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The Higher Order Thinking Skill of Students Assisted by Mathematics Olympiad Senior High School in Solving Algebra Problems in Terms of Self-Regulated Learning

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ABSTRACT

This study aims to describe the higher-order thinking skills of students assisted by the Mathematics Olympiad of SMA Negeri 2 Jember in solving algebra probelms in terms of self-regulated learning. This research is included in qualitative description research. Data were obtained from the results of self-regulated learning questionnaires, written tests/higher-order thinking skills tests, and interviews. Self-regulated learning questionnaire data aims to group students in low, medium, and high categories. In this study, there were 5 research subjects where 4 students with high self-regulated learning ability and 1 student with moderate self-regulated learning ability. Test and interview result data are used to describe the higher-order thinking skills of students assisted by the Mathematics Olympiad in solving algebra problems. The results showed that students with high self-regulated learning ability met all indicators of higher-order thinking skills, and students with moderate self-regulated learning ability were meeting until the evaluation stage. Students with low self-regulated learning skills were not found in the subjects of this study because of the limitations of olympiad students who are the subject of research.

***Keywords*:** *olympiad students, high order thinking skills, self-regulated learning, algebra problems*

Kemampuan Berpikir Tingkat Tinggi Siswa Binaan Olimpiade Matematika SMA dalam Memecahkan Masalah Aljabar Ditinjau dari *Self-Regulated Learning*

ABSTRAK

Penelitian ini bertujuan untuk mendeskripsikan kemampuan berpikir tingkat tinggi siswa binaan olimpiade matematika SMA Negeri 2 Jember dalam memecahkan masalah aljabar ditinjau dari *self-regulated learning*. Penelitian ini termasuk dalam studi kasus pada siswa olimpiade. Data diperoleh dari hasil angket *self-regulated learning*, tes tulis/tes kemampuan berpikir tingkat tinggi, dan wawancara. Data angket *self-regulated*

learning bertujuan untuk mengelompokkan siswa dalam kategori rendah, sedang, dan tinggi. Pada penelitian ini terdapat 5 subjek penelitian dimana 4 siswa dengan kemampuan *self-regulated learning* tinggi dan 1 siswa dengan kemampuan *self-regulated learning* sedang. Data hasil tes dan wawancara digunakan untuk mendeskripsikan kemampuan berpikir tingkat tinggi siswa binaan olimpiade matematika dalam memecahkan masalah aljabar. Hasil penelitian menunjukkan bahwa, siswa dengan kemampuan *self-regulated learning* tinggi memenuhi seluruh indikator kemampuan berpikir tingkat tinggi, siswa dengan kemampuan *self-regulated learning* sedang memenuhi sampai tahapan mengevaluasi. Sedangkan siswa dengan kemampuan *self-regulated learning* rendah tidak ditemukan dalam subjek penelitian ini karena keterbatasan siswa olimpiade yang menjadi subjek penelitian.

***Kata Kunci*:** siswa olimpiade, kemampuan berpikir tingkat tinggi, *self-regulated learning*, masalah aljabar

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1. Introduction

The ability to think is the ability of students to develop ideas and knowledge by connecting parts of knowledge appropriately and quickly which is expected to produce effective conclusions (Fallentza et al., 2020). The ability to think is divided into two levels, as described in Bloom's Taxonomy. The ability to think in the revision of Bloom's Taxonomy by the first three levels, namely: remembering (C1), understanding (C2), and applying (C3), is a lower-order thinking Skill (LOTS), while the next three levels, namely: analyzing (C4), evaluating (C5), and creating (C6), is a Higher Order Thinking Skill (HOTS) (Krathwohl, 2002).

Higher-order thinking skill is a process that goes beyond simply retaining and communicating information. Higher-order thinking skills are the ability to integrate, alter, and transform existing information and experience to think critically and creatively to make decisions and solve issues in new situations (Rofiah et al., 2013). Higher-order thinking skills make individuals able to interpret, analyze, or manipulate information (Irawati, 2018). HOTS occurs when a person associates new information with information previously stored in his memory and connects it, as well as reorganizes and expands the information to attain a goal or discover a solution to an intractable situation (Agustyaningrum, 2015). Using HOTS on learning in the classroom was to further enhance students' creativity and critical thinking abilities (Nadifah & Shodikin, 2024).

Based on the official website of the International Mathematics Olympiad (IMO) 2023 the results of the Indonesian Mathematical Olympiad Team are ranked 39 out of 112 countries. Indonesian student representatives at the IMO 2023 event won 1 Silver Medal, 3 Bronze Medals, and 3 Honourable Mentions with Olympiad questions tested covering algebra, combinatorics, geometry, and number theory. Mahbub (2023) said that Olympiad questions require students to have good analytical skills, think more actively, and recall all the information they have received in solving Mathematics Olympiad problems which require

higher-order thinking skills (HOTS). According to Witri et al (2019), higher-order thinking skills (HOTS) help students to think more extensively and deeply about the subject matter, so HOTS is a more complicated thinking ability to locate or solve problems. According to Abosalem (2016), problem-solving exercises are an effective technique to build higher-order thinking skills. In addition to being useful for the Olympiad, the capacity to think at a higher level is required in learning so that students can address real-world problems. Higher-order thinking abilities (HOTS) encourage pupils to think more extensively and deeply about the subject matter, hence HOTS is a more complicated thinking ability to answer problems (Witri et al., 2019). Problem-solving is the first step for students in developing ideas or ideas to form new knowledge and develop mathematical skills (Purnamasari & Setiawan, 2019). Another definition of problem-solving is a strategy that students use in understanding, using assessment, solving methods, and solving models to find solutions to problems (Bernard & Mariam, 2018). he purpose of school-based mathematics education is to teach students how to think and reason in order to reach conclusions, as well as to build problem-solving abilities and the ability to convey information or communicate ideas orally, in writing, and so on (Sumartini, 2018). Problem-solving is needed in the higher-order thinking process, namely, each student has a way of high-order thinking indicators including analyzing, evaluating, and creating information (Purbaningrum, 2017). Students who often participate in the Olympiad certainly have different thinking patterns or ways from students who have never participated in the Olympiad (Rohim & Sari, 2019). Olympiad students who won medals in the OSN event are students with good problem-solving skills (Mairing et al., 2011). According to the opinion of Prasiti & Mairing (2010), one good problem solver is the Olympiad student.

