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ANALYSIS OF STUDENTS' MATHEMATICAL PROBLEM-SOLVING ABILITY ON THE CONCEPT OF LIMITS REVIEWED FROM THEIR MATHEMATICAL THINKING STYLES AT MAS PP AMIRUDDINIYAH PURBA SARI, BANDAR TINGGA VILLAGE, BILAH HULU SUBDISTRICT, LABUHANBATU REGENCY

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Abstract

This study aims to explore how students understand and solve problem-solving tasks on the topic of function limits, as well as how their thinking styles influence their performance. The research used a qualitative approach supported by quantitative data. Data were collected through tests, thinking-style questionnaires, and interviews with 30 eleventh-grade students. The results show that students' abilities vary: some can solve the problems well, some perform moderately but still make mistakes, and some struggle to understand the steps involved. Most students fall into the moderate category. Students with an analytic thinking style tend to be more organized and able to follow problem-solving steps clearly, while those with less systematic thinking styles often stop midway or feel confused about which step to take next. These findings indicate that students' thinking styles affect how they solve problems. Therefore, teachers need to adjust their teaching strategies to match students' thinking characteristics so that they can better understand the concepts and improve their problem-solving skills.

***Keywords**: Problem Solving, Function Limits, Thinking Styles.*

INTRODUCTION

Mathematics plays an important role in helping students develop logical, analytical, and critical thinking skills. Mathematics learning does not only require students to be able to perform calculations, but also to understand problems, select appropriate strategies, and produce correct solutions. This ability, known as problem-solving ability, is one of the indicators that shows whether students truly understand mathematical concepts or merely memorize solution procedures (Anugerah et al, 2024). Previous studies have shown that students who possess strong conceptual understanding tend to perform better in solving various types of mathematical problems (Fitriyana & Sutirna, 2022).

The concept of limits is one of the essential topics in the high school curriculum. It serves as a foundation for learning calculus topics such as derivatives and integrals. Unfortunately, many students struggle with limits due to the abstract nature of the materialn (Azzahra & Rahayu, 2025; Pathuddin et al, 2023). Students are required to imagine the value of a function approaching a certain number rather than computing it directly. Several studies have revealed that students often make errors when connecting limit values represented symbolically, graphically, or verbally. Representational errors, procedural errors, and misconceptions in distinguishing between the value of a function and the value of a limit are among the common issues that arise (Azzahra et al, 2025; KEPA & RAMLI, 2021; Mutahharah et al, 2022). These findings indicate that students' conceptual understanding of limits in schools still needs improvement. In addition, the development of HOTS-based problems has been proven to enhance students' critical thinking and problem-solving abilities in abstract mathematics topics, including limits (Khamdanah et al, 2022).

Difficulties in understanding limits are influenced not only by students' mastery of the material but also by their mathematical thinking styles. Every student has a different thinking style, such as analytic, visual, reflective, or global (Khairunnisa et al., 2022; Yuliana & Hartini, 2022). These thinking styles influence how students process information, choose problem-solving strategies, and evaluate their answers. Recent research has shown that students with analytic and reflective thinking styles tend to perform better when solving complex mathematical problems, including limit problems, because they are able to trace each step of the problem-solving process more carefully (Pathuddin et al., 2025; Ulandari et al., 2025). In contrast, students who rely solely on procedural steps without understanding the underlying concepts often face difficulties when dealing with problems that require deeper reasoning (Patingki et al, 2022; Yulianto et al, 2024).

A similar situation is found at MAS PP Amiruddiniyah Purba Sari. Many students are able to solve simple limit problems but struggle when given more challenging or non-routine problems (Aryani et al, 2024). Observations indicate that students tend to memorize formulas or procedures without understanding their meaning. As a result, they fail to connect the concept of limits with graphs or other mathematical representations, leading to inaccurate solutions. This condition suggests that variations in students' problem-solving abilities may be influenced by differences in their mathematical thinking styles.

Several studies have examined problem-solving ability and students' thinking styles, yet research specifically linking these two aspects in the context of limit material is still very limited. Pathuddin et al. 2023, reported that difficulties in understanding limits are associated with low metacognitive skills, but their study did not consider differences in students' thinking styles. Moreover, research on thinking styles in relation to limit problems has rarely been conducted, even though this topic requires strong representational and analytical abilities (Marlina, 2025; Sihotang et al, 2021).

