Analysis of Algebraic Thinking Process in Terms of Learning Styles of Elementary School Students

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Abstract. Algebraic thinking ability is defined as an individual's ability to build ideas and interpret patterns and functions using mathematical tools and symbols. This research method is descriptive qualitative which aims to analyze the algebraic thinking process of elementary school students in terms of learning styles. The research subjects were fifth grade students using purposive sampling with test and interview methods. The algebraic thinking indicators used and relevant for elementary school students are as follows: 1) generalization; (2) abstraction; (3) Dinamic thinking; (4) Modeling; (5) analytical thinking; and 5) Organization The four thoughts can be identified through student learning styles, namely: 1) visual; 2) hearing; 3) read/write; and. Data analysis uses the Miles and Huberman technique which includes data reduction, data presentation and conclusions. The conclusion of this study is that students' learning styles affect algebraic thinking processes. The visual learning style makes it easier for students to recognize patterns through pictures or diagrams, while the auditory learning style prefers oral explana-tions. Students with a reading writing learning style have good abilities in analyzing writ-ten information, drawing conclusions from reading.

Keywords: Process Think Algebra, Elementary School, Learning Style.

1 Introduction

Learning mathematics at the primary and secondary education levels has complex challenges in developing students' abilities. Mathematics is not only about calculations, but also involves thinking logically, critically, using mathematical symbols and finding keywords in problem solving [1]–[3] In an effort to develop students' mathematical understanding, algebra becomes a key element that enables the modeling and analysis of complex mathematical relationships. However, the journey in understanding algebra is often a challenge for many students. Algebraic thinking is a process that involves the analysis of quantity relations, understanding structure, study of change, generalization, problem solving, modeling, justification, proof, and prediction[4].

M. Salimi et al. (eds.), *Proceedings of the 7th International Conference on Learning Innovation and Quality Education (ICLIQE 2023)*, Advances in Social Science, Education and Humanities Research 873,
https://doi.org/10.2991/978-2-38476-301-6_54

Algebraic thinking involves mathematical reasoning processes that occur within an algebraic framework. This is also a form of reasoning that supports students in preparing mathematical thinking skills in various fields. Many students have difficulty understanding basic mathematical concepts. They often have difficulty interpreting and understanding the meaning of the new symbols they encounter [5].

Algebraic thinking is described in two aspects, namely generalization and symbolization with three stages: general arithmetic, functions, and modeling. The aspect of symbolization includes generalizations that symbolize order and boundaries systematically, while the aspect of generalization includes reasoning and systematic actions related to generalizations in conventional symbol systems. This model is adapted for special research on elementary school students and is illustrated in Figure 1. Simulation and generalization work is required in all three stages, however generalization work tends to occur more frequently in general arithmetic, while representational work occurs more frequently in modeling studies [6].

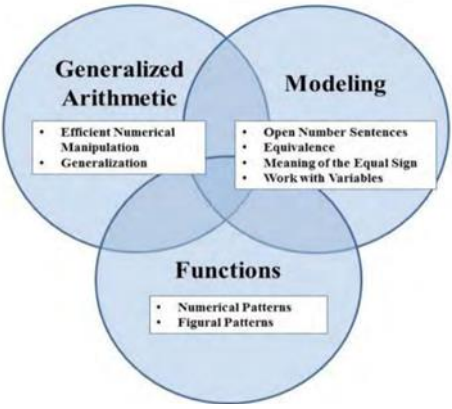

Fig. 1. Algebraic thinking framework [6].

One of the key factors that can affect understanding of algebra is the student's learning style. Each individual has different preferences and ways of learning, which include various learning styles such as visual, auditory, kinesthetic, or text-oriented. Learning styles play an important role in how students process information and digest learning material, including in the context of learning mathematics and algebraic thinking. Differences in learning styles affect students' ability to communicate mathematical ideas received during learning through the process of absorbing, processing and organizing information[7].

