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Analysis of the Algebraic Reasoning Ability of State Madrasah Tsanawiyah Students in Solving Mathematical Problems based on Cognitive Style

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Abstract

This article aims to describe the algebraic reasoning abilities of state Islamic boarding school students in solving mathematical problems based on a reflective and impulsive style. This research uses a qualitative type because it observes and narrates the phenomena and symptoms that students have. The triangulation used is technical triangulation through interviews, observations, and documents such as cognitive tests (MFFT) and algebraic reasoning material tests. The interviews used are structured based on indicators of algebraic reasoning, namely understanding problems, making generalizations, creating general forms or formulas, and solving problems or carrying out general forms. The results show that students with a reflective cognitive style can understand arithmetic sequences and series material well, carry out generalizations by generating letter symbols and making standard formulas, and carry out calculations correctly and provide conclusions. This is different from impulsive cognitive students, students tend not to come up with letter symbols when making generalizations, students immediately use ready-made formulas and carry out calculations with correct results, and do not provide conclusions.
Keywords: State Tsanawiyah Madrasah, Solving Mathematical Problems, Algebraic Reasoning, Cognitive Style*.*

1. Introduction

Education is important in building national civilization. Through education, conscious efforts to shape character and improve the cognitive human resources of the nation are better. According to Omeri (2015), national education functions to develop abilities and form a dignified national character and civilization in order to make the nation's life more intelligent. Shaping the character and character of students can be done from an early age and the level of education they are taking. The madrasah tsanawiyah level of education is the level of education for children aged around 12-15 years, which is equivalent to junior high school. According to Abdurrohman & Nursikin (2023), Tsanawiyah madrasas make Islam the main subject. The main aim is to shape the character of students with noble morals and prepare them to continue their education to a higher level, both in the academic and religious fields. So, basically Madrasah Tsanawiyah (MTs) is a formal educational institution in Indonesia which is equivalent to junior high school (SMP) usually for students aged 12 to 15 years. This madrasah integrates the general curriculum with Islamic religious learning, providing a balanced education between general knowledge and religious knowledge.

Madrasah students have different responses to the knowledge conveyed in class. This is of course related to the cognitive terms used in education to describe the understanding and knowledge possessed. Cognitive types can be observed from various individual behaviors. When students in class work on the questions given, students show varying responses because the understanding and knowledge that each of them has is different. Students can work on questions quickly without knowing whether the procedure

used is right or wrong, and they can work on questions slowly because they are careful about understanding the questions given. The student's condition shows a reflective and impulsive cognitive style. Students who have a reflective cognitive style tend to spend more time analyzing problems, considering various solutions, and checking the accuracy and completeness of each hypothesis. In contrast, an impulsive cognitive style is characterized by a tendency to make decisions quickly and respond based on what immediately comes to mind without critical examination (Rochika & Cintamulya, 2017). This was added by Ramdhani, et al., (2024) that students with a reflective cognitive style tend to be slower in responding to stimuli, because they need time to think about the information received. On the other hand, students who have an impulsive cognitive style react quickly to stimuli without carrying out in-depth analysis. So, the difference between reflective and impulsive cognitive styles can be seen in the speed of students' responses to solving the problems given. The reflective cognitive style is characterized by in-depth analysis and critical thinking, so students tend to be slow in responding. In contrast, the impulsive cognitive style is characterized by quick decisions and immediate reactions without in-depth analysis.

