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Analysis Of Students' Problem-Solving Abilities *Open-Ended* Type Problems In Class XI IPA SMAN 1 Kota Solok

Ade Syafrinaldo[1)], Suherman Suherman[2)]✉
[1)] *Department of Mathematics, Universitas Negeri Padang, Padang, Indonesia*
E-mail: Ade14syafrinaldo@gmail.com
✉[2)] *Department of Mathematics, Universitas Negeri Padang, Padang, Indonesia*
E-mail: Suherman@fmipa.unp.ac.id

✉ Correspondence Author

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Abstract
The purpose of this study is to reveal whether students' problem-solving abilities have changed in solving problems, especially *Open-ended problems* . The application of *Open-ended type questions* is used as an effort to train students' problem-solving abilities in mathematics learning. This study is a combination of descriptive research and Pre-experiment with *a one group pre-test-post-test design* . The conclusions of this study are 1) The problem-solving abilities of class XI IPA 5 students of SMAN 1 Kota Solok who have been trained using *Open-ended type problem-solving ability questions* in learning, have changed towards the better compared to before. 2) The application of learning using *Open-ended questions* helps students to play an active role during learning activities because it can help students be more open in developing various answers in solving problems.

INTRODUCTION

Mathematics is a universal science that underlies the development of modern technology, plays a vital role in various disciplines, and develops human reasoning. Through learning mathematics, a person can develop logical, analytical, systematic, critical, and creative thinking skills, as well as the ability to collaborate (Sihaloho et al., 2017; Zulkarnaen et al., 2022). Mathematics is also a basic science encompassing several aspects, including applied and reasoning, which play a role in enhancing mastery of science and technology. From this explanation, it is clear that mathematics serves as a servant of science. This means that mathematics, in addition to being a science that develops for itself, also serves science in its development and operations.

Recognizing the importance of mathematics in the development of students' knowledge, the government has implemented or made mathematics compulsory from elementary school (SD) to high school (SMA) and onward to university. This aims to equip students with the ability to think logically, analytically, systematically, critically, and creatively in mathematics, in accordance with its function (Fatmawati et al., 2022; Sasmita & Kusuma, 2023). In mathematics learning, there are eight objectives students are expected to achieve. These objectives are stated in the Minister of

Education and Culture Regulation (Permendikbud) No. 58 of 2014, including understanding mathematical concepts, using reasoning, solving problems, and communicating ideas.

One of the things that attracts the attention of researchers, regarding students' thinking abilities in mathematics learning, is problem-solving abilities. Problem-solving abilities are a product of a person's thinking process. Problem-solving abilities according to Polya in Saraswati & Prasetyo, (2020); Wiranti, (2022) involve several aspects, namely being able to understand a problem, build or plan ideas, and implement them, as well as review what has been done. Along with current developments, the problems of life that humans must face are also increasingly complex, so that with problem-solving abilities, students will have various solutions to a problem and can express their ideas or concepts to solve the given problem.

The Program for International Student Assessment , abbreviated as PISA, is an international assessment of the skills and abilities of 15-year-old students. PISA is held every three years and is sponsored by the OECD (*Organization for Economic Co-operation and Development*) . The results of the 2012 PISA study placed Indonesia at 64th place out of 65 participating countries. In mathematics, Indonesia obtained an average score of 375, while the international average score was 494. It can be seen that Indonesia's average score in mathematics is far below the international average. Mathematical literacy *is* one of the evaluation focuses in PISA. The purpose of the PISA mathematical literacy test is to measure how students apply their knowledge to solve a series of problems in various real-world contexts. To solve these problems, students must work on a number of mathematical competencies. The competencies that students must master to work on mathematical literacy problems include: the only one is the competence to communicate mathematically. Based on PISA results above can it is said that the ability of Indonesian students to solve mathematical literacy problems that require the ability to communicate in various situations is still low.

Based on the description above, it can be seen that the mathematical problem-solving abilities of students in Grade X MIPA 5 are still low . One reason Low problem-solving skills are characterized by a teacher-centered learning process and a lack of practice in solving problem-solving questions. The learning process is still dominated by only the most intelligent students . This results in low problem-solving skills in students .

Problem-solving skills are a person's ability to understand a problem, plan a solution, implement it, and review what has been accomplished. Problem-solving skills need to be developed in mathematics learning. Therefore, learning activities should contribute to developing students' problem-solving skills. Problem-solving skills are one of the goals of mathematics learning (Rasimin & Ma'mun, 2021; Wiwin et al., 2017).

