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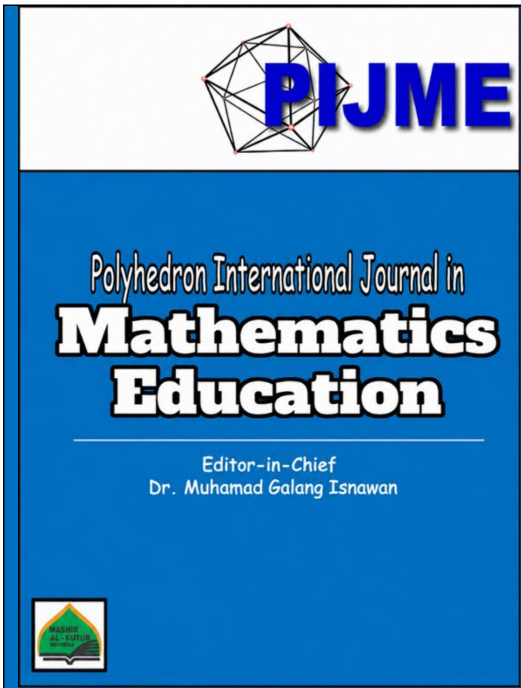

Bridging cognitive outcomes and mathematical self-confidence: a randomized comparative study on problem-solving pedagogy

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Original Article

Bridging cognitive outcomes and mathematical self-confidence: a randomized comparative study on problem-solving pedagogy

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Abstract
This study was motivated by the low mathematics learning outcomes and self-confidence of eleventh grade students. Most students have not reached the minimum completion limit of 75. In addition, the learning process is still teacher-centered so that students tend to feel bored, lack focus, and lack confidence in solving mathematical problems. This study aims to determine the effect of the Problem-Solving learning model on self-confidence and mathematics learning outcomes. The design of this study is a static group comparison design. Participants were selected using a random sampling technique, with class XI F2 as the control class and class XI F3 as the experimental class. The research instruments used were a self-confidence questionnaire and a mathematics learning outcome test. Data were analyzed using a t-test with the help of SPSS software at a significance level of 0.05. The results showed that the Problem-Solving learning model had a significant effect on students' self-confidence, as indicated by a significance value of 0.004 <0.05. In addition, the Problem-Solving learning model also had a significant effect on students' mathematics learning outcomes with a significance value of 0.015 <0.05. Thus, it can be concluded that the application of the Problem-Solving learning model is able to improve self-confidence and mathematics learning outcomes. As a recommendation, the Problem-Solving learning approach is suggested as one of the strategic choices in mathematics education to increase students' self-confidence and learning achievements, and can be considered for application to various materials and different levels of education.

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1. Introduction

In contemporary mathematics education, developing students' cognitive competencies and affective dispositions has become a global priority in response to the demands of 21st-century learning (Boadu & Boateng, 2024). Large-scale international assessments such as PISA consistently report that many students in developing countries continue to experience difficulties in mathematical problem-solving, critical reasoning, and conceptual understanding. At the same time, math anxiety and low self-efficacy remain major challenges that negatively impact student engagement and achievement in mathematics classes (Amry & Syahputra, 2020; Sudirman et al., 2026). Research has shown that students with low self-efficacy in their mathematics abilities are more likely to avoid challenging tasks, experience anxiety when solving problems, and demonstrate weak persistence in learning situations (Bendol & Jr, 2025). Furthermore, Ozkal (2019) explains that low mathematics self-efficacy significantly contributes to students' avoidance behavior and poor mathematics engagement.

From a social cognitive theory perspective, mathematics self-efficacy can be understood through the concept of self-efficacy, which is students' belief in their ability to organize and perform the actions necessary to successfully complete mathematics tasks (Parsons et al., 2011). Students with high mathematics self-efficacy tend to exhibit greater persistence, stronger motivation, and better problem-solving performance compared to students with low self-efficacy. Previous studies have shown that self-efficacy significantly contributes to students' mathematics achievement, engagement, and problem-solving abilities (Shimizu, 2022). In addition, Clemente & Ypon (2024) found that interventions targeting mathematics self-efficacy positively influenced students' learning achievement and class participation. Furthermore, mathematics self-efficacy is strongly associated with students' willingness to communicate ideas, actively participate in discussions, and apply various solution strategies when facing complex problems.

