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Algebraic Thinking Profile of Junior High School Students with Reflective Cognitive Style in Solving Mathematics Problems

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ABSTRACT

The differences in algebraic thinking when solving problems are determined by the characteristics of students. One of the distinguishing characteristics is cognitive style. The aim of this study was to describe the algebraic thinking profile of students who have reflective cognitive styles in solving math problems. This research is descriptive qualitative research, focusing grade 8 junior high school students with reflective cognitive style. Data collection methods using tests and interviews. This study used three types of tests, the Matching Familiar Figure Test (MFFT) to determine students' cognitive style, the Mathematics Ability Test (AMT) to measure students' mathematical abilities, and the Problem-Solving Test (PST) to obtain data related to students' algebraic thinking profile in solving math problems. Data analysis is conducted in three stages: data reduction, data presentation, and conclusion drawing. The results showed that the algebraic thinking of students with reflective cognitive style in solving problems meets the three aspects of algebraic thinking indicators, namely performing activities to generalize the pattern and determine the next term of the given pattern, represent and compare data in tabular form, and understand the meaning of variables and use variables in the form of letters or symbols as a representation of something unknown value in algebraic form. Students with a Reflective Cognitive Style in solving problems can understand the problems given well, be careful and thorough in writing the steps of completion, straightforward and coherent in answering questions so that the answers given tend to be correct.
Keywords**:** *Algebraic Thinking, Problem-Solving, Reflective Cognitive Style.*

Profil Berpikir Aljabar Siswa SMP dengan Gaya Kognitif Reflektif dalam Menyelesaikan Masalah Matematika

ABSTRAK

Berpikir aljabar siswa dalam memecahkan masalah berbeda-berbeda berdasarkan karakteristik yang dimiliki siswa. Salah satu karakteristik yang membedakan yaitu gaya kognitif. Tujuan penelitian ini yaitu mendskripsikan profil berpikir aljabar siswa dengan gaya kognitif reflektif dalam memecahkan masalah matematika. Penelitian ini merupakan

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penelitian deskriptif kualitatif, dengan subjek penelitian adalah siswa kelas 8 SMP dengan gaya kognitif reflektif. Teknik pengumpulan data dengan menggunakan metode tes dan wawancara. Penelitian ini menggunakan tiga jenis tes, yaitu tes Matching familiar Figure Test (MFFT) untuk menentukan gaya kognitif siswa, Tes kemampuan Matematika untuk mengukur kemampuan matematika siswa dan Tugas Pemecahan Masalah (TPM) untuk memperoleh data terkait profil berpikir aljabar siswa dalam memecahkan masalah matematika. Hasil penelitian menunjukkan bahwa berpikir aljabar siswa dengan gaya kognitif reflektif dalam memecahkan masalah memenuhi tiga aspek indikator berpikir aljabar yaitu melakukan aktivitas menggenaralisasikan pola dan menentukan suku selanjutnya dari pola yang diberikan, merepresentasikan dan membandingkan data dalam bentuk tabel, serta memahami makna variabel dan menggunakan variabel yang berupa huruf atau simbol sebagai representasi sesuatu yang belum diketahui nilainya pada bentuk aljabar. Siswa dengan gaya kognitif reflektif dalam memecahkan masalah memiliki kemampuan memahami permasalahan yang diberikan dengan baik, hati-hati dan teliti dalam menulis langkah-langkah penyelesaian, lugas dan runtut dalam menjawab pertanyaan sehingga jawaban yang diberikan cenderung benar.
Kata Kunci**:** *Berpikir Aljabar, Pemecahan Masalah, Gaya Kognitif Reflektif*

1. Introduction

Algebra is one of the important concepts taught in mathematics at school[1]. Algebra is a competency that must be learned by students because it is a provision for the benefit of the development of knowledge and technology[2]. Algebra serves as a mathematical tool to represent and analyze quantitative relationships, model situations, and solve problems[3]. Algebra is a skill that involves understanding different representations, such as equations, graphs, and solving problems using symbols in the form of letters as a representation of unknown values[4].

