Interdisciplinary Academic and Research Journal, 6 (2), March-April 2026
Old ISSN 2774-0374: New ISSN 2985-2749
Website: https://so03.tci-thaijo.org/index.php/IARJ/index
Article ID: e293239

Active and Inquiry-Based Learning to Improve Mathematics Achievement and Problem-Solving in High School

Zhenyi Li[1], Tinnakorn Attapaiboon[2] and Nirat Jantharajit[3]
Nakhon Phanom University, Thailand
E-mail: 164615553@qq.com, ORCID ID: https://orcid.org/0009-0009-2001-8551
E-mail: tinnakattapaiboon@163.com, ORCID ID: https://orcid.org/0009-0005-2014-9771
E-mail: n20jann@hotmail.com, ORCID ID: https://orcid.org/0009-0005-1098-8109
Received 03/09/2025 Revised 18/09/2025 Accepted 20/10/2025

Abstract

Background and Aim: Developing 21st-century skills such as critical thinking, problem-solving, and collaboration has become a priority in education. Active learning and inquiry-based learning are recognized as effective strategies for promoting these skills. This study examines their impact on senior high school students' mathematics achievement and problem-solving abilities.

Materials and Methods: A quasi-experimental design was conducted with 30 first-year students in Zhaotong, Yunnan Province, China. Over 15 lessons, active and inquiry-based strategies were integrated into mathematics instruction. Pre- and post-tests assessed academic achievement and problem-solving, and paired-sample t-tests with effect size analysis were used to evaluate the effectiveness of the intervention.

Results: The findings revealed significant gains in both mathematics achievement (Cohen's d = 1.39) and problem-solving ability (Cohen's d = 1.37). Additionally, a strong positive correlation was found between students' academic performance and problem-solving skills (r = 0.68).

Conclusion: This study adds empirical support for integrating active and inquiry-based learning into high school mathematics instruction. It provides evidence that these strategies enhance students' mastery of mathematical concepts and foster broader cognitive skills, contributing to the development of key competencies essential for academic success.

Keywords: Active Learning; Inquiry-Based Learning; Academic Achievement; Problem-Solving Ability; Mathematics Education

Introduction

Over the past two decades, China's educational system has undergone substantial reforms aimed at improving the quality of secondary education. The Ministry of Education's New High School Curriculum Reform Plan (2004) was a pivotal step, emphasizing a departure from traditional rote memorization and exam-centric teaching methods. This reform called for fostering students' creativity, problem-solving abilities, and independent learning skills, reflecting a global

Citation: Li, Z., Attapaiboon, T., & Jantharajit, A. (2026). Active and Inquiry-Based Learning to Improve Mathematics Achievement and Problem-Solving in High School, Thailand. Interdisciplinary Academic and Research Journal, 6(2), e293239; DOI: https://doi.org/10.60027/iarj.2026.e293239

shift towards more learner-centered approaches. The traditional model, characterized by repetitive memorization and rigid examination preparation, has frequently been criticized for limiting students' ability to apply knowledge flexibly in complex, real-world situations (Johnson, 2020; Liu, 2020). Empirical studies support this critique, noting that this approach fails to cultivate critical thinking and adaptive problem-solving skills, which are essential for students' success in the 21st century (Hadi & Novaliyosi, 2019).

In mathematics education, these shortcomings are particularly evident. Conventional teaching methods, which prioritize formula memorization and standardized problem-solving routines, do not sufficiently encourage students to develop logical reasoning or adaptive problem-solving abilities (Kusuma, 2017; Liu, 2018). To address these gaps, educational strategies such as active learning and inquiry-based learning (IBL) have gained traction as effective pedagogical approaches. Active learning emphasizes student engagement in interactive activities, experimentation, and reflective practices, all of which have been shown to improve both academic performance and knowledge retention in STEM fields (Freeman et al., 2014). IBL complements this by framing mathematics as a process of inquiry and exploration, encouraging students to think critically and independently rather than passively receiving information (Chu et al., 2021; Margunayasa et al., 2019).

Despite these efforts, the enduring influence of the gaokao examination system continues to shape teaching practices in China, with a significant number of educators still prioritizing exam performance over holistic student development, particularly in subjects like mathematics (Hadi & Novaliyosi, 2019). This focus on standardized testing is not only pervasive but also poses significant challenges to the integration of more dynamic teaching methods. For example, according to a recent survey, approximately 70% of teachers report that the pressure of preparing students for the gaokao restricts their ability to implement innovative instructional strategies (Liu & Zhang, 2021). As a result, the incorporation of active learning and IBL into the classroom remains an urgent yet complex task.

