Metacognition skills and higher order thinking skills (HOTS) in mathematics

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Abstract. Based on the results of interviews with teachers and observations of mathematics students of class VIII at the school where the research is, the difficulty of students in learning material related to high-level thinking problems (HOTS) when receiving or understanding concepts given by the teacher. This study aims to find out how the influence of metacognition skills to the ability of Higher Order Thinking Skills (HOTS) MTs N 1 Kudus students and bias can be used as a trigger to increase Higher Order Thinking Skills (HOTS) skills. Hypothesis testing uses simple linear regresi. The results of this study indicate that: 1) there is a positive and significant correlation to the Higher Order Thinking Skills (HOTS) skills of 60.8%; 2) there is a positive and significant correlation to the Higher Order Thinking Skills (HOTS) skills based on indicators of metacognition skills (awareness = 43.8%, regulation = 65.5%, and evaluation = 57.8%).

1. Introduction
Metacognition is the thought process of a person in his own thought process when building strategies for problem solving. The term metacognition was first introduced by Flavell [1]. metacognition is an individual's awareness in managing one's own mind and consists of several strategies used by students to plan learning, monitor thoughts, and control their own thoughts. Brown [2]. divides metacognition into two categories namely knowledge of cognition and regulation of cognition. Knowledge cognition refers to self-activity that involves conscious reflection on a cognitive ability and activity. While the regulation of cognition refers to activities related to self-regulation mechanisms during ongoing learning.

Students in the context of learning consciously think about what kind of thinking strategies will be used in solving a problem faced. [3]. that each metacognitive strategy, when used appropriately, can enable students to export as much as possible, memorize basic facts and learn lower levels of skills. From these skills, students can find out the development of their thinking as well as the strengths and weaknesses in determining appropriate learning strategies in learning.

Metacognitive skills possessed by each individual have different levels because it depends on each knowledge and how each individual manages the thought process. [4]. that metacognitive skills are a set of competencies that are interconnected for learning and thinking, as well as the skills needed for active learning, critical thinking, reflective assessment, problem solving, and decision making. [5]. says that there are three aspects found in metacognitive skills, namely awareness (self-awareness), regulation (regulation), and evaluation (assessment). Determination of the level of metacognitive skills is based on criteria adapted from Schraw & Dennison [6]. for adults, poor (x ≤ 50), poor (51-69), sufficient (70-79), and good (80 ≥ x ). As in Table 1. Indicators of metacognition skills.
### Table 1. Indicators of metacognitive

| Variable | Indicators |
|----------|------------|
| Metacognition awareness | Declarative Knowledge | able to process / use skills aware of one's own skills, intelligence, and abilities |
| | Procedural Knowledge | Knowledge of how to do it |
| | Conditional Knowledge | Knowledge of why and when to use procedures Select important information used |
| Metacognitive Regulation | Planning | Know what the goals are Know what skills and resources must be involved Determine how much time is needed Choose the right strategy Elaborate information from various sources Designing what will be done |
| | Monitor | Consider the accuracy of the results of data collection Identify sources of error from the data obtained Choose the right repair strategy when the strategy chosen doesn't work Monitor self progress and provide input for himself / self feedback |
| Metacognition evaluation | Evaluation | Assess the achievement of objectives Assess the effectiveness of the strategies that have been used |

Based on the results of interviews with mathematics teachers in class VIII at the school where the study was, students' difficulties in learning material related to high-level thinking problems (HOTS) when receiving or understanding concepts given by the teacher. Students tend to learn by prioritizing memorization and lack of understanding the concept process that is structured to answer questions, resulting in most students find it difficult to grasp or understand the concepts given by the teacher. Metacognitive students in the context of learning, students will consciously think about what kind of thinking strategies will be used in solving a problem faced, especially questions that are at the level of high-level thinking ability (HOTS) [3] that each metacognitive strategy, when used correctly, can enable students to move beyond limits, memorize basic facts and learn lower levels of skills. From this skill, students can find out the development of their thinking and their strengths and weaknesses in determining appropriate learning strategies in learning.

According to Saputra [7], states that high-level thinking is a process of thinking in learners in a higher cognitive level that is developed from a variety of cognitive concepts and methods and learning taxonomies such as problem solving methods, bloom taxonomy, and taxonomy of learning, teaching, and assessment. These high order thinking skills (HOTS) include problem solving skills, creative thinking skills, critical thinking, logical thinking, argumentative abilities, and decision making abilities. According to [8]. High order thinking skills (HOTS) have the following opinion:

"higher order thinking is using the thinking widely to find new challenges. Higher order thinking demands someone to apply new information or knowledge that he has got and manipulates the information to reach the possibility of answer in the new situation ".

The ability to think at a high level or High order thinking skills (HOTS) is interpreted as the wider use of the mind to find new challenges. This ability to think at a higher level requires someone to apply new information or prior knowledge and manipulate information to reach possible answers in new situations. In line with the opinion of Brookhart [9]. HOTS can be understood as an ability of students to be able to connect the lesson with other elements beyond what the teacher teaches to be socialized with.
Senk, et al (1997) cited by [10], in the International Electronic Journal of Mathematics Education describe the characteristics of high order thinking skills (HOTS) as: "solving tasks where no algorithm has been taught, where justification or explanation is required, and where more than one solution might be possible. So the purpose of the statement above is thinking high level or HOTS is the ability to complete tasks where no algorithm has been taught, which requires justification or explanation and may have more than one solution that might be used.