However, numerous experts have found that algebraic material is challenging for students to comprehend in learning[5]. Causes of students' difficulties in learning algebraic material include difficulties in identifying variables and coefficients, as well as difficulties in determining problem-solving[6]. The results of Setyawati & Ratu's research on 32 seventh-grade junior high school students related to student learning difficulties in algebra material show that student difficulty factors include numeracy difficulties, visual perception difficulties, and lack of understanding of mathematical language[7]. Kusumaningsih et al. in their research showed that algebra is often considered one of the most difficult and abstract math materials[8]. Furthermore, the results of Malihatuddarojah & Prahmana's research show that some students make errors in solving problems about the operation of algebraic forms, including errors in identifying variables, negative signs, forms of algebraic equations, and solving fractions[9].

Rivera's research shows that there is a significant difference between the arithmetic learned in the previous level and the algebra students are learning[10]. This is because arithmetic is limited to computing numbers whose quantity can be directly imagined. In algebra, students are confronted with symbols (variables) as a general form of something that is unknown. This needs to be considered, especially regarding the algebraic thinking of junior high school students as a tool for solving math problems. Ketterlin-Geller and Chard suggest that developing students' algebraic thinking skills and knowledge is influenced by an understanding of counting[11]. Students must have procedural proficiency, which includes computational fluency and conceptual understanding, to apply in problem-solving and algebra. By combining skills and knowledge, students are able to use algebraic thinking to solve problems.

Algebraic thinking is an important and fundamental part of mathematical thinking and reasoning skills[12]. Lew in his article explains that success in algebra depends on at least six kinds of mathematical thinking abilities, as follows: generalization, abstraction, analytic

thinking, dynamic thinking, modeling, and organization[13]. Algebraic thinking according to Van de Walle, et al. is a mental activity that involves using patterns that lead to generalizations (especially with operations) from experience with numbers and calculations, formulating mathematical ideas using symbols, and exploring concepts from patterns and functions[14].

Problem-solving is one of the tools that can be used to study the emergence of students' algebraic thinking. Problem-solving plays an important role in the development of algebra as well as being an interesting field to examine thinking and conceptual changes from arithmetic thinking to algebraic thinking[15]. Students' algebraic thinking process can be explored of them by using problem-solving[16], [17]. According to Suharnan's opinion, most problem-solving or concept-formation activities involve the thinking process[18]. The algebraic thinking process and its characteristics can be studied by involving students in problem-solving situations.

The following indicators were used in this study to measure algebraic thinking, which was adapted from the description proposed by Wongyai & Kamol[16].

Table 1 Algebraic Thinking's Indicators.

Aspect of Algebraic Thinking	Indicators
Pattern	a. Finds the terms of the given pattern b. Generalize patterns
Representation	a. Represent data in the form of tables, graphs, or diagrams b. Interpret and compare data in the form of tables, graphs, or diagrams
Variable	Understand and use variables in the form of letters or symbols as a representation of something whose value is unknown in algebraic form

Problem-solving activities have different characteristics for each student. The difference is possible because there are differences in the cognitive style of each student. Cognitive style is an individual's tendency to comprehend, recall, process, think, interpret information, and solve problems [19]. Cognitive styles that have been found by experts are quite diverse, one of which is a cognitive style based on conceptual differences in tempo or differences in the time used by a person in responding to a stimulus that is classified into two groups: reflective cognitive style and impulsive cognitive style[20]. Reflective and impulsive cognitive style as the characteristics of the cognitive system that combines decision-making time and performance in solving problems[21].

Students with impulsive cognitive styles have the characteristics of being fast in answering a problem but less thorough, so they tend to give answers that are less precise or wrong. Students with reflective cognitive styles have characteristics slow in answering a problem but thorough, so they tend to give the right answer[22]. The results of research by Victor et al. on 90 students who showed that students who have a category of impulsive cognitive style have a tendency of long response latency and higher error scores than students who are categorized as reflective cognitive style[23]. Warli's research revealed that students with a reflective cognitive style have more creativity in problem-solving than those with an impulsive cognitive style[24].

