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ALGEBRAIC THINKING PROFILE OF JUNIOR HIGH SCHOOL STUDENTS IN SOLVING PROBLEMS: PERSPECTIVE OF MATH ANXIETY

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Abstrak

Kemampuan berpikir aljabar perlu dikembangkan pada siswa karena dengan kemampuan ini memfokuskan siswa pada relasi dan representasi dalam pemecahan masalah. Tiga siswa SMP Al Falah Surabaya terlibat dalam penelitian deskriptif kualitatif yang bertujuan mengeksplorasi proses berpikir aljabar siswa SMP ditinjau dari kecemasan matematikanya. Pemilihan subjek dilakukan memberikan angket kecemasan, tes kemampuan matematika, dan diakhiri tugas pemecahan masalah. Subjek dipilih dengan memberikan kuesioner kecemasan yang berisi 30 pertanyaan dengan 4 pilihan jawaban dan menggunakan kuesioner, tes kemampuan matematika yang terdiri dari 10 soal materi aljabar untuk kelas 7 dan 8 dari ujian nasional SMP yang dimodifikasi. Data dikumpulkan melalui pemberian tugas pemecahan masalah dan wawancara. Hasil penelitian ini menunjukkan siswa dengan tiga kecemasan yang berbeda dalam menyelesaikan masalah memunculkan tiga indikator berpikir aljabar yaitu identifikasi, generalisasi, dan penggunaan generalisasi. Perbedaan terletak pada tingkat keberhasilan dalam menggunakan indikator berpikir aljabar. Rekomendasi penelitian ini yaitu perlu adanya perhatian dan perlakuan khusus dari guru terhadap siswa dengan kecemasan tinggi yang cenderung kebingungan saat memahami masalah.
Kata kunci: Berpikir Aljabar; Kecemasan; Matematika; Pemecahan Masalah

Abstract

Algebraic thinking skills need to be developed in students because this ability focuses students on relationships and representations in problem solving. Three Al Falah Surabaya junior high school students were involved in a descriptive qualitative study to explore the algebraic thinking process of junior high school students in the perspective of their mathematics anxiety and problem solving task. Subject was selected by providing anxiety questionnaire content 30 question with 4 choose answer and use questionnaire, math ability test consist of ten question content of algebra for seven and eight grade from national examination forjunior high school which modified. Data were collected through giving problem solving tasks and interviews. The results of this study showed that students with three different anxieties in solving problems presented three indicators of algebraic thinking, including identification, generalization, and application of generalization. The difference is the success rates in using the algebraic thinking indicators. The recommendation of this study is the importance of special attention and

treatment from teachers to students with high anxiety who have a tendency to get confused when understanding the problem.
Keywords: Algebraic Thinking; Anxiety; Math; Problem-Solving

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INTRODUCTION

Algebra is one branch of mathematics that plays a role in representing mathematical concepts and ideas. This shows the important role of algebra which is the gateway to the study of higher mathematics (Hadi & Faradillah, 2019; Kaput, 1998). This role underlies algebra studied from elementary to higher education. For this reason, in algebra learning, students are not only emphasized on an algebraic activity but focus on their thought process (Kaput, 1998).

Mathematics cannot be separated from thinking activities, so one of the thinking activities when students learn mathematics is algebraic thinking (Cahyaningtyas et al., 2018). Algebraic thinking skills need to be developed in students because this ability focuses students on relationships and representations in problem solving. Students who have the ability to think algebraically can certainly be able to develop their understanding of algebra. Through the problem solving provided, the teacher can explore and understand the algebraic thinking process of students when faced with problems.

The facts that occur at Al Falah Surabaya Junior High School are students' low understanding of number concepts, confusion in performing arithmetic operations, and difficulty in compiling equations from the given problem situation. The researcher as a teacher at the school identified the causes of the problem finding several causes of student difficulties caused by many factors. Some of the factors include abstract math material, inappropriate learning methods, passive students, a less meaningful learning process, evaluation, and motivation. After further investigation, an interesting fact was found, namely that students experience anxiety during math learning.

