



SYSTEMATIC LITERATURE REVIEW: ALGEBRAIC THINKING SKILLS IN MATHEMATICAL PROBLEM SOLVING

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ABSTRACT

This study aims to provide a systematic picture in improving students' algebraic thinking skills in solving mathematical problems through the Systematic Literature Review (SLR) method. This research will analyze articles published between 2020 and 2024, focusing on the development, techniques used, and the influence of algebraic thinking skills in solving mathematical problems. The results of the study show that students' algebraic thinking skills are very important in building critical and creative thinking skills, which has an impact on solving complex problems effectively. The study also highlights effective learning strategies, such as cooperative approaches and technology integration, to improve algebraic thinking skills

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1. INTRODUCTION

Mathematics is a strong component of basic education, because there is not a single branch of science that does not involve mathematics (Kusomo Wicaksono, Sastriawati, & Hafiz, 2024). Mathematics as a universal science that has an important role in helping students face various problems in daily life. One of the important branches of mathematics is algebra (Maulida, 2024).

Algebra is a branch of mathematics that uses mathematical statements that describe the relationships between things. In algebra, mathematical variables and symbols that can be used in simplifying sentences into mathematical models in solving problems in daily life will be introduced (Thoyyibah & Susanti, 2024). One of the most important processes in mathematical reasoning is algebraic thinking by extracting information from situations, presenting information mathematically in words, diagrams, tables, graphs and equations as well as interpreting and applying mathematical findings (Purwa Kusuma, Budi Waluya, Hidayah, & Rochmad, 2021).

Algebraic thinking is closely related to making generalization patterns. In the algebraic thinking process, there is an activity of generalizing numbers through numbers and calculations using symbols such as letters (variables) which are carried out by recognizing problems. There are five forms of algebraic thinking, namely: 1) Generalization from arithmetic, 2) using meaningful symbols, 3) studying the arrangement of number systems, 4) studying patterns and functions, 5) mathematical modeling processes. The way that can be done to hone the algebraic thinking skills of students and students is to provide mathematical problems (Thoyyibah & Susanti, 2024).

Algebraic thinking skills are an important aspect of mathematics education that functions to help students solve mathematical problems. According to Susanti (2024), this ability involves the ability of individuals to use algebraic symbols to analyze relationships, pay attention to structures, generalize, model, draw structures, and predict. Algebraic thinking not only includes the use of symbols, but also involves deeper cognitive processes, such as generalizations from arithmetic, the use of meaningful symbols, the study of patterns and functions, and mathematical modeling. According to Nissa (2015), problem solving is an effort to find a way out of the difficulties faced. In an educational context, problem-solving not only helps students understand mathematical concepts, but also develops critical and creative thinking skills. Good characteristics in problem solving include the ability to understand concepts, note similarities and differences, and the ability to estimate and analyze.

There is a significant relationship between algebraic thinking skills and mathematical problem solving. Research by Thooyibah and Susanti (2024) shows that a deep understanding of algebraic concepts supports students' ability to solve more complex mathematical problems. Students who have good algebraic thinking skills tend to use more effective strategies in solving problems, as revealed by Ismayanti, Masriyah, and Khabibah (2022).

Research to determine students' ability to solve mathematical problems has been carried out by many previous researchers, including research that has been conducted by Ahmad A.R, Sulis A.M, and Emy S. (2022), stating that students with the characteristics of a concrete sequential type of thinking tend to solve equations in order and according to plan. Students with abstract sequential thinking tend to solve equations in order and not according to plan. Students with the characteristics of concrete random type thinking tend to solve problems randomly and according to plan. Students with the characteristics of abstract random type thinking tend to solve problems randomly and not according to plan (Rohman, Mahmudah, & Siswanah, 2022)

Then research in 2021 written by Aprillia Dwi Arny and Oemi Noer Qomariyah concluded that the ability to solve mathematical problems in students can be influenced by gender factors. In the study, male students showed better consistency in following problem-solving steps, while female students experienced errors in calculations despite being able to understand problems and plan solutions (Laili & Qomariyah, 2021)

The research of Komarudin Muhamad Zaelani (2019) with the research title "Algebraic Thinking Ability of Junior High School Students in Solving TIMSS-Based Algebra Problems" states that overall there are problems for students, namely in understanding the meaning of the sign equal to ($=$) as a sign of equivalence between segments (Zaelani, 2019)

Creative thinking for students is very important in today's era of global competition, because at the level of complexity of problems in all aspects of life today is very high. Creative thinking is a habit of sharp thinking with intuition driving imagination, revealing many new ideas, and unexpected inspirations (Novianti & Hasti Yumianta, 2018).