The Olympiad is a forum for students to develop talents in academic and non-academic fields at the district, provincial, national, and international levels. Mathematics is one of the subjects tested in the Olympiad in the academic field in addition, according to Devita & Pujiastuti (2020), mathematics is characterized by its emphasis on deductive processes that require logical and axiomatic reasoning starting with an inductive process that involves constructing conjectures, mathematical models, analogies, and/or generalizations by observing large amounts of data. Mathematical Olympiad is an event aimed at participants who want to measure their potential in the field of mathematics (Dewi et al., 2019). Mathematical Olympiad is one solution to proving students' potential and talent in mathematics (Parinters et al., 2018). Mathematics Olympiad questions have different characteristics from questions that are usually tested or given during practice at school. The characteristics of Mathematics Olympiad problems include the following: (1) The problems given are unusual and open-ended, which requires problem-solving. (2) The problems are divergent, that is, they have more than one alternative solution. (3) the process requires students to have skills in reasoning and mathematical communication skills (Shobikhah, et al., 2021). Based on these three characteristics of the problem, students' strategies and plans for solving the Olympiad questions are very necessary (Mairing et al., 2011). One of the materials tested and influenced assessment in the Mathematics Olympiad is algebra. Facts in the field show that the level of mastery of algebra material for students who are not Olympiad fostered students is still low, so students have difficulty in doing algebra problems (Setiawan et al., 2018). The low ability of students in algebra material is influenced by students low Self-Regulated Learning (SRL) in learning (Kholifasari et al., 2020).

Self-regulated learning is the active and constructive process of students creating objectives for their learning process and working to monitor, regulate, and control cognition, motivation, and behavior, all of which are guided and driven by goals (Adicondro & Purnamasari, 2011). Self-regulated learning affects students' problem-solving abilities. If students' self-regulated learning skills are good, then their problem-solving skills are good (Ansori & Herdiman, 2019). Students fostered by Mathematics Olympiad require high self-

regulated learning to solve problems in Mathematics Olympiad problems (Trisnowali, 2015). The same thing was also revealed by other researchers that students with high SRL ability can meet the indicators of analyzing and evaluating, students with moderate SRL ability meet the analyzing indicator, and students with low SRL ability have not met all indicators of higher order thinking ability (Anggita, 2019). Based on the description above, researchers are interested in researching the higher-order thinking skills of students fostered by the Mathematics Olympiad in solving algebra problems in terms of self-regulated learning, because algebra is a material tested in the Mathematics Olympiad. Based on Pradanti's research (2024), prospective mathematics teacher students have difficulty understanding the concepts needed in solving algebra problem olympiad problems, so this study is interested in knowing the ability of high school students to solve algebra problems, because high school students and college students have different learning experiences.

Self-regulated learning has indicators and sub-indicators that are used in making questionnaires, namely cognitive strategy, motivation strategy, and behavioral strategy. Cognitive strategy is a way to maximize brain performance so that students can think and receive learning well. This strategy is divided into three parts, namely rehearsal and elaboration, organization, and metacognitive. Motivation strategy is an effort in students to be able to do assignments and carry out learning activities well so that students can achieve pre-planned goals. This strategy is divided into three parts, namely self-consequating, environmental structuring, and mastery, relative ability, and performance self-talk. Behavioral strategy is an effort to select, structure, and create an environment to optimize their learning, where students control themselves and try to find ways to solve the learning problems they face. This strategy is divided into two parts: effort regulation and help-seeking (Wolters et al., 2003).

Based on the descriptions above, it is necessary to conduct a study was conducted to describe the higher-order thinking skills of students, especially students assisted by the Mathematics Olympiad in solving algebra problems so that they can be useful for the advancement of mathematics in Indonesia in general.

2. Research Method

2.1 Types of Research

The type of research used in this study is a case study research with a qualitative approach and the final goal is to describe the higher-order thinking skills of students fostered by the High School Mathematics Olympiad in solving algebra problems in terms of self-regulated learning. The research area is SMA Negeri 2 Jember. Techniques in determining research areas using purposive area techniques.

2.2 Research Subjects

The subjects of the study used the technique of deliberate selection of subjects. The subjects of the study were 5 students who represented the school in the National Science Olympiad at least the district level. All students were given a self-regulated learning questionnaire, based on the results of the questionnaire 4 students with high self-regulated learning ability and 1 student with moderate self-regulated learning ability. Furthermore, higher-level thinking test questions are given to measure students' ability to solve algebra problems. Alternative answers to question number one there are two alternative answers, namely alternative one using the same algebra modification with the function domain and alternative two using complex numbers, question number two three alternative answers use the possible values (2, -1, -1), (-1, 2, -1), and (-1, -1, 2) will get the values x, y, and z

different but if added the results are the same, and question number three there are two alternative answers, alternative answer one by forming an algebra pattern that corresponds to the question and alternative answers two substituting natural numbers into equations to form a convergent series. Students' answers with different alternative answers and correct values will be interviewed to describe their higher-order thinking skills.

2.3 Research Instruments

The research instruments used were self-regulated learning questionnaires, written tests, and interview guidelines. The questionnaire used is adoption Wahdana (2022) with validity values $V_a = 4{,}33$ on a scale of 5 that is declared valid. Written tests and interview guidelines based on aspects of format validation, content validation, language validation, and construction validation consecutively with validity scores $V_a = 3{,}59$ and $V_a = 3{,}36$ On a scale of 4 it is categorized as valid and can be used to collect the data needed in this study.

2.4 Data Collection and Analysis

Researchers collected data on higher-order thinking skills by administering written tests and interviews. Students do the questions first to completion, after which an interview will be conducted with the conditions that have been set. The interview was conducted offline using the help of a voice recorder on a mobile phone. The interviews used in this study were semi-structured. Next, data on high-level thinking skills were analyzed based on higher-order thinking ability indicators shown in Table 1.

Table 1. Higher Order Thinking Ability Indicators

No	Ability	Research Indicators	Research Sub Indicators
1.	Analyzing (C4)	Students can process polynomial shapes into simpler ones to look for patterns or relationships that exist to obtain polynomial values at a certain point.	**A.1:** Students can process polynomial shapes into simpler ones to look for patterns or relationships that exist to obtain polynomial values at a certain point.
			A.2: Students are not able to process polynomial forms into simpler ones to look for patterns or relationships that exist to obtain polynomial values at a certain point.
2.	Evaluating (C5)	Students can provide an assessment of the solution of algebra problems in the form of a system of three-variable linear equations using appropriate criteria, to determine the values of x, y, and z.	**B.1:** Students can assess the solution of algebra problems in the form of a system of three-variable linear equations using appropriate criteria, to determine the values of x, y, and z.
			B.2: Students are unable to assess the solution of algebra problems in the form of a system of three-variable linear equations using appropriate criteria, to determine the values of x, y, and z.
3.	Creating (C6)	Students can generalize ideas to construct new equations using different arithmetic series 1, to find the coefficient values of the new equation.	**C.1:** Students can generalize ideas to construct new equations using different arithmetic series 1, to find the coefficient values of the new equation.
			C.2: Students are unable to generalize ideas to construct new equations using different arithmetic series 1, to find the coefficient values of new equations.

The indicators of higher-order thinking skills in Table 1 are seen based on students' steps in solving problems with levels C4, C5, and C6. If students can solve these level questions, students can meet research sub-indicators **A.1, B.1,** and **C.1**.