Specifically, Luo et al. (2009) explained that math anxiety refers to an unhealthy mood response when students face math problems. This is shown through panic, loss of reason, distress, nervousness, fear, and so on. This anxiety is one of the emotional factors found in many literatures so that it becomes one of the reasons students dislike math (Suren & Kandemir, 2020) and inhibits their algebraic thinking process when faced with solving algebraic problems.

Research on algebraic thinking has been a topic of interest lately (Arina & Lukito, 2019; Cahyaningtyas et al., 2018; Chimoni et al., 2018; Farida & Hakim, 2021; Hadi & Faradillah, 2019; Kusumaningsih et al., 2018, 2020; Nada et al., 2020; Naziroh et al., 2018) and others. Algebraic thinking research is reviewed from various points of view including learning styles (Arina & Lukito, 2019; Kusumaningsih et al., 2020; Rosdiana et al., 2018), gender (Kusumaningsih et al., 2018, 2020; Naziroh et al., 2018), representation characteristics (Nada et al., 2020), algebra skills (Chimoni et al., 2018; Farida & Hakim, 2021; Naziroh et al., 2018). From some of the above studies, it shows that there is a gap in research on algebraic thinking in terms of math anxiety.

Math anxiety is the anxiety experienced by students in learning mathematics. Math anxiety is a feeling of discomfort, tension, fear that occurs when studying and doing math tasks. (Ocak & Yamaç, 2013; Suren & Kandemir, 2020). Math anxiety is deeply rooted and often begins with students' previous educational experiences. The development of math anxiety includes explanations of math failure, negative attitudes from teachers, and cognitive tendencies (Bursal & Paznokas, 2006; Trezise & Reeve, 2018). Negative experiences with math from kindergarten to high school cause math anxiety in students.

This is what inspired the researcher to explore the algebraic thinking process of junior high school students in terms of their math anxiety. The inspiration is based on students' poor understanding of arithmetic so that it has implications for their algebraic thinking. Thus, the purpose of this study is to describe the algebraic thinking of junior high school students based on the level of student anxiety in

solving problems according to the stages determined by Krulik & Rudnick (Tohir et al., 2018).

METHOD

Three Al Falah Surabaya junior high school students were involved in a descriptive qualitative research to describe students' algebraic thinking profile in terms of their mathematics anxiety. The research subjects were determined after administering the student anxiety questionnaire (AKS) online through google form. Adaptations made by researchers include the used of language that is easy for students to understand, math ability tests using national exam questions. The results of this adaptation were validated before being used in this study. This questionnaire was adapted by the researcher from Bursal & Paznokas (2006) and (Charles et al., 2003) using The Revised-Mathematics Anxiety Survey and is in the form of a Likert scale.

After that, researchers also grouped students based on their mathematical ability (KMS). This data was obtained by researchers using ten description questions on seventh and eighth grade math materials. This question was modified by the researcher based on the junior high school national exam question, the results of which obtained a grouping of student ability levels . From the AKS and KMS results, three subjects with the same anxiety level, ability level, and communication fluency were obtained, namely KR 31, KR 23, and KR 44.

The three subjects were given an algebraic problem solving task (TPMA) and continued with the interview process. Before being used, TPMA was validated by experts, revised, and tested for readability. Researchers interviewed the three subjects based on unstructured interview guidelines to dig deeper into students' algebraic thinking flow when solving TPMA. In unstructured interviews, the interviewer is not bound to a specific list of questions. Instead, they can adjust the direction of the interview based on the responses given by the respondents. This allowed the researcher to explore themes that emerged spontaneously, supporting a qualitative approach that prioritizes in-depth exploration (Sugiyono, 2013). During

the interview, the researcher documented and analyzed it after transcribing the interview results. TPMA data obtained by researchers were then analyzed based on the stages of problem solving described by Krulik & Rudnick (Tohir et al., 2018) as follows.