Students in solving questions have varied responses and this part is the main activity in the learning process in class. This is because it will be a form of evaluation of student understanding and learning achievements in class. Problem solving math problems requires thinking systematically, logically, critically, and not giving up easily until you finally find a solution. NCTM states that problem solving ability is the main hope and goal in mathematics learning. Apart from that, it also helps students develop skills to solve problems in everyday life (Azhar, et al., 2021). According to Sumartini (2016), from a curriculum perspective, the ability to solve problems is one of the goals of mathematics learning in schools. This goal includes training in thinking and reasoning to draw conclusions, sharpening problem-solving skills, and improving the ability to convey information or communicate ideas through various media such as verbal, written, images, graphs, maps and diagrams. Mathematical problem solving ability is the skill that students have to use mathematics to solve various problems, whether related to mathematics, other sciences, or everyday situations. According to Harahap & Surya, this ability is a complex cognitive activity, which involves processes for handling and solving problems using various strategies. Meanwhile, Ulva emphasized that mathematical problem solving is one of the important basic abilities for students. From the opinions of these experts, it can be concluded that mathematical problem solving is a high-level thinking process that requires more complex thinking, and is important to learn in the learning process (Layali & Masari, 2020).

Mathematics has various scientific branches such as statistics, trigonometry, algebra, and sequences and series. Every mathematical problem requires proper problem solving to find a solution. At various levels of education, concrete problem solving is required to develop critical and appropriate character. At the madrasah tsanawiyah level, learning more about sequences and series is mandatory because students can improve and understand the patterns given, so that they become critical and consistent characters. According to Ispita, et al., (2023), arithmetic sequences and series have an important role and are often studied at various levels of education. An arithmetic sequence is a series of numbers that follow a certain pattern with consistent differences. Meanwhile, an arithmetic series is the sum of the terms in the series.

A number sequence is a sequence of numbers formed based on certain rules. An arithmetic sequence is a type of sequence in which every two consecutive terms have the same difference. Examples are 6, 9, 12, 15, and so on. The difference between numbers in an arithmetic progression is called the difference, which is usually denoted by a letter *b*; for this example, the difference in value is 3. The numbers that form a sequence are called terms, with the*n* symbolized as U*n*. So, the fifth term of a sequence is written as U_5, while the first term is denoted by a letter *a* (Anwar, 2017).

Arithmetic sequences and series have many benefits in everyday life, especially in financial planning and management. For example, when calculating loan installments, we often use an arithmetic series to determine the total payment that must be made each month. Apart from that, this concept also helps in organizing time, such as creating schedules for recurring activities, as well as in calculating statistics and analyzing data, which is useful in various fields, from business to education. By understanding arithmetic sequences and series, we can make better and more efficient decisions in everyday life. Nurjanah, et al., (2023) state that an arithmetic series is the result of the addition of the terms in an arithmetic series, where the terms are added together. In general, it can be written as $U_1 + U_2 + U_3 + U_4 + U_5$, and so on.

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2. Method

This research was carried out at three Islamic boarding schools in East Kalimantan, namely MTs Negeri Model Samarinda, MTs Negeri 2 Balikpapan, and MTs Negeri 1 Tenggarong. The research will be carried out from July to September 2024. This article aims to describe and understand the algebraic reasoning abilities of East Kalimantan state Tsanawiyah madrasah students in solving mathematical problems based on cognitive style. This research uses qualitative research because it wants to observe the phenomena and symptoms found in state madrasah tsanawiyah students, especially class VIII. This class level was chosen because students are considered more prepared and are not distracted by other activities, so they can focus on working on questions well. Waruwu, (2023) explains qualitative research as a strategy for describing a phenomenon, looking for symptoms in objects observed and presenting it narratively in the context of scientific research. Because this research is descriptive in nature, it is necessary to carry out in-depth analysis so that the results are of higher quality (Safarudin, et al., 2023)

The steps taken to obtain research data are as follows:

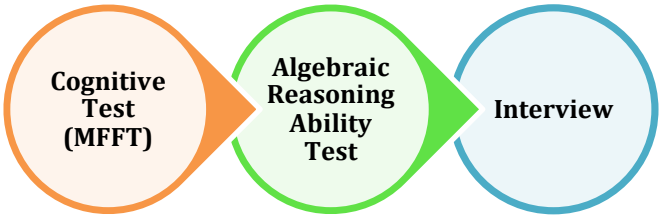

Figure 1. Steps in Obtaining Research Data

The initial step taken was to prepare instruments in the form of cognitive test questions and algebraic reasoning ability tests, as well as interview guidelines. The cognitive test questions use image/figural matching instruments and the algebraic reasoning ability test uses arithmetic sequence and series material. The interview guide is prepared based on indicators of algebraic reasoning, namely understanding the problem, making generalizations, creating general forms or formulas, and carrying out general forms or solving problems. After the instrument was prepared, the second step was carried out, namely the test question script and interview guide were validated by 2 mathematics education experts. Test questions and interview guides that are deemed suitable for use are duplicated and distributed to students according to the established research schedule.