In mathematics education research, problem-solving ability is recognized as one of the core competencies that students must master to adapt to complex real-world situations. According to George Pólya, mathematical problem-solving involves four important stages: understanding the problem, designing a plan, implementing the plan, and reviewing the solution (Larenio & Futalan, 2025). Similarly, Tachie (2019) argues that successful mathematical problem-solving relies not only on cognitive knowledge but also on affective factors such as beliefs, self-confidence, and self-regulation. The socio-constructivist perspective further explains that knowledge is actively constructed through social interactions, discussions, and collaborative meaning-making (Kharroubi & Mediouni, 2024). Through active participation in problem-solving activities, students gradually develop confidence in their mathematical thinking because they are given the opportunity to test ideas, justify arguments, and reflect on their learning process. Therefore, problem-solving learning is highly relevant to improving students' mathematical affective and cognitive outcomes.

The growing international emphasis on problem-solving pedagogy is also in line with curriculum reforms implemented in many countries, including Indonesia through the Independent Curriculum (Kurikulum Merdeka). This curriculum emphasizes competency-based learning, student autonomy, critical thinking, creativity, and authentic assessment. Unlike traditional content-oriented curricula, the independent curriculum encourages teachers to design contextual and student-centered learning experiences that enable students to actively construct knowledge through inquiry and problem-solving activities. Learning achievement in this curriculum is measured through the learning objective achievement criteria, which assess students' holistic mastery of competencies, including conceptual understanding, reasoning, and attitudes toward learning. Therefore, the implementation of innovative learning models that promote mathematical competence and affective development is becoming increasingly important in the context of contemporary mathematics education in Indonesia. Supporting this imperative, Isnawan et al. (2024) demonstrated that designing contextual instructional materials responsive to students' learning obstacles can significantly reduce barriers in mathematical understanding, underscoring the need for innovative pedagogical approaches in Indonesian mathematics classrooms. Hendriana et al. (2018) reported that students with low self-efficacy tend to experience greater difficulty in applying mathematical problem-solving strategies. Similarly, Zhou et al., (2020) found that mathematical self-efficacy and emotional engagement significantly influenced students' problem-solving performance.

Observations conducted on September 18–19, 2025, at SMA Negeri 1 Candung revealed similar conditions. Mathematics learning was still dominated by the teacher, with students tending to listen passively and complete assignments without active discussion or exploration. Students appeared hesitant to express their opinions, lacked confidence when solving problems in front of the class, and demonstrated low participation during mathematics lessons. This observation aligns with Korkor and Bonyah (2024), who reported that students' lack of comprehension of mathematical concepts directly led to their inability to translate and solve word problems, indicating a close link between conceptual understanding, confidence, and problem-solving performance. Results of an initial self-confidence questionnaire administered to eleventh-grade students further indicated that students' mathematics self-confidence remained at a moderate level and had not yet developed optimally. Furthermore, students' mathematics learning outcomes remained relatively low, as many students had not yet achieved the school's minimum competency criteria. Interviews with mathematics teachers revealed that students often lacked confidence when faced with non-routine mathematics problems and tended to avoid active participation in class discussions.

One learning approach considered capable of addressing this issue is the problem-solving learning model. Problem-solving pedagogy emphasizes students' active involvement in identifying problems, analyzing information, designing solution strategies, implementing solutions, and evaluating results. This model is theoretically based on constructivist and socio-cognitive learning theories because it positions students as active builders of knowledge while fostering self-confidence through meaningful learning experiences. Dermawan et al. (2020) stated that the problem-solving learning model enables students to independently analyze and solve mathematical problems. Furthermore, Naz & Qayyum (2025) showed that problem-solving-based learning significantly improves students' mathematical reasoning and critical thinking skills. Furthermore, Pourdavood et al. (2020) found that students engaged in independent problem-solving activities tend to develop higher levels of self-confidence because they are encouraged to formulate and defend their own mathematical solutions.

Some studies focus exclusively on mathematics achievement or problem-solving abilities, while others primarily investigate self-confidence or self-efficacy. Consequently, limited research has explored how problem-solving pedagogy simultaneously impacts students' cognitive achievement and affective development within an integrated framework. This gap is theoretically important because contemporary mathematics education increasingly recognizes that academic success is inseparable from students' beliefs, emotions, and self-confidence in learning mathematics. Interventions that only improve cognitive performance without strengthening students' affective dispositions may not produce sustainable learning outcomes.