A review of previous studies highlights a clear research gap. Many studies focus solely on problem-solving ability without considering students' thinking styles (Hutagaol et al, 2024; Wahyuni et al., 2024). On the other hand, research on thinking styles often does not examine limit material, which is abstract in nature (Muqtada & Rahayu, 2023). In addition, no studies have been found that explore the role of thinking styles in limit problem-solving within the context of schools such as MAS PP Amiruddiniyah Purba Sari, which has distinct educational characteristics compared to conventional schools.

Various approaches can be used to improve students' problem-solving abilities, such as problem-based learning, the use of visual media, or strengthening mathematical representation techniques (Hapsah et al., 2025; Wulandari & Machromah, 2024). However, the effectiveness of these approaches depends on their alignment with students' thinking styles. Without understanding how students think, teachers will find it difficult to select appropriate instructional strategies. Therefore, this study seeks to analyze students' problem-solving abilities based on their mathematical thinking styles in order to obtain a more comprehensive picture that can serve as a foundation for designing more suitable learning strategies.This study aims to describe the relationship between mathematical thinking styles and problem-solving abilities in the topic of limits. The results are expected to assist teachers in designing more targeted instructional models and contribute to the field of mathematics education, particularly in understanding limit concepts and variations in students' thinking styles (Grahita, 2022; Hana & Ramlah, 2025; Setiana et al., 2021).

The novelty of this study lies in its focus on the relationship between students' mathematical thinking styles and their ability to solve limit problems-an area that has rarely been explored in previous research. Most existing studies separately discuss problem-solving skills or thinking styles, but they do not specifically connect these two aspects within the context of limit concepts, which are known to be abstract and challenging for students. This study also brings a new perspective by examining students from a pesantren-based school, MAS PP Amiruddiniyah Purba Sari, whose learning environment and characteristics differ from conventional schools. In addition, the use of a combination of tests, questionnaires, and interviews provides a more comprehensive understanding of how students with different thinking styles approach, process, and solve limit problems. These aspects collectively form the key novelty of this research.

RESEARCH METHODS

This study employed a descriptive qualitative approach supported by quantitative data. The qualitative approach was selected because the research focused on obtaining an in-depth understanding of students' thinking processes in solving limit function problems, while the quantitative data served as a complement to identify patterns of problem-solving abilities through test and questionnaire scores. This study did not provide any specific treatment to the subjects; instead, it described the students' abilities and thinking styles as they naturally appeared based on field findings. The research was conducted at MAS PP Amiruddiniyah Purba Sari, located in Bandar Tingga Village, Bilah Hulu District, Labuhanbatu Regency. The implementation took place during the even semester of the 2025/2026 academic year, covering the stages of instrument preparation, data collection through tests, questionnaires, and interviews, as well as data analysis. The selection of the research site was based on preliminary observations indicating that students still experienced difficulties in understanding the concept of limits and had not yet demonstrated optimal problem-solving abilities.

The objects of this study were students' mathematical problem-solving abilities and mathematical thinking styles in the topic of limit functions. The subjects consisted of 30 eleventh-grade students who had previously learned the topic. The subjects were selected using purposive sampling, as only students who had studied limits were considered relevant sources of information. This technique also allowed the researcher to select students categorized into high, medium, and low ability levels based on test results, thereby yielding more comprehensive data. The research procedure consisted of three stages: preparation, implementation, and analysis. In the preparation stage, the researcher developed research instruments consisting of a problem-solving ability test, a mathematical thinking style questionnaire, and an interview guide. These instruments were then validated for content by expert lecturers to ensure alignment between the indicators and the research objectives. After being revised according to the validators' suggestions, the instruments were ready to be used.

The implementation stage began with administering the test to all eleventh-grade students to measure their abilities based on Polya's problem-solving steps. Following the test, the questionnaire was distributed to determine the students' thinking style tendencies. Based on the results of the test and questionnaire, representatives from the high, medium, and low categories were selected for further interviews. The interviews were conducted using a semi-structured format, allowing the researcher to explore in depth the students' thinking processes while solving limit problems. The analysis stage was carried out after all data had been collected, involving the processing of test scores, calculation of questionnaire results, and analysis of interview data.

The main instruments used in this study were a problem-solving ability test, a mathematical thinking style questionnaire, and a semi-structured interview guide. The problem-solving ability test consisted of two non-routine essay questions on limit functions, constructed based on Polya's four steps: understanding the problem, devising a plan, carrying out the plan, and looking back. Each student's response was scored using a rubric that assessed the quality of their solution according to these indicators. Test validity was obtained through content validity, assessed by two mathematics education experts who provided feedback on the alignment of indicators with the measurement objectives. Reliability was ensured through inter-rater reliability analysis.