If the problem of students' low problem-solving abilities is left untreated, it can result in one of the goals of mathematics learning not being achieved. To overcome the above problem, one way that can be done is by implementing problem-solving questions that can make students more active during the learning process and able to apply ideas and concepts from previously studied material to the problem. One question that can be applied to overcome this problem is the provision of *open-ended questions* . *Open-ended* questions are useful for developing students' thought processes so they can train their thinking skills and find solutions, so that problems can be solved in various ways or solutions.

Journal of Education, Teaching, and Learning
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Based on the description above, a study was conducted with the aim of seeing and describing the differences in students' problem-solving abilities in solving *Open-ended type questions* with their previous abilities in class XI IPA SMAN 1 Kota Solok during implementation in learning and to reveal whether the problem-solving abilities of class XI IPA SMAN 1 Kota Solok students given *Open-ended type questions* in the learning process will experience changes and to see how the problem-solving abilities of class XI IPA SMAN 1 Kota Solok students when given *Open-ended type questions* in the learning process . The problem-solving ability indicators used in the study are the problem-solving ability indicators according to Polya [4].

METHODS

This research is a combination of pre-experimental and descriptive research. Descriptive research aims to describe the development of problem-solving abilities of class XI IPA students at SMA 1 Kota Solok during the implementation of *Open-ended questions* in learning. Pre-experimental research aims to reveal whether the problem-solving abilities of students who use *Open-ended questions* experience changes in their abilities with the research design used *One Group Pre-test-Post-test Design* [3].

The sample in this study was class XI IPA 5 as the research subjects selected by *purposive sampling*. The research subjects' prior knowledge was controlled by administering *a pre-test* at the beginning of the study. The independent variable in this study is open-ended questions. The dependent variable is students' problem-solving abilities. The data used in this study are primary and secondary. The primary data is students' problem-solving abilities, obtained from *pre-tests, post-tests*, and interviews. The secondary data is the number of students who participated in the study.

The research procedure is divided into 3 stages, namely the preparation stage, the implementation stage, and the completion stage. The research instruments used are problem-solving ability tests and interviews. The problem-solving ability test is given at the beginning (*pre-test*) and at the end (*post-test*), and is used to see the improvement of problem-solving abilities. The data analysis technique used is descriptive data analysis to see the development of problem-solving abilities, and the t-test to reveal whether the problem-solving abilities of students who use *open-ended type questions* are better than those who do not use *open-ended questions* in class X IPA SMA 1 Kota Solok.

The data obtained was analyzed by calculating the increase in ability by looking at the difference in *pre-test* - *post-test* (d) values and the normalized t-test as in [1] with the following equation:

$$d = posttest - pretest$$

$$t_{hitung} = \frac{Md}{\sqrt{\frac{\sum x^2 d}{N(N-1)}}}$$

After obtaining the difference between *the pre-test* and *post-test values* , a hypothesis test was conducted using the normal *gain value. The hypothesis test aims to determine whether the open-ended* questions given have an effect or not. The t-test was conducted using Microsoft Excel software, where the statistical hypothesis is: If $t_{tabel} \geq t_{hitung}$ there is no significant difference between the two data points, if $t_{tabel} \leq t_{hitung}$ there is a significant difference between the two data

Journal of Education, Teaching, and Learning
Volume 10, 2025 Special Issue. Page 278-285
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points, it means that the treatment we administered had an effect on the research subjects with α = 0.05.

RESULT AND DISCUSSION

A. *Pre-test and Post-test* Data on Core Competency 1

Table 1. Students' Problem-Solving Abilities 1

Group	N	Max Score	X_{max}	X_{min}	$\bar{X}$	$\bar{G}$
Pre-test	36	100	96	0	60.61	17.22
Post-test	36	100	96	32	77.94	

Table I shows that the average mathematical problem-solving ability of grade XI MIPA 5 students during *the Post-test* was higher than the average *Pre-test score* . This is also evident from the higher minimum *Post-test score compared to the Pre-test* . Coincidentally, the maximum score of *the Pre-test* and *Post-test* were the same. The gain score for Basic Competency 3.3 was 17.22. The gain score was used to assess changes in students' problem-solving abilities.