Therefore, the novelty of this study lies in its integrated examination of mathematics self-confidence and learning outcomes within a single problem-solving learning framework. Unlike previous studies that treated the cognitive and affective domains separately, this study positions both domains as mutually reinforcing dimensions of mathematics learning — where improvements in self-confidence and cognitive achievement are understood as interdependent outcomes of the same instructional intervention. This integrative perspective is consistent with recent quasi-experimental evidence demonstrating that constructivist instructional models simultaneously improve both students' cognitive performance and affective dispositions in mathematics — with the two domains reinforcing each other throughout the learning process (Mustikaningsih et al., 2025).

Accordingly, this study aims to examine the magnitude and significance of the effect of the Problem-Solving learning model on students' mathematical self-confidence and mathematics learning outcomes among eleventh-grade students at SMA Negeri 1 Candung. Specifically, the study addresses the following research questions:

1) To what extent does the Problem-Solving learning model significantly affect students' mathematical self-confidence compared to conventional instruction, and how large is the practical effect of this intervention?
2) To what extent does the Problem-Solving learning model significantly affect students' mathematics learning outcomes compared to conventional instruction, and how meaningful is the educational impact of this intervention?

2. Method

2.1 Research Design

This study employed a quantitative approach using a quasi-experimental method with a Randomized Control Group Only Design in the form of The Static Group Comparison Design. The study aimed to investigate the role of the Problem-Solving learning model in enhancing students' mathematical self-confidence and mathematics learning outcomes among eleventh-grade students at SMA Negeri 1 Candung, Indonesia during the 2025/2026 academic year.

The research involved two groups, namely an experimental group and a control group. The experimental class received instruction through the Problem-Solving learning model, whereas the control class was taught using conventional teacher-centered instruction. At the end of the intervention, both groups were administered a mathematics achievement test and a self-confidence questionnaire to evaluate the effect of the treatment.

The selection of The Static Group Comparison Design without a pre-test was based on methodological considerations. The absence of a pre-test was intended to minimize testing effects, instrument sensitization, and practice bias that could influence students' responses during post-test measurement. Previous methodological studies have suggested that repeated exposure to similar mathematical tasks before treatment may increase students' familiarity with problem structures and consequently threaten the authenticity of experimental outcomes. In addition, the implementation of a pre-test on self-confidence was considered potentially problematic because students' awareness of being assessed psychologically could alter their affective responses during the treatment process. Therefore, the post-test-only design was considered more appropriate for capturing the natural effect of the instructional intervention.

Nevertheless, the researchers acknowledge that the use of a static group comparison design may weaken internal validity because the study does not directly measure participants' baseline conditions through pre-testing. To address this limitation, several statistical controls were implemented prior to sample selection, including tests of normality, homogeneity, and equality of means among the population groups. These procedures were intended to ensure that the selected classes had relatively equivalent academic characteristics before the intervention was conducted. Despite these efforts, the findings of this study should still be interpreted cautiously because the possibility of uncontrolled external variables cannot be entirely eliminated. To provide a clearer picture of the stages of research implementation, the research procedures are presented in the following flowchart.

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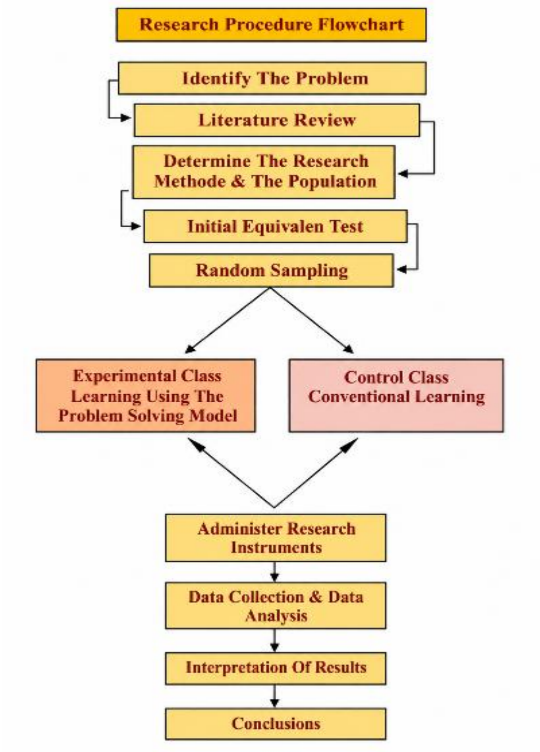
Figure 1
Research Procedure Flowchart



2.2 Population and Sample

The population of this study consisted of all eleventh-grade students at SMA Negeri 1 Candung during the 2025/2026 academic year. The population comprised three classes: XI F1 with 30 students, XI F2 with 30 students, and XI F3 with 23 students, resulting in a total population of 83 students. The sampling technique used in this study was random sampling, meaning that each class had an equal opportunity to be selected as the research sample. Prior to sample selection, baseline equivalence analysis was conducted to ensure that the population groups possessed comparable characteristics in terms of mathematics ability. The analysis included normality testing using the Shapiro–Wilk test, homogeneity testing using Levene's test, and equality of means testing using one-way ANOVA.