This study seeks to address a critical research gap: although active learning and inquiry-based learning have been widely studied in various STEM contexts, their effects in Chinese high school mathematics classrooms remain insufficiently explored. By investigating the impact of these instructional strategies on students' mathematics achievement and problem-solving abilities, this study aims to contribute empirical evidence supporting pedagogical innovation in China. Additionally, it offers practical guidance for educators seeking to integrate these methods into their teaching practices. Through this research, the broader educational community will gain valuable insights into the benefits of fostering deeper cognitive engagement and problem-solving skills, both of which are essential for success in an increasingly complex global society.

Citation: Li, Z., Attapaiboon, T., & Jantharajit, A. (2026). Active and Inquiry-Based Learning to Improve Mathematics Achievement and Problem-Solving in High School, Thailand. Interdisciplinary Academic and Research Journal, 6(2), e293239; DOI: https://doi.org/10.60027/iarj.2026.e293239

Objectives

This study aims to evaluate the impact of active learning and inquiry-based learning on senior high school students' mathematics achievement and problem-solving abilities. Specifically, it seeks to:

1. to assess the effect on mathematics achievement. Determine whether active and inquiry-based learning significantly improves students' academic performance in mathematics.

2. to assess the effect on problem-solving ability. Examine whether these instructional strategies enhance students' skills in analyzing, reasoning, and solving mathematical problems.

Hypothesis

Hypothesis 1: Active and inquiry-based learning will significantly increase mathematics achievement compared to pre-intervention scores.

Hypothesis 2: Active and inquiry-based learning will significantly improve problem-solving ability compared to pre-intervention scores.

Literature Review

The cultivation of 21st-century skills—such as critical thinking, problem-solving, collaboration, and communication—has emerged as a central goal in contemporary education. Inquiry-based learning (IBL) has gained prominence for its ability to foster these competencies, transforming students from passive recipients of knowledge into active participants in the construction of understanding. Chu et al. (2021) demonstrate that IBL promotes questioning, investigation, and evidence-based reasoning, all of which contribute to higher-order thinking and a sense of ownership in learning. This approach aligns with global educational reform trends, as it emphasizes adaptability and problem-solving, qualities that are increasingly vital in rapidly evolving educational and societal contexts.

However, while IBL provides a robust foundation for fostering cognitive skills, research suggests that its impact can be amplified when combined with other student-centered pedagogies. For example, Darmuki and Hariyadi (2019) emphasize the Jucama learning model, which aligns with students' learning styles and significantly improves performance in communication-based tasks. This model highlights the importance of tailoring instructional strategies to individual learning preferences, suggesting that such personalization enhances engagement and academic achievement. Similarly, Jaiswal and Al-Hattami (2020) argue that student-centered methods not only boost academic performance but also promote creativity and problem-solving skills. These studies support the idea that IBL, when integrated with personalized and interactive teaching methods, can significantly enhance both cognitive and

Citation: Li, Z., Attapaiboon, T., & Jantharajit, A. (2026). Active and Inquiry-Based Learning to Improve Mathematics Achievement and Problem-Solving in High School, Thailand. Interdisciplinary Academic and Research Journal, 6(2), e293239; DOI: https://doi.org/10.60027/iarj.2026.e293239

academic outcomes. However, there is a tension in the literature about the ideal balance between inquiry-based and structured approaches. Some scholars suggest that too much freedom in IBL may overwhelm students, especially in complex subjects like mathematics, where clear frameworks may help guide learning (Liu, 2020).

In addition to cognitive outcomes, emotional well-being plays a critical role in students' learning experiences. Research by Davey et al. (2022) reveals that student anxiety has increased over the past two decades, leading to negative impacts on academic performance. This underscores the importance of addressing not only cognitive but also socio-emotional factors in education. Large-scale assessments, such as TIMSS and PISA, have shown that educational systems that focus solely on academic content, without considering students' emotional resilience and well-being, often fail to prepare students for long-term success (Hopfenbeck et al., 2018). For instance, in the 2018 PISA study, countries with a more balanced emphasis on both cognitive and socio-emotional skills, such as Finland, demonstrated higher student achievement in mathematics and problem-solving (OECD, 2019). These findings suggest that while IBL and student-centered methods contribute to cognitive development, they must be integrated with strategies that support students' emotional well-being and metacognitive skills to maximize their effectiveness.

