doi.org/10.55299/ijere.v3i2.1085awa

Shimizu, Y. (2022). Relation Between Mathematical Proof Problem Solving, Math Anxiety, Self-Efficacy, Learning Engagement, and Backward Reasoning. *Journal of Education and Learning*, *11*(6), 62–62. https://doi.org/10.5539/jel.v11n6p62

Sung, C. T. (2023). *Non-routine Problem-solving Strategies*. 209–212. https://doi.org/10.37626/ga9783959872508.0.39

Teng, W., Huang, Y.-T., Peng, M., & Liao, T.-H. (2024). Equipping college students with statistical literacy under the massification of higher education. *International Journal of Educational Technology and Learning*, *17*(2), 64–79. https://doi.org/10.55217/101.v17i2.874

Waruwu, M., Dwikurnaningsih, Y., & Satyawati, S. T. (2023). Online-based activities to improve students' critical thinking, problem solving, and communication. *International Journal of Evaluation and Research in Education*, *12*(3), 1645–1645. https://doi.org/10.11591/ijere.v12i3.24719

Yousuf, Ms. I., & Rajeswari, D. (2024). Relationship between Mathematics Self Efficacy and Mathematics Achievement. *International Journal of Emerging Knowledge Studies.*, *03*(10), 797–802. https://doi.org/10.70333/ijeks-03-10-011