Data on higher-order thinking skills derived from data from written test results and interviews were analyzed using qualitative data analysis techniques. Researchers reduced the written test data using the categories in Table 1. The interview data were reduced and

presented in the form of transcripts of interviews between researchers and subjects. Presentation of data on written test results and interviews in the form of descriptions to describe students' higher-order thinking skills. Interview data is obtained after the test questions are done by students, the next process is continued by conducting interviews with selected subjects using the following coding.

1. Students with high self-regulated learning (ST) ability and students with moderate self-regulated learning (SS) ability. The codes used in this study are ST1 students who answer with alternative answer 1, ST2 who answer with alternative answer 2, SS1 who answer with alternative answer 1, and so on.
2. The first rule, is if the researcher asks and comments on the ST1 interview subject at the 1st interview and starts from the first question, then write the code PST101, for ST2 with the code PST201 and SS1 with the code PSS101. This coding applies to subjects, interviews, and interview questions posed to students.
3. The second rule, is if the SS1 interview subject answers or comments on the question asked by the researcher at the 1st interview and starts from the first answer, then it is written with the code ST101, for ST2 the code ST102, and SS1 the code SS101. This coding applies to every subject, interview, and question asked by the researcher.
   Furthermore, the validity test of the data will be carried out using the triangulation method. The triangulation method is done by comparing data between data from written tests and interview data. The last stage carried out in this study is the drawing of conclusions. Conclusions are made based on the analysis of the data that has been presented

3. RESULT AND DISCUSSION

3.1 Result

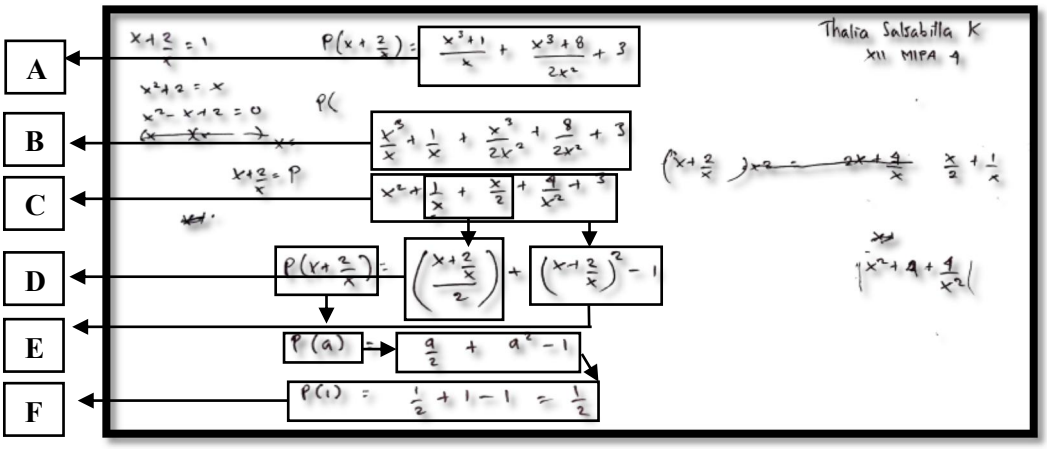
Data on higher-order thinking skills were obtained from written test data and confirmed through interview data. The results of written tests and interviews are used to describe qualitatively to analyze students' higher-order thinking skills in solving algebra problems with the levels of analyzing, evaluating, and creating shown in Table 2.

Table 2. Algebra Higher Level Thinking Test Questions

Ability	Question
Analyzing	A polynomial satisfies $P(x)$ $$P\left(x+\frac{2}{x}\right)=\frac{x^3+1}{x}+\frac{x^3+8}{2x^2}+3$$ Determine the value of $\mathrm{P}(1)$
Evaluating	If is a round number that meets x, y, z $$x^2y+y^2z+z^2-20=xy^2+yz^2+zx^2-22=3xyz$$ So, the result of the sum of the three numbers is....
Creating	It is known that the series of real numbers for every natural number n satisfies $$\frac{na_1+(n-1)a_2+\ldots+2a_{n-1}+a_n}{n^2}=1$$ Create a formula that matches the formula above, and then specify the value of $a_1a_2a_3a_4a_5\ldots a_{2019}$ be...

Subjects with High Self-Regulated Learning (ST)

The following answers are presented by subjects with high self-regulated learning (ST) with alternative answer 1 in solving the analyzing level questions.



Picture 1. ST1 Answer Results Number 1

Based on Picture 1 **(A)** students write down polynomial equations known by the problem, **(B)** students operate polynomial forms into fractional forms, **(C)** then the work process continues to convert algebra forms into simple ones. **(D)** and **(E)** the next step, change the form of the equation on the right to the algebra form corresponding to the polynomial domain, **(F)** finally suppose a domain with the variable a and the substitution for the value of the domain is equal to 1 and the polynomial value is half.

Based on the test result data, an interview is still needed to check the validity of the test result data to describe higher-order thinking skills in the analyzing category (C4). The following is an interview excerpt from alternative answer 1 (ST1) from 4 students with high self-regulated learning ability.

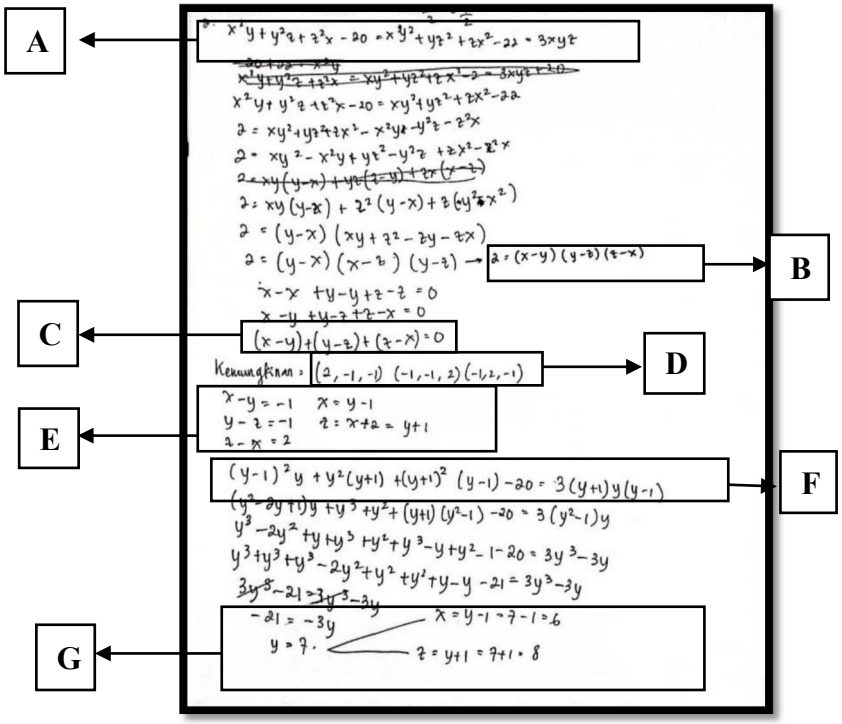
PST101: "In your opinion, sort the question numbers from the easiest until it's difficult?"
ST1101: "I think the order is easy to difficult yes number 1,2,3"
PST102: "Explain what is known in question number 1?"
ST102: "In question number 1 it is known that a polynomial satisfies"