This research will identify how individual learning styles can influence algebraic understanding, so that it will help identify the suitability between teaching methods and student learning styles that can impact their ability to think algebra. By understanding the relationship between algebraic thinking problems and student learning styles, it is hoped that educators can better identify individual learning needs and adapt teaching approaches accordingly. In addition, this research invites readers to raise awareness of the importance of respecting the diversity of learning styles in the

learning process, so that each student has an equal opportunity to develop a strong understanding of algebra and master essential mathematical skills in their future life. As research results suggest ways to begin teaching algebraic thinking should be explored. In this context, training and curricula must prepare themselves to increase teachers' knowledge and experience and to improve students' algebraic thinking.

Teachers need to pay attention to students' algebraic thinking skills and be aware of the factors that influence them. The ability to think algebra has the potential to develop skills in solving mathematical problems both formally and in everyday life. During the algebra learning process, students are involved in developing ways of thinking using various forms of algebraic representations such as tables, words, pictures, diagrams, or mathematical expressions. In addition, students are also trained to simplify sentences into mathematical models that are easier to understand[4], [8]–[11]. The following explains how learning styles represent algebraic thinking processes according to Askew, M. et al [12].

Table 1. The Role of Learning styles in Algebraic Thinking processes

Learning Style	Algebraic Thought Process
Visual	Using pictures or graphical representations to visualize patterns, relationships, or the algebraic operations involved.
Auditory	Utilize hearing by listening to explanations, class discussions, or listen to themselves while explaining the steps in problem solving through the exchange of ideas and explanations together
Reading-Writing	Solve problems with keywords that have been written when reading or taking notes from the teacher's explanation. Explanations are more complex than other learning styles.

2 Method

This research method uses descriptive qualitative. Researchers are involved intensively in a community to get a comprehensive picture of a situa-tion or experience which is then processed and the results are described [13]. The research data was collected in depth with the aim of obtaining a clear and detailed picture of students' algebraic thinking profiles in solving algebraic problems, with an emphasis on Visual, Auditory, and Kinesthetic learning styles. The research subjects consisted of 10 fifth grade students from SD Kelapa Dua Weta 02 Pagi. Three female students were selected as subjects, each representing a different learning style, namely visual, auditory, and kinesthetic learning styles. The selected students have balanced mathematical abilities, are at the intermediate level, according to recommendations from the mathemat-

ics teacher and daily test scores. The data collected in this study involved the use of written tests and interviews. The research instrument consisted of two parts, namely the students' algebraic thinking process test questions and the interview guide. The algebraic thinking process test was prepared by the researcher in the form of a description question given to the research subject. The purpose of this test is to observe and understand how students think algebraically in solving problems based on predetermined indicators of algebraic thinking. The test consists of three essay questions with a time limit of 45 minutes. Before being given to the subject, the test questions have been approved by the supervisor. The interview guide is used to gather information about how students think algebraically in solving problems, as well as to understand their answers on the test more clearly. The test results are then considered based on each student's learning style. The following aspects of algebraic thinking are used in this study.

Table 2. Algebraic Thinking Components [14]

Aspects of Algebraic Thinking	**Indicator**	**Code**
Generalization (G)	Identify relationships between objects and determine the pattern of the combination of certain objects	G1
Abstraction (Ab)	Representing and substituting variables using symbols as unknown values.	Ab1
Dynamic Thinking (D)	Solve problems using various tactics	D1
Modeling (M)	Describe the conditions of the problem into a mathematical model	M1
Analytical Thinking (An)	Solve problems with equations to find the value of an unknown variable	An1
Organization (O)	Select and arrange data by grouping into tables, pictures, diagrams, or words that describe the situation and the relationship between the conditions of the problem	O1

Data analysis from interviews used the Miles & Huberman interactive model approach. The data analysis process involves three steps, namely data reduction, data presentation, and conclusion or validation. The reduced data is the result of interviews. Data reduction was carried out by transcribing the results of the recorded interviews, presenting the results of the interviews in writing by quoting the statements of the research subjects, and correcting copies of the interview results to minimize deficiencies and errors.