The questionnaire was used to identify students' mathematical thinking styles. It consisted of 20 statements on a Likert scale from 1 to 5, measuring four thinking styles: visual, analytic, reflective, and global. Each aspect was designed to assess how students receive, process, and interpret mathematical information. Content validity was established through expert judgment, while reliability was measured using Cronbach's Alpha, with an alpha value above 0.70 indicating acceptable reliability. The third instrument, the semi-structured interview guide, served to explore students' thinking processes more deeply based on their test and questionnaire results. The guide included questions about how students understood the problems, their reasons for choosing specific strategies, and how they verified their answers. The flexible nature of the interview allowed students to express their thoughts naturally.

Data collection techniques in this study included tests, questionnaires, and interviews. The test was used to assess students' problem-solving abilities, the questionnaire to determine their dominant thinking styles, and the interviews to clarify test and questionnaire findings as well as to explore students' reasons for selecting specific strategies. Test data were analyzed by categorizing students' scores into high, medium, and low levels based on predetermined score ranges. Questionnaire data were analyzed by calculating the scores for each aspect to identify the dominant thinking style. Interview data were analyzed using Miles and Huberman's qualitative analysis steps: data reduction, data display, and conclusion drawing. The credibility of qualitative data was ensured through source triangulation and method triangulation. Source triangulation was conducted by comparing information obtained from students in the high, medium, and low categories. Method triangulation was conducted by comparing findings from tests, questionnaires, and interviews. In addition, member checking was performed by confirming interview interpretations with the students to ensure the accuracy of meaning. The analysis and conclusions were also consulted with the academic supervisor to ensure objectivity and accuracy.

RESULT AND DISCUSSION

Result

This research was conducted at MAS PP Amiruddiniyah Purba Sari, located in Bandar Tingga Village, Bilah Hulu District, Labuhanbatu Regency. The purpose of the study was to describe students' mathematical problem-solving abilities in relation to their mathematical thinking styles. Data were obtained through tests, questionnaires, and interviews, and were analyzed qualitatively using descriptive methods in accordance with the steps of the research procedure. The analysis was carried out based on Polya's problem-solving indicators: understanding the problem, devising a plan, carrying out the plan, and looking back.

1. Results of the Mathematical Problem-Solving Ability Tes

a. Categories of Problem-Solving Ability

Table 1. Score Categorization

Category	Score Range	Number of Student
High	80–100	10
Medium	40–79	14
Low	0–39	6

Table 1. shows that students' mathematical problem-solving abilities are divided into three categories: high, medium, and low. A total of 10 students fall into the high category with scores ranging from 80–100, indicating that they are able to understand the problems, plan appropriate strategies, and carry out the problem-solving steps effectively. The largest number of students is in the medium category, totaling 14 students with scores of 40–79, who are generally able to solve most of the problems but still make several mistakes in choosing strategies or performing calculations. Meanwhile, 6 students fall into the low category with scores of 0–39, showing that they experience difficulties from the initial stage of understanding the problem to determining the solution steps. Overall, this score distribution indicates that most students are still in the medium category, suggesting the need for improvement in conceptual understanding and problem-solving strategies.

2. Results of the Mathematical Thinking Style Questionnaire

The questionnaire consisted of 20 statements grouped into four categories: visual (1–5), analytic (6–10), reflective (11–15), and global (16–20). The summary is shown below:

Table 2. Summary of Thinking Style Scores and Dominant Styles

Thinking Style	Number of Students
Analytic	17
Visual	8
Reflective	2
Global	1
Mixed	2

The thinking styles table shows that most students have an analytic thinking style, with a total of 17 students, meaning they tend to think systematically, logically, and in a structured way when solving problems. There are 8 students with a visual thinking style, who usually understand problems more easily when accompanied by pictures or illustrations. Meanwhile, 2 students have a reflective thinking style, indicating that they are careful, thorough, and like to recheck their work even though it takes more time. Only 1 student has a global thinking style, which means they view problems as a whole but may sometimes overlook important details. In addition, there are 2 students with a mixed thinking style, showing that they do not rely on one dominant pattern of thinking and can use different approaches depending on the situation. Overall, these data indicate that most students are more comfortable using logical and structured steps in solving mathematical problems.