The type of triangulation used is technical triangulation by collecting data through interviews, observations and documents such as cognitive tests and algebraic reasoning abilities. Cognitive tests produce categorizations, namely reflective and impulsive. The following are indicators of reflective and impulsive cognitive styles:

Table 1. Table Types of Cognitive Styles

No	Types of Cognitive Styles	Indicator
1	Impulsive	Fast, not accurate
2	Reflective	Slow, tends to be accurate

(Source: Rochica & Cintamulya, 2023)

Table 2. The Indicators of Algebraic Reasoning

No	The steps	Indicator
1	Understanding the Problem	Subjects write down all the information provided in solving the problem

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2	Generalize	The subject does not display symbols (Information provided as is)
		The subject uses letter symbols and understands their meaning
		Subjects discover pattern regularity through the letter symbols or variables created
3	Create general shapes or formulas	Subjects can state generalization results in the form of standard formulas
		Subjects perform operations on letter symbols or variables
4	Run a general form or solve a problem	Subjects can perform calculation operations correctly
		Subjects can carry out general forms and provide conclusions

(Source: Adapted from Indraswari & Zakiyah, 2020).

3. Results and Discussion

The initial test carried out to obtain data was a cognitive test. The test was carried out in Class VIII of MTs Negeri Model Samarinda, MTs Negeri 2 Balikpapan, and MTs Negeri 1 Tenggarong. The instrument uses image similarity test questions or *MFFT*. Based on the results of cognitive tests, it shows that 2 groups, namely impulsive and reflective, in each school have quite comparable percentages. The following are the results of cognitive tests at three state madrasah schools in East Kalimantan.