Importantly, existing research on the effectiveness of IBL and student-centered teaching in STEM subjects often overlooks the specific context of Chinese high school mathematics education. While these methods have been widely studied in various international contexts, the implementation and impact of IBL in the Chinese educational system, particularly in mathematics, remain underexplored. Moreover, the literature tends to focus heavily on cognitive outcomes, with less attention given to how socio-emotional factors, such as anxiety or motivation, mediate the success of these teaching strategies. This gap highlights the need for a comprehensive study that not only examines the cognitive and academic impacts of IBL and active learning in mathematics but also considers how these methods can be implemented to support students' emotional well-being.

In summary, while inquiry-driven and student-centered pedagogies have been shown to stimulate deep cognitive engagement and improve academic outcomes, the integration of these approaches with personalized instruction and emotional support is essential for cultivating the full spectrum of 21st-century skills. This study addresses a critical gap in the literature by examining the effects of active and inquiry-based learning in Chinese high school mathematics classrooms, with particular attention to both cognitive and socio-emotional factors that influence student achievement and problem-solving abilities.

Citation: Li, Z., Attapaiboon, T., & Jantharajit, A. (2026). Active and Inquiry-Based Learning to Improve Mathematics Achievement and Problem-Solving in High School, Thailand. Interdisciplinary Academic and Research Journal, 6(2), e293239; DOI: https://doi.org/10.60027/iarj.2026.e293239

Conceptual Framework

The conceptual framework for this study aims to examine the relationship between the instructional strategies of active learning and inquiry-based learning (IBL) and the learning outcomes of senior high school students in mathematics. The framework outlines the independent and dependent variables that guide this research, along with their hypothesized relationships.

Independent Variables

The independent variables in this study are the instructional strategies of active learning and inquiry-based learning (IBL). Active learning involves engaging students in activities such as problem-solving, group discussions, and hands-on experiments. This strategy emphasizes student participation, encouraging students to take an active role in their learning, think critically, and apply knowledge to real-world contexts. IBL focuses on students' active exploration of mathematical problems through questioning, investigation, and self-directed learning, which fosters deeper understanding and critical thinking skills.

By combining these two instructional strategies, this study seeks to promote greater student engagement and cognitive development, thereby enhancing both students' academic achievement and problem-solving abilities.

Dependent Variables

The dependent variables in this study are learning achievement and problem-solving ability. Learning achievement refers to the level of knowledge, skills, and understanding students acquire as a result of the instructional interventions. This is assessed through tests evaluating students' mastery of mathematical concepts and their ability to apply these concepts to solve problems.

Problem-solving ability refers to students' capacity to identify, analyze, and solve mathematical problems. It is a critical skill for the development of mathematical thinking and is essential both in academic settings and in real-world contexts. This variable is measured through assessments that evaluate students' problem-solving approaches, strategy selection, and the accuracy of their solutions.

Relationship Between Variables

It is hypothesized that active learning and inquiry-based learning (IBL) will have a positive effect on both learning achievement and problem-solving ability. Through active participation and inquiry, students are expected to improve their understanding of mathematical concepts, develop stronger problem-solving skills, and become more engaged in their learning process.

The combination of these two instructional strategies is anticipated to create an interactive and dynamic learning environment that fosters critical thinking, enhances problem-solving capabilities, and enables students to apply their knowledge in diverse contexts.

Citation: Li, Z., Attapaiboon, T., & Jantharajit, A. (2026). Active and Inquiry-Based Learning to Improve Mathematics Achievement and Problem-Solving in High School, Thailand. Interdisciplinary Academic and Research Journal, 6(2), e293239; DOI: https://doi.org/10.60027/iarj.2026.e293239

By investigating the impact of these strategies on students' learning outcomes, the study seeks to provide empirical evidence on the effectiveness of active learning and IBL in improving educational outcomes in mathematics. This framework will guide the analysis of how these teaching methods influence students' cognitive development and problem-solving skills.

Mothodology

This section outlines the methodology employed to examine the impact of active learning and inquiry-based learning on the mathematics achievement and problem-solving abilities of senior high school students. The study design is a quasi-experimental, single-group pretest-posttest design, where data were collected before and after the intervention. This section includes details on the sampling procedures, research instruments, data collection methods, and data analysis techniques.

1. Population and Research Sample

The study population comprised first-year senior high school students in Zhaotong, Yunnan Province, during the 2024 academic year. Initially, 60 students from two intact classes were considered for the study. A cluster random sampling procedure was used to randomly select one class (n = 30) from the two available classes. This ensured that the entire class, rather than individual students, was chosen, maintaining the natural group structure and minimizing selection bias. The final sample included students from diverse demographic backgrounds, thereby enhancing the representativeness of the sample.