3. Interview Results

Interviews were conducted with student representatives from each score category and thinking style. The results showed the following patterns:

a. High-category students (analytic style)

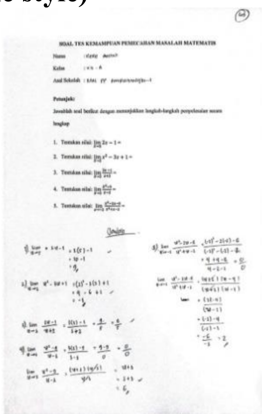

Figure 1. Student Test Sheet for High Category Problem-Solving Ability

The figure shows the student's answer sheet for the mathematical problem-solving test, which consists of five questions on the topic of limits. Based on the work shown, this student completed all the questions very well and achieved a perfect score of 100. In questions 1 to 3, the student was able to directly substitute the given value into the function correctly. In question 4, the student initially obtained an indeterminate form, but understood that such a form needed to be simplified first. The student factored the numerator, canceled the common factors, and then substituted the value, resulting in the correct final answer. In question 5, although the student also encountered an indeterminate form at the beginning, they did not stop there. Instead, the student again factored the numerator and denominator, simplified the expression, and substituted the value correctly, ultimately arriving at the right answer. This demonstrates that the student has a strong conceptual understanding of limits and uses systematic problem-solving strategies. When these written results are compared with the interview, it appears that students in the high-score category are generally able to recognize which steps to take when encountering an indeterminate form. They understand when direct substitution is appropriate and when factoring or simplification is necessary. This student's thinking process is also orderly, careful, and confident in the steps taken. This aligns with the interview findings, which show that high-performing students typically possess more mature analytical abilities and are able to solve problems using appropriate strategies that lead them to the correct answers.

b. Students in the medium category (visual / light analytic thinking style)

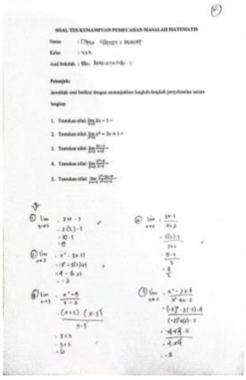

Figure 2. Student Test Sheet for Medium Category
Problem-Solving Ability

The figure shows the student's answer sheet for the mathematical problem-solving test on the topic of limits. Students were asked to solve five limit problems and show their steps. From the answers provided, the student was able to correctly solve the first four questions. In questions 1, 2, and 3, the student directly substituted the value into the function, and the results were correct. In question 4, the student understood that the expression produced an indeterminate form, so they factored and simplified it before substituting the value, resulting in the correct answer. However, in question 5, the student made an error by directly substituting the value into the function without factoring first, even though the expression also produced an indeterminate form. As a result, the final answer was incorrect. When these results are compared with the interview, a clear pattern emerges that matches the student's level of ability. Students with higher ability can usually identify the steps needed, including factoring when encountering an indeterminate form. Students in the medium category are able to handle problems that require direct substitution but still struggle when additional techniques, such as factoring, are needed. Meanwhile, students with lower ability tend to insert values directly without checking the form of the problem, which often leads them to stop midway or produce incorrect answers when faced with an indeterminate form. Overall, this figure illustrates that differences in student ability can be seen from how they think and choose strategies when solving limit problems.

c. Students in the low category (impulsive / global thinking style)

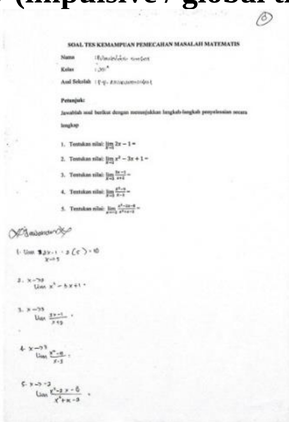

Figure 3. Student Test Sheet for Mathematical Problem-Solving
Ability in the Low Category

The figure shows a student's answer sheet from a mathematical problem-solving test on the topic of function limits. The sheet contains five limit problems that should be solved completely with the required steps. However, based on the student's work, it is clear that they only wrote a small portion of the answers and did not complete the given problems. In question number 1, the student wrote a few initial steps by substituting the value 5 into the function, but the final calculation was not completed. Meanwhile, for questions 2 through 5, the student only wrote the limit expressions without any further process or final answers. This indicates that the student did not understand or was unable to proceed with the necessary problem-solving steps, especially for questions that require substitution or factorization.

