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The effect of problem-based learning on the mathematical disposition of indonesian senior high school students: A quasi-experimental study

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Abstract

Background: Mathematical disposition is a key affective factor influencing students' confidence, persistence, flexibility, and interest in mathematics. However, previous studies have reported that many students still show low mathematical disposition, as reflected in limited confidence, low persistence, and passive participation in mathematics learning
Aims: This study examined the effect of problem-based learning (PBL) on senior high school students' mathematical disposition.
Methods: This study employed a quantitative approach using a quasi-experimental method with a nonequivalent pretest - posttest control group design. The sample consisted of two eleventh-grade classes (n = 60) at SMA Negeri 2 Majene, West Sulawesi, Indonesia, selected through cluster random sampling. Students completed a Likert-scale questionnaire on mathematical disposition, and the data were analyzed using descriptive statistics, N-Gain scores, and independent-samples t-tests.
Result: The results showed that PBL significantly improved students' mathematical disposition. The experimental class's scores increased from 47.9 to 83.6, whereas the control class increased from 44.9 to 54.2. The experimental class achieved a high N-Gain score of 0.7, indicating strong improvement, while the control class showed a low gain of 0.2. Hypothesis testing revealed a statistically significant effect ($p < 0.001$).
Conclusion: PBL was effective in improving students' mathematical disposition through active, collaborative, and reflective learning experiences. This study is novel in focusing on mathematical disposition as the primary outcome and implementing PBL among students with initially low disposition.

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INTRODUCTION

Education develops human resources by fostering critical, adaptive, and sustainable thinking, particularly through STEM subjects. In the educational context, mathematics learning significantly contributes to the development of logical, analytical, and systematic reasoning as a foundation for decision-making (Cresswell & Speelman, 2020; Hidayat et al., 2023; Pickering et al., 2025; Tursynkulova et al., 2023; M. Wang et al., 2025; Zhai et al., 2024). Mathematics education also plays a role in encouraging higher-order thinking skills, which are a key requirement in twenty-first-century education (OECD, 2019; Szabo et al., 2020). Mathematical ability depends on both cognitive and affective factors, including mathematical disposition. In this study, mathematical disposition is operationally defined as students' tendency to respond positively to mathematics through attitudes, beliefs, motivation, self-confidence, persistence, flexibility in thinking, curiosity, and interest in solving mathematical problems. These indicators reflect how students perceive mathematics, how willing they are to engage in mathematical tasks, and how persistent they are when facing

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challenging problems (DiNapoli, 2023; Matthews, 2020; Skilling et al., 2020). Previous research has found that mathematical dispositional ability is influenced by student engagement and academic achievement (Awofala et al., 2024; Maamin et al., 2021; Punzalan, 2026).

Students with positive disposition engage actively and persist in problem-solving, whereas those with low disposition tend to show mathematics anxiety, low motivation, and task avoidance (Chen & Lin, 2020; Demir, 2023; He et al., 2026; J. Wang & Guo, 2026). These conditions negatively impact both the learning process and mathematics learning outcomes. Low mathematical disposition is evident both nationally and in international assessments such as PISA. PISA findings indicate that students' attitudes toward mathematics significantly impact their academic performance (Darmawan, 2020; Hwang & Son, 2021; Liou, 2021; Wen & Dubé, 2022). National research indicates that many students still exhibit low mathematical dispositional ability, as evidenced by limited interest, low self-confidence, and lack of persistence in learning mathematics (Gyan & Mensah, 2025; Samuel & Warner, 2021; Yi & Na, 2020).

Similar conditions were also found at SMA Negeri 2 Majene, as observed through classroom assessments and preliminary observations. Students tended to lack confidence, participate passively, and develop negative perceptions of mathematics. They were also inclined to avoid difficult mathematical problems and showed limited persistence in problem-solving activities. These conditions contributed to low learning outcomes, indicating that students' mathematical disposition had not yet developed optimally. One factor contributing to low mathematical disposition is the use of conventional teacher-centered methods that limit student engagement. Such instruction often restricts students' active participation and provides limited opportunities for them to construct mathematical understanding independently (Darling-Hammond et al., 2020). As a result, learning becomes less meaningful and fails to foster positive attitudes toward mathematics.