Table 1
Baseline Equivalence Test of Population Academic Ability

Class	N	Mean Score	SD	Normality Sig.
XI F1	30	73.40	8.21	0.121
XI F2	30	72.87	7.95	0.200
XI F3	23	71.96	8.10	0.176

Based on Table 1, the initial academic ability of the population was relatively equivalent across the three classes. Class XI F1 obtained the highest mean score (73.40) with a standard deviation of 8.21, followed by XI F2 with a mean score of 72.87 and a standard deviation of 7.95, while XI F3 had a mean score of 71.96 and a standard deviation of 8.10, The differences in mean scores among the classes were minimal, indicating that the students' initial academic abilities were comparable. Furthermore, the normality test results showed significance values of 0.121, 0.200, and 0.176 for XI F1, XI F2, and XI F3, respectively, all of which exceeded the 0.05 threshold. These results indicate that the data were normally distributed. Therefore, it can be concluded that the three classes had equivalent baseline academic abilities and were suitable for further comparison in the study.

Table 2

Homogeneity and Equality of Means Test

Test	Sig. Value	Interpretation
Levene's Test	0.428	Homogeneous
One-Way ANOVA	0.731	No significant difference

Based on Table 2, the results of the homogeneity and equality of means tests indicate that the three classes met the assumptions required for further statistical analysis. The Levene's Test produced a significance value of 0.428, which is greater than 0.05, indicating that the variances among the groups were homogeneous. In addition, the One-Way ANOVA yielded a significance value of 0.731, which also exceeds 0.05, suggesting that there was no statistically significant difference in the mean scores among the classes. These findings confirm that the groups were comparable in terms of their initial academic ability and could be considered equivalent prior to the implementation of the treatment.

2.3 Experimental Treatment Protocol

To ensure replicability and transparency, the instructional procedures implemented in both groups are presented in the following treatment matrix. Table 3 presents the differences in instructional procedures between the experimental and control classes. In the experimental class, the Problem-Solving Model was implemented through a series of student-centered activities, beginning with the introduction of contextual mathematical problems related to real-life situations. Students were encouraged to identify relevant information, discuss solution strategies collaboratively, implement their chosen approaches, and evaluate the effectiveness of their solutions. Throughout the process, the teacher acted as a facilitator, guiding students through questioning techniques and supporting active learning. In contrast, the control class followed a conventional learning approach in which the teacher directly explained mathematical concepts, demonstrated solution procedures, and served as the primary source of information. Students mainly listened to explanations, completed routine exercises individually, and focused on obtaining correct final answers. These differences highlight the emphasis on active problem-solving and student engagement in the experimental class compared to the more teacher-centered approach in the control class.

Table 3

Experimental Treatment Matrix

Experimental Class (Problem-Solving Model)	Control Class (Conventional Learning)
Students were introduced to contextual mathematical problems related to daily life situations.	Teacher explained mathematical concepts directly through lectures and examples.
Students identified known and unknown information from the problem.	Students listened to explanations and copied solution procedures from the board.
Students discussed possible solution strategies collaboratively in groups.	Students individually completed routine exercises provided by the teacher.
Students implemented selected strategies and presented their reasoning.	Teacher demonstrated correct answers and provided procedural reinforcement.
Students evaluated and reflected on the effectiveness of their solutions.	Learning evaluation focused mainly on obtaining correct final answers.
Teacher acted as facilitator and guided students through questioning techniques.	Teacher acted as the primary source of information during instruction.

2.4 Research Instruments

Two instruments were used in this study: a mathematical self-confidence questionnaire and a mathematics learning achievement test.