$$P\left(x+\frac{2}{x}\right)=\frac{x^3+1}{x}+\frac{x^3+8}{2x^2}+3$$

PST103: "Explain what was asked in question number 1?"
ST103: "The queried value is determined by P(1)"
PST104: "Describe the first steps in solving the problem?"
ST104: "The first step is to separate the form from the algebra of the polynomial, after which finding patterns similar to functions in polynomials"
PST105: "Briefly explain how to solve the problem?"
ST105: "In the beginning this was the form of the problem was changed into a fractional form and next look for the same pattern with $x+\frac{2}{x}$, $\frac{x+\frac{2}{x}}{2}$ *and squared* $\left(x+\frac{2}{x}\right)^2$ *but still. It needs to be reduced by 1, then suppose* $x+\frac{2}{x}=a$, *then value substitution a=1. So that the polynomial value is half for a=1"*
PST106: "Do you think there is an alternative answer to what you wrote?"
ST106: "Maybe there is, I tried from $x+\frac{2}{x}=1$, *later the x value is imaginary and substitution to polynomial".*

Based on interview excerpts and answer sheets, 4 students with high self-regulated learning skills met the higher-order thinking skills of the analyzing category (C4) because they met the research sub-indicator **A.1**

The following answers are presented by subjects with high self-regulated learning (ST) with alternative answers 1 in solving the evaluating level questions.



Picture 2. ST1 Answer Results Number 2

Based on Picture 2 **(A)** ST1 uses the leftmost and middle equations, namely: $x^2y + y^2z + z^2 - 20 = xy^2 + yz^2 + zx^2 - 22$, **(B)** It then operated algebraically until obtaining an algebra pattern *(x-y)(y-z)(z-x)*=2. **(C)** Students then look for possible values by relating them to equations *(x-y) + (y-z) + (z-x)* = 0. **(D)** The next step, ST1 looks for 3 numbers that add up to 0 and the results of 2 times which may include (2,-1,-1), (-1,-1,2), and (-1,2-1). **(E)** Then, take one of the three possibilities i.e. (-1,-1,2) to form a 3-variable linear equation directed into the variable y. **(F)** The last step, is substitution to the leftmost and rightmost equations. **(G)** obtained the values of y = 7, x = 6, and z = 8. However, ST1 forgot to add up the three numbers even though that was what was asked in the question.

Based on the test result data, an interview is still needed to check the validity of the test result data to describe higher-order thinking skills in the evaluating category (C5). Here is an interview excerpt for alternative answer 1 (ST1).

PST101: "Explain what you know about question number 2?"
ST101: "Known x,y,z an integer and $x^2y + y^2z + z^2 - 20 = xy^2 + yz^2 + zx^2 - 22$""
PST102: "Explain what was asked in question number 2"
ST102: "The result of the sum of the three numbers"
PST103: "Describe the first steps in solving the problem?"
ST103: "Forming the algebra pattern"
PST104: "Briefly explain how to solve the problem"
ST104: "Forms an algebra pattern of the problem and finds the values of possibilities such as (2,-1,-1), (-1,-1,2), (-1,2,-1) continuously operated and substituted to obtain the values of x, y, and z"
PST105: "Do you think there is an alternative answer to what you wrote?"

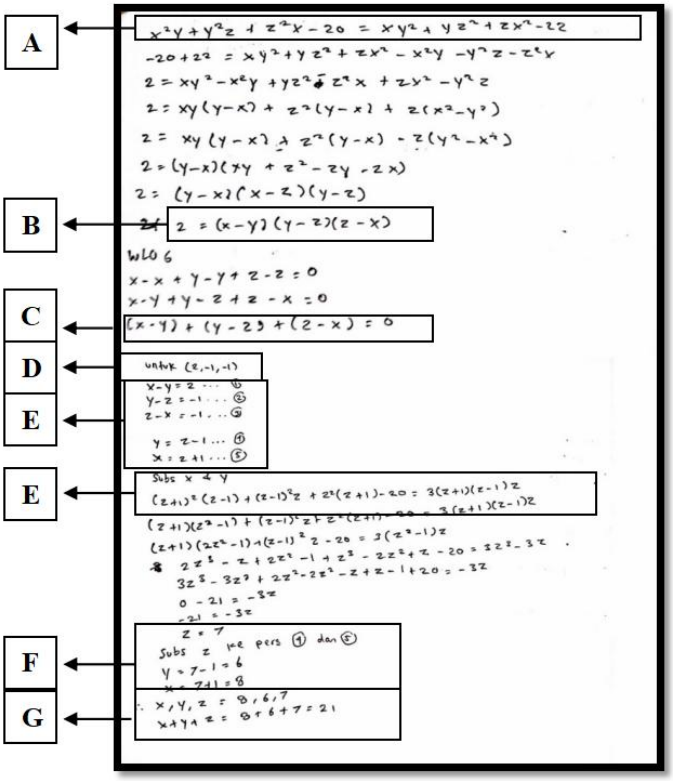
ST105:"There is because I only used (-1,-1,2) to find the values of x, y, and z, and we can use other possibilities"

PST106: "Okay, smart, then why don't you add up the three numbers? That's what the question asks"

ST10: "Oh yes I forgot I haven't added it up".

Based on interview excerpts, ST1 can find the probability value of the algebra pattern, namely (2,-1,-1), (-1,-1,2), (-1,2,-1) but only uses one probability value, namely (-1,-1,2) to get the value (*x,y,z*) = (6,7,8). If ST1 uses the possibilities (2,-1,-1) and (-1,2,-1) then respectively (*x,y,z*) = (8,6,7) and (7,8,6) the three numbers if added together will be the same value which is 6+7+8=8+6+7=7+8+6=21. Based on the answer sheet, students with high self-regulated learning skills meet the higher-order thinking skills of the evaluating category (C5) because they meet the research sub-indicator **B.1**. However, in the alternative answer, answer 1 (ST1) does not add up the three numbers because it forgets.

Here is an alternative answer 2 to question number 2 evaluation level from students with high self-regulated learning ability using other possibilities obtained without reducing their generality.



