E-ISSN : 2684-7175

Lentera Sriwijaya: Jurnal Ilmiah Pendidikan Matematika
Volume 06, No. 1, May 2024, pp. 1-11

ANALYSIS OF MATHEMATICAL REASONING ABILITY ON QUADRATIC FUNCTION MATERIAL OF JUNIOR HIGH SCHOOL STUDENTS IN TERMS OF INITIAL MATHEMATICAL ABILITY (IMA)

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Abstract

Mathematical reasoning is a tool for understanding mathematical concepts by developing solutions to problems with the answers and abilities they have. This research aims to analyze mathematical reasoning abilities in the quadratic function material of junior high school students in terms of Initial Mathematics Ability (IMA) The method used in this research is descriptive qualitative. The research subjects were students of SMP Negeri 6 Semarang class IX B consisting of 6 students selected from 32 students based on Initial Mathematics Ability (IMA). The data collection technique is through a written test in the form of 2 descriptive questions on mathematical reasoning ability. The results of this research are: (1) Students who have high Initial Mathematical Ability (IMA) can fulfill all ability indicators and aspects of mathematical reasoning ability, (2) Students who have moderate Initial Mathematical Ability (IMA) can only fulfill indicators 2 and 3, as well as some indicators 1 and 4, and (3) students who have low Initial Mathematical Ability (IMA) meet indicator 1 and indicator 2. These results show that different Initial Mathematical Abilities (IMA) have different mathematical reasoning abilities.

Keywords: *Initial Mathematics Ability, Mathematical Reasoning Ability, Quadratic Functions*

Abstrak

Penalaran matematis memiliki peran penting dalam pembelajaran matematika karena dapat mengembangkan pola pikirnya, mengembangkan kreativitasnya, dan mengembangkan kejelian dalam pembelajaran. Penelitian ini bertujuan untuk menganalisis kemampuan penalaran matematis pada materi fungsi kuadrat siswa SMP ditinjau dari Kemampuan Awal Matematika (KAM). Metode yang digunakan penelitian ini adalah deskriptif kualitatif. Subjek penelitian yaitu siswa SMP Negeri 6 Semarang kelas IX B yang terdiri dari 6 siswa dipilih dari 32 siswa berdasarkan Kemampuan Awal Matematika (KAM). Teknik pengumpulan data melalui tes tertulis berupa soal uraian kemampuan penalaran matematis sebanyak 2 soal uraian. Teknik analisis data dilakukan dengan reduksi data, penyajian data, dan penarikan kesimpulan. Hasil penelitian ini adalah: (1) siswa yang memiliki Kemampuan Awal Matematis (KAM) tinggi dapat memenuhi semua indikator kemampuan dan aspek kemampuan penalaran matematis, (2) siswa yang memiliki Kemampuan Awal Matematis (KAM) sedang hanya dapat memenuhi indikator 2 dan 3, serta sebagain indikator 1 dan 4, dan (3) siswa yang memiliki Kemampuan Awal Matematis (KAM) rendah memenuhi indikator 1 dan indikator 2. Hasil tersebut menunjukkan bahwa Kemampuan Awal Matematis (KAM) yang berbeda mempunyai kemampuan penalaran matematis yang berbeda pula.

Kata kunci: Kemampuan Awal Matematika, Kemampuan Penalaran Matematis, Fungsi Kuadrat

How to Cite: Imkhala, M.F., Supandi, S., Purwanto, P. (2024). Analysis of Mathematical Reasoning Ability on Quadratic Function Material of Junior High School Students in Terms of Initial Mathematical Ability (IMA). Lentera Sriwijaya: Jurnal Ilmiah Pendidikan Matematika, 6 (1), 1-11

Mathematics is one of the substantial and useful sciences for all areas of people's lives (Nurulaeni & Rahma, 2022). According to Wanti (2017) Mathematics is a process of reasoning, character building and thinking patterns, forming an objective, honest, systematic, critical and creative attitude and as a supporting science in drawing a conclusion. This is in accordance with the opinion of

Susanto (2016: 185) mathematics is one of the disciplines that can improve thinking argumentation skills, contribute to solving everyday problems and in the world of work, and provide support in the world of work, and provide support in the development of science and technology. This is proof that mathematics is important because it is the queen in all areas of life so that it becomes the focus of learning as a provision for students.