Problem-based learning (PBL) effectively improves students' mathematical disposition by promoting active problem-solving. PBL is a student-centered instructional model that utilizes authentic problems as the context for learning, thereby encouraging students to think critically, collaborate, and construct knowledge independently (Bara & Xhomara, 2020; Williamson, 2023). This model is consistent with constructivist learning theory, which emphasizes meaningful learning through experience and social interaction. Through discussion, collaboration, and reflection, PBL can enhance student engagement and foster positive attitudes toward mathematics. Numerous studies have demonstrated the positive impact of PBL on students' mathematical disposition. International studies have reported that PBL enhances student motivation and engagement in learning activities (Almulla, 2020; Raza et al., 2019; Rehman et al., 2024; Tirado-Morueta et al., 2024; Tsai et al., 2020). Likewise, national studies have shown that students who learn through PBL demonstrate better mathematical disposition than those who experience conventional instruction (Ndia et al., 2025; Rehman et al., 2025). Furthermore, PBL promotes social interaction and collaboration, which contributes to the development of positive learning attitudes.

However, prior studies often treat mathematical disposition as a secondary variable and overlook low-disposition students in authentic classroom settings. Most studies examine mathematical disposition alongside cognitive variables, resulting in limited attention to disposition as an independent affective construct. Second, existing studies generally examine mathematical disposition alongside cognitive variables, resulting in limited attention to mathematical disposition as an independent construct. Third, relatively few studies have investigated the effectiveness of PBL among senior high school students with initially low mathematical disposition in authentic classroom settings. This study is novel in treating mathematical disposition as the primary variable and testing PBL through problem-solving, collaboration, and reflection. This study was conducted among senior high school students with low initial disposition, offering context-specific insights for adaptive mathematics instruction.

LITERATURE REVIEW

Mathematical disposition is recognized as an essential affective component in mathematics education because it influences how students perceive, approach, and engage with mathematical tasks. The concept encompasses students' confidence, perseverance, curiosity, flexibility in thinking, and willingness to explore multiple solution strategies when encountering mathematical problems (DiNapoli & Miller, 2022; He et al., 2026). Students with positive mathematical disposition tend to demonstrate greater persistence in solving challenging tasks and are more likely to view mathematics as meaningful and useful in everyday life. Conversely, negative disposition is often associated with mathematics anxiety, low motivation, avoidance behavior, and reduced participation during learning activities. Consequently, developing mathematical disposition has become an important objective alongside cognitive achievement in contemporary mathematics education.

The significance of mathematical disposition has been highlighted in various educational frameworks and international assessments. Research has consistently shown that affective characteristics play a substantial role in determining students' mathematical performance and long-term engagement with the subject (Irvine, 2020; Lee et al., 2023; Wong et al., 2024; Xiao & Sun, 2021). Positive attitudes toward mathematics contribute to increased self-efficacy, stronger problem-solving behavior, and improved academic outcomes. Furthermore, students who possess favorable mathematical dispositions are generally more resilient when facing complex mathematical challenges and demonstrate greater readiness to participate in collaborative learning environments. Therefore, educational interventions that promote positive mathematical attitudes are considered essential for supporting sustainable mathematics learning.

Problem-Based Learning (PBL) is a student-centered instructional approach that utilizes authentic and meaningful problems as the starting point for learning. Rooted in constructivist learning theory, PBL encourages learners to actively construct knowledge through investigation, discussion, collaboration, and reflection (Almulla, 2020; Williamson, 2023). Rather than receiving information passively, students are required to identify problems, formulate hypotheses, gather relevant information, and propose solutions based on evidence and logical reasoning (Han et al., 2026; Kwangmuang et al., 2021; Tursynkulova et al., 2023). This learning process promotes deeper conceptual understanding while simultaneously fostering critical thinking and communication skills. As a result, PBL has gained widespread attention as an effective pedagogical strategy for enhancing both cognitive and affective learning outcomes.

The theoretical connection between PBL and mathematical disposition can be explained through the active learning experiences provided during problem-solving activities. When students engage in collaborative inquiry and are encouraged to explore multiple solution pathways, they develop greater confidence in their mathematical abilities. The opportunity to discuss ideas with peers and justify reasoning also strengthens students' flexibility in thinking and willingness to take intellectual risks. Moreover, confronting authentic problems helps students recognize the relevance of mathematics to real-life situations, thereby increasing interest and motivation to learn. Through these mechanisms, PBL creates a learning environment that supports the development of positive mathematical dispositions.