2.4.1 Self-Confidence Questionnaire

The self-confidence questionnaire was developed based on Bandura's self-efficacy theory and indicators of mathematical self-confidence proposed in previous mathematics education studies. The questionnaire employed a five-point Likert scale ranging from strongly disagree (1) to strongly agree (5). The questionnaire consisted of four indicators: confidence in solving mathematical problems independently, courage to express mathematical opinions and arguments, persistence when facing mathematical difficulties, and positive beliefs regarding mathematical ability. Examples of questionnaire items included: "I am confident that I can solve difficult mathematics problems if I try seriously", "I feel confident when explaining mathematical ideas in front of the class", and "I do not easily give up when facing challenging mathematics tasks." The instrument was validated through expert judgment and empirical testing. Product Moment correlation analysis showed that 21 items were valid, with item validity coefficients ranging from 0.412 to 0.781. Reliability testing using Cronbach's Alpha produced a coefficient of 0.892, indicating high internal consistency reliability.

2.4.2 Mathematics Learning Achievement Test

The mathematics achievement test consisted of essay questions designed to measure students' conceptual understanding, reasoning ability, and mathematical problem-solving skills. The test items were developed based on the learning objectives specified in the Independent Curriculum. Instrument testing showed that all items met the criteria for validity, reliability, level of difficulty, and discriminating power. The item validity coefficients ranged from 0.436 to 0.804, while the reliability coefficient obtained using Cronbach's Alpha was 0.871, indicating high reliability. The difficulty index ranged from 0.31 to 0.69, suggesting moderate item difficulty, and the discrimination index ranged from 0.32 to 0.71, indicating acceptable discriminating power.

2.5 Data Collection Procedures

Data collection was conducted after the treatment process had been completed in both classes. Students in the experimental and control groups completed the mathematical self-confidence questionnaire and the mathematics achievement test during the same assessment session. Prior to administration, students were informed about the purpose of the study and were assured that their responses would remain confidential and would be used solely for research purposes.

2.6 Data Analysis

The collected data were analyzed using IBM SPSS Statistics software. Preliminary analyses included normality testing using the Shapiro–Wilk test and homogeneity testing using Levene's test. Hypothesis testing was conducted using the Independent Sample t-test. The self-confidence data were analyzed using the Independent Sample t-test with the "equal variances not assumed" option because the homogeneity assumption was violated. Meanwhile, the mathematics achievement data were analyzed using the standard Independent Sample t-test because the data met the assumptions of normality and homogeneity.

In addition to significance testing, this study also calculated effect size using Cohen's d to determine the practical significance of the treatment. Confidence intervals (95% CI) were also reported to provide a clearer interpretation of the magnitude and educational impact of the findings. The results showed that the Problem-Solving learning model significantly affected students' mathematical self-confidence, with $t = 2.718$; $p = 0.009$, Cohen's $d = 0.74$, indicating a moderate practical effect. Furthermore, the model significantly influenced mathematics learning outcomes, with $t = 2.517$, $p = 0.015$; Cohen's $d = 0.70$; also indicating a moderate educational impact. These findings suggest that the Problem-Solving learning model contributes not only to statistically significant improvement but also to meaningful enhancement in students' affective and cognitive development in mathematics learning.

3. Results and Discussion

3.1 Results

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This study aimed to examine the effect of the Problem-Solving learning model on students' mathematical self-confidence and mathematics learning outcomes among eleventh-grade students at SMA Negeri 1 Candung. Research data were collected through a self-confidence questionnaire and a mathematics learning achievement test administered to the experimental and control groups after the treatment process had been completed.

3.1.1 Students' Mathematical Self-Confidence

Students' self-confidence data were obtained through a questionnaire consisting of 21 valid statements distributed to 53 students, including 23 students in the experimental class and 30 students in the control class. The descriptive statistical results are presented in Table 4.

Table 4

Descriptive Statistics of Students' Self-Confidence

Class	N	Mean	Std. Deviation	Variance
Experimental	23	81.30	5.64	31.86
Control	30	75.73	9.19	84.48

Table 4 indicates that the mean score of students' self-confidence in the experimental class (M = 81.30) was higher than that of the control class (M = 75.73). These findings suggest that students who participated in mathematics learning through the Problem-Solving model demonstrated higher levels of self-confidence than students who received conventional instruction.

a. Normality Test

A normality test was conducted using the Shapiro–Wilk test through IBM SPSS Statistics software to determine whether the data were normally distributed. The results are presented in Table 5.

Table 5

Normality Test Results for Self-Confidence Data

Class	N	Sig.	Α	Description
Experimental	23	0.200	0.05	Normally Distributed
Control	30	0.074	0.05	Normally Distributed

Based on the data presented in the table, the normality test results indicate that both the experimental and control groups met the assumption of normal distribution. The experimental class, consisting of 23 students, obtained a significance value of 0.200, while the control class, with 30 students, obtained a significance value of 0.074. Since both significance values are greater than the alpha level of 0.05, the null hypothesis of normality cannot be rejected. Therefore, the data from both groups can be considered normally distributed, indicating that the assumption of normality was satisfied and that parametric statistical analyses could be appropriately applied in subsequent data analysis.

b. Homogeneity Test

The homogeneity test was conducted using Levene's Test through IBM SPSS Statistics software.