Mathematics learning includes five basic mathematical abilities which are the five process standards according to NCTM (Putri, Sulianto, & Azizah, 2019) namely problem solving, reasoning, communication, connection and representation. It is stated that reasoning is one of the important basic mathematical abilities that students must have. Therefore, in learning mathematics students are required to have good mathematical reasoning skills, because reasoning is needed in learning mathematics (Julaeha & Kadarisma, 2020). Irianti (2020) mentioned that the term mathematical reasoning is also known as mathematical reasoning.

Mathematical reasoning ability greatly affects student learning achievement. Supported by research by Hajar, Sofyan, & Amalia (2021) states that reasoning ability is needed to achieve good math learning outcomes, the higher the level of reasoning possessed by students, the faster the learning process will be in order to achieve learning indicators. With mathematical reasoning skills, students can develop their mindset, develop their creativity, and develop foresight in learning (Kusumawardani et al., 2018). In line with Wicaksono, Sugiyanti, & Zuhri, (2023) who stated that students who have mathematical reasoning skills will easily know the solution obtained is correct by justifying the steps used.

Mathematical reasoning is an ability that needs and is important for students to have. The importance of having mathematical reasoning skills in students is basically in line with the vision of mathematics, especially to meet future needs (Sumarmo et al, 2018). According to Septian (2014) reasoning is a tool for understanding mathematics and mathematical understanding is used to solve problems. With reasoning skills, students can understand concepts by developing solutions to problems with their answers and abilities.

According to the NCTM process standards (2000), some of the abilities classified in mathematical reasoning include (a) drawing logical conclusions, (b) giving explanations for models, facts, properties, relationships, or patterns, (c) estimating answers and solution processes, (d) using patterns of relationships to analyze situations, (e) proposing counterexamples, (f) following rules of inference, checking the validity of arguments, proving, and constructing valid arguments, (g) constructing direct proofs, indirect proofs, and proofs by mathematical induction.

According to the results of the IMSTEP-JICA survey (Muslimin & Sunardi, 2019) the low understanding of students in mathematics is caused by mathematics learning that concentrates too much on procedural and mechanistic matters, teacher-centered learning, mathematical concepts are conveyed

informatively, and students are trained to solve many problems without deep understanding Muhammad (2017) added that mathematical reasoning ability is still low due to several student errors when answering mathematical reasoning questions, so it is necessary to master the prerequisite material. Of course, teachers must be able to understand students' problems in mathematical reasoning ability in order to get a solution by providing guidance and training students to work on mathematical reasoning problems (Maskur et al., 2020). One alternative that can be used is to measure Initial Mathematical Ability (IMA) as a form of mastery of prerequisite material before learning takes place. Supported by Nurfadilah, Nindiasari, & Fatah (2020) stated that students' initial abilities are students' learning achievements in the previous material, so that in one class can be grouped into three groups based on their initial abilities, namely high, medium, and low initial groups.

The selection of quadratic function material in this study is because this material consists of learning materials that can lead students' mathematical reasoning skills. Reasoning in the process of solving quadratic function problems includes logical and systematic stages of the mathematical thinking process (Siahaya, Ayal & Ngilawajan, 2021). The mathematical thinking process itself is an event that a person experiences when receiving a response so as to produce the ability to connect something with something else mathematically to solve or answer a problem or problem so as to produce ideas, solutions or logical answers. If many students have difficulty in reasoning, it is a mathematical problem

METHODS

This research is a descriptive qualitative research with the research subjects are 32 students of class IX B who were given a diagnostic test and then 6 students were taken according to the category of Mathematics Initial Ability (IMA). The research subjects were selected by purposive sampling based on the consideration of the test results of students who made mistakes in solving reasoning problems. The research was conducted at SMP Negeri 6 Semarang in the odd semester of the 2023/2024 school year. Data analysis techniques were carried out by data reduction, data presentation, and conclusion drawing.

This research data was obtained using an instrument in the form of two description questions to determine the extent of the student's reasoning ability in learning mathematics on quadratic function material based on student grouping according to Initial Mathematical Ability (IMA). According to Sujalmo (Nisa et al., 2023) the categorization of students' initial mathematical ability can be done as in Table 1.

Table 1. Category of Mathematics Initial Ability

Average	*Criteria*
Score<65	Low
65≤ Score < 80	Medium
Score ≥ 80	High

After students are grouped according to the category of Mathematical Initial Ability (IMA), then the analysis of mathematical reasoning ability is carried out. The following are indicators of questions on reasoning ability used and the aspects studied.