Picture 3. ST2 Answer Results Number 2

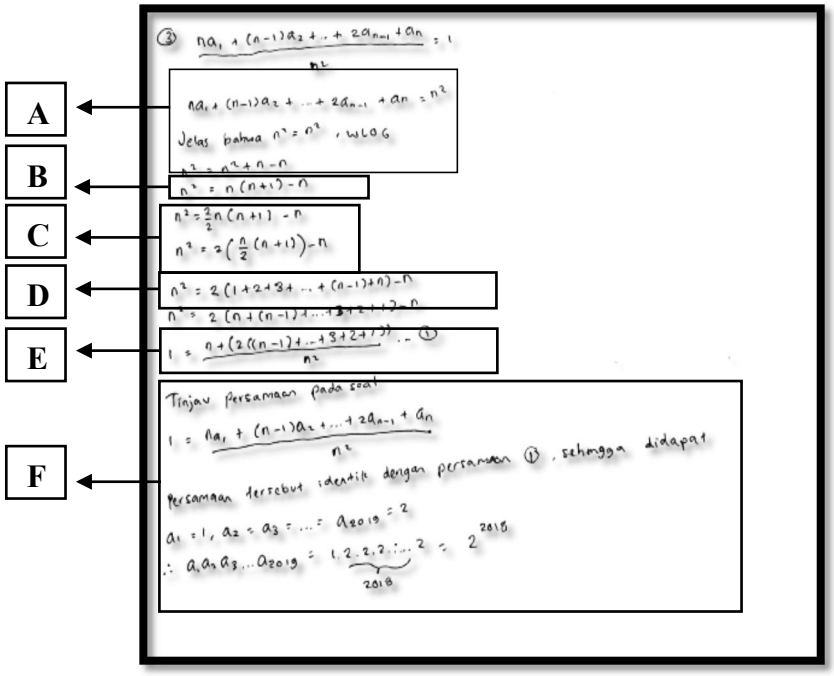
Based on Picture 3 **(A)** ST2 takes 2 equations left and center, namely: $x^2y + y^2z + z^2 - 20 = xy^2 + yz^2 + zx^2 - 22$ **(B)** the goal is to obtain algebra patterns *(x-y)(y-z)(z-x)*=2, **(C)** The next step is to do without loss of generality (WLOG) with the equation *(x-y) + (y-z) + (z-x)* = 0 **(D)** which satisfies, namely (2,-1,-1), **(E)** then substitution to get three-variable linear equations which is then directed into the variable z only. **(F)** The last step is the substitution of the 2 equations in the problem, **(G)** to obtain the value of $z = 7$, and get $x = 8$, $y = 6$, **(H)** so that the sum result is 21.

Based on the test result data, an interview is still needed to check the validity of the test result data to describe higher-order thinking skills in the evaluating category (C5). Here is an interview excerpt for alternative answer 2 (ST2).

PST201: "Explain what is known in question number 2?"
ST201: "Known x,y,z is a round number that meets
$x^2y + y^2z + z^2 - 20 = xy^2 + yz^2 + zx^2 - 22 = 3xyz$"
PST202: "Explain what was asked in question number 2"
ST202:"Searched for the sum of the three numbers x, y, and z"
PST203: "Describe the first steps in solving the problem?"
ST203: "That first step, we take two equations first and then move the coefficients that similarly, after that, we find the same shape from it as (y — x) and then factor or exclude"
PST204: "Briefly explain how to solve the problem"
ST204: "Maybe first look for the two equations that are left and center, continue to move the numbers usually and then find the same form (x-y) other factors such as (z-x) and (y-z) so that we get 2= (x-y) (y-z) (z-x), then we without loss of generality (WLOG) with (x-y)+(y-z)+(z-x)=0, then that satisfies for (2,-1,-1) and can substitute x-y=2, and y-z=-1, z-x=-1, after that, it can be changed to y=z-1 and x=z+1, then substituted to the left and rightmost equations and then later will obtain the value of z = 7, then substituted to y = z-1 obtained y = 6 and x=z+1=7+1=8, then add x+y+z=8+6+7=21"
PST205: "Do you think there is an alternative answer to what you wrote?"
ST205: "There is a possible".

Based on interview excerpts, ST2 was able to obtain algebra patterns and use the term without loss of generality or without reducing generality to equations. ST2 is only able to take the possibility (2,-1,-1) without looking at other possibilities so that the value (*x,y,z*) = (8,6,7) is obtained. Based on the answer sheet, 4 students with high self-regulated learning skills meet the higher-order thinking skills of the evaluating category (C5) because they meet the research sub-indicator **B.1**.

The following answers are presented by subjects with high self-regulated learning (ST) with alternative answers 1 in solving the level of **creating questions**.



Picture 4. ST1 Answer Results Number 3

Based on Picture 4 **(A),** ST1 tries to decipher the equation to be proved, then uses without loss of generality (WLOG) with $n^2=n^2+n-n$, **(b)** which then initiates the completion of factoring the form $n^2=n^2+n-n$ to $n^2=n(n+1)-n$. **(C)** The next step, operated by multiplying the identity number that is $\frac{2}{2}$ at $n(n+1)$ so that it is obtained $\frac{2}{2}n(n+1)-n$, **(D)** then operated to obtain the general form of an arithmetic series with a difference of 1 through $2\left(\frac{n}{2}(n+1)\right)-n=2(1+2+3...+(n-1)+n)-n$, **(E)** the last step modifies the algebra form until an identical form to the problem is obtained and **(F)** the value of the coefficient sought is obtained

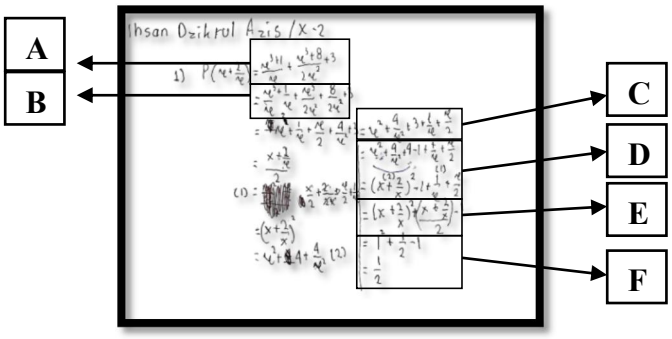
Based on the test results, an interview is still needed to check the validity of the test result data to describe higher-order thinking skills in the category of creation (C6). Here is an interview excerpt for alternative answer 1 (ST1).

PST101: "Explain what you know about question number 3?"
ST101: "The line of the number of reals for each number of natives n that meet $\frac{na_1+(n-1)a_2+...+2a_{n-1}+a_n}{n^2}=1$"
PST102: "Explain what is asked in question number 3"
ST102:"Specify the value of a_1 *multiple* a_2 *to* a_{2019}*"*
PST103: "Describe the first steps in solving the problem?"
ST103: "second-time field with n2after that we without loss of generality (WLOG) with $n^2=n^2+n-n$*"*
PST104: "Briefly explain to solve the problem"
ST104:"from$n^2=n^2+n-n$ *modified right segment to* $n^2=2/2(n+1)-n$ *become* $n^2=2(n+1)/2-n$*, continue to form (n+1)/2 is the same kayak shape 1+2+3+....+(n-1)+n So it's the same cake form the problem by dividing the two fields by* n^2 *then this The equation is similar to the problem, but in this equation* $a_1=1$ *the value of the coefficient* a_2 *to* a_{2019} *is 2 so that if multiplied everything is so* 2^{2018}*"*
PST105: "Do you think there is an alternative answer to what you wrote?"
ST105: "Should exist".