Table 6

Homogeneity Test Results for Self-Confidence Data

Groups	Sig.	Α	Decision	Description
Experimental and Control	0.004	0.05	Sig. < α	Not Homogeneous

Based on the homogeneity test results, the significance value obtained was 0.004, which is lower than the alpha level of 0.05. Since the significance value is less than α (0.004 < 0.05), the null hypothesis of equal variances is rejected. This indicates that the variances of the experimental and control groups were not homogeneous. Therefore, the assumption of homogeneity of variance was not met, suggesting that there was a significant difference in the variability of scores between the two groups. Consequently, statistical procedures that do not assume equal variances should be considered in subsequent analyses.

c. Hypothesis Testing

The hypothesis testing results for self-confidence are presented in Table 7.

Table 7

Independent Sample t-Test Results for Self-Confidence

Data	t-value	Df	Sig. (2-tailed)	α	Decision
Experimental vs Control	2.718	48.37	0.009	0.05	Reject H_0

The results showed a t-value of 2.718 with a significance value of 0.009, which was smaller than the significance level of 0.05. Therefore, the null hypothesis (H_0) was rejected, indicating that the Problem-Solving learning model significantly affected students' mathematical self-confidence. To determine the practical significance of the treatment, effect size analysis was also conducted using Cohen's d. The calculation produced a Cohen's d value of 0.74, indicating a moderate-to-large practical effect according to Cohen's interpretation criteria. This finding suggests that the Problem-Solving learning model not only produced statistically significant differences but also generated meaningful improvements in students' confidence in mathematics learning.

3.1.2 Students' Mathematics Learning Outcomes

Students' mathematics learning outcomes were measured using an essay test on geometric transformations, including translation, reflection, rotation, and dilation. The test consisted of four essay questions completed within 60 minutes.

Table 8

Descriptive Statistics of Mathematics Learning Outcomes

Class	N	Max	Min	Mean	Std. Deviation	Variance
Experimental	23	100	30	71.65	23.61	557.33
Control	30	100	16	55.27	23.04	530.62

Table 8 shows that the mean score of mathematics learning outcomes in the experimental class (M = 71.65) was higher than that of the control class (M = 55.27). This finding indicates that students who learned through the Problem-Solving learning model achieved better mathematics learning outcomes than those taught using conventional learning approaches.

a. Normality Test

The normality test results for mathematics learning outcomes are presented in Table 9.

Table 9

Normality Test Results for Mathematics Learning Outcomes

Class	N	Sig.	α	Description
Experimental	23	0.200	0.05	Normally Distributed
Control	30	0.053	0.05	Normally Distributed

Based on the normality test results presented in the table, both the experimental and control groups satisfied the assumption of normal distribution. The experimental class, consisting of 23 students, obtained a significance value of 0.200, while the control class, with 30 students, obtained a significance value of 0.053. Since both significance values are greater than the alpha level of 0.05, the null hypothesis of normality cannot be rejected. Therefore, the data in both groups can be considered normally distributed. These findings indicate that the normality assumption was met, allowing the use of parametric statistical tests for further analysis of the research data.

b. Homogeneity Test

The homogeneity test results for mathematics learning outcomes are presented in Table 10,

Table 10

Homogeneity Test Results for Mathematics Learning Outcomes

Groups	Sig.	α	Decision	Description
Experimental and Control	0.623	0.05	Sig. > α	Homogeneous

Based on the homogeneity test results, the significance value obtained was 0.623, which is greater than the alpha level of 0.05. Since the significance value exceeds α (0.623 > 0.05), the null hypothesis of equal variances cannot be rejected. This indicates that the variances of the experimental and control groups were homogeneous. Therefore, the assumption of homogeneity of variance was satisfied, suggesting that the distribution of scores across the two groups was relatively consistent. As a result, the data met one of the key assumptions required for conducting parametric statistical analyses and comparing the performance of the two groups.

c. Hypothesis Testing

Because the data met the assumptions of normality and homogeneity, hypothesis testing was conducted using the Independent Sample t-test.