Table 2. Indicators and Aspects of Reasoning Ability

Reasoning Ability Indicator	*Reasoning Ability Aspect*
1. Presenting mathematical statements through writing, drawings, sketches, or diagrams 2. Making conjectures 3. Draw conclusions, organize evidence, provide reasons / evidence for the correctness of the solution 4. Draw conclusions on statements 5. Drawing out the validity of an argument	1. Students can solve problems through writing, drawings, sketches, or diagrams presented in the problem 2. Students can estimate the maximum value of the function 3. Students can compile proofs of problem solutions 4. Students can draw conclusions on statements 5. Students can determine the validity of an argument from problems

Subjects consisting of six people based on the category of Initial Mathematical Ability (IMA) are considered the highest answer score in each category including high student 1 (ST1), high student 2 (ST2), medium student 1 (SS2), medium student 2 (SS2), low student 1 (SR2) and low student 2 (SR2), checking the validity of the data with source triangulation, namely checking the results of the answers to the questions of one subject with other subjects, and analyzing the data qualitatively to identify students in fulfilling indicator one (I1), indicator 2 (I2), indicator 3 (I3), indicator 4 (I4), up to indicator 5 (I5), and drawing conclusions

RESULT AND DISCUSSION

After the diagnostic test was conducted as a measure of Mathematics Initial Ability (IMA), grouping was carried out according to the high, medium, and low categories. The results of the percentage of students based on the category of Mathematics Initial Ability (IMA) are presented in Table 3 as follows.

Table 3. Percentage of Students by Category of Mathematics Initial Ability (IMA)

IMA category	*Number of students*	*Percentage*
Higk	11	34,38%
Medium	9	28,13%
Low	12	37,5%

Based on Table 3 above, the categories of Initial Mathematical Ability (IMA) were obtained, including 11 students in the category of Initial Mathematical Ability (IMA), 9 students in the category of moderate EAM, and 12 students in the category of low IMA. This proves that the dominant category is students with low Initial Mathematical Ability (IMA) which is 37.5%, followed by the high category of 34.38%, and finally the medium category of 28.13%.

Furthermore, six subjects were selected based on the category of Mathematics Initial Ability (IMA) by considering the highest answer score in each category. Two students represented the category of high initial mathematical ability (IMA), two students represented the category of medium initial mathematical ability (IMA), and two other students represented the category of low initial mathematical ability (IMA). The six students representing each category of Mathematical Reasoning Ability (IMA) were given a mathematical reasoning test on Quadratic Function material with a total of two questions.

The data results and discussion of the analysis of mathematical reasoning ability according to the indicators and aspects of reasoning ability according to Julaeha & Kadarisma (2020) based on the category of students with high, medium, and low Initial Mathematical Ability (IMA) are as follows.

a. Mathematical Reasoning Ability of Students with High Initial Mathematical Ability (IMA)

After the mathematical reasoning test was given to ST1 and ST2, the fulfillment and suitability of the answers with the indicators of mathematical reasoning ability classification were analyzed. The results of the analysis of students who both have high Initial Mathematical Ability (IMA) are compared. The results of the analysis of ST1 and ST2 answers are presented in Figure 1 below.