While the sample size was determined based on the available class groups, a power analysis was not conducted due to the constraints of using intact classes. However, the sample size is considered sufficient for a preliminary investigation of the intervention's effects.

2. Research Instruments

Three main instruments were developed and validated for this study:

Instructional Plans: Fifteen lesson plans were created to integrate active learning and inquiry-based learning strategies. Each plan focused on key mathematical concepts and included interactive activities and inquiry tasks. The plans underwent expert review by three mathematics education specialists to ensure content validity and pedagogical soundness.

Learning Achievement Test: A 20-item multiple-choice test was designed to assess students' mastery of mathematical concepts and their ability to apply them. Before implementation, the test was piloted with 15 students from a comparable school. Necessary revisions were made based on feedback. The test's internal consistency reliability was confirmed with a Cronbach's α of 0.82, indicating good reliability. In addition to expert review, further evidence of construct

Citation: Li, Z., Attapaiboon, T., & Jantharajit, A. (2026). Active and Inquiry-Based Learning to Improve Mathematics Achievement and Problem-Solving in High School, Thailand. Interdisciplinary Academic and Research Journal, 6(2), e293239; DOI: https://doi.org/10.60027/iarj.2026.e293239

validity was obtained through a comparison of the test's alignment with the curriculum objectives and theoretical frameworks in mathematics education.

Problem-Solving Ability Scale: A 15-item rating scale was used to evaluate students' cognitive and strategic problem-solving skills, including problem analysis, strategy selection, and solution accuracy. The scale was also piloted and refined based on feedback. The instrument achieved a Cronbach's α of 0.85, suggesting high reliability. Evidence of criterion validity was established by linking the scale's scores with students' prior performance in problem-solving tasks. Table 1 summarizes the research instruments and their psychometric properties.

Table 1 Summary of Research Instruments and Reliability Results

Instrument	Items	ValidationProcess	Reliability (Cronbach'sα)
Instructional Plans	15	Expert review (3 specialists)	–
Learning Achievement Test	20	Pilot test(n=15), expert validation	0.82
Problem-Solving Ability Scale	15	Pilot test(n=15), expert validation	0.85

3. Data Collection

Data were collected at three points: pre-test (before the intervention), mid-point (during the intervention), and post-test (after the intervention). Baseline data were collected to assess students' initial levels of achievement and problem-solving ability. The instructional interventions, which spanned 15 lessons, were implemented with progress monitored at the mid-point. The post-intervention data provided outcome measures for both achievement and problem-solving ability. Ethical procedures adhered to institutional guidelines, with informed consent obtained from all participants and their guardians. Institutional approval was secured from the school's ethics review board before the study commenced. Participant confidentiality was ensured through anonymous data collection, and all information was stored securely in accordance with ethical standards.

4. Data Analysis

Data analysis included both descriptive and inferential statistics. Descriptive statistics (means, standard deviations) summarized student performance at each time point (pre-test, mid-test, post-test). To assess the effectiveness of the intervention, a paired-sample t-test was conducted to compare pre-test and post-test scores. This statistical test was chosen to determine

Citation: Li, Z., Attapaiboon, T., & Jantharajit, A. (2026). Active and Inquiry-Based Learning to Improve Mathematics Achievement and Problem-Solving in High School, Thailand. Interdisciplinary Academic and Research Journal, 6(2), e293239; DOI: https://doi.org/10.60027/iarj.2026.e293239

whether there were significant differences between students' achievement and problem-solving abilities before and after the intervention.

Before applying the t-test, the assumptions of normality and homogeneity of variance were tested. Shapiro-Wilk tests were conducted to check for normality of the data, and Levene's test was used to assess the homogeneity of variance. If these assumptions were not met, non-parametric alternatives (such as the Wilcoxon signed-rank test) were considered.

In addition, effect sizes (Cohen's d) were calculated to evaluate the practical significance of the observed changes. These combined results allowed for a thorough examination of the intervention's impact on students' academic performance and problem-solving ability.

Results

1. Participant Demographics

The 30 participants were first-year high school students aged 15–16. Gender distribution was balanced (55%male, 45%female). Their socioeconomic backgrounds ranged from rural to urban households in Zhaotong, Yunnan Province, with most families in the low-to-middle income range.