Table 11

Independent Sample t-Test Results for Mathematics Learning Outcomes

Data	t-value	Df	Sig. (2-tailed)	α	Decision
Experimental vs Control	2.517	51	0.015	0.05	Reject H_0

The results showed a t-value of 2.517 with a significance value of 0.015, which was lower than 0.05. Therefore, the null hypothesis (H_0) was rejected, indicating that the Problem-Solving learning model significantly influenced students' mathematics learning outcomes.To evaluate the magnitude of the treatment effect, Cohen's d effect size analysis was conducted. The analysis yielded a Cohen's d value of 0.70, indicating a moderate practical effect. This result demonstrates that the Problem-Solving learning model had not only statistical significance but also meaningful educational impact on students' mathematics achievement. Overall, these findings indicate that the implementation of the Problem-Solving learning model contributed positively to both students' affective development, represented by mathematical self-confidence, and cognitive achievement, represented by mathematics learning outcomes.

3.2 Discussion

Research findings indicate that the Problem-Solving learning model significantly contributes to improving students' self-confidence and mathematics learning outcomes. This increase in self-confidence can be explained by Bandura's Self-Efficacy Theory, which states that an individual's belief in their abilities develops through successful experiences in completing challenging tasks. In Problem-Solving learning, students have the opportunity to understand problems, design strategies, implement solutions, and evaluate results independently, resulting in repeated success experiences. This finding aligns with research by Rahmah & Soro (2022), which states that mastery experience is a key factor in building student self-confidence. In line with these findings, Efwan et al. (2024) found that students with low self-confidence consistently failed to meet any indicators of mathematical thinking, while those with high self-confidence demonstrated superior problem-solving engagement — reinforcing that self-confidence is a determining factor in mathematical competenceThis research is also supported by Zakariya (2022), who found that mathematical self-efficacy is positively correlated with student engagement and persistence in mathematics learning. Furthermore, research by Rahayuningdewi & Faradillah, (2020) shows that the problem-solving method positively influences students' self-confidence and mathematical understanding.

From a psychological perspective, students' confidence increases when they begin to develop strategies and solve problems independently. In the initial stages, some students experience doubt and anxiety in mathematics due to their unfamiliarity with non-routine problems. However, after going through several problem-solving processes, students began to demonstrate greater confidence in their abilities. This condition aligns with the Self-Regulated Learning theory, which emphasizes that successful control of thought processes can increase academic self-confidence. This research finding is supported by Brand et al. (2023), who explained that success in completing challenging tasks can strengthen students' perceptions of self-competence. Furthermore, Luttenberger et al. (2018) found that increased self-confidence contributed to a decrease in math anxiety. Research by Azzahra & Nurhanurawati (2024) also showed that students with high levels of self-confidence tended to be more capable of completing all stages of problem-solving according to Polya than students with low self-confidence.

The effectiveness of the Problem-Solving learning model can also be explained through constructivism theory, which states that knowledge is actively constructed through learning experiences and social interactions. In learning, students not only receive information from the teacher but also engage in discussions, arguments, and negotiations of meaning with peers. Gillies (2017) stated that collaborative learning can improve the quality of students' conceptual understanding through meaningful interactions. These findings are supported by Alturki & Aldraiweesh (2023) who explains that problem-solving-based learning encourages students to build deeper knowledge through idea exploration and reflection. Furthermore, the 6E Learning Cycle approach, supported by dynamic geometry technology, can improve students' mathematical communication and learning independence through active involvement in the knowledge construction process (Sies et al., 2025).

The collaborative learning environment created during Problem-Solving learning also contributes to reducing students' math anxiety. In Vygotsky's sociocultural theory, learning occurs optimally through social interaction and scaffolding by individuals with higher abilities. During the learning process, students who better understand the material help their peers solve math problems, creating a more supportive learning environment. These findings are supported by Gillies (2017), who showed that group work can increase student participation and self-confidence. Research by Luttenberger et al., (2018) also revealed that a positive learning environment can reduce students' math anxiety. In addition, the research results of Mayangsari & Qohar (2025) show that collaborative learning based on Team Games Tournament (TGT) is able to improve students' mathematical disposition and strengthen their involvement during the learning process.

The improvement in students' mathematics learning outcomes in this study can be explained by Ausubel's theory of meaningful learning, which emphasizes that learning is more effective when new information is connected to students' existing knowledge structures. Through the Problem-Solving learning model, students not only memorize procedures but also analyze situations, connect concepts, evaluate strategies, and reflect on the results obtained. This finding is supported by (Tam, 2018), who stated that problem-based learning can improve students' higher-order thinking skills and conceptual understanding. Furthermore, Aprisal & Abadi, (2018) found that problem-solving activities significantly improved students' mathematical reasoning abilities. Furthermore, a research report by Kurnaz, (2018) showed that the use of Augmented Reality in geometry learning helps students build stronger conceptual understanding through interactive mathematical visualizations.