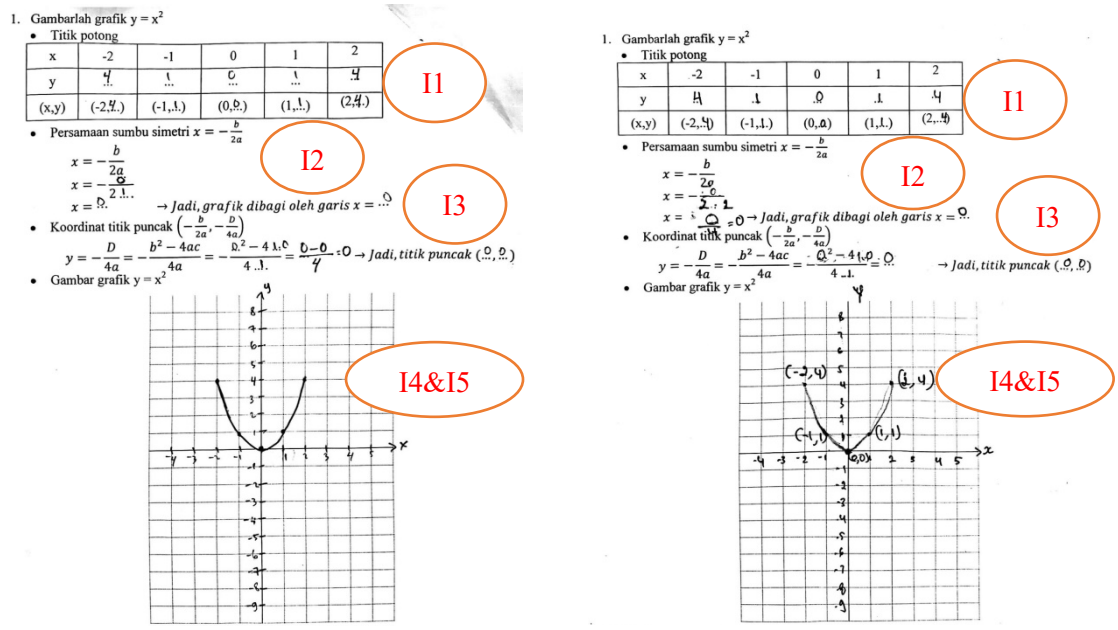

Figure 1. ST1 and ST2 job analysis results

Based on the results of ST1 and ST2 worksheets in Figure 1, students have solved mathematical reasoning problems on Quadratic Function material item 1 and have met all

indicators of mathematical reasoning ability. ST1 and ST2 have fulfilled indicator 1, as evidenced by the completion of the focus of the problem through writing, namely from the shape of the quadratic function, five correct coordinate points are obtained. $y = x^2$ obtained five correct coordinate points. In indicator 2, it is evident that ST1 and ST2 are able to make conjectures, namely determining the value of the axis of symmetry with students must first determine the values of a, b, and c from the coefficients on a function. $y = x^2$. Furthermore, the evidence of fulfillment of indicator 3 is that ST1 and ST2 are able to compile evidence from the solution of the problem. After obtaining the value of the axis of symmetry, the value is used to find the vertex and the determinant value formula is also used. The solution steps are written coherently, systematically, and correctly. Indicator 4 is evidenced by the conclusion from obtaining the value of the axis of symmetry and determinant which is then used as material for sketching the graph of the quadratic function that fulfills the function in the problem. The sketch of the quadratic function graph presented correctly and clearly is the function graph opening upwards to form a parabola. Finally, ST1 and ST2 have fulfilled indicator 5 which is that students have re-examined the answers given from the beginning to the conclusion.

Based on the analysis of students who have high Mathematical Reasoning Ability, it is evident that students can fulfill all indicators and aspects of students' mathematical reasoning ability. Thus, students with high initial mathematical ability also have high mathematical reasoning ability. Students who have high initial mathematical ability have dispositional knowledge to think and act systematically and efficiently in applying certain mathematical principles to various contexts and problems in everyday life (Noviarsyh Dasaprawira et al., 2019; Permatasari et al., 2018; Wijaya, 2016).

b. Mathematical Reasoning Ability of Students with Moderate Initial Mathematical Ability (IMA)

The results of the mathematical reasoning test to SS1 and SS2 were then analyzed for the fulfillment and suitability of the answers to the classification indicators of mathematical reasoning ability. The results of the analysis of students who both have moderate Mathematical Reasoning Ability (IMA) are compared. Students who have moderate Mathematical Reasoning Ability (IMA) have solved mathematical reasoning problems on Quadratic Function material, but are only able to fulfill some indicators of mathematical reasoning ability. This is different from students who have high initial mathematical ability (IMA) who are able to fulfill all indicators of mathematical reasoning ability. The following are the results of the analysis of SS1 and SS2 answers in Figure 2.