Based on Table I, a t-test was carried out, with values $\boldsymbol{\alpha} = \mathbf{0,05}$ and $\boldsymbol{db} = \mathbf{35}$ then the calculated t = 6.069 is obtained . Meanwhile t_{table} with a 95% confidence level is t_{table} = 1.645 , because t_{count} (6.069) > t_{table} (1.645) then there is a significant difference between the two data in question so that it can be said that the results of the analysis of the learning process that has introduced *open-ended questions* are more influential than before the *open-ended questions were introduced*.

B. *Pre-test and Post-test* Data on Core Competency 2

Table 2. Students' Problem-Solving Abilities 2

Group	N	Max Score	X_{max}	X_{min}	$\bar{X}$	$\bar{G}$
Pre-test	36	100	100	0	74.11	17.69
Post-test	36	100	100	0	91.81	

Table II shows that the average mathematical problem-solving ability of grade XI MIPA 5 students during *the Post-test* was higher than the average *Pre-test score* . This is also evident from the higher minimum *Post-test score compared to the Pre-test* . Coincidentally, the maximum score of *the Pre-test* and *Post-test* were the same. The gain score for Basic Competency 3.4 was 17.69. The gain score was used to assess changes in students' problem-solving abilities.

Based on Table II, a t-test was carried out, with values $\boldsymbol{\alpha} = \mathbf{0,05}and\boldsymbol{db} = \mathbf{35}$ then the calculated t = 2.946 is obtained . Meanwhile t_{table} with a 95% confidence level is t_{table} = 1.645 , because t_{count} (2.946) > t_{table} (1.645) then there is a significant difference between the two data in question so that it can be said that the results of the analysis of the learning process that has introduced *open-ended questions* are more influential than before the *open-ended questions were introduced* . The interpretation of the increase in the mathematical communication skills of the sample group is shown in the table and diagram below:

Journal of Education, Teaching, and Learning
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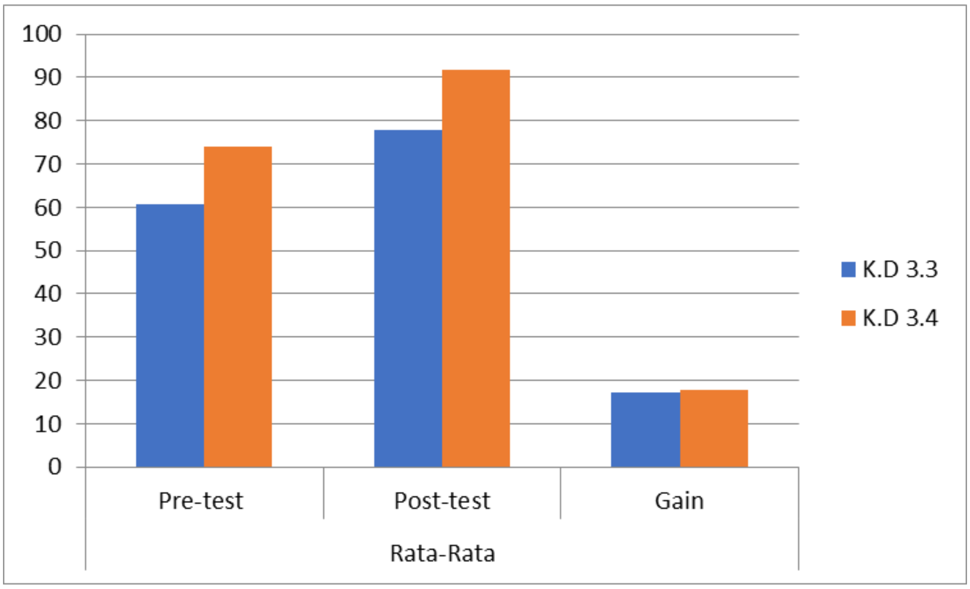

Figure 1. Comparison of Average Results of Pre-test, Post-test and Gain Score of Students

C. Interview

Based on interviews conducted with ten students, it can be concluded that teachers have not yet introduced problem-solving questions to students. When students were introduced to the learning process, which began with *a pre-test* and ended with *a post-test , participants found it easier to follow the learning process. The open-ended* problem-solving questions used also helped students to develop their abilities well. In the interviews, researchers also observed students' abilities based on the completion of the *post-test questions* given at that time. It was proven that after learning with *open-ended questions* , students were generally able to solve *open-ended questions* well, especially regarding matrix material.

The development of students' problem-solving abilities is driven by the implementation of *open-ended questions* . This implementation is one way to develop students' problem-solving abilities in schools and can effectively develop students' abilities.