2. Academic Achievement

Before the intervention, students' average score was 62.5 (SD=8.3), reflecting a basic but limited understanding of mathematics. After 15 lessons based on active and inquiry-based learning, the post-test mean rose to 70.3 (SD=7.1). A paired-sample t-test confirmed this difference was statistically significant (t (29) =5.21, p<0.001), with a large effect size (d=1.39).

Table 2 Academic Achievement: Descriptive and Inferential Statistics(n=30)

Test	Mean(M)	SD	Variance	t(29)	p	Cohen's d
Pre-test	62.5	8.3	69.2			
Post-test	70.3	7.1	50.4	5.21	0.000**	1.39

Note. p<0.001

These findings suggest that the intervention improved student performance across the entire group, with reduced score dispersion indicating more consistent outcomes.

3. Problem-Solving Ability

The problem-solving scale revealed similar progress. Pre-test scores averaged 58.2 (SD=7.5), while post-test scores increased to 66.7(SD=6.2). The paired-sample t-test indicated significant improvement (t (29) =5.86, p<0.001), with a large effect size (d=1.37).

Citation: Li, Z., Attapaiboon, T., & Jantharajit, A. (2026). Active and Inquiry-Based Learning to Improve Mathematics Achievement and Problem-Solving in High School, Thailand. Interdisciplinary Academic and Research Journal, 6(2), e293239; DOI: https://doi.org/10.60027/iarj.2026.e293239

Table 5 Problem-Solving Ability: Descriptive and Inferential Statistics (n=30)

Test	Mean (M)	SD	Variance	t (29)	p	Cohen'sd
Pre-test	58.2	7.5	56.3			
Post-test	66.7	6.2	38.4	5.86	0.000**	1.37

Note. $p< 0.001$

This outcome demonstrates that the instructional approach not only enhanced content knowledge but also strengthened strategic reasoning and analytical skills.

4. Correlation Between Achievement and Problem-Solving

Pearson correlation analysis indicated a strong positive relationship between mathematics achievement and problem-solving ability ($r=0.68$, $p<0.001$). Students who performed better in problem-solving tended to achieve higher scores in mathematics, highlighting the mutually reinforcing nature of these two competencies.

Table 6 Correlation Between Academic Achievement and Problem-Solving Ability(n=30)

Variable	1	2
1. Academic Achievement	1	
2. Problem-Solving Ability	0.68***	1

Note. *$p<0.001$

Overall, the intervention significantly improved both academic achievement and problem-solving ability, with large effect sizes in both domains. The strong positive correlation between the two outcomes suggests that cognitive and analytical skills develop in tandem when active and inquiry-based learning strategies are employed.

Discussion

1. Comparison with Existing Research

The findings of this study indicate that active learning and inquiry-based learning (IBL) significantly improved students' mathematics achievement and problem-solving abilities. These results are consistent with a substantial body of prior research. Meta-analyses have shown that active learning enhances student performance and reduces failure rates, largely by increasing

Citation: Li, Z., Attapaiboon, T., & Jantharajit, A. (2026). Active and Inquiry-Based Learning to Improve Mathematics Achievement and Problem-Solving in High School, Thailand. Interdisciplinary Academic and Research Journal, 6(2), e293239; DOI: https://doi.org/10.60027/iarj.2026.e293239

classroom engagement, formative feedback, and learner accountability (Freeman et al., 2014). The improvement in problem-solving ability observed in this study also aligns with research demonstrating how IBL fosters higher-order thinking and knowledge transfer (Chu et al., 2021; Margunayasa et al., 2019). However, the effect sizes observed in this study are notably larger than those commonly reported in the literature. This discrepancy can likely be attributed to the close alignment between the intervention tasks and the assessment instruments, a high level of teacher motivation and implementation fidelity, and the novelty effect in a historically exam-oriented educational environment. This study extends prior findings by demonstrating substantial effect sizes within the specific context of an exam-focused Chinese education system, where traditional methods dominate. While the results are promising, their external generalizability requires further investigation, particularly in diverse educational contexts.

2. Boundaries of Interpretation

Although the intervention produced significant results, the findings are best understood as evidence for the effectiveness of guided inquiry, rather than fully open inquiry. The instructional design in this study provided clear goals, structured scaffolds, and ongoing formative feedback, which helped manage cognitive load while still offering students opportunities for autonomy. In mathematics, where concepts are dense and abstract, fully open inquiry can often result in uneven learning outcomes and potential frustration due to the complexity of the material. Cognitive load theory supports this view, emphasizing that without adequate support, excessive cognitive load can hinder learning (Sweller, 1988). Therefore, the advantages demonstrated in this study should be interpreted as evidence for structured guided inquiry, which aligns with existing models of cognitive support for novice learners, such as those proposed by Vygotsky (1978) and more recent adaptations of his zone of proximal development. This approach effectively balances the need for guided instruction with the development of student independence.