This research aims to summarize the findings and a clear picture of the challenges and strategies in improving algebraic thinking skills in solving mathematical problems. Further to explore how algebraic thinking skills can be developed through various learning methods and how they contribute to the improvement of students' problem-solving skills. Thus, this research is expected to make a significant contribution to the development of students' algebraic thinking skills, as well as a reference for more effective mathematics teaching methods.

2. RESEARCH METHODE

Method *Systematic Literature Review* (SLR) is the main approach used by the authors in this study. SLR was chosen because it allows researchers to systematically identify, evaluate, and synthesize research results related to algebraic thinking skills in mathematical problem solving. SLR also collects the results of previous studies and evaluates the quality and relevance of the studies conducted. Next, the SLR process will involve several steps. This includes searching the literature, filtering articles according to inclusion and exclusion criteria, conducting quality assessments, and finally synthesis. (Kurniawan, Agoestanto, & Wijayanti, 2023)

At this stage, it should be noted that *the Systematic Literature Review* (SLR) has a procedural process, which can be fulfilled to obtain an accurate analysis. More specifically, SLR can be done in stages including: (1) Choose a topic and determine the question according to the topic of literature review Literature review must be guided by the main research question; (2) Determine the scope of the review; (3) Select the database to be used to perform the search; (4) Do a search and find literature; (4) Literature review, this section is a more in-depth part and takes longer to understand and pour it into written form.

The first stage in SLR is the search and identification of literature relevant to the research topic. The data search needed in this study is through the databases of Google Scholar, Semantic Scholar, Neliti, and Garuda. To ensure that the identified literature is relevant to the research topic, the researcher uses the following combination of keywords, (1) Algebraic Thinking; (2) Algebraic Thinking Ability; (3) Solving Mathematical Problems. The research is focused on literature published in the last 5 years, namely from 2020 to 2024, so that the results of the analysis remain relevant and up-to-date. The second step is to classify the data obtained can be used in this study or not. To maintain the quality and relevance of the research, inclusion and exclusion criteria are applied to the collected literature, which are as follows:

Table 3. 1 Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
An article that focuses on algebraic thinking skills in the context of mathematical problem solving.	Articles that are not relevant to the topic, for example only discuss algebra without relating it to problem solving.
Articles published in the period 2020-2024.	Articles published before 2020.
Articles obtained through the google scholar, semantic scholar, neliti, and garuda databases.	Articles obtained outside the Google Scholar, Semantic Scholar, Neliti, and Garuda databases.
Articles written in Indonesian or English.	Articles written in other than Indonesian or English.

The inclusion and exclusion criteria used must be detailed and clear, including the type of study experimentally, non-experimentally, and so on. This research classifies each scientific article related to algebraic thinking skills in solving mathematical problems, so that the data analysis used is by reviewing the scientific article. Furthermore, the articles are grouped according to the type of data.

3. RESULT AND ANALYSIS

Distance Based on the selection criteria for the articles to be selected, as mentioned in the previous chapter, 14 articles were obtained, of which 12 were national articles, and 2 were international articles. The following is a table of selected research articles, according to the topic of algebraic thinking skills in solving mathematical problems.

Table 4. 2 Description of Reviewed Articles

No.	Author	Journal Title	Year	Source
1	1. Ida Farida 2. Dari Lokman Hakim	Algebraic Thinking Skills of Junior High School Students on the Material Two- Variable Linear Equation System (SPLDV)	2021	Google Scholer
2	1. Ramadan Kusumo Wicaksono 2. Gosni Student 3. M. Hafiz	Profile of Algebraic Thinking Skills of High School Students in Jakarta	2024	Google Scholer
3	1. Vingky Zulfa Asria 2. Chuchi Noorhayati	Application of SSCS Learning Model to Analyze Students' Algebraic Thinking Skills and Understanding of Mathematical Concepts and Thinking Habits	2024	Garuda