Another study on the profile of mathematical problem-solving of students with reflective-impulsive cognitive styles conducted by Azhil's research shows that reflective cognitive style students have an average value of 75% can solve problems correctly, while impulsive cognitive

style students have an average value of 25% can solve problems correctly[25]. The difference in the results of the study is due to the characteristics of reflective students in solving problems tend to be more careful, solving problems tend to go through stage by stage, and re-examine the solutions that have been done, this certainly requires a relatively long time compared to students with impulsive cognitive style.

It can be concluded that each student has a distinct cognitive style that affects their ability to solve problems. Using relevant research, the researchers aim to develop research that focus on students' reflective cognitive style in solving math problems at the junior high school level. This study aims to describe the algebraic thinking profile of junior high school students with reflective cognitive styles in solving math problems.

2. Methods

The type of research used in this study is descriptive research with a qualitative approach. Qualitative research has made humans the main research instrument and describes the research data based on facts in the field[26]. Thus, there are two types of instruments in the study, the main instrument is the researcher himself and supporting instruments include MFFT (Matching Familiar Figure Test) test questions that have been developed by Warli to determine the cognitive style owned by the subject, the Mathematics Ability Test (AMT) to measure students' mathematical abilities, Problem-Solving Test (PST) in the form of description questions to explore the emergence of algebraic thinking profiles and interview guidelines. Data collection techniques in this study used test and interview methods.

This study took one subject, namely grade VIII junior high school students who have a reflective cognitive style. The basis for the selection of subjects in this study is the statement of Pitta-Pantazi et al. that the ability of students' algebraic thinking to solve problems in the age range of 13 to 17 years is influenced by a set of cognitive systems[27]. Subject selection begins by giving the MFFT test, then the MFFT test data is analyzed by calculating the number of correct answers and the time record of working on all MFFT test items.

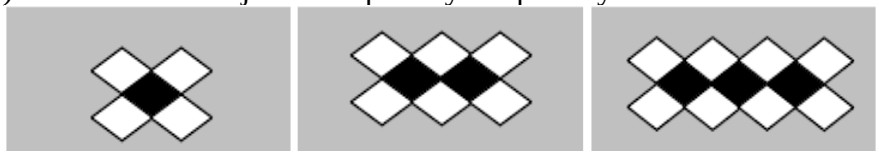
Students are said to have a reflective cognitive style if students can answer questions correctly more than or equal to 7 or ($f \geq 7$) and the time used to do the problem more than 7.28 minutes or ($t > 7.28$). Students are said to have an impulsive cognitive style if students can answer questions correctly less than 7 or ($f < 7$) and the time used to do the problem is less than or equal to 7.28 minutes or ($t \leq 7.28$). The following is a classification table of reflective-impulsive cognitive style based on frequency and time.

Table 2 Classification of Cognitive Styles.

Cognitive Styles	Time (t)	Correct Answer (f)
Reflective	$t > 7{,}28$	$f \geq 7$
Impulsive	$t \leq 7{,}28$	$f < 7$

The problem-solving test data that has been obtained is analyzed based on the algebraic thinking indicators in Table 1 and matched with alternative solutions. Interviews were analyzed by data reduction, data presentation, and conclusion drawing. Data validation using triangulation techniques, namely comparing the data from the problem-solving test results with the interview data.

The following problem-solving test questions are used in this research:

> Perhatikan gambar susunan sejumlah manik-manik dua warna (hitam dan putih) di bawah ini dan jawablah pertanyaan-pertanyaan berikut!
>
> 
>
> a. Jika terdapat 14 manik-manik hitam, maka berapa banyak manik-manik putih yang diperlukan untuk susunan seperti pada gambar? Jelaskan!
> b. Jika terdapat *x* manik-manik hitam, berapa banyak manik-manik putih yang diperlukan untuk susunan seperti pada gambar? Jelaskan!

3. Result and Discussion

The subject of this study was a student of class VIII junior high school with reflective cognitive style hereinafter referred to as SR, who was previously given the Matching Familiar Figures Test (MFFT). SR has completed the MFFT test with a record time of 11 minutes 37 seconds and correct answers more than 7. This indicates that SR has a reflective cognitive style. Furthermore, the profile of algebraic thinking of junior high school students with reflective cognitive style in solving mathematical problems is analyzed in three indicators, including patterns, representations, and variables, each of which will be discussed as follows.