3. Limitations and Threats to Validity

Several limitations should be acknowledged when interpreting the results. First, the study used a single-group pretest-posttest design without a control group, which makes it difficult to rule out alternative explanations such as history effects, test effects, or regression to the mean. Second, while the research instruments demonstrated acceptable reliability, they were researcher-developed and closely aligned with the intervention, which could have inflated the observed effects. The problem-solving scale, which was used to assess students' problem-solving ability, was teacher-rated, which raises the potential for expectancy bias—where the teacher's expectations might influence how they rate student performance. Additionally, there could be some rating bias if teachers unconsciously rated students more favorably due to their involvement in the intervention. This potential bias should be acknowledged in future studies. Third, while the

Citation: Li, Z., Attapaiboon, T., & Jantharajit, A. (2026). Active and Inquiry-Based Learning to Improve Mathematics Achievement and Problem-Solving in High School, Thailand. Interdisciplinary Academic and Research Journal, 6(2), e293239; DOI: https://doi.org/10.60027/iarj.2026.e293239

sample was drawn from a single school in Zhaotong, Yunnan (n = 30), within a specific exam-oriented cultural context, this limits the study's external validity. Finally, the absence of classroom process data (e.g., teacher–student interactions, fidelity checks) prevents the identification of the precise mechanisms driving the observed improvements. These limitations suggest that the findings should be interpreted with caution, and further studies using more rigorous designs are needed to confirm the results.

4. Implications for Policy and Practice

Despite its limitations, this study provides several important insights for educational practice and policy. The significant improvements in achievement and problem-solving ability suggest that traditional, lecture-based, exam-oriented teaching should be reconsidered in favor of more interactive, student-centered approaches. Teachers should incorporate strategies such as group discussions, project-based tasks, and real-world problem-solving into mathematics curricula to foster engagement and transferable skills. At the policy level, curriculum and assessment systems should be reviewed to emphasize reasoning and problem-solving as explicit objectives, rather than focusing narrowly on content mastery.

While the study suggests that policy-level changes could support the integration of active and inquiry-based learning, such recommendations should be considered cautiously. Systemic reforms—such as revising exam blueprints—require broader empirical evidence from diverse educational contexts before they can be effectively implemented. Professional development programs should also move beyond one-off workshops to provide sustained support through peer collaboration, lesson study, and classroom observation, enabling teachers to refine their inquiry-based practices. Furthermore, given the negative impact of student anxiety on learning outcomes (Davey et al., 2022), classrooms should balance challenge with adequate support by providing clear goals, transparent criteria, and constructive feedback to alleviate stress and foster positive learning experiences.

5. Directions for Future Research

Future research should employ more rigorous experimental designs, such as cluster-randomized controlled trials or matched comparison groups, to strengthen causal inference. Additionally, studies should collect classroom process data (e.g., fidelity logs, questioning strategies, task complexity) to identify which components of active and inquiry-based learning are most effective in enhancing student outcomes. Research should also be extended to other contexts and subjects, using delayed posttests and standardized measures to assess the durability and generalizability of the effects over time. Mechanisms underlying the impact of these strategies—such as whether the gains are mediated by factors like self-efficacy, metacognitive regulation, or motivation—should also be explored. Finally, comparative studies that directly test

Citation: Li, Z., Attapaiboon, T., & Jantharajit, A. (2026). Active and Inquiry-Based Learning to Improve Mathematics Achievement and Problem-Solving in High School, Thailand. Interdisciplinary Academic and Research Journal, 6(2), e293239; DOI: https://doi.org/10.60027/iarj.2026.e293239

guided inquiry against traditional instruction or fully open inquiry would provide valuable insights into the boundary conditions for different groups of learners and help clarify which instructional approach is most effective in different contexts.

Conclusion

This study provides valuable evidence supporting the effectiveness of active learning and inquiry-based learning in enhancing both mathematics achievement and problem-solving ability. The recommendations outlined above aim to guide educators, policymakers, and researchers in fostering more engaging and effective learning environments. By continuing to explore and refine these approaches, we can better equip students with the skills needed to succeed in both academic and real-world contexts.

Recommendation

Based on the findings of this study, which demonstrate the positive effects of active learning and inquiry-based learning strategies on academic achievement and problem-solving ability, the following recommendations are made for educators, policymakers, and future research in the field of mathematics education.