4	1. Khushna Alfi Muyachhar 2. Masduki	Students' Algebraic Thinking Profiles in Solving Generalization Problems and Dynamic Thinking Reviewed from the Cognitive Style of Fi-FD	2023	Garuda
5	1. Mita Nurlatifah 2. Dari Lokman Hakim	Algebraic Thinking Skills of Junior High School Students in Solving Mathematics Problems Thinking at a Higher Level	2022	Garuda
6	1. Eny Suryowati 2. Lia Budi Trisanti	Algebraic Thinking Process in Grade VIII Students in Solving Geometric Pattern Problems	2021	Neliti
7	1. Zhilal Hafidzoh 2. Titi Rohaeti 3. Desy Lusiyana	Algebraic Thinking Ability Profile Reviewed from Gender	2022	Semantic Scholar
8	John Hariaman Nada	Characteristics of Students' Mathematical Problem Solving in Solving Algebraic Thinking Problems Reviewed from the School Level	2023	Semantic Scholer
9	1. Cutlets Esti Utami 2. Cici Ekawati 3. Agung Handayanto	Profile of Algebraic Thinking Ability in Solving Mathematical Problems Reviewed from Students' Reflective Cognitive Styles	2020	Neliti
10	1. Mifta Ismayanti 2. Masriyah 3. City Khawri	Algebraic Thinking Process of Junior High School Students in Solving Mathematical Problems	2022	Neliti
12	1. Rifqoh Thoyyibah 2. Elly Susanti	Investigation of Students' Algebraic Thinking Skills in Solving Mathematical Problems	2024	Google Scholer
13	1. Deni Pratama 2. Masduki	Exploration of Student's Algebraic Thinking Skills in Solving TIMSS Problems in Terms of Reflective-Impulsive Cognitive Style	2024	Google Scholer
14	1. Jona Belle I love 2. Ednalyndulay 3. Miguel Talenjale 4. Cherry Balanquit 5. Martin Nobis, Jr	Investigating the Influence of Attitude, Prior Knowledge, and Critical Thinking on Solving Algebraic Equations	2024	Google Scholer

After finding articles/journals that are in accordance with the research topic to be discussed, namely the ability to think algebraically in solving mathematical problems, then all the selected articles are analyzed and presented in the following table:

Table 4. 2 Article Literature Analysis

Author	<i>Journal</i> : Title	Methods	Research Results
A Doctor of Medicine from Ida Farida	<i>Journal of Innovative Mathematics Learning</i> : Algebraic Thinking Skills of Junior High School Students on Two-Variable Linear Equation System (SPLDV) Material	Qualitative descriptive method. The instrument is in the form of a description test of 2 SPLDV questions and documentation.	The results of the study show that the algebraic thinking ability of junior high school (SMP) students tends to be low. Of the 30 students studied, only 20% of students had high algebraic thinking skills, 16.67% of students thought moderate algebra, and 13.33% of students thought low algebra. This indicates that there are still many students who are not able to meet the Graduate Competency Standards, which is caused by a lack of student understanding of algebraic concepts.
Ramadhan Kusumo Wicakson, et al.	<i>National Seminar of FITK UIN Jakarta</i> : Profile of Algebraic Thinking Skills of High School Students in Jakarta	Quantitative descriptive method. The instrument is in the form of 6 questions describing algebraic thinking skills.	The results of this study provide an overview that the algebraic thinking ability of high school students in the Kebayoran Baru area is classified as moderate with an average percentage of 54.6%, with details of each school, namely SMAN 82 Jakarta at 62.13%, SMAN 46 Jakarta at 43.33%, and SMAN 70 Jakarta at 58.45%.
Vingky Zulfa Asria and Suci Nurhayati	<i>Journal of Educational Window</i> : Application of SSCS Learning Model to Analyze Students' Algebraic Thinking Skills and Understanding Mathematical Concepts and Habits	Qualitative method. The instrument is in the form of a test of ability and ability of concepts and habits of mathematical thinking	The results of the study show that students who learn using the SSCS learning model have a good conceptual understanding. In addition, students also have good mathematical thinking habits. This is evidenced by the results of the questionnaire which shows that it is in accordance with the answers given by students and is at a fairly high level.
Khusna Ali Muyassaroh and Masduki	<i>Journal of Mathematics and Mathematics Education</i> : Students' Algebraic Thinking Profiles in Solving Generalization Problems and Dynamic Thinking Reviewed from the Cognitive Style of Fi-FD	Qualitative method with case study design. The instruments are in the form of the GEFT test, algebraic thinking test questions, and interview guidelines.	Students with the Field Independent cognitive style are able to solve dynamic thinking problems accurately by applying the known relationship between quantities in the problem. In contrast, students with the Field Dependent cognitive style struggle to understand the relationship between quantities in dynamic thinking problems, which leads to difficulties in solving them.