Discussion

During the research, several problems were discovered. Students were not yet trained to start lessons on time, so they tended to arrive late to class, which resulted in them being half-assed in their learning. At the start of the exam, students tended to be noisy and sometimes unprepared for the exam, both physically and environmentally. Teachers motivated students with stories and sometimes offered advice at the end of the meeting or lesson as an effort to minimize these negative outcomes.

During the implementation of learning, participants were asked to work on questions, worksheets, and read books but all of that was not implemented, they immediately asked their friends and sometimes there were those who saw their friends without thinking first, but the teacher tried to provide direction and explanation to students that in working on questions, they could work on the parts they understood first and to work on questions during the quiz, they should work according to their abilities. Students tended to take a long time in working on worksheets, taking notes and always wanting to be explained by the teacher, so the teacher also reminded them to study the previous material and the material to be studied at home so that the implementation of learning ran smoothly, not only from the teacher. During the research, there were several days where the study time was shortened due to events at school, so that it affected the implementation of the research because the time available for each stage was increasingly limited (Mufarrohah & Setyawan, 2024; Surya et al., 2017).

The results of this study demonstrate that the use of open-ended problems in mathematics learning significantly improves students' problem-solving abilities. Before the implementation, students tended to rely on fixed procedures and single-solution thinking patterns, which limited their flexibility in approaching mathematical challenges. However, after being exposed to open-ended problem situations, students became more capable of exploring various solution strategies and reasoning processes. This shift reflects not only cognitive development but also a change in mindset from viewing mathematics as a subject with one "correct" answer to one that values creativity and reasoning diversity (Devi, 2023; Wulandari & Fitria, 2021).

Furthermore, the findings indicate that open-ended learning encourages students to take an active role during the learning process. Students were more engaged in discussing ideas, testing multiple hypotheses, and comparing reasoning with their peers. This aligns with the constructivist learning theory, which emphasizes active participation and knowledge construction through interaction and exploration. The classroom environment became more dynamic, where mistakes were not seen as failures but as opportunities for reflection and improvement. This change in classroom culture contributed significantly to the improvement in problem-solving competence (Handayani, 2021; Zohri et al., 2025).

In addition, the application of open-ended problems helped teachers better identify students' thinking patterns and misconceptions. Through observing the different solutions generated, teachers could provide more targeted feedback and guide students toward deeper mathematical understanding. This approach proved more effective than traditional closed-ended exercises, which often mask students' reasoning processes. Therefore, the open-ended method not only enhances student performance but also enriches the instructional assessment process, allowing teachers to adapt their pedagogy to individual learning needs (Sundari et al., 2025; Widiyana et al., 2021).

Overall, the study highlights the transformative impact of integrating open-ended problems into mathematics instruction. It fosters higher-order thinking skills, promotes creativity, and nurtures students' confidence in tackling unfamiliar or complex problems. The improvement in problem-solving ability observed among the students of SMAN 1 Kota Solok signifies the potential of this approach to be applied more widely across educational levels. Future research could further investigate the long-term effects of open-ended learning on students' mathematical reasoning, self-efficacy, and collaboration skills to strengthen evidence-based pedagogical practices in mathematics education (Mastarani, 2020; Mayani, 2022; Santika et al., 2023).

CONCLUSIONS

Based on the analysis results, it can be concluded that the problem-solving abilities of class XI IPA 5 students of SMAN 1 Kota Solok improved after being trained with open-ended problem-solving questions. The use of this approach not only enhanced their problem-solving skills but also encouraged active participation during learning activities, as it provided opportunities for students to explore and develop diverse solutions in addressing problems.

CONFLICTS OF INTEREST STATEMENT

In relation to this research, the author declares that there is no conflict of interest and such matters.

AUTHOR CONTRIBUTIONS

As the principal investigator, Ade Syafrinaldo was fully responsible for all stages of the research, including methodology design, data collection (through questionnaires, tests, and interviews), data analysis, and writing of the research manuscript. Dr. Suherman, S.Pd, M.Si, as the research supervisor, provided crucial conceptual guidance and direction from the initial stage to the final draft, including problem formulation, instrument validation, and comprehensive manuscript review. Prof. Dr. Edwin, M.Pd, and Fridgo Tasman, S.Pd, M.Sc, contributed as co-supervisors, providing valuable input regarding academic substance, supporting theories, and research methodology, which significantly improved the quality and depth of analysis in this article. As well as the many inputs and motivations from family and friends that I can mention one by one.

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