Based on interview excerpts, ST1 tries to form an algebra pattern that fits the problem by using the term without loss of generality (WLO) through $n^2=n^2+n-n$ whose purpose is to form a general pattern of arithmetic series widely the equation $\frac{n(n+1)}{2}=1+2+3+...+(n-2)+(n-1)+n$, then ST1 Modify the shape until it is equal to the problem and get the value of the coefficient value to ba search $a_1=1, a_2=a_3=...=a_{2019}=2$ The final result obtained by multiplying all the coefficients obtained is $2^{2018.}$ Based on the answer sheet, 4 students with high self-regulated learning skills meet the higher-order thinking skills of the creation category (C6) because they meet the research sub-indicator **C.1**.

Subject with Self-Regulated Learning While (SS)

The following answers are presented by subjects with moderate self-regulated learning (SS) with alternative answers 1 in solving the analyzing level questions**.**



Picture 5. SS1 Answer Results Number 1

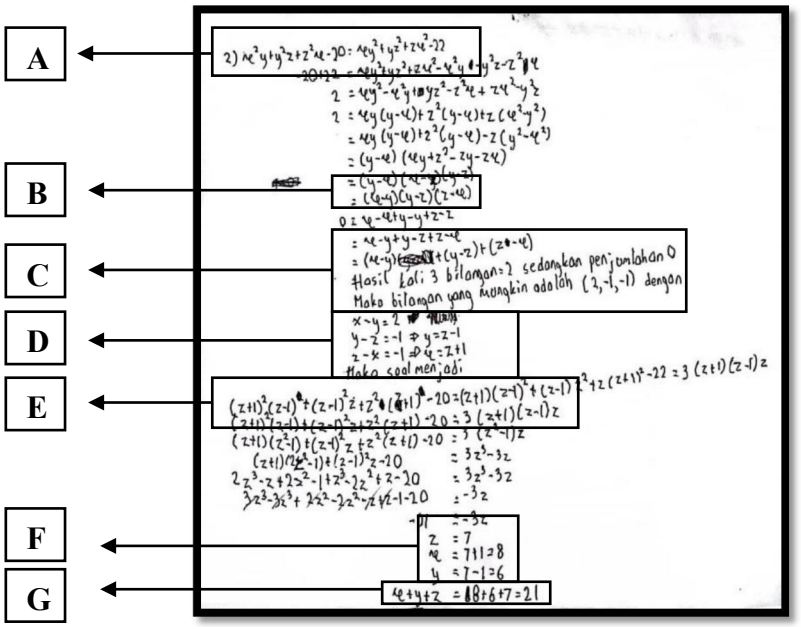
Based on Picture 5 alternative answer 1 (SS1) **(A)** writes the polynomial form, **(B)** then operates the polynomial form into a fractional form, **(C)** then the work process continues to convert the algebra form into simple. **(D)** The next step, grouping the algebra form corresponding to the polynomial domain and converting 3 into 4-1, **(E)** the right equation turns into a polynomial domain form, **(F)** without doing SS1 direct substitution for the domain value equal to 1 and obtained the polynomial value is half

Based on the test result data, an interview is still needed to check the validity of the test result data to describe higher-order thinking skills in the analyzing category (C4). Here is an interview excerpt for alternative answer 1 (SS1).

PSS101: "In your opinion, do you order the question numbers from easiest to difficult?"
SS101: "I think the order of the questions from the easiest is from number 1 to 3 in all order."
PSS102: "Explain what you know about it in question number 1?"
SS102 "suatu polinom $P\left(x+\frac{2}{x}\right)=\frac{x^3+1}{x}+\frac{x^3+8}{2x^2}+3$"
PSS103: "Explain what was asked in question number 1?"
SS103:"then asked P(1)"
PSS104: "Describe the first steps in solving the problem?"
SS104: "The first one we describe"
PSS105: "Briefly explain how to solve the problem?"
SS105: "We break it down into simple forms like $P\left(x+\frac{2}{x}\right)=x^2+\frac{1}{x}+3+\frac{x}{2}+\frac{4}{x^2}$
then subtract by 1 plus 1 to $P\left(x+\frac{2}{x}\right)=x^2+\frac{4}{x^2}+4-1+\frac{1}{x}+\frac{x}{2}$ *and*
obtained algebra patterns into $P\left(x+\frac{2}{x}\right)=\left(x+\frac{2}{x}\right)^2+\frac{\left(x+\frac{2}{x}\right)}{2}-1$ *and results finally so half for the value of P(1)"*
PSS106: "Do you think there is an alternative answer to what you wrote?"
ST106: "There must be".

Based on interview excerpts and answer sheets, 1 student with self-regulated learning skills is meeting the higher-order thinking skills of the analyzing category (C4) because it meets the research sub-indicator **A.1**.

The following answers are presented by subjects with moderate self-regulated learning (SS) with alternative answers 1 in solving the evaluating level questions**.**



Picture 6. SS1 Answer Results Number 2

Based on Picture 6 **(A)** students use the leftmost and middle elaboration, namely: $x^2y + y^2z + z^2 - 20 = xy^2 + yz^2 + zx^2 - 22$, **(B)** of the 2 equations used to find the algebra pattern *(x-y)(y-z)(z-x)*=2, **(C)** then connected with the equation *(x-y) + (y-z) + (z-x)* = 0 and wrote that looking for 3 numbers if added then the result is 0 and if at times then the result is 2, the number that satisfies is (2,-1,-1), **(D)** then substitution to get three-variable linear equations which is then directed into variable z only. **(E)** The last step is the substitution of the 3 equations in the problem, **(F)** to obtain the value of *z* = 7, and get *x* = 8, *y* = 6, **(G)** so that the sum result is 21.

Based on the test results, an interview is still needed to check the validity of the test result data to describe higher-order thinking skills in the evaluating category (C5). Here is an excerpt of an interview from SS1.

PSS101: "Explain what you know about it in question number 2?"
SS101:"It is known that for example

$$x^2y + y^2z + z^2 - 20 = xy^2 + yz^2 + zx^2 - 22 = 3xyz$$

PSS102: "Explain what is asked in question number 2"
SS102: "How many is the value x+y+z"
PSS103: "Explain the first step in solving the problem?"
SS103: "From the question $x^2y + y^2z + z^2 - 20 = xy^2 + yz^2 + zx^2 - 22$ *all of them moved to one of the segments to the left."*
PSS104: "Briefly explain how to solve the problem"
SS104: "Then it is explained continuously until we find the result (x-y) times (y-z) and (z-x) it is equal to 2 then we find the number if added the result is 0 and multiplied by 2 then which satisfies it x-y=2, y-z=-1, and z-x=-1, then substitute to the problem by replacing y=z-1 and x=z+1, the result can be z=7, x=8 and y=6 and if added together the result is 21"
PSS105: "Do you think there is an alternative answer to what you wrote?"
SS105: "may exist".