3 Results and Discussion

After collecting data through a questionnaire, the researcher chose 3 research subjects from a total of 10 students taking into account the same criteria, namely the same gender, different learning styles, and equal mathematical ability. So that 3 female students were selected with visual, auditory, and reading-writing learning styles, as well as having math abilities that were at the intermediate level. The following is a list of the 3 selected subjects: 1) Female students with a visual learning style; 2) Female students with an auditory learning style; 3) Female students with a kinesthetic learning style. The following questions are used to see students' algebraic thinking processes.

Table 3. Research Subject Code

Name	Learning Style Category	Mathematics Ability	Subject Code
FAN	Reading-Writing	medium	SRW
JL	Visual	medium	SV
SS	auditorial	medium	SA

After that, the three subjects were given an algebraic thinking process test and an interview, using the following algebraic thinking test questions:

Table 4. Question Algebraic Thinking Components

No	Question
1	There are 15.5 liters of kerosene in the can. Mother used 3 4/3 liters of kerosene from the can to fill the stove. The remaining kerosene in the can is..
2	Mother bought 3/4 kg of brown sugar, It also bought 3 1/2 kg of white sugar. At home available 4/9 kg of rock sugar. Mother intends to make a cake using white sugar. How much white sugar is left if you use 1 4/3 kg of the cake you are going to make?
3	Father's salary in the textile company a month is Rp. 2,100,000, 2/4 of his salary is saved 1/3 part is used for fare and will be daily. The rest is for family needs. A lot of money used for family needs is…

The results and discussion of the analysis of algebraic thinking data with the subject of visual, auditory, and Reading-Writing styles in solving algebraic problems are as follows:

3.1 Results and Analysis of Thinking Process Data on Visual Learning Style Subjects

Fig. 2. the results of answer number 1-2 on students with a visual learning style

The results of the data analysis showed that SV subjects succeeded in achieving each indicator at stages G1, Ab1, D1, M1, An1, and O1. At the G1 stage, SV is able to identify relationships and find patterns. Even though the subject's answer sheet number 3 did not state in writing what was known, the subject mentioned it in the interview. At stage Ab1, SV succeeded in solving the problem by using the equations in questions number 1, 2, and 3. Even though the answer sheet did not explicitly state what was known, in questions number 1, 2, and 3 SV immediately wrote down the numbers and added the questions given, for example in question number 1 SV immediately wrote "15.5 L = mother used 3 4/3 L" and wrote down the question "what is the number now?". At the M1 stage, SV immediately performed arithmetic operations using a mathematical model, namely 3 4/3 = 13/4 which was then simplified to 4.3 L, and concluded the answer results were "15.5 - 4.3 L = 11.2 L". At the O1 stage, SV succeeded in presenting and mentioning an overview of the situation and the relationship between the overall problem conditions.

3.2 Results and Analysis of Thinking Process Data on Auditory Learning Style Subjects

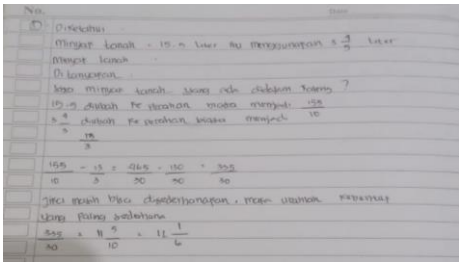

Fig. 3. the results of answer number 1 on students with a Auditory learning style

The results of the data analysis showed that the SA subject was able to carry out each indicator at stages G1, Ab1, D1, M1, An1, and O1. At stage G1, SA is able to identify relationships between objects and find patterns from a given set of objects. For example, SA answers the question by immediately writing 15.5 L = you use 3 4/3 L, and SA finds the current amount by doing the arithmetic operation 3 4/3 : 13/3 = 4.5 L, then subtracting from 15.5 L to get 11.2 liters. In addition, at stage A1, SA is able to write down and mention what they know briefly, sometimes using symbols, although there are some parts that are not written using symbols such as on the answer sheet for a particular subject number. At stage BD1, SA solves problems using one approach, namely creating a mathematical model in questions number 1, 2, and 3 by converting them into equations that include known information, questions asked, and expected problem solving results. SA managed to solve the equation to get answers to questions number 1, 2, and 3.