Pedagogical Recommendations for Teachers

Integrate Active Learning and Inquiry-Based Learning Strategies. Given the significant improvements observed in both academic achievement and problem-solving ability, it is recommended that educators incorporate active learning and inquiry-based learning strategies into their mathematics curriculum. These student-centered approaches encourage greater student engagement, promote critical thinking, and enhance the application of mathematical concepts in real-world contexts. Teachers should design interactive lessons that encourage students to explore, question, and collaboratively solve problems, fostering an environment conducive to deeper learning.

Specifically, educators should include activities such as group discussions, problem-solving tasks, case studies, and projects that allow students to apply their knowledge in authentic contexts. This not only supports academic performance but also nurtures essential problem-solving skills that students can apply beyond the mathematics classroom.

Provide Training and Support for Teachers

For successful implementation, teachers must receive adequate training in active learning and inquiry-based methods. Training programs should focus on equipping teachers with strategies for managing classroom dynamics, promoting student collaboration, and assessing student outcomes using both formative and summative methods. Schools should support teachers by

Citation: Li, Z., Attapaiboon, T., & Jantharajit, A. (2026). Active and Inquiry-Based Learning to Improve Mathematics Achievement and Problem-Solving in High School, Thailand. Interdisciplinary Academic and Research Journal, 6(2), e293239; DOI: https://doi.org/10.60027/iarj.2026.e293239

providing access to educational technologies, collaborative planning opportunities, and professional learning communities where teachers can share best practices and refine their teaching approaches.

Promote Problem-Solving Tasks in the Curriculum

As problem-solving ability is a key outcome of this study, it is recommended that teachers integrate problem-solving tasks more prominently into the mathematics curriculum. These tasks should include not only routine problems but also real-world applications that require students to use critical thinking, creativity, and collaboration. Teachers should encourage students to approach problems from multiple perspectives, apply various strategies, and reflect on their reasoning processes. By providing opportunities for students to engage with complex, real-world problems, teachers will foster environments where students can develop independent, critical problem-solving skills.

Policy Recommendations for Administrators and Educational Authorities

Encourage Student-Centered Approaches in Mathematics Education. The findings suggest that traditional, lecture-based, exam-oriented teaching should be reconsidered. Policymakers should encourage the adoption of more interactive, student-centered approaches to teaching. This includes incorporating group discussions, project-based tasks, and real-world problem-solving into the curriculum to foster student engagement and the development of transferable skills. Curriculum and assessment frameworks should be reviewed to emphasize reasoning and problem-solving skills, alongside content mastery.

Provide Professional Development for Educators. At the policy level, professional development programs should move beyond isolated workshops and focus on sustained, collaborative support for teachers. Professional development should include peer collaboration, lesson study, and classroom observation, allowing teachers to refine their inquiry-based practices. This will enable teachers to continuously improve their methods and better meet the needs of their students.

Directions for Future Research

Investigate Long-Term Effects of Active and Inquiry-Based Learning

While this study provides compelling evidence of the effectiveness of active learning and inquiry-based learning in improving academic achievement and problem-solving abilities, further research is needed to explore the long-term effects of these strategies. Future studies should examine whether improvements in students' academic performance and problem-solving abilities are sustained over time and whether these skills transfer to other subjects or real-world applications.

Explore the Specific Components of Effective Teaching Strategies

Citation: Li, Z., Attapaiboon, T., & Jantharajit, A. (2026). Active and Inquiry-Based Learning to Improve Mathematics Achievement and Problem-Solving in High School, Thailand. Interdisciplinary Academic and Research Journal, 6(2), e293239; DOI: https://doi.org/10.60027/iarj.2026.e293239

Future research should investigate which components of active and inquiry-based learning contribute most to student success. For example, studies could focus on the role of teacher feedback, student collaboration, or self-regulation in enhancing learning outcomes. Longitudinal studies would provide valuable insights into how these teaching strategies influence students' cognitive and social development over the course of their education.

Address Individual Differences in Learning Styles and Needs

As students have varying learning styles, abilities, and prior knowledge, research should explore how active and inquiry-based learning can be tailored to accommodate these differences. Differentiated instruction, personalized feedback, and the use of adaptive technologies are key areas for investigation. Understanding how to best support diverse learners will ensure that all students benefit from active learning and inquiry-based methods.