Previous empirical studies have reported positive relationships between the implementation of PBL and improvements in students' affective characteristics, including motivation, engagement, self-confidence, and mathematical disposition. Most existing studies, however, have primarily focused on cognitive outcomes such as achievement, conceptual understanding, and problem-solving skills, while mathematical disposition often receives secondary attention. In addition, relatively few studies have specifically examined the effectiveness of PBL among senior high school students who initially exhibit low mathematical disposition. This gap indicates the need for further investigation into the role of PBL in fostering affective development within authentic classroom settings. Therefore, the present study seeks to contribute to the literature by examining mathematical disposition as the primary outcome variable and evaluating the effectiveness of PBL among Indonesian senior high school students with initially low levels of mathematical disposition.

METHOD

Research Design

This study employed a quantitative approach using a quasi-experimental method with a nonequivalent pretest-posttest control group design. The design was selected to examine the effect of Problem-Based Learning (PBL) on students' mathematical disposition by comparing an experimental group and a control group before and after the intervention. Both groups completed a pretest prior to the implementation of the learning treatment and a posttest after the intervention period. Although this design allows researchers to investigate causal relationships in authentic classroom settings, some external variables remain beyond experimental control. The experimental group received mathematics instruction through the PBL model, whereas the control group was taught using conventional teacher-centered instruction. PBL was selected because previous studies have reported its effectiveness in promoting student engagement, collaborative learning, and positive attitudes toward mathematics.

Participant

The study was conducted at SMA Negeri 2 Majene, West Sulawesi, Indonesia, during the 2022/2023 academic year. The target population consisted of 245 eleventh-grade students distributed across eight classes. A cluster random sampling technique was employed to select the sample because students were organized into naturally existing classroom groups. Two intact classes were randomly assigned as the research sample. Class XI.1 was designated as the experimental group and Class XI.2 as the control group. Each class consisted of 30 students, resulting in a total sample size of 60 participants. The two groups possessed relatively similar academic characteristics and were taught using the same mathematics curriculum.

Instrument

Data were collected using a mathematical disposition questionnaire developed on a four-point Likert scale. The instrument consisted of both positive and negative statements designed to measure four dimensions of mathematical disposition: self-confidence, flexibility in mathematical thinking, persistence in problem-solving, and curiosity toward mathematics. Students responded to each statement by selecting one of four response categories ranging from strongly disagree to strongly agree. Prior to its administration, the questionnaire underwent validity and reliability testing to ensure the quality of measurement. Instrument reliability was evaluated using Cronbach's Alpha coefficient, with values greater than 0.60 considered acceptable for educational research. The questionnaire was administered twice during the study, namely before the intervention (pretest) and after the intervention (posttest), to assess changes in students' mathematical disposition over time.

Data Analysis

The collected data were analyzed using both descriptive and inferential statistical techniques. Descriptive statistics, including means and standard deviations, were used to summarize students' mathematical disposition scores before and after the intervention. Prior to hypothesis testing, normality and homogeneity tests were conducted to ensure that the data met the assumptions required for parametric analysis. To measure the magnitude of improvement in mathematical disposition, normalized gain (N-Gain) scores were calculated and categorized into high, moderate, and low improvement levels. Furthermore, an independent-samples t-test was performed to compare posttest scores between the experimental and control groups. Statistical significance was determined at the 0.05 level. All analyses were conducted to determine whether the implementation of Problem-Based Learning produced a significant improvement in students' mathematical disposition compared with conventional instruction.

Research Procedure

The research was implemented in three stages. The first stage involved preparation activities, including preliminary classroom observations, preparation of lesson plans, validation of research instruments, and coordination with the participating school. The second stage consisted of the implementation of the learning intervention. At the beginning of the study, both groups completed the pretest questionnaire. The experimental group then received instruction using the Problem-Based Learning model, while the control group participated in conventional learning activities. The PBL implementation followed four main phases: problem orientation, investigation, collaboration, and reflection. These phases encouraged students to actively identify problems, explore possible solutions, discuss ideas with peers, and evaluate their learning experiences. Following the completion of the intervention, both groups completed the posttest questionnaire. The final stage involved data organization, statistical analysis, and interpretation of the findings.