When these results are compared with the interview, the findings are consistent. Students in the low-score category often feel confused about how to start the problem and tend to stop midway through the process. They recognize the form of the problem but do not know what step to take next. Such students commonly express fear of making mistakes, uncertainty in choosing a method, and lack of confidence in their own abilities. Their thinking style tends to be trial-and-error and unsystematic, so when faced with a difficult problem, they stop immediately without trying alternative strategies. The figure highlights the differences in how low-category students work compared to those in the moderate or high categories, where low-category students rarely write complete solutions and struggle to explain the steps needed to solve limit problems.

4. Data Triangulation

Based on the answer sheet, it is clear that the student in the low category was unable to complete the limit problems given. They only wrote a few steps on question number 1, limited to substituting a number into the function without continuing the calculation. For questions 2 to 5, the student merely copied the limit expressions without attempting any solution. This shows that the student had significant difficulty in initiating the solution process and did not know what to do after writing the initial form of the problem. When compared with the interview findings, the results align. Low-category students admitted feeling confused when starting the problems, afraid of making mistakes, and often stopped halfway because they were unsure of the next step. Their thinking style was generally unstructured and based on trial and error, causing them to stop working when the problem seemed difficult without trying alternative strategies. The consistency between test results and interview explanations indicates that data triangulation is fulfilled, as both sources reinforce the same understanding of the low-category student's abilities.

Discussion

The findings of this study reveal that students' problem-solving abilities on the topic of limits vary widely and are strongly influenced by their mathematical thinking styles. These results reinforce previous research emphasizing that thinking style is a key factor affecting how students process information, choose strategies, and make decisions when solving mathematical problems. In this study, students with an analytical thinking style were the most dominant and consistently demonstrated stronger problem-solving skills compared to those with other thinking styles. This can be seen from the way they followed Polya's steps systematically, identified indeterminate forms accurately, and immediately selected suitable strategies such as substitution, factorization, or algebraic simplification.

Students with a visual thinking style generally fell into the moderate category. They were capable of understanding straightforward problems but struggled when the tasks required more complex algebraic manipulation. Although they could grasp the overall idea of the problem, they did not always succeed in connecting visual representations with the symbolic procedures needed to solve limit problems. This aligns with the theory of mathematical representation, which states that difficulties often arise when students have to transition between visual and symbolic forms of representation.

Meanwhile, students with a reflective thinking style tended to be careful and detail-oriented, yet they often took longer to make decisions. They could review and check their steps thoroughly, but their slow start in determining the initial strategy frequently caused them to run out of time and fail to complete all problems. In contrast, students with a global or impulsive thinking style tended to make more mistakes. They often substituted values immediately without examining the structure of the function, leading them to stop when encountering an indeterminate form. This indicates that a global thinking style—which focuses more on the overall picture than on specific details-is less suitable for limit problems that require procedural accuracy.

An important insight from this research is that high-performing students were mostly from the analytical thinking group, while low-performing students were dominated by those with global or impulsive styles. Moreover, the triangulation of data-from tests, questionnaires, and interviews-showed consistent results, strengthening the validity of the findings. These conditions highlight the need for learning strategies that consider the diversity of thinking styles. Teachers should integrate approaches that support all types of learners, such as using a combination of visual representations, clear procedural guidance, and emphasis on reasoning and reflection. By doing so, instruction on limits can go beyond procedural fluency and enhance conceptual understanding, thereby improving students' problem-solving abilities more evenly.

CONCLUSION

From the test results given to 30 students, it was found that most students were in the moderate category, with 14 students scoring between 40–79. Ten students were in the high category with scores of 80–100, while six students were in the low category with scores of 0–39. Students in the high category were able to solve all limit problems well, following Polya's problem-solving stages systematically, such as understanding the problem, choosing the right strategy, performing substitution or factorization, and checking their answers. Students in the moderate category could complete simpler problems, such as direct substitution, but often made mistakes when the problems required additional steps like factorization. Students in the low category struggled from the beginning, writing only partial steps and often stopping before completing the solutions.

The questionnaire results showed that the analytic thinking style was the most dominant, with 17 students categorized as analytic thinkers, followed by 8 visual, 2 reflective, 1 global, and 2 mixed. Students with an analytic thinking style tended to perform better and solve the problems correctly, while those with visual, reflective, or global styles experienced more difficulties. Interview findings were also consistent with the test and questionnaire results: low-category students reported feeling confused, afraid of making mistakes, and easily giving up, while high-category students could explain their strategies clearly and confidently. Thus, the data from the test, questionnaire, and interview support one another, indicating that students' mathematical problem-solving abilities are strongly influenced by their thinking styles, with clear differences between the high, moderate, and low categories.

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