The results of this study also demonstrate a reciprocal relationship between the cognitive and affective aspects of mathematics learning. These findings can be explained by Yıldızlı & Saban (2016), who stated that mathematical success is determined not only by mastery of concepts and procedures, but also by students' beliefs, attitudes, and self-regulation. Students who successfully solve math problems gain positive experiences that boost their self-confidence. Conversely, increased self-confidence encourages students to participate more actively and persevere when facing difficulties. This finding is supported by Sadi & Dağyar (2017), who found that positive beliefs about their ability to learn mathematics are associated with increased academic achievement. Research by Krisnadi & Kandaga, (2024) shows that increased student engagement in mathematics learning contributes to the development of academic self-confidence and mathematical problem-solving abilities. Furthermore, Ramadhani, (2018) found that students with high self-confidence tend to have better mathematical problem-solving abilities than students with low self-confidence.

However, several limitations should be acknowledged. The use of a Static Group Comparison Design without pre-testing limits the study's ability to fully control internal validity. Furthermore, as highlighted by Nopriana et al. (2024), students' learning obstacles in mathematics are often rooted in both students' readiness (ontogenic obstacles) and the sequencing of instructional materials (didactical obstacles), factors that were not fully examined in the current study and warrant attention in future research designs. Although baseline equivalence testing was conducted prior to treatment implementation, uncontrolled external variables may have influenced the findings. Furthermore, this study involved participants from only one school context, which may limit the generalizability of the results to broader educational settings. Future research is therefore recommended to use longitudinal or mixed methods approaches involving larger and more diverse populations to provide a deeper understanding of the long-term relationship between problem-solving instruction, mathematics self-confidence, and academic achievement.

This study adhered to ethical standards for educational research. Prior to data collection, formal permission was obtained from the school administration of SMA Negeri 1 Candung. Students were informed of the purpose of the study, the voluntary nature of participation, and the confidentiality of their responses. Informed consent was obtained from all participants before the study was conducted. To protect participant privacy, all collected data was anonymized and used exclusively for research purposes. Student identities were not disclosed in any publications or research reports. Furthermore, the researchers ensured that the learning intervention did not negatively impact students' academic rights, class participation, or assessment opportunities. This study was conducted in accordance with general ethical principles of educational research, including voluntary participation, confidentiality, and respect for participant well-being.

4. Conclusion

Based on the study results, it can be concluded that the Problem-Solving learning method has a positive and significant impact on the self-confidence and mathematics learning outcomes of eleventh-grade students at SMA Negeri 1 Candung. The implementation of this method encourages students to be more active in the learning process, more confident when expressing mathematical ideas, and more persistent in facing challenging problems. This not only improves academic achievement but also strengthens students' emotional engagement in learning mathematics. These findings emphasize the importance of combining cognitive and emotional aspects in mathematics learning and support the implementation of student-centered learning in accordance with the needs of the Independent Curriculum. However, this study has several limitations, namely, it was only conducted in one school with a limited sample size, and it only focused on self-confidence and learning outcomes without considering other factors such as mathematics anxiety, learning motivation, and metacognitive awareness. Furthermore, this study was also conducted over a relatively short period of time, so it cannot yet show the long-term impact of the Problem-Solving learning method. Therefore, future research is recommended to involve a larger and more diverse sample group, and explore other emotional and cognitive variables that may influence the mathematics learning process. Also, it is necessary to apply a longer research design in order to get a more complete picture of the effectiveness of the Problem-Solving method in improving the quality of mathematics learning in a sustainable manner.

Declarations

AI Use Statement

During the preparation of this manuscript, the authors used ChatGPT (OpenAI) for language editing assistance. The authors reviewed and edited the content and took full responsibility for the final manuscript.

Data Availability Statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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Conflict of Interest

The authors declare no conflict of interest.

Ethical Approval

Permission to conduct the research was obtained from the school administration, and informed consent was obtained from all participants.

Authors' Contributions

ZFP : Conceptualization, methodology, investigation, formal analysis, writing—original draft preparation, and visualization.
TR : Conceptualization, methodology, supervision, writing—review and editing, and validation.
I : Data curation, writing—review and editing.
UAW : Writing—review.

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