Examine the Role of Socio-Emotional Factors

Although not a primary focus of this study, the positive correlation between problem-solving ability and socio-emotional factors such as student motivation and anxiety warrants further research. Exploring how emotional resilience and social responsibility impact academic and problem-solving outcomes could provide deeper insights into the holistic development of students. This could involve examining how teacher-student relationships, classroom environments, and emotional well-being influence learning and achievement, which may further enhance the effectiveness of active learning strategies.

References

Chu, S. K. W., Reynolds, R. B., Tavares, N. J., Notari, M., & Lee, C. W. Y. (2021). *21st-century skills development through inquiry-based learning: From theory to practice*. Springer International Publishing. https://doi.org/10.1007/978-3-030-59940-0

Darmuki, A., & Hariyadi, A. (2019). Eksperimentasi model pembelajaran Jucama ditinjau dari gaya belajar terhadap prestasi belajar mahasiswa mata kuliah berbicara di Prodi PBSI IKIP PGRI Bojonegoro. *KREDO: Jurnal Ilmiah Bahasa dan Sastra, 3*(1), 62–72. https://doi.org/10.24176/kredo.v3i1.3079

Davey, G. C. L., Meeten, F., & Field, A. P. (2022). What's worrying our students? Increasing worry levels over two decades and a new measure of student worry frequency and domains. *Cognitive Therapy and Research, 46*(2), 406–419. https://doi.org/10.1007/s10608-021-10266-6

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences of the United States of America, 111*(23), 8410–8415. https://doi.org/10.1073/pnas.1319030111

Hadi, S., & Novaliyosi, N. (2019, November). TIMSS Indonesia (Trends in International Mathematics and Science Study). In *Prosiding Seminar Nasional & Call For Papers*. Universitas Siliwangi. http://jurnal.unsil.ac.id/

Hopfenbeck, T. N., Lenkeit, J., El Masri, Y., Cantrell, K., Ryan, J., & Baird, J. A. (2018). Lessons learned from PISA: A systematic review of peer-reviewed articles on the Programme for International Student Assessment. *Scandinavian Journal of Educational Research, 62*(3), 333–353. https://doi.org/10.1080/00313831.2016.1258726

Jaiswal, P., & Al-Hattami, A. (2020). Enhancing learners' academic performances using student-centered approaches. *International Journal of Emerging Technologies in Learning (iJET), 15*(16), 4–16. https://doi.org/10.3991/ijet.v15i16.15903

Johnson, C. (2020). Teaching the test: How schools discourage phronesis. In D. C. Pritchard (Ed.), *Vice epistemology* (pp. 225–238). Routledge. https://doi.org/10.4324/9780429023101

Kusuma, A. P. (2017). Implementasi model pembelajaran Student Teams Achievement Division dan Team Assisted Individualization ditinjau dari kemampuan spasial siswa. *Al-Jabar: Jurnal Pendidikan Matematika, 8*(2), 135–144. https://doi.org/10.24042/ajpm.v8i2.2014

Liu, L., & Zhang, J. (2021). *Successful online learning experience: Perceptions of Chinese undergraduate students*. *Journal of Education and Learning, 10*(1), 74–81. https://eric.ed.gov/?id=EJ1283293

Liu, T. (2020). Cultivating students' innovation ability in junior high school mathematics teaching under the new curriculum standards. *Legendary Stories: Lectures from a Hundred Schools, 10*, 45–47. [Journal in Chinese]

Liu, Y. (2018). The skillful use of "one question, multiple solutions" to penetrate mathematical core literacy. *Mathematics and Chemistry Learning (High School Edition), 2*, 10–13. [Journal in Chinese]

Margunayasa, I. G., Dantes, N., Marhaeni, A. A. I. N., & Suastra, I. W. (2019). The effect of guided inquiry learning and cognitive style on science learning achievement. *International Journal of Instruction, 12*(1), 737–750. https://doi.org/10.29333/iji.2019.12147a

Sindall, R., & Barrington, D. J. (2020). Fail fast, fail forward, fail openly: The need to share failures in development. *Research for All, 4*(1), 86–96. https://doi.org/10.14324/RFA.04.1.08

Sweller, J. (1988). *Cognitive load during problem solving: Effects on learning*. *Cognitive Science, 12*(2), 257–285. https://doi.org/10.1207/s15516709cog1202_4

Teng, M. F., & Yang, Z. (2023). Metacognition, motivation, self-efficacy belief, and English learning achievement in online learning: Longitudinal mediation modeling approach. *Innovation in*

Language Learning and Teaching, 17(4), 778–794. https://doi.org/10.1080/17501229.2022.2088273

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.