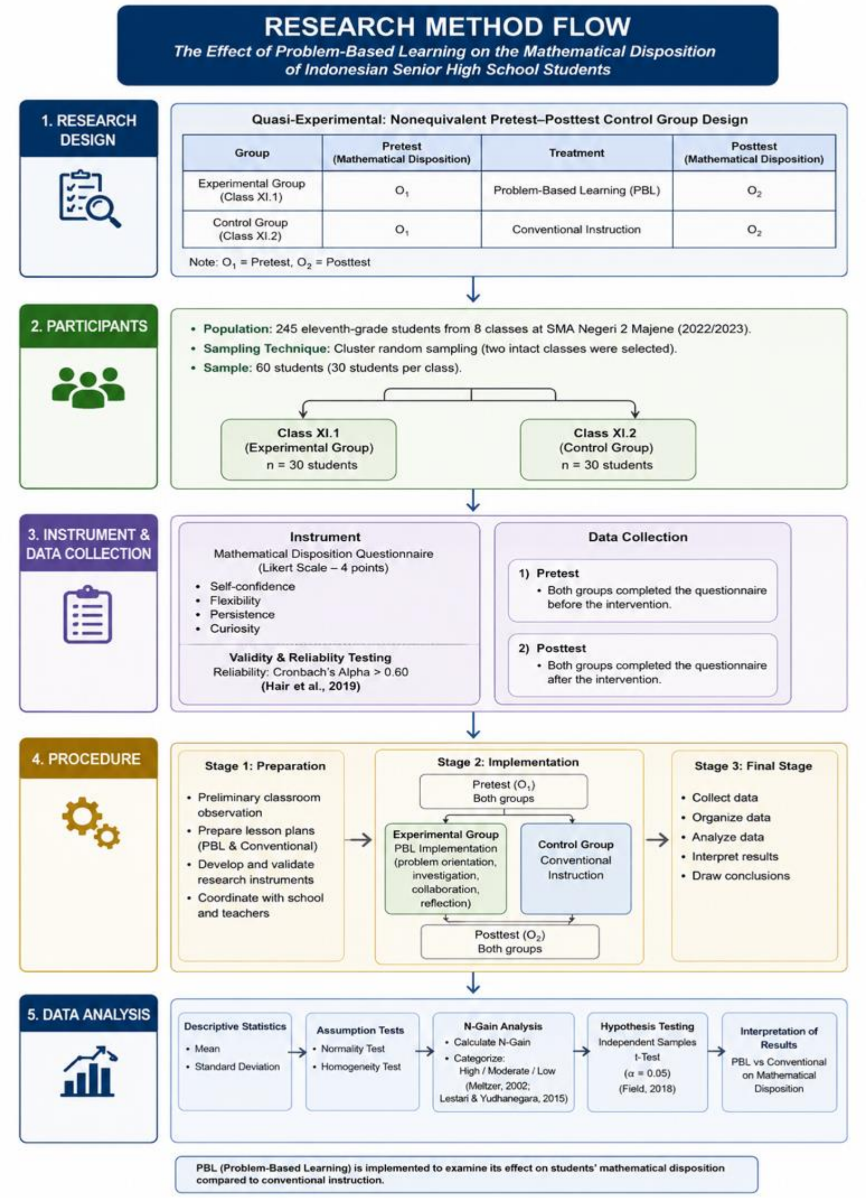

Figure 1. Research Method Flow.

RESULTS AND DISCUSSION

Results

Students' Mathematical Disposition

Descriptive Analysis

Descriptive analysis showed that the experimental class increased by 35.73 points, from 47.90 to 83.63, whereas the control class increased by only 9.33 points, from 44.87 to 54.20. The difference in score improvement between the two groups was 26.40 points, indicating that the increase in mathematical disposition was greater in the class taught using PBL.

Table 1. Students' Mathematical Disposition Scores

Class	Pre-Questionnaire (Mean)	Post-Questionnaire (Mean)	Category
Experimental	47.90	83.63	Poor → Very Good
Control	44.87	54.20	Poor → Poor

Experimental group scores rose from 47.90 (poor) to 83.63 (very good), showing a 35.73-point increase after PBL implementation. Control group scores increased marginally from 44.87 to 54.20, remaining poor. Before PBL, 66% of students were poor; after PBL, 63% were very good and 37% were good.