Table 1. Algebra Thinking Indicator

Indicator	Aspect	Code
Identification	- Interpret symbols as variables correctly	I_1
	- Constructs an equation using symbol representation	I_2
	- Determines the value of the variable correctly	I_3
Generalization	- Substituting variables with numbers	G_1
	- Exploring the properties of numbers	G_2
	- Looking at the structure of numbers	G_3
The application of generalization	- Applies the properties of whole number operations correctly	F_1
	- Using the equal sign operationally/relationally correctly	F_2

The data triangulation carried out by researchers is time triangulation, researchers compare the data from TPMA 1 and 2. Both are said to be valid if they produce consistent findings so that the right conclusion is obtained. Time triangulation in this research is studying a problem over a certain period of time. To identify changes regarding the ability to solve problems and the anxiety felt when solving problems. TPMA was carried out at the same time for three selected students with equal ability levels with different anxiety.

RESULTS AND DISCUSSION

In this section the researcher presented the results of this study as follows.

1. The Subject KR 31

Subject KR 31 is a subject with high anxiety in mathematics. The following are the results of KR 31's work in solving TPMA.

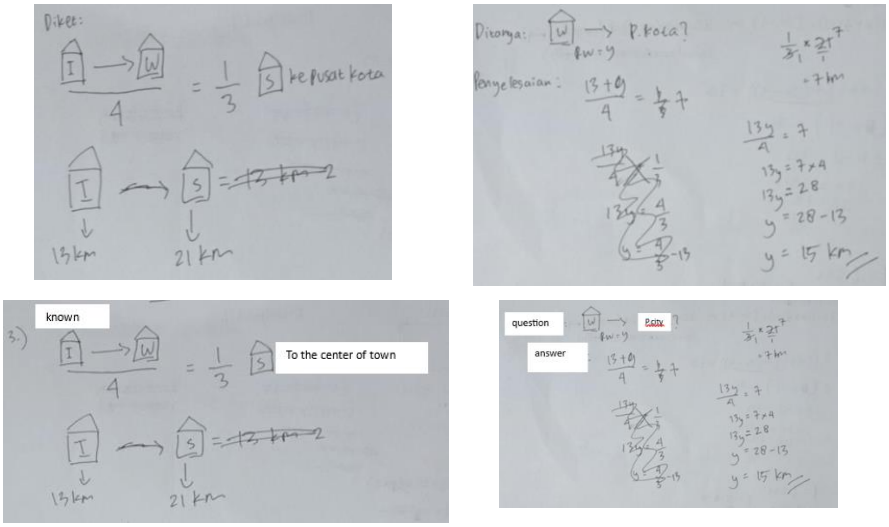

Figure 1. The Work of KR31 of High Math Anxiety

The researcher conducted an interview with KR 31 and identified it based on the indicators of algebraic thinking with the following interview excerpt.

P	:	*What does it mean to generalize?*	
KR 31	:	*I suppose I for the distance of Ita's house, W for the distance of Wahyu's house, S for the distance of Syaiful's house.*	I_1
P	:	*What makes them unique?*	
KR 31	:	$\frac{13+9}{4}$ *has the plus hyphen while* $\frac{13y}{4}$ *has the multiplier hyphen*	G_3
P	:	*Why* $\frac{13+9}{4}$ *can become* $\frac{13y}{4}$*?*	
KR 31	:	*I was adding 13+y into 13y*	G_2
	:		
P	:	*Explain why 13y = 28 can be y=28-13*	
KR 31	:	*I moved 13 to the right section so that the equation that was originally 13y = 28 into y = 28 - 13*	F_2

From the work of KR 31 and the interview excerpt above, it can be seen that the subject with a high level of anxiety started his work by illustrating by memorizing the distance of Ita's house with the symbol "I", the distance of Wahyu's house with the symbol "W", and the distance of Saiful's house with the symbol "S". Figure 1 shows that the equation made by KR 31 is correct and in accordance with the given problem situation.

Based on the indicators of algebraic thinking, it can be seen that the first step of KR 31 is to identify the TPMA situation by compiling equations according to the given conditions. Generalization was started by KR 31 by drawing

illustrations and coding symbols as in Figure 1. At this stage, KR 31 experienced anxiety when replacing the variable Wahyu's house from the symbol "W" to y.