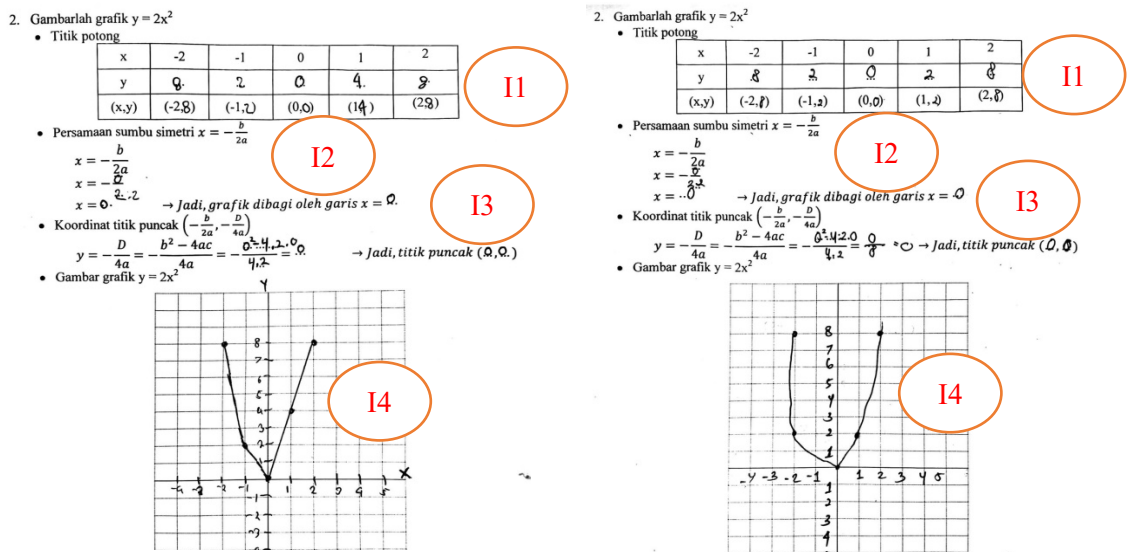

Figure 2. SS1 and SS2 job analysis results

Based on the results of SS1 and SS2 worksheets on question 2 according to Figure 2, several indicators of mathematical reasoning ability were successfully met. SS2 has fulfilled indicator 1, as evidenced by the completion of the focus of the problem through writing, namely from the shape of the quadratic function $y = x^2$ obtained five correct coordinate points, while SS1 has presented the writing but there is still one wrong coordinate point calculation. In indicator 2, it is evident that SS1 and SS2 are able to make conjectures, namely determining the value of the axis of symmetry with students must first determine the values of a, b, and c from the coefficients on a function. $y = x^2$. Furthermore, the evidence of fulfillment of indicator 3 is that SS1 and SS2 are able to compile evidence of the solution to the problem. After obtaining the value of the axis of symmetry, the value is used to find the vertex and the determinant value formula is also used. The solution steps are written coherently, systematically, and correctly. In indicator 4, SS1 and SS2 were able to draw conclusions from the acquisition of the value of the axis of symmetry and determinant, but the sketch of the quadratic function graph presented did not fulfill the function in the problem. The sketch of the quadratic function graph drawn is already in the form of a parabolic shape, but SS1 is still wrong at the coordinate point and SS2 is wrong at the coordinate point. (1,4) and SS2 was wrong at the coordinate point (−2,2). Finally, SS1 and SS2 did not check the validity of an argument as evidenced by the errors in indicator 1 and indicator 4 that have not been met.

Based on the analysis of students who have moderate Mathematical Reasoning Ability (IMA), it shows that students can only fulfill some indicators and aspects of students' mathematical reasoning ability. This means that students with moderate Mathematical Reasoning Ability (IMA) have moderate mathematical reasoning ability. The existence of student errors in working on mathematical reasoning problems affects the achievement of goals and results. This is in line with Indriani, Yuliani, and Sugandi, (2018) who stated that in reasoning ability students convey

information by communicating ideas through pictures, tables, diagrams, graphs, both orally and in writing.

c. Mathematical Reasoning Ability of Students with Low Initial Mathematical Ability (IMA)

The results of SR1 and SR2 answers in solving mathematical reasoning problems were analyzed based on indicators and aspects of mathematical reasoning ability. After being analyzed, the answers of students who both have low Initial Mathematical Ability (IMA) are compared. The results of the analysis of SR1 and SR2 answers are presented in Figure 3 as follows.