3.3 Results and Analysis of Thinking Process Data on Reading-Writing Learning Style Subjects

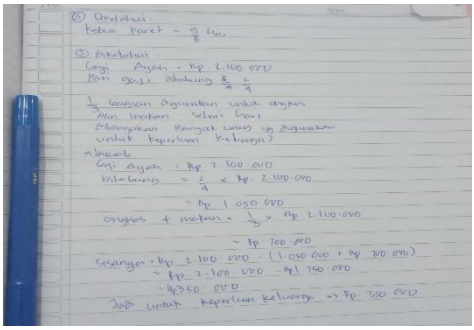

Fig. 4. the results of answer number 3 on students with a visual learning style

The results of the data analysis showed that SRW subjects were able to carry out each indicator at stages G1, Ab1, D1, M1, An1, and O1. At the G1 stage, SRW is able to identify relationships between objects and find patterns from a given set of objects. identify relationships and find patterns. SK includes in writing and mentions what is known in the problem. SRW states in writing and mentions the information known in the problem. Question (P): "What is known in the problem?" SRW answered (SRW): "You know kerosene = 15.5 L, you use 3 4/3 liters of kerosene." SRW then wrote down the questions that had to be answered, namely the remaining oil in the can. At the Ab1 stage, SRW uses symbols when writing and briefly mentions known information. When asked whether SRW understood the meaning of the questions, SRW answered that he understood the meaning of questions number 1, 2, and 3.

This study analyzes students' algebraic thinking processes with visual, auditory, and kinesthetic learning styles. The results of the analysis show that at stage G1, students with a visual learning style find it easier to recognize patterns through pictures

or diagrams, auditory students prefer oral explanations, and kinesthetic students prefer practical experiences. At the Ab1 stage, the visual learning style tends to write with pictures, the auditory likes verbal, and the kinesthetic likes body movements. At stage D1, the visual is more comfortable with images and likenesses, the auditory prefers to talk, and the kinesthetic prefers physical objects. At the M1 stage, students adjust how to describe problems with their learning style. At the An1 stage, learning styles affect problem-solving approaches with equations. At stage O1, students present results according to their individual learning style preferences.

Relevant research results show support for students to engage with higher levels of mathematical thinking [15] and influence on problem solving skills [16] Task patterns positively affect students' algebraic abilities [17]–[20] Besides that, by understanding the meaning of operations, the understanding of symbols for non-numeric quantities, positive integers and rational numbers influences the development of algebraic thinking. Thinking algebra from elementary school can be implemented with a conducive learning atmosphere. That previously could be a reason for researchers to conduct research with elementary school students [21], [22]. The process of identifying thought processes will be facilitated by studying learning styles' awareness of their strengths such as learning styles and how leveraging their strengths can improve their academic performance [23]. Dalmolin, et al suggested that determining students' learning styles will ultimately improve their educational experience [24].

4 Conclusion

The conclusion of this study is that students' learning styles affect algebraic thinking processes. The visual learning style makes it easier for students to recognize patterns through pictures or diagrams, while the auditory learning style prefers oral explanations. Students with a reading writing learning style have good abilities in analyzing written information, drawing conclusions from reading. Learning styles also influence the way students write and presents information on algebraic problems, as well as their approach to solving problems with equations. Therefore, teachers need to understand students' learning styles and apply appropriate learning strategies to support the development of students' algebraic thinking effectively. By paying attention to students' learning styles in learning mathematics, it is hoped that the learning process will be more effective and can be adapted to the individual needs of each student.

5 Research Recommendations

1. This research can be a basis for further research by taking a larger sample and a more complete variety of learning styles. Further research can explore the influence of learning styles on understanding mathematical concepts and algebraic problem solving abilities.
2. The results of this study can be used by teachers in developing learning strategies that are more effective and in accordance with the needs of students' algebraic thinking based on their individual learning styles. Teachers can use different ap-

proaches for students with visual, auditory, and kinesthetic learning styles to increase their understanding.
3. Teachers can develop skills in recognizing student learning styles through more intensive observation and interaction with students. With a better understanding of student learning styles, teachers can provide more individualized and effective learning.

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