On the use of generalization, KR 31 generalized $\frac{13+y}{4}$ into a simplified form of $\frac{13y}{4}$ without understanding the nature of addition. KR 31 used the equal sign operationally by moving 13 to the right segment. This shows the work process done by KR 31 is not correct because he immediately moves to the right segment without understanding the meaning of the operation. The researcher triangulated KR 31's algebraic thinking by giving TPMA 2 and the triangulation results are presented in Table 2.

Table 2. Triangulation Algebraic Thinking KR 31

Indicator	TPMA 1	TPMA 2
Identification	Initiate identification by illustrating and visualizing each house with a specific symbol.	Starting numbers with specific symbols and constructing equations that fit the problem situation
Generalization	Started the solution by initializing Ita's house with variable "I", Wahyu's house with variable "W", and Saiful's house with variable "S".	Start by replacing age with a specific number i.e. "45" to understand the meaning of variables and operate based on number properties
The application of generalization	Make errors in operating to make a simplified form without understanding the nature of addition operations	Capable of performing whole number operations appropriately

Table 2 above, shows the results of triangulation of subjects with high math anxiety based on algebraic thinking indicators presented in Table 3 below.

Table 3. Triangulation of Subjects with High Math Anxiety

Identification	Generalization	The application of generalization
- Identifying the problem - Constructing the equation - Modeling	- Understand the meaning of variables - Exploring the properties of whole numbers	- Using the properties of whole number operations - Using the equal sign operationally

2. The Subject KR 23

Subject KR 23 is a subject with moderate anxiety in mathematics. The following are the results of KR 23's work in solving TPMA.

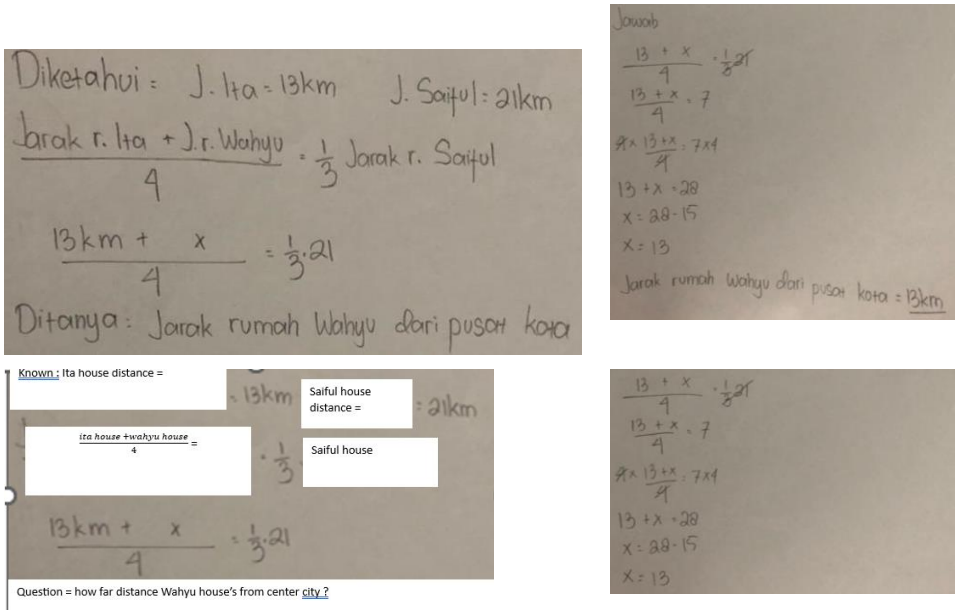

Figure 2. The Work of KR 23 of Middle Math Anxiety

The researcher conducted an interview with KR 23 and identified it based on the indicators of algebraic thinking with the following interview excerpts.

P	:	*Tell me what you did after reading this problem?*	
KR 23	:	*I wrote the equation according to the problem*	I_4
P	:	*Why does the second row say x+10-3 = 25?*	
KR 23	:	*I multiplied 5 by 2*	F_1
P	:	*Why is +7 in the equation x + 7 = 25, the next equation becomes x = 25 - 7. Can you explain!*	
KR 23	:	*I want to get the value of x so I have to move +7 from the left segment to the right segment to become -7.*	F_2

The work of KR 23 and the interview excerpt above, it can be seen that the subject with a moderate level of anxiety started his work by identifying through reading and understanding TPMA. Furthermore, KR 23 wrote down what was known and compiled the equation according to the given understanding. KR 23 did not appear to generalize by changing in the form of symbols. Generalization using symbols makes some students confused because it is too abstract. The indicator of using generalization is seen when multiplying 5 with 2, then adding 10 with -3.