Based on the SS1 interview excerpt using equations $x^2y + y^2z + z^2 - 20 = xy^2 + yz^2 + zx^2 - 22$ get an algebra pattern that is connected to a number plus the result is 0 and if multiplied the result is 2 that is (2, -1, -1). *z*=7, *x*=8 and *y*=6 are obtained. Based on the answer

sheet, 1 student with self-regulated learning ability is meeting the higher-order thinking ability of the evaluating category (C5) because it meets the research sub-indicator **B.1**.Students with self-regulated learning skills are not answering question number 3 for higher-order thinking skills in the category of creating (C6) so that they meet the C.2 research sub-indicator**.**

Based on research conducted at SMA Negeri 2 Jember on 5 students assisted by the Mathematics Olympiad, the results of the self-regulated learning questionnaire showed 1 student with moderate self-regulated learning and 4 students with high self-regulated learning. Selection of interview research subjects based on alternative answers given by students who have high and medium self-regulated learning abilities.

3.2 Discussion

Students' self-regulated learning ability influences their High Order Thinking Skills (HOTS), or the ability to think at a high level when solving issues (Hodiyanto and Muhammad, 2020). According to the study's findings, based on student work and interview results, students with high self-regulated learning ability achieved indicators of analyzing (C4), evaluating (C5), and creating (C6), whereas students with moderate self-regulated learning ability achieved indicators of analyzing (C4) and evaluating (C5). No indicators of low self-regulated learning ability were found in this study.

These results are new findings in research on higher-order thinking skills in terms of self-regulated learning because based on research conducted by Anggita (2019). The results of the study are students with high self-regulated learning abilities can meet the indicators of analyzing (C4) and evaluating (C5), students with self-regulated learning abilities are meeting the analyzing indicators (C4) and students with low self-regulated learning abilities have not met all indicators of higher-order thinking ability.

The comparison of students' answers with high and moderate self-regulated learning abilities lies in the flow of working on the questions. In question number 1 about polynomial material with the level of analyzing (C4), students with high self-regulated learning abilities in the process immediately go through several stages in working on the problem and immediately assume a domain with variable a then the substitution and answer are correct. This is different from what is done by students with self-regulated learning abilities who are answering questions with a very coherent answer scheme and do not do domain emulating in the final answer, but directly substitution and correct answers. This is a new thing when compared to the results of Nugraheni et al's (2021) research on students with high self-regulated learning and are solving analyzing level (C4) questions, namely students with self-regulated learning abilities can interpret the questions but the answers are not correct, then students with high self-regulated learning abilities have similar answers to moderate self-regulated learning students but can answer correctly after asked repeatedly.

Question number 2 with three-variable linear equations material with the level of evaluating questions (C5), students with high self-regulated learning ability can obtain 2 alternative possible answers, but students with moderate self-regulated learning ability are only able to obtain 1 alternative answer and all answers between high and medium are correct. This is a new thing when compared to the results of Nugraheni et al's (2021) research on students with high self-regulated learning who are solving evaluating level questions (C5), namely students with self-regulated learning are having difficulty solving problems and students with high self-regulated learning abilities can solve the questions well.

Question number 3, arithmetic series material with a difference of 1 student with high self-regulated learning ability can solve the problem well, but students with self-regulated learning ability are not answering the question. This is according to the results of research by Nugraheni et al (2021) students with high self-regulated learning and are solving creating-

level questions (C6), namely students with high self-regulated learning abilities can solve problems correctly and students with self-regulated learning abilities are unable to solve these problems.

4. Conclusion

Based on data analysis and discussion of the results of high-level thinking tests in solving algebra problems, it was concluded that students with high self-regulated learning abilities meet all higher-order thinking indicators with detailed analysis (C4) can process polynomial forms into simpler to find patterns or relationships that exist to obtain polynomial values at a certain point, evaluate (C5) able to provide an assessment of the solution of algebra problems into the form of a system of three-variable linear equations using appropriate criteria, to determine the values of x, y, and z, by providing two alternative answers, and create (C6) able to generalize ideas to construct new equations using different arithmetic series 1, to find the coefficient values of new equations, by providing only one alternative answer. Students with low self-regulated learning ability only reach the evaluation level (C5) and only provide 1 alternative answer. Students with low self-regulated learning skills were not found in the study. These results are new findings in research on higher-order thinking skills in terms of self-regulated learning when compared to the results of the study.

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6. References

Abosalem, Y. (2016). Assessment Techniques and Students' Higher-Order Thinking Skills. *International Journal of Secondary Education*, 4 (1), 1-11. https://doi.org/10.11648/j.ijsedu.20160401.11

Adicondro, N., & Purnamasari, A. (2011). Efikasi Diri Dukungan Sosial Keluarga dan *Self Regulated Learning* Pada Siswa Kelas VII. *Indonesian Psychological Journal*, 8(1), 17. https://doi.org/10.26555/humanitas.v8i1.448

Agustyaningrum, N. (2015). Mengambangkan Keterampilan Berpikir Tingkat Tinggi dalam Pembelajaran Matematika SMP. *Jurnal Progam Studi Pendidikan Matematika*, 4(1), 39-46. https://doi.org/10.33373/pythagoras.v4i1.567

Anggita, S. (2019). Deskripsi Kemampuan Berpikir Tingkat Tinggi Siswa SMP Negeri 1 Kersana dalam Menyelesaikan Masalah *Open Ended* Ditinjau dari *Self Regulated Learning*. *Skripsi*. Purwokerto: Fakultas Keguruan dan Ilmu Pendidikan Universitas Muhammadiyah Purwokerto.

Ansori, Y., & Herdiman, I. (2019). Pengaruh Kemandirian Belajar terhadap Kemampuan Pemecahan Masalah Matematis Siswa SMP. *Journal Of Mathematics Education IKIP Veteran Semarang*, 3(1), 11-19. https://doi.org/10.31331/medivesveteran.v3i1.646

Bernard, M., & Mariam, S. (2018). Analisis Kemampuan Pemecahan Masalah Matematis Siswa SMP Kelas IX Pada Materi Bangun Datar. *SJME (Supremum Journal of Mathematics Education)*, 2(2), 77–83. https://doi.org/10.35706/sjme.v2i2.1317

Dewi, S. S., Hariastuti, R. M., & Utami, A. U. (2019). Analisis Tingkat Kesukaran Dan Daya Pembeda Soal Olimpiade Matematika (Omi) Tingkat Smp Tahun 2018. Transformasi : *Jurnal Pendidikan Matematika dan Matematika*, 3(1), 15–26. https://doi.org/10.36526/tr.v3i1.388

Fallentza, D. S. A., Setyawati, R. D., & Rahmawati, N. D. (2020). Analisis Kemampuan Berpikir Tingkat Tinggi Siswa SMP dalam Menyelesaikan Soal Matematika Tipe HOTS. *Jurnal Penelitian dan Karya Ilmiah*, 1(1), 77–83.