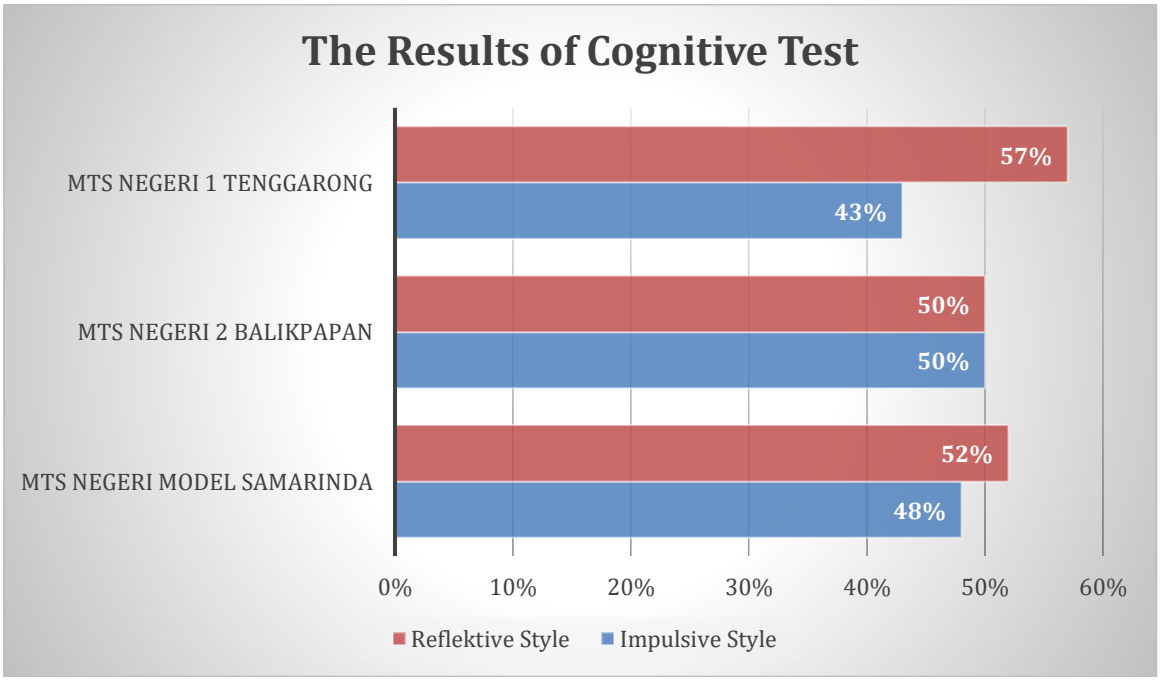

Figure 2. Test Percentage *MFFT*

The test results show the time required for students to answer the test *MFFT* namely MTs Negeri Model Samarinda obtained an average time of 8.52 minutes, MTs Negeri 2 Balikpapan 13.18 minutes, and MTs Negeri 1 Tenggarong 6.95 minutes. The following is Table 3 relating to the average time for taking test questions for each group in three state Tsanawiyah madrasah schools in East Kalimantan:

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Table 3. Cognitive Test Time Results

No	School	Median (minutes)	Cognitive Type	Time (minutes)
1	MTs Negeri Model Samarinda	7.51	Impulsive	6.15
			Reflective	11.07
2	MTs Negeri 2 Balikpapan	13.30	Impulsive	11.27
			Reflective	15.09
3	MTs Negeri 1 Tenggarong	7.36	Impulsive	5.21
			Reflective	9.27

(Source: Research Results, 2024)

Impulsive students showed a faster time working on test questions than the reflective group. This happened in the three state madrasah tsanawiyah schools in East Kalimantan, namely MTs Negeri Model Samarinda, MTs Negeri 2 Balikpapan, and MTs Negeri 1 Tenggarong. According to Fatma & Suwarno (2023), reflective students think longer before answering and are more often correct, while impulsive students answer quickly but are not always correct. Fastest time to complete test questions *MFFT* achieved by MTs Negeri 1 Tenggarong. As for the accuracy of impulsive and reflective students in answering test questions correctly, the following results were obtained:

Table 4. Average of Questions Answered Correctly by Students

No	School	Cognitive Type	Average Correct Answer
1	Samarinda Model State MTs	Impulsive	11
		Reflective	11
2	MTs Negeri 2 Balikpapan	Impulsive	11
		Reflective	11
3	MTs Negeri 1 Tenggarong	Impulsive	10
		Reflective	11

(Source: Research Results, 2024)

Based on the results obtained from three state madrasah tsanawiyah schools in East Kalimantan, reflective and impulsive students tended to have the same correct answer results on cognitive tests. This happened at MTs Negeri Model Samarinda and MTs Negeri 2 Balikpapan, while at MTs Negeri 1 Tenggarong there were differences in questions answered correctly. If observed carefully, impulsive and reflective students tend to have the same correct answers because they are used to working on figural questions in preparation for the national assessment test. According to Berlianto & Putra (2023), the national assessment questions contain literacy which includes figural, students need to practice to be able to solve problems. What differentiates the two groups of students when working on cognitive test questions is their careful attitude in answering the questions. Reflective students tend to consider various possible answers, so they require quite a long time compared to impulsive students.

After carrying out a cognitive test which divides students into reflective and impulsive groups, students are then given an algebraic reasoning test with the following results:

Table 5. Results of Student Algebra Reasoning based on Cognitive Style

No	Algebraic Reasoning Indicators	Cognitive Type	Samarinda Model State MTs	MTs Negeri 2 Balikpapan	MTs Negeri 1 Tenggarong