N-Gain Analysis

The observed improvement was supported by N-Gain results, with the experimental group achieving a high gain of 0.7 and the control group achieving a low gain of 0.2. Hypothesis testing further confirmed a statistically significant difference between the groups ($p < 0.001$).

Inferential Analysis

Hypothesis testing using the independent-samples t-test showed a statistically significant effect ($p < 0.001$). Thus, PBL significantly improved students' mathematical disposition.

Discussion

The findings of this study demonstrate that Problem-Based Learning (PBL) significantly improved students' mathematical disposition, as evidenced by the substantial increase in the experimental group's mean score from 47.90 to 83.63, the high N-Gain value of 0.70, and the statistically significant difference observed between the experimental and control groups. These results indicate that PBL is effective not only in enhancing cognitive outcomes but also in fostering positive affective characteristics that support mathematics learning (Hui & Mahmud, 2023; Rehman et al., 2025). The improvement is particularly meaningful considering that students initially exhibited low levels of confidence, persistence, and engagement in mathematics classrooms. Similar findings, who found that students exposed to PBL demonstrated significantly higher mathematical disposition compared to those receiving conventional instruction (Ndia et al., 2025; Rehman et al., 2025). Likewise, Hmelo-Silver (2020) argued that authentic problem-solving activities encourage learners to become more actively engaged in the learning process and develop greater confidence in their abilities. The present findings also align with, who emphasized that PBL provides meaningful learning experiences that encourage students to take responsibility for their own learning (Almulla, 2020; Hsbollah & Hassan, 2022; Ngereja et al., 2020; Silma et al., 2024; Smith et al., 2022). In contrast, the control group in this study showed only a modest improvement, suggesting that conventional instruction may be insufficient to substantially influence students' affective development. This difference highlights the importance of instructional approaches that actively involve students in constructing knowledge rather than merely receiving information. Therefore, the significant gains observed in the experimental group provide empirical evidence that PBL can effectively address low mathematical disposition among secondary school students.

The effectiveness of PBL in improving mathematical disposition can be explained through the active learning processes embedded within the model. During the intervention, students were required to analyze contextual problems, discuss alternative solutions with peers, and reflect on their reasoning processes, all of which contributed to deeper engagement with mathematics. These learning experiences are consistent with constructivist theory, which posits that knowledge is constructed through active interaction with learning environments and social collaboration. According to positive attitudes toward mathematics emerge when students perceive themselves as capable problem-solvers and experience success in mathematical tasks (Russo & Minas, 2020). The collaborative nature of PBL creates opportunities for students to exchange ideas, challenge assumptions, and receive feedback from peers, thereby strengthening their confidence and flexibility in thinking. Similar observations were, who found that meaningful participation in mathematical discussions significantly contributes to students' motivation and persistence (Xiao & Sun, 2021). Furthermore, that students' attitudes toward mathematics are shaped not only by achievement outcomes but also by the quality of learning experiences they encounter. The present findings support this perspective by demonstrating that students who actively participated in problem-solving activities developed more favorable dispositions toward mathematics. Unlike passive learning environments, PBL encourages students to view challenges as opportunities for exploration rather than obstacles to success. Consequently, the learning environment created through PBL appears to play a crucial role in promoting positive affective development.

Another important finding is that mathematical disposition can be intentionally developed through instructional intervention rather than emerging automatically as a consequence of cognitive achievement. Previous studies have frequently treated mathematical disposition as a secondary variable accompanying academic performance, resulting in limited understanding of how instructional models directly influence affective outcomes. The current study extends existing literature by positioning mathematical disposition as the primary outcome variable and demonstrating that targeted pedagogical strategies can significantly enhance this construct. This finding supports, who emphasized that mathematical disposition requires deliberate cultivation through supportive learning environments and meaningful learning experiences. Similarly, noted that positive dispositions toward mathematics are influenced by classroom practices that encourage autonomy, collaboration, and reflective thinking (Irvine, 2020). The substantial improvement observed in the experimental group suggests that affective dimensions of learning should receive equal attention alongside cognitive achievement. This perspective is particularly relevant in contemporary mathematics education, where students are expected not only to master mathematical concepts but also to develop resilience and confidence in applying them. Moreover, the findings challenge traditional assumptions that affective characteristics develop naturally without explicit instructional support. Instead, the results indicate that carefully designed learning experiences can substantially influence how students perceive and engage with mathematics. Therefore, educational practitioners should consider affective development as a central objective when designing mathematics instruction.