3.1 Algebraic Thinking of Students with Reflective Cognitive Style in solving Pattern problems

The following are written answers of students with reflective cognitive style for question point a.

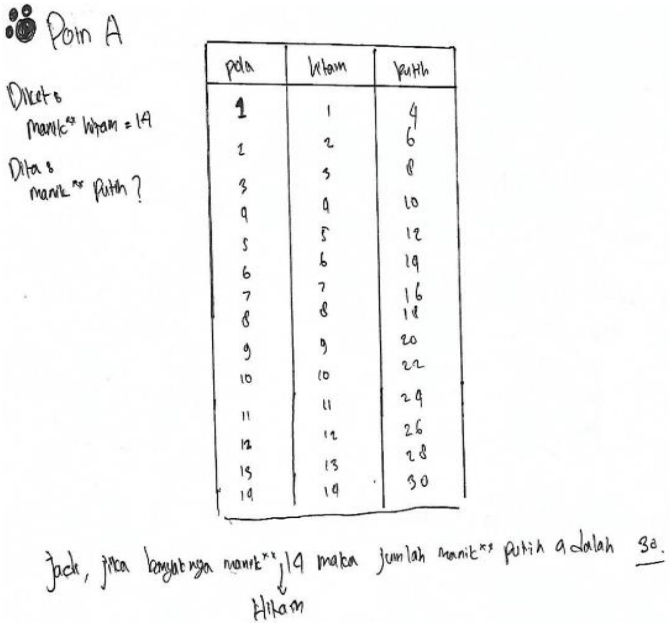


Figure 1 SR Subject's Answer to Question Point A

The following is a transcript of interview results of students with reflective cognitive style about point a.

P5: How do you determine the white beads if you know there are 14 black beads?

SR5: Because each pattern is always different. The black beads from the first, second, and third patterns always increase by one.
P6: Then what about the white beads?
SR6: There are four white beads in the first pattern, six in the second, and eight in the third, meaning that from the first pattern to the second and the third, there are two more.
P7: What does the number of black beads have to do with the number of white beads?
SR7: If the black beads increase by one, then the white beads increase by two.

Based on written answers and interview transcripts, students with reflective cognitive styles can write answers and explain what is meant by the problem correctly and coherently, the mathematical symbols used are also clear and correct. Students with reflective cognitive style perform activities to determine the relationship between patterns to determine the next term of the given pattern. This meets the indicators of pattern aspect algebraic thinking, which is generalizing patterns and finding the terms of the given pattern, then from the answer it is known that students with reflective cognitive style can determine the next term of the given pattern, so they can answer the question point a correctly. This is in accordance with the results of research by Maharani et al. that students with reflective cognitive style write the steps of problem solving in detail so that the resulting answers tend to be correct[28].

3.2 Algebraic Thinking of Students with Reflective Cognitive Style in Solving Representation Problems

The following are the written answers of students with reflective cognitive style for question point b.

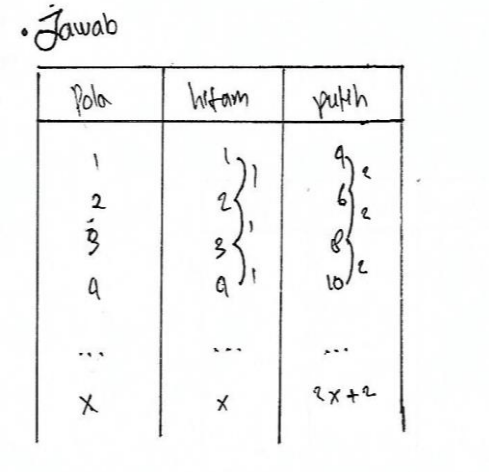


Figure 2 SR Subject's Answer to Question Point B

The following is a transcript of interview results of students with reflective cognitive style about point b.
P18: How did you determine the number of white beads?
SR18: The black one always adds one, the white one always adds two, and the white one is always even. if the number of black beads is x, I remember I was taught that the even number pattern is 2x+2, Then I tried it to the answer to point A and it turned out to be correct.
P19: How do you know that your steps are correct?
SR19: I recalculated, I checked it.