Mita Nurlatifah and Dori Lukman Hakim	<i>Sesiomatranslation: Algebraic Thinking Skills of Junior High School Students in Solving Mathematics Problems Thinking at a Higher Level</i>	Qualitative descriptive method. The instruments are in the form of observations, description questions and interviews.	The results of the study showed that the algebraic thinking ability of grade VIII students at SMP Negeri 6 West Karawang in solving high-level thinking problems was still low. This can be seen from the results of students' answers that do not fully meet the indicators of algebraic thinking ability, both in evaluating (C5) and creating (C6) questions. Students have difficulty understanding and solving problems, especially in identifying the main problems in the problems.
Eny Suryowati and Lia Budi Trisanti	<i>Journal of Studies, Research and Development of Education: Algebraic Thinking Process in Grade VIII Students in Solving Geometric Pattern Problems</i>	Qualitative method. The instruments are in the form of geometric guidelines and interviews.	The results of the study showed that the subjects found patterns in the images. The subject can present a drawing pattern with a number pattern and can draw for the next pattern. The subject can determine an unknown pattern (pattern to n) in the form of mathematical equations.
Zhilal Hafidzoh, dkk	<i>Algoritma Journal of Mathematics Education : Algebraic Thinking Ability Profile Reviewed from Gender</i>	Descriptive qualitative method. The instruments are in the form of an algebraic thinking ability test and an interview test	The results showed that subjects with male gender in the high category were able to meet all indicators of algebraic thinking ability, namely generational, transformation, and global meta level, while female gender was unable to meet one of these indicators, namely transformation indicators.
John Hariaman Nada	<i>Journal of Mathematics and Mathematics Education: Characteristics of Students' Mathematical Problem Solving in Solving Algebraic Thinking Problems Reviewed from the School Level</i>	Qualitative method with a phenomenological approach. The instruments are in the form of written tests and interviews.	The results of this study show that the characteristics of student problem-solving develop along with the increase in educational level. Junior high school students showed better ability to solve problems by thinking algebraically, but they still used simple strategies if they thought it was faster and easier. These results show the need to improve more structured learning in problem-solving, so that students are more trained in dealing with problems that require logical and critical thinking.

Schnitzels Esti Utami, dkk	<i>Scientific Journal of Mathematics Education:</i> Profile of Algebraic Thinking Ability in Solving Mathematical Problems Reviewed from the Reflective Cognitive Style of Junior High School Students	Qualitative descriptive method. The instruments are in the form of cognitive style questionnaires, written tests, and interviews.	The results showed that the ability to think algebraically in solving students' mathematical problems with a cognitive reflective style met five indicators, namely generalization, modeling abstraction, analytical thinking, and dynamic thinking. The subject understands and rewrites the information clearly and performs mathematical manipulations to reach the right conclusions.
Mifta Ismayanti, dkk	<i>Jurnal Education and Development:</i> Algebraic Thinking Process of Junior High School Students in Solving Mathematical Problems	This study uses a case study approach. The instruments are in the form of written tests and semi-structured interviews.	The results showed that the difference in algebraic thinking ability between high-ability and low-ability students had a significant effect on their ability to solve mathematical problems. High-ability students have a better understanding of applying mathematical models and evaluating solutions, while low-ability students need more practice to develop algebraic thinking skills.
Ratna Maulida	<i>Multidisciplinary Journal Warehouse :</i> Identification of Algebraic Thinking Ability and Mathematical Resilience in SPLDV Problem Solving Based on Cognitive Style	Qualitative descriptive method with a postpositivist approach. The instruments are in the form of cognitive tests and interviews, and supporting instruments include the Matching Familiar Figure Test (MFFT), algebraic thinking test questions, and mathematical resilience questionnaires.	The results showed that students with reflective cognitive styles had better algebraic thinking skills compared to students with impulsive cognitive styles. Reflective students are able to generalize patterns, think about problems, and use symbolic representations effectively. In contrast, impulsive students have difficulty generalizing patterns and applying analytical techniques consistently. In addition, most students are in the category of intermediate algebraic thinking skills, with 64.8% of students having below-average abilities.
Rifqoh Thoyyibah and Elly Susanti	<i>Journal of Analysis :</i> Investigation of Students' Algebraic Thinking Skills in Solving Mathematical Problems	Qualitative descriptive method. The instrument is in the form of a story question related to algebra material and an interview.	The results show that students with good math skills also have good algebraic thinking skills, meeting all indicators such as generational, transformation, and global meta levels appropriately. In contrast, students with moderate math skills are only able to meet transformation indicators and global meta levels, but with incorrect answers.