Hodiyanto, H. & Muhammad, F. (2020). The Self Regulated Learning, Habit of Mind, and Creat As High Order Thinking Skills Predictors. *Jurnal Progam Studi Pendidikan Matematika,* 9(1), 21-30. https://doi.org/10.24127/ajpm.v9i1.2589

Irawati, T. N. (2018). Analisis Berpikir Tingkat Tinggi Siswa SMP dalam Menyelesaikan Soal Pemecahan Masalah Matematika Pada Materi Bilangan Bulat. *Gammath,* 3(2),1-6. https://doi.org/10.32528/gammath.v3i2.1599

Kholifasari, R., C. Utami., & Mariyam. (2020) Analisis Kemampuan Literasi Matematis Siswa Ditinjau dari Karakter Kemandirian Belajar Materi Aljabar, *Jurnal Derivat,* 7(2), 2549-2616. https://doi.org/10.31316/j.derivat.v7i2.1057

Krathwohl, D.R. (2002). A Revision of Bloom's Taxonomy. *Theory Into Practice*, 41, (4). https://doi.org/10.1207/s15430421tip4104_2

Mahbub, L. (2023). Proses Berpikir Tingkat Tinggi Siswa Binaan Olimpiade Matematika dalam Memecahkan Masalah Geometri Ditinjau dari Tipe Kepribadian Sensing dan Intuiting. Skripsi. Jember: Fakultas Keguruan dan Ilmu Pendidikan Universitas Jember.

Mairing, J. P., Budayasa, I. K., & Juniati, D. (2011). Profil Pemecahan Masalah Siswa Peraih Medali OSN Matematika. *Jurnal Pendidikan dan Pembelajaran*, 18(1),65-71.

Nadifah, L., & Shodikin, A. (2024). Analysis of Student Ability Solving Hots Problems Material Exponent Equation Reviewed From's Beginning Ability. *Jurnal Penelitian Pendidikan Matematika*, 8(1), 37-50. https://doi.org/10.32502/jp2m.v8i1.8809

Nugraheni, N., St. Budi., & Walid, W. (2021), HOTS Study Primary Teacher Education UNNES Students Based On Self-Regulated Learning. *Jurnal Prima Edukasia*, 9(1), 127-134. https://doi.org/ 10.21831/jpe.v9i1.36359

Parinters Makur, A., Charitas, R., Prahmana, I., Gunur, B., Stkip, S., & Paulus, R.-F.-N. (2018). Kemampuan Berpikir Tingkat Tinggi, Peserta Osk Matematika Tingkat SD, dan Strategi Think, Talk, and Write. *Jurnal Pendidikan Matematika*, 12(2), 23–32. https://doi.org/10.22342/jpm.12.2.5677.23-32

Pradanti, P., N., Agustyaningrum, & D.W., Astuti, (2024). Analisis Kesulitan Calon Guru Matematika dalam Menyelesaikan Soal Olimpiade Bidang Aljabar. *Jurnal Matematika dan Pembelajaran,* 9(1),15-26. https://doi.org/10.56013/axi.v9i1.2491

Prastiti, T.D, & Mairing. (2010). Karakter Peraih Medali OSN Matematika dalam Menyelesaikan Masalah. repository.ut.ac.id/2544/1/fkip201025.pdf

Devita P.W.C & Pujiastuti, W.C.(2020). Analisis Kemampuan Pemecahan Masalah Matematika Ditinjau Dari Gender. *Kreano: Jurnal Matematika Kreatif-Inovatif*, 11(1), 110-117. http://dx.doi.org/10.15294/kreano.v11i1.23601

Purnamasari, I., & Setiawan, W. (2019). Kemampuan Pemecahan Masalah Matematis Siswa SMP pada Materi SPLDV Ditinjau dari Kemampuan Awal Matematika (KAM). *Journal of Medives : Journal of Mathematics Education IKIP Veteran Semarang*, 3(2), 207–215. https://doi.org/10.31331/MEDIVESVETERAN.V3I2.771

Rofiah, E., Aminah, N. S., & Ekawati, E. Y. (2013). Penyusunan Instrumen Tes Kemampuan Berpikir Tingkat Tinggi Fisika Pada Siswa SMP. *Jurnal Pendidikan Fisika*, 1(2), 17-22.

Rohim, M. F., & Sari, A. F. (2019). Keterampilan Siswa Memecahkan Masalah Olimpiade Matematika Ditinjau dari Kepribadian Tipe Sensing dan Intuiting. *Jurnal Elemen*, 5(1), 80. https://doi.org/10.29408/jel.v5i1.1047

Setiawan, Y. B., Hapizah, H., & Hiltrimartin, C. (2018). Kesalahan Siswa dalam Menyelesaikan Soal Olimpiade SMP Konten Aljabar. *Jurnal Riset Pendidikan Matematika*, 5(2), 233–243. https://doi.org/10.21831/jrpm.v5i2.18191

Shobikhah, A., Siswono, T. Y. E., & Prastiti, T. D. (2021). Analisis Kemampuan Berpikir Kreatif Siswa Berbakat dalam Menyelesaikan Soal Olimpiade Matematika. *JPMI (Jurnal Pendidikan Matematika Indonesia)*, 6(2), 83-90. http://dx.doi.org/10.26737/jpmi.v6i2.2520

Sumartini, T. S. (2018). Peningkatan Kemampuan Pemecahan Masalah Matematis Siswa melalui Pembelajaran Berbasis Masalah. *Mosharafa: Jurnal Pendidikan Matematika*, *5*(2), 148–158. https://doi.org/10.31980/mosharafa.v5i2.270

Trisnowali, A. (2015). Profil Disposisi Matematis Siswa Pemenang Olimpiade Pada Tingkat Provinsi Sulawesi Selatan. *Journal of EST*, 1(3), 47-57. https://doi.org/10.26858/est.v1i3.1826

Purbaningrum, K. A. (2017). Kemampuan Berpikir Tingkat Tinggi Siswa SMP dalam Pemecahan Masalah Matematika Ditinjau dari Gaya Belajar. *Jurnal Penelitian dan Pembelajaran Matematika*, *10*(2). https://doi.org/10.30870/jppm.v10i2.2029

Wahdana, A.H. (2022). Kemampuan Literasi Matematika Siswa SMA dalam Menyelesaikan Soal HOTS Pokok Bahasan SPLTV Ditinjau Dari Self-Regulated Learning. Skripsi. Jember: Fakultas Keguruan dan Ilmu Pendidikan Universitas Jember.

Witri, S., Febrian, F., & Rosmery Tambunan, L. (2019). Deskripsi Kemampuan Berpikir Tingkat Tinggi Siswa dalam Menyelesaikan Soal Fungsi Kelas X SMAN 2 Tanjungpinang. *Jurnal Gantang*, *4*(2), 155–160. https://doi.org/10.31629/jg.v4i2.1527

Wolters, C.A., Pintrich, P.R., dan Karabenick. (2003). *Assessing Academic Self-Regulated Learning*. ChildTrends: National Institutes of Health. https://doi.org/ 10.1007/0-387-23823-9_16