The novelty of this study is further reflected in its focus on students whose initial mathematical disposition was categorized as poor. Both groups began the intervention with relatively low disposition scores, indicating limited confidence, persistence, and interest in mathematics. Despite similar starting points, students exposed to PBL demonstrated considerably greater improvement than those in the control group. This finding contributes to the literature by showing that PBL is particularly effective for learners who initially possess negative attitudes toward mathematics. Previous studies have often examined heterogeneous student populations without specifically considering baseline disposition levels, making it difficult to determine whether instructional interventions are equally effective for students with low affective readiness. The present results suggest that PBL can serve as an effective intervention strategy for addressing negative mathematical attitudes and fostering more productive learning behaviors. These findings are consistent with research, which reported that problem-based instructional approaches improved students' confidence and willingness to engage in mathematical tasks (Abate et al., 2022; Ahmad et al., 2023). Furthermore, the results support indicating that positive attitudes toward mathematics are closely associated with improved learning engagement and academic achievement. By focusing on students with initially low disposition, this study provides valuable evidence regarding the potential of PBL to reduce affective barriers in mathematics learning. Consequently, the findings offer practical implications for educators seeking to improve student engagement in classrooms where negative attitudes toward mathematics remain prevalent.

The observed improvements in mathematical disposition were likely driven by the integration of problem-solving, collaboration, and reflection throughout the learning process. These three components encouraged students to actively participate in learning activities, develop confidence through peer interaction, and persist when encountering challenging mathematical problems. Learning motivation theory suggests that students are more likely to develop positive attitudes when they experience autonomy, competence, and meaningful social interaction during learning activities. The findings of this study provide empirical support for this theoretical perspective by demonstrating that students became more confident and persistent after participating in PBL activities. However, several limitations should be acknowledged when interpreting these findings. The study involved a relatively small sample of 60 students from a single senior high school, which may limit the generalizability of the results to broader educational contexts. In addition, the intervention was conducted within a specific cultural and institutional setting that may influence students' responses to the instructional approach. Future studies should involve larger and more diverse samples, include longitudinal designs, and examine additional affective variables such as mathematical anxiety, self-efficacy, and learning motivation. Comparative studies across different educational levels and geographical regions may also provide a more comprehensive understanding of the effectiveness of PBL. Despite these limitations, the findings strongly suggest that PBL represents a promising instructional approach for fostering positive mathematical disposition and supporting holistic mathematics learning.

Implications

The findings of this study have important theoretical, pedagogical, and practical implications for mathematics education. From a theoretical perspective, the results provide empirical support for constructivist learning theory by demonstrating that students' mathematical disposition can be intentionally developed through active and collaborative learning experiences rather than emerging solely from cognitive achievement. The study also strengthens the growing body of literature emphasizing the significance of affective factors in mathematics learning and highlights mathematical disposition as a critical outcome that deserves equal attention alongside academic performance. From a pedagogical perspective, the findings suggest that mathematics teachers should incorporate Problem-Based Learning (PBL) into classroom instruction to foster students' confidence, persistence, flexibility, and curiosity when engaging with mathematical tasks. The positive changes observed among students with initially low mathematical disposition indicate that PBL can serve as an effective intervention for learners who experience difficulties, low motivation, or negative attitudes toward mathematics. Furthermore, the use of contextual problems and collaborative activities can create more meaningful learning environments that encourage active participation and deeper engagement in mathematical thinking. The results also imply that instructional success should not be evaluated solely based on cognitive achievement but should include indicators related to students' affective development and learning attitudes. At the school level, curriculum developers and educational leaders may consider integrating student-centered learning approaches into mathematics programs to support holistic learning outcomes. Professional development programs for teachers should likewise emphasize strategies for designing authentic problem-solving activities that promote both cognitive and affective growth. In addition, the findings highlight the importance of creating classroom environments that encourage discussion, reflection, and social interaction as mechanisms for developing positive mathematical dispositions. For policymakers, the study provides evidence that educational reforms aimed at improving mathematics learning should address affective dimensions in addition to academic competencies. Ultimately, these findings suggest that fostering positive mathematical disposition through PBL may contribute to the development of more motivated, resilient, and self-confident learners who are better prepared to meet the challenges of twenty-first-century education.