Furthermore, moving +7 to the right segment and the results obtained are less precise.

The researcher triangulated KR 23's algebraic thinking by giving TPMA 2 and the triangulation results are presented in Table 4.

Table 4. Triangulation of KR 23's Algebraic Thinking

Indicator	TPMA 1	TPMA 2
Identification	Write down the known things, formulate equations by memorizing the distance of the house with variables and the equation made is correct	Starts by writing the knowns and constructs the equation
Generalization	Replacing the distance between Ita and Saiful's houses with known values and simplifying fractional numbers into whole numbers.	Replacing the age with the known number
The application of generalization	Multiplying fractional numbers in the left and right segments with a number. Move the number to the right hand side	Multiplied the left and right sides of the equation and moved it to the right side.

Table 4 above, shows the results of triangulation of subjects with moderate math anxiety based on algebraic thinking indicators presented in Table 5 below.

Table 5 Triangulation of Subjects with Moderate Math Anxiety

Identification	Generalization	Generalization Applicatiion
- Identifying the problem - Constructing the equation - Modeling	- Understand the meaning of variables - Exploring the properties of whole numbers	- Using the properties of whole number operations - Using the equal sign operationally

3. Subjek KR 44

Subject KR 44 is a subject with moderate anxiety in mathematics. The following are the results of KR 44's work in solving TPMA.

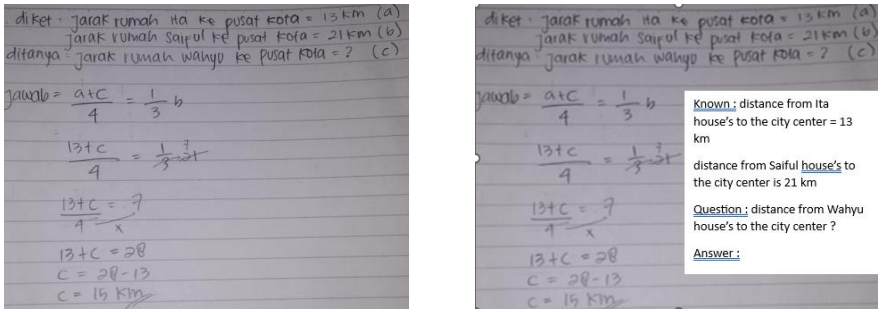

Figure 3. The Work of KR 44 of Low Math Anxiety

The researcher conducted an interview with KR 44 and identified it based on the indicators of algebraic thinking with the following interview excerpts.

P	:	*In this problem after reading the problem, what ideas came to mind?*	
KR 44	:	*I wrote down what is known in the probleml*	I_1
P	:	*Then?*	
KR 44	:	*I suppose the distance of ita's house to the city center with the letter "a", the distance of saiful's house to the city center whit the letter "b", and the distance of wahyu's house to the city center with the letter "c".*	I_3
P	:	*After you have generalized. What's the next step?*	
KR 44	:	*I set up the question*	I_2
P	:	*Can you continue?*	
KR 44	:	*I repleced a, and b with the number 13 and 21.*	G_1
P	:	*And then ?*	
KR 44	:	*I multiplied* $\frac{1}{3}$ *by 21.*	F_1
P	:	*next ?*	
KR 44	:	*I multiplied 7 by 4*	F_1
P	:	*Why is that ?*	
KR 44	:	*Ecause i want to change the fraction* $\frac{13+c}{4}$ *to 13 + c.*	G_2
P	:	*Why should the fraction be changed?*	
KR 44	:	*To make is easier to solve the problem, i need to make the question into 13 + c. So i move 4 to the right hand side.*	G_2
P	:	*Then ?*	
KR 44	:	*I move + 13 to the right. I get the value c = 15.*	F_2

The work of KR 44 and the interview excerpt above, it can be seen that the subject with a moderate level of low started his work after reading and understanding the gien situation, then identified by compiling an equation and generalizing with a variable. The subject generalized by exploring the number

properties of the equation made. The use of generalization was done by KR 44 by multiplying $\frac{1}{5}$ with 45. Then continued to multiply 7 with 9 and move +29 to the right segment.