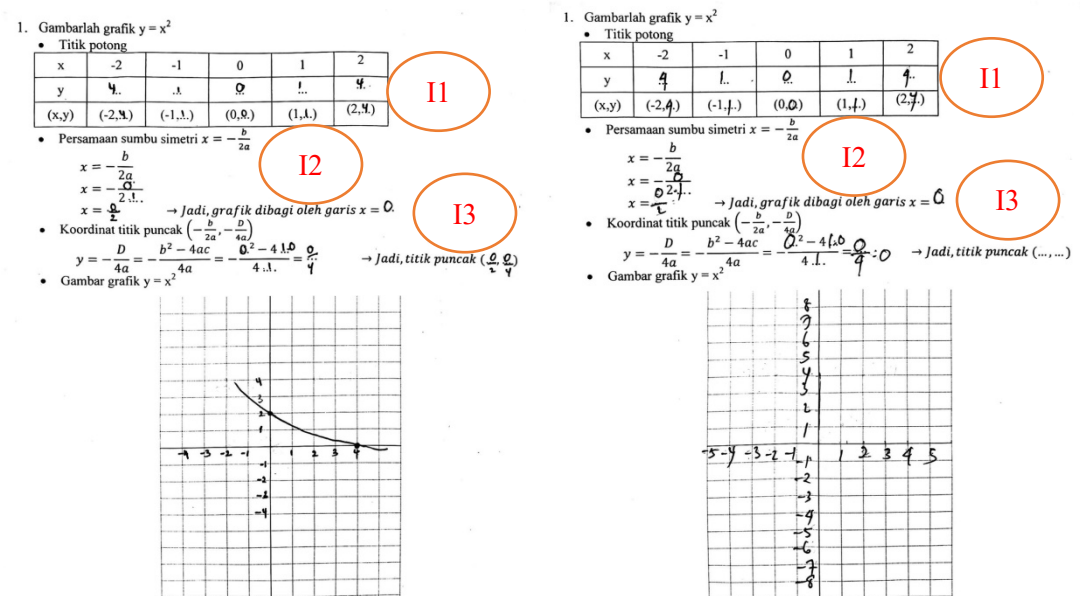

Figure 3. SR1 and SR2 job analysis results

Based on the results of SR1 and SR2 worksheets on question 1 according to Figure 3, only some indicators of mathematical reasoning ability were successfully met. SR1 and SR2 have fulfilled indicator 1, as evidenced by the completion of the focus of the problem through writing, namely from the shape of the quadratic function, five correct coordinate points are obtained. $y = x^2$ obtained five correct coordinate points. In indicator 2, it is evident that SR1 and SR2 are able to make conjectures, namely determining the value of the axis of symmetry with students must first determine the values of a, b, and c from the coefficients on a function. $y = x^2$. Furthermore, in indicator 3, SR1 and SR2 have compiled the solution to the problem, although some are still wrong. The error in indicator 3 is that SR1 is not appropriate in writing the result of the cusp, while SR2 does not write the final result of the cusp at all. This is evidence that the solution steps are incomplete and there are still errors. In indicator 4, SR1 and SR2 have not been able to draw conclusions from the acquisition of the value of the axis of symmetry and determinant and the sketch of the quadratic function graph presented has not fulfilled the function in the problem. Finally, SR1 and SR2 did not check the validity of an argument as evidenced by the errors in indicator 3 and indicator 4 that have not been met.

Based on the analysis of students who have low Mathematical Reasoning Ability (IMA), it shows that students can only fulfill some indicators and aspects of students' mathematical reasoning ability. This means that students with low Mathematics Initial Ability (IMA) have low mathematical reasoning ability. This is in accordance with Juniawan's research (2020) which states that students who have low initial mathematical ability have low mathematical reasoning ability.

The achievement of reasoning ability cannot be separated from the direction and assistance of the teacher as a facilitator during the continuity of the learning process. In line with Nurjanah, Kadarisma, & Setiawan (2019), teachers have an important role for students in helping to understand and solve problems in learning mathematics so that students' reasoning skills can also be improved. Thus, reasoning ability is an important ability in learning quadratic functions. Problem solving in solving quadratic function problems teaches students to draw a conclusion. In line with Utami (2014) that reasoning is a thinking activity to find a logical conclusion based on statements that have proven their validity. This indicates that learning the quadratic function requires sufficient reasoning skills to help students understand the material so that learning objectives can be achieved optimally.

CONCLUSIONS

Based on the results of the research and discussion, it can be concluded that: (1) students who have high Mathematical Reasoning Ability (IMA) can fulfill all ability indicators and aspects of mathematical reasoning ability, (2) students who have medium Mathematical Reasoning Ability (IMA) can only fulfill indicators 2 and 3, as well as some indicators 1 and 4, and (3) students who have low Mathematical Reasoning Ability (IMA) fulfill indicator 1 and indicator 2.

Based on the results of this study, it is expected for teachers or other researchers to examine student reasoning by paying attention to the initial mathematical ability (IMA) based on high, medium, and low categories.

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