Limitations and Suggestions for Future Research

Several limitations should be considered when interpreting the findings of this study. First, the study involved a relatively small sample of 60 students drawn from a single senior high school in Majene, Indonesia, which may limit the generalizability of the results to broader educational contexts and student populations. Second, the quasi-experimental design did not allow for complete control of all external variables that might have influenced students' mathematical disposition during the intervention period. Third, the study focused exclusively on mathematical disposition as the primary outcome variable and did not examine potential relationships with other important constructs such as mathematical achievement, self-efficacy, learning motivation, or mathematics anxiety. In addition, data collection relied primarily on self-reported questionnaire responses, which may be subject to response bias and may not fully capture students' actual attitudes and behaviors during mathematics learning. The intervention was also conducted over a limited period, making it difficult to determine whether the observed improvements in mathematical disposition would be sustained over time. Furthermore, contextual factors such as teacher characteristics, classroom climate, and school culture were not examined in detail, despite their potential influence on affective learning outcomes. Future research should involve larger and more diverse samples from different schools, regions, and educational levels to improve the external validity of the findings. Longitudinal studies are also recommended to investigate the long-term effects of Problem-Based Learning on students' mathematical disposition and related affective characteristics. Researchers may further explore the interaction between mathematical disposition and other cognitive or psychological variables to obtain a more comprehensive understanding of students' mathematics learning experiences. The use of mixed-methods approaches, including classroom observations and interviews, may provide richer insights into the mechanisms through which Problem-Based Learning influences students' attitudes and engagement. Finally, future studies should compare Problem-Based Learning with other student-centered instructional models to identify the most effective strategies for fostering positive mathematical disposition in diverse educational settings.

CONCLUSION

The findings of this study provide strong evidence that Problem-Based Learning (PBL) significantly improves students' mathematical disposition in senior high school mathematics classrooms. The experimental group experienced a substantial increase of 35.73 points, rising from an initial mean score of 47.90 to 83.63 after the intervention, whereas the control group demonstrated a comparatively modest increase of only 9.33 points, from 44.87 to 54.20. This substantial difference indicates that students who participated in PBL developed more positive attitudes toward mathematics than those who learned through conventional instructional approaches. The effectiveness of PBL was further confirmed by the high N-Gain value of 0.70, which indicates a strong level of improvement, and by the statistically significant difference between groups ($p < 0.001$). In addition to quantitative improvements, meaningful changes were also observed in the distribution of mathematical disposition categories. Prior to the intervention, most students in the experimental group were classified in the poor category, reflecting low confidence, limited persistence, and weak engagement in mathematics learning. Following the implementation of PBL, the majority of students shifted into the very good category, while the remaining students reached the good category, indicating a substantial positive transformation in their affective responses toward mathematics. These findings suggest that PBL effectively creates learning experiences that encourage students to become more confident, persistent, flexible, and curious when solving mathematical problems. The study also demonstrates that mathematical disposition is not a fixed characteristic but can be developed through carefully designed instructional strategies that promote active participation, collaboration, and reflection. Furthermore, the results highlight the importance of addressing affective dimensions of learning alongside cognitive achievement, as positive mathematical disposition plays a crucial role in students' willingness to engage with challenging mathematical tasks. An important contribution of this study is the evidence that PBL is particularly beneficial for students who initially exhibit poor mathematical disposition, suggesting that the model can serve as an effective intervention for improving negative attitudes toward mathematics. Overall, this study concludes that Problem-Based Learning is a powerful pedagogical approach for fostering positive mathematical disposition and supporting more meaningful, engaging, and holistic mathematics learning experiences in secondary education.

AUTHOR CONTRIBUTIONS STATEMENT

Amran Yahya designed the study, developed the research framework, analyzed and interpreted the data, and prepared the manuscript. Nurbayani conducted the classroom learning implementation using the *problem-based learning* model, assisted in the data collection process, administered the research instruments, and contributed to the organization of research data during the study. Both authors contributed to reviewing the manuscript critically for important intellectual content and approved the final version of the manuscript.

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