The researcher triangulated KR 44's algebraic thinking by giving TPMA 2 and the triangulation results are presented in Table 6.

Table 6. Triangulation KR 44's Algebraic Thinking

Indicator	TPMA 1	TPMA 2
Identification	Write down what is known, make a memorization, and set up an equation	Set up equations and make generalizations
Generalization	Replace the distance variable with a number and convert frantions into equation form	Replace variables with values and understand the properties of number operations so as to be able to operate
The application of generalization	Moe +13 to the right	Multiply and move numbers

Table 6 above, shows the results of triangulation of subjects with moderate math anxiety based on algebraic thinking indicators presented in Table 7 below.

Table 7. Triangulation of Subjects with Low Math Anxiety

Identification	Generalization	The Application of Generalization
- Identifying the problem - Constructing the equation - Modeling	- Understand the meaning of variables - Exploring the properties of whole numbers	- Using the properties of whole number operations - Using the equal sign operationally

The results of the research described by the researcher above, show that each group of students with different levels of anxiety is able to complete the task in different ways and strategies. In line with previous research (Chimoni et al., 2018; Luo et al., 2009) that with their abilities, each group is able to complete tasks with different numbers and types of problems. Each subject with their own level of anxiety has different anxiety in creating models.

Each subject with different levels of anxiety, starts the next job by identifying the problem situation, generalizing, and applying the generalization. As stated by Naziroh et al. (2018) every stage that students do must be passed, only

what distinguishes the calmness shown by each subject. Bailoor & Rao (2013) reinforces the role of semantics in the learning process carried out by teachers and is reinforced by previous research (Prayitno, Purwanto, Subanji, Susiswo, Mutianingsih, et al., 2020) on the role of semantics in understanding the meaning of a given variable.

This difference indicates that there are different representations that students can use when solving problems. Some researchers have found the use of combinations in choosing representations that make it easier for students to solve problems (Chamidah et al., 2022; Muttaqien, 2016; Nada et al., 2020; Prayitno, Purwanto, Subanji, Susiswo, & As'ari, 2020). Students who have low mathematical anxiety tend to be more flexible in determining the most appropriate representation to solve problems. This is what supports students to succeed in their learning (Ocak & Yamaç, 2013; Suren & Kandemir, 2020) because the motivation came from here.

In the context of algebraic thinking, teachers also play an important role in designing their learning through creative algebraic tasks. The hope is that it can foster student creativity when faced with problems. As described in previous research (Mastuti & Prayitno, 2023) that teachers must also be able to design creative tasks that do not only provide one answer to a given situation. Students must be accustomed to exploring their abilities in the learning process in the classroom. In fact, teachers still often do not feel confident to get out of their comfort zone in order to develop their ability to explore their students' abilities.

Teachers who have professional skills should be supported by satisfactory TPACK skills. TPACK plays an important role in learning, especially for junior high school students whose thinking stage is still semi-concrete (Mutianingsih et al., 2023; Prayitno et al., 2023). Teachers must be able to be active in developing algebraic thinking skills for their students because this is the gateway for students to learn mathematics at the next level.

CONCLUSION

The algebraic thinking profile obtained in this study includes identification which includes (1) writing known information, (2) composing

equations, and (3) generalizing. Furthermore, generalizing which includes (1) understanding the meaning of variables and (2) exploring integers, and applying generalizations which includes (1) using the properties of integer operations and (2) using the equal sign operationally and or rationally. Recommendations from the results of this study are the need for special attention and treatment from teachers for students with high anxiety who tend to be confused when understanding problems. Different teaching patterns are needed, especially for students with high anxiety and teachers need to have creativity in developing varied and creative algebraic tasks so as to stimulate students' algebraic thinking.

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