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1	Understanding the Problem	Impulsive	Students write down the information from the question by displaying letter symbols and the question asked by letter symbols	Students write down information from the question by presenting letter symbols and the question being asked in sentences	Students write down information from the question by bringing up letter symbols, without asking what is asked
		Reflective	Students write down the information from the question by displaying letter symbols and the question asked by letter symbols	Students write down the information from the question by displaying letter symbols and the question asked by letter symbols	Students write down information from the question by presenting letter symbols and the question being asked in sentences
2	Generalizing	Impulsive	Students find regular patterns, without using letter symbols	Students find regular patterns without using letter symbols	Students use the initial term or value of a, the difference or value of b, and the formula for the nth term (U_n).
		Reflective	Students find regular patterns with letter symbols and write down the initial term (a), difference (b), and the formula for the nth term and arithmetic series.	Students find regular patterns with letter symbols	Students find regular patterns using letter symbols and write down the initial term (a), difference (b), and the formula for the nth term and arithmetic series.
3	Create General Forms or Formulas	Impulsive	Students do not create general shapes	Students do not create general shapes	Students use the nth term formula (U_n).
		Reflective	Students connect the regularity of the patterns to produce a series formula and the nth term	Students use the formula for the nth term and arithmetic series, without connecting the regularity of the pattern	Students connect the regularity of the patterns to produce a series formula and the nth term
4	Run a general form or solve a problem	Impulsive	Students do not provide conclusions, students obtain calculation results from the regularity of the patterns created	Students provide conclusions, students obtain calculation results from the regularity of the patterns created	Students run the formula by substituting known values. Students perform calculations correctly. Students do not provide conclusions because they forget and are in a hurry.
		Reflective	Students run formulas by substituting known values and performing correct calculations. Students do not write conclusions.	Students run formulas by substituting known values and performing correct calculations. Students also provide appropriate conclusions.	Students run formulas by substituting known values and performing correct calculations. Students also provide appropriate conclusions.

(Source: Results of Algebraic Reasoning Ability Based on Cognitive Style, 2024)

The results of students' reflective work on arithmetic sequences and series problems can be seen in Figure 3 below:

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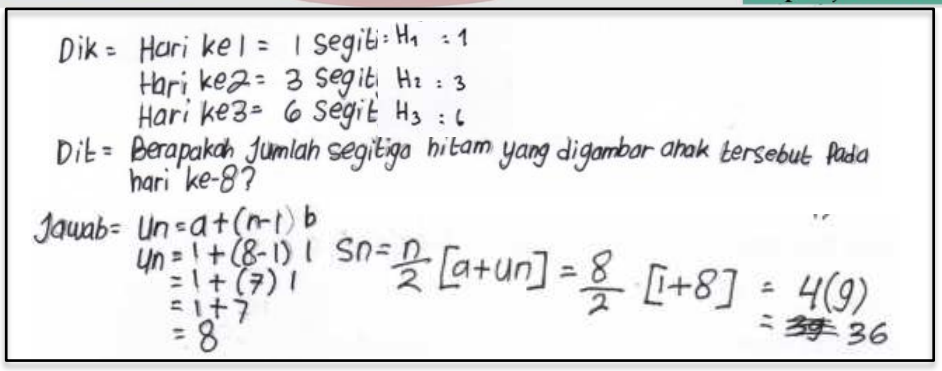

Figure 3. Reflective Students in Working on Algebra Reasoning Problems

Based on the results of the students' work above, at the stage of understanding the problem, reflective students can write down the information they know and ask about from the questions given. According to Hayuningrat & Listiawan (2018), students in the reflective group can be said to be fluent in stating things they know and asking from the questions given. Reflective students in carrying out generalizations find pattern regularities by using letter symbols and formulas for the nth term and arithmetic series. Reflective students tend to be more thorough and accurate in working on problems because it takes quite a long time to solve the problem. According to Ulya, Sumaji, & Rahayu (2023), reflective students are able to understand problems by writing down information that is known and asked, creating formulas that are used and running them, and checking again. Reflective students can carry out correct calculations because the values given in the questions look simple. Based on interview dialogue with reflective students in solving problems or creating general forms, students find it easy to carry out calculations because the known values are not too large, so students can easily add, subtract and multiply.