Deni Pratama and Masduki	<i>Journal of Mathematics Education: Exploration of Student's Algebraic Thinking Skills in Solving TIMSS Problems in Terms of Reflective-Impulsive Cognitive Style</i>	Qualitative method with a case study approach. The instruments in the form of algebraic thinking tests are received from TIMSS, MFFT (Matching Familiar Figure Test), and interviews.	The results showed that students with reflective and impulsive cognitive styles were able to solve problems related to generalizations and abstractions. Reflective students use more systematic problem-solving steps than impulsive students. Both can use patterns and symbols to solve math problems, but individual differences such as cognitive styles must be facilitated by teachers so that students are more successful in learning math.
Jona Belle Adoro, dkk	<i>Formosa Journal of Multidisciplinary Research: Investigating the Influence of Attitude, Prior Knowledge, and Critical Thinking on Solving Algebraic Equations</i>	Descriptive-correlation design method. The instruments are in the form of a 15-item questionnaire and a 15-item Likert survey.	The results showed that most students had very low performance in solving algebraic equations. Although there was a statistical analysis conducted, no significant correlation was found between the factors studied (attitudes, prior knowledge, and critical thinking skills) and the students' performance in solving algebraic equations. Pearson's correlation analysis showed a weak negative tendency, but an insignificant p-value weakened the validity of the relationship.

Algebraic thinking is often defined as the ability to understand and use symbols in solving problems. According to research conducted by (Thoyyibah & Susanti, 2024) a deep understanding of algebraic concepts significantly supports students' ability to solve more complex mathematical problems.

The results of analysis and literature studies show that there is a strong relationship between algebraic thinking skills and problem-solving skills. For example, research (Ismayanti, Masriyah, & Khabibah, 2022) has found that students with high algebraic skills tend to use more effective strategies in solving math problems

Some teaching methods, such as cooperative learning and technology integration, have been identified as effective strategies in improving students' algebraic thinking skills. Studies by (Utami, Ekawati, & Handayanto, 2020) mention that this approach not only strengthens the understanding of algebraic concepts but also students' problem-solving skills.

Most of the research analyzed uses qualitative approaches that can provide deep insights into students' thought processes, such as surveys and tests as data collection tools. For example, research by (Hafidzoh, Rohaeti, & Lusiyan, 2022) developing a test to measure students' algebraic thinking skills. On the other hand, there are studies with a quantitative approach, such as in a study (Wicaksono, Satriawati, & Hafiz, 2024) using regression analysis to assess the influence of algebraic thinking on ability.

4. CONCLUSION

This research emphasizes the importance of algebraic thinking skills in helping students solve mathematical problems. A literature review reveals a strong link between the two aspects, while various teaching approaches have proven effective in improving these abilities. However, there are still gaps in this research, so further exploration is needed with a more diverse and comprehensive approach. This research is expected to make a significant contribution to the development of students' algebraic thinking skills, as well as a reference for more effective mathematics teaching methods.

Most studies highlight the cognitive aspects of algebraic thinking, while those that address affective components, such as students' motivation and attitudes toward math are few. So the suggestion for future research is to be able to integrate these two aspects so as to provide a more complete picture of algebraic thinking skills

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