Based on written answers and interview transcripts, it is known that students with reflective cognitive styles use generalization patterns that have been found to determine problem-solving. Students model the situation using tables to determine problem-solving. This fulfills the indicator of representation algebraic thinking (representing data in the form of tables, graphs, or diagrams). Students determine the next term by analyzing the relationship between numbers

using patterns that have been found through the relationship between the number line and the picture to solve the problem.

Students model or represent problems using mathematical expressions. So based on this description, students fulfill the indicator of representation algebraic thinking (interpreting and comparing data to tables, graphs, or diagrams) in solving problems. In addition, in the SR19 transcript, it is known that students double-check to ensure that the answers they do are the correct answers. This is in accordance with the results of research by Satriawan et al. that students with a reflective cognitive style are very careful so that if there is an error students with a reflective cognitive style will realize and correct it[29].

3.3 Algebraic Thinking of Students with Reflective Cognitive Style in Solving Representation Problems

The following are written answers of students with reflective cognitive style for question point c.

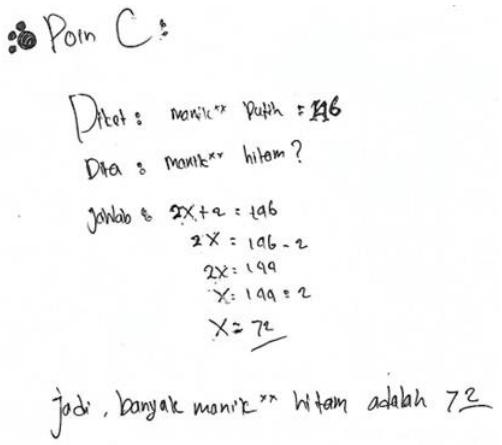


Figure 3 SR Subject's Answer to Question Point C

The following is a transcript of interview results of students with reflective cognitive style about point c.

P23: How do you solve the problem from the information you already know?
SR23: We know that there are 146 white beads, so we can find the black beads using 2x+2 from point B earlier.
P24: What is 2x+2 and what is x?
SR24: That's the general pattern of many white beads, x is many black beads.
P25: What did you do next?
SR25: Since the number of white beads is 146, I made it like this 2x+2=146. Then I calculated it until I found x, now that's the number of black beads 72.

Based on the written answers and interview transcripts, it is known that students with reflective cognitive style use patterns that have been found through the relationship between the number line from the previous problem (Point B). This is by the results of research by Satriawan et al. that students with reflective cognitive style tend to use the same way that has been found or planned in solving problems[29]. Students understand the meaning of the value of x in the problem as a symbol or representation of something whose value is unknown, then students can also operate algebraic forms to determine the final result of problem-solving. Based on this description, it is known that students with a reflective cognitive style fulfill the variable indicator which is understanding and using variables in the form of letters or symbols as a representation of something whose value is unknown in algebraic form.

4. Conclusion

Based on the results of data analysis and discussion, it can be concluded that the algebraic thinking of students with reflective cognitive styles in solving problems related to patterns meets two indicators, accordance (1) generalizing patterns and (2) finding terms from the given pattern, then from the answers given it is known that students can write answers and explain what the question means correctly and coherently, the mathematical symbols used are also clear and correct. Then the algebraic thinking of students with reflective cognitive style in solving problems related to representation meets two indicators, accordance (1) representing data in the form of tables, graphs, or diagrams, in this case, students model the situation using tables to determine problem-solving; and (2) interpreting and comparing data to tables, graphs, or diagrams, in this case, students analyze the relationship between numbers using patterns that have been found and model or represent problems using mathematical expressions.

Furthermore, the algebraic thinking of students with a reflective cognitive style in solving problems related to variables fulfills the indicators of variables, accordance understanding and using variables in the form of letters or symbols as a representation of something whose value is unknown in algebraic form. Students with a reflective cognitive style in solving problems appear to understand the problems given, careful and thorough in writing the steps of completion, straightforward and coherent in answering questions so that the answers given tend to be correct.

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