Next, the results of impulsive students' work on arithmetic sequences and series problems can be seen in Figure 4 below:

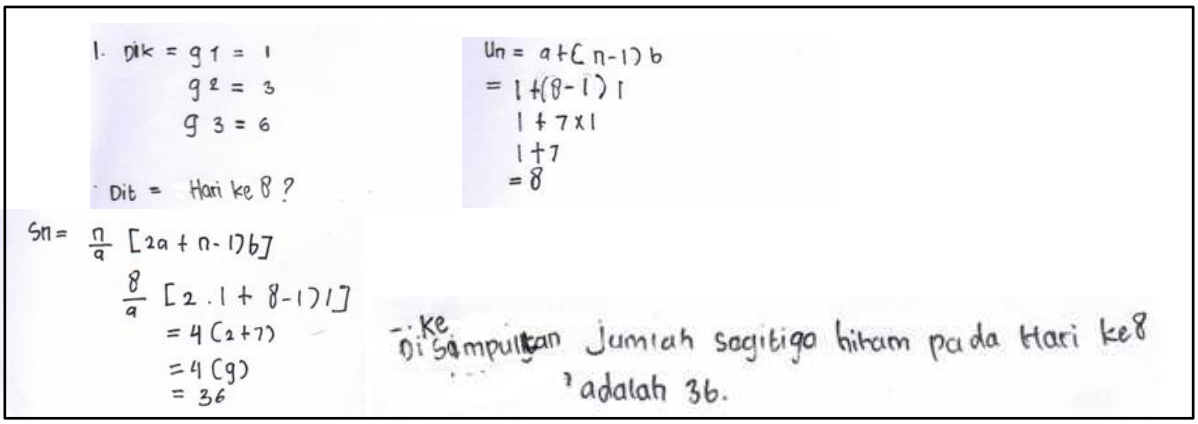

Figure 4. Impulsive Students in Working on Algebra Reasoning Problems

At the stage of understanding the problem, impulsive students are able to provide information from the questions given, but students do not fully write down what is asked. According to Sholihah, et al. (2024), shows that fast accurate or impulsive students do not fully write down the information they know and are asked about in the questions. At the generalization stage, students impulsively discover pattern regularities without using letter symbols or directly using formulas for sequences of nth terms and arithmetic series based on previous learning experiences. At the stage of making general shapes, students are able to carry out calculations correctly and write appropriate conclusions. According to Avianti & Ratu (2020), impulsive students are able to write conclusions correctly in solving problems in the questions. Based on the interview dialogue with students who are impulsive in creating general forms or formulas, students cannot produce formulas constructively because they are confused about connecting things they know. Students already have knowledge regarding formulas because they have

studied them in previous classes, so they are confident in solving problems. According to Fitriana, Suhendra, & Juandi (2023), impulsive cognitive students respond quickly in solving problems and believe in their own abilities.

4. Conclusion

Based on the results and discussion of students' algebraic reasoning based on the impulsive and reflective cognitive styles above, it can be concluded as follows:

Impulsive students work on test questions more quickly than reflective students at the state Tsanawiyah madrasah in East Kalimantan. At the stage of understanding the problem, impulsive students tend to write down the information they know and ask about using letter symbols, but it was found that there were students who did not write down what they were asking about. Reflective students tend to write the information they know and are asked about using letter symbols, but it was found that there were students who wrote down what they were asking about using sentences.

In the generalization stage, impulsive students tend to find pattern regularities without using letter symbols, while reflective students find pattern regularities using letter symbols and using formulas for the nth term and arithmetic series.

In the stage of creating general shapes, impulsive students create regular patterns without using letter symbols so they do not produce general shapes, while reflective students create regular patterns using letter symbols and produce general shapes or arithmetic series formulas.

Stages of carrying out general forms or solving problems, impulsive students can solve problems with the regularity of the patterns created and the answers produced are correct, as well as representing conclusions. Reflective students can solve problems with regular patterns and generate letter symbols, as well as carry out correct calculations and represent correct conclusions.

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