Quoted from [11], the dimensions of high-level thinking ability that Bloom is described in the following Table 2.

| The Knowledge Dimension | The Cognitive Process Dimension |
|--------------------------|---------------------------------|
| Analyze (C4)              | Evaluate (C5)                   | Create (C6)                   |
| Factual Knowledge         | Making structure,               | Comparing,                    | Joining |
|                          | classifying                     | correlating                   |
| Conceptual Knowledge      | Explain analyze                 | Examine,                      | Planning |
|                          |                                 | interpret                     |
| Procedural Knowledge      | Distinguish                     | Conclude,                     | Arrange, |
|                          |                                 | resume                        | Formulate |
| Metacognitive Knowledge   | Create, find                    | Make assess                   | Realization |

Seeing from the discussion above high-level thinking (HOTS), the research is that higher order thinking skills have 3 indicators of analysis (C4), evaluation (C5), and creating (C6). Knowledge is also metacognitive knowledge is knowledge that consists of three aspects of strategy, task and self. 1) Strategy knowledge or awareness (self-awareness) related to knowledge of strategies for learning, 2) Knowledge of tasks or regulations related to using thinking in the right conditions and aspects. 3) Self-knowledge or evaluation related to strengths and weaknesses of self to reflect learning activities that have been done. The indicators chosen came from the many indicators in Bloom’s Taxonomy that were revised by Anderson and Krathwol. These indicators are considered important for measuring the high-level thinking of HOTS junior high school students.

So the purpose of this study is to find out whether there is an effect of metacognitive skills on students' higher order thinking skills (HOTS), in terms of quantitative analysis to see the percentage of influence and qualitative analysis aimed at detecting which metacognitive skills are still lacking on HOTS questions. So the author intends to conduct research under the title "metacognition skills and higher order thinking skills (HOTS) in mathematics".

2. Method
This research is quantitative and qualitative research.

2.1. Quantitative research
This quantitative research is a type of correlation research. This research is a type of correlation research. The population of this study is students of class VIII B in MTs N 1 Kudus in the academic year 2019/2020. The determination of the sample in this study was determined by cluster random sampling technique, namely students of class VIII B with a total of 24 students. The variables in this study consisted of independent variables namely metacognitive skills and researchers examined the effect on the dependent variable namely the ability of students to high-level thinking (HOTS). The instrument in this study was a 5 item description question to determine students high-level thinking (HOTS) abilities and for a questionnaire sheet consisting of 3 indicators developed in 25 assessment items to measure students' metacognitive skills. Then the data is processed using SPSS 25.0.

The first hypothesis testing was carried out using three analytical methods in the SPSS 25.0 program the effect of metacognitive skills on students' high-level thinking ability Skills (HOTS). The first hypothesis testing using the following analysis: 1) Normality test to test whether the data are normally distributed, the data normality test is performed on the dependent variable (mathematical high-level thinking ability) with data criteria said to be normally distributed if the Kolmogrov Smirnov is a significance value > 0.05 ; 2) Linearity test to test the linearity of metacognitive skills data on the ability of Higher Order Thinking Skills (HOTS) by using a simple regression equation, Y = α + βX.
Data is said to be linear if the significance value < 0.05; 4) Simple linear regression test to determine the size of the influence of independent variables is metacognitive skills and the dependent variable is the ability of students to (HOTS) by using the general form of simple linear regression equation, \( Y = a + bX \).

The second hypothesis testing is only done by one method in the SPSS 25.0 program, namely the effect of the component's metacognitive skills (self-awareness, self-regulation and assessment) on the ability of High Order Order Thinking Skills (HOTS) students. So the second hypothesis testing is also analyzed by using a simple linear regression test that is \( Y = a + bX \). The difference between testing the first hypothesis and the second hypothesis is the first hypothesis to determine the effect of overall metacognitive skills on the ability of Higher Order Thinking Skills (HOTS) while the second hypothesis to determine the effect of component metacognitive skills (self-awareness, self-regulation and assessment) on the ability of Higher Order Thinking Skills (HOTS) students.

2.2. Qualitative research
Qualitative research is research to understand phenomena experienced by research subjects (behaviors, perceptions, actions, etc.) holistically and by describing (in the form of words and languages) [15]. This is in the form of an analysis of students' metacognition and its causes in the Higher Order Thinking Skills (HOTS) questions.

3. Result and Discussion
3.1. Quantitative research
The study was conducted in class VIII MTs N 1 Kudus and the time of the study was conducted on October 9, 2019 academic year 2019/2020. The research was conducted on Social Arithmetic in Class VIII B with a total of 24 students. The researchers in this study produced metacognitive skills data and students' Higher Order Thinking Skills (HOTS) skills. Metacognitive skills data are replaced with variables (X) obtained from a questionnaire through 3 indicators outlined by 25 assessment items. Data on the ability of Higher Order Thinking Skills (HOTS) is replaced with variables (Y) obtained from the problem description 5 items containing 3 indicators of Higher Order Thinking Skills (HOTS), namely analyzing, evaluating, creating.

Researchers made two hypotheses that were analyzed using the SPSS 25.0 program. in testing the first hypothesis the researcher wants to know the correlation of metacognitive skills and the ability of Higher Order Thinking Skills (HOTS) students with three analyzes namely normality, linearity, and simple linear regression tests. Data normality test is tested on dependent variables (the ability of Higher Order Thinking Skills (HOTS)). By passing the Kolmogorov Smirnov test on the SPSS 25.0 obtained normality data in the following Table 3.

| Table 3. Normality test data capabilities on Higher Order Thinking Skills (HOTS) |
|-----------------|----------|---------|----------|---|---|
|                 | Kolmogorov-Smirnov\(^a\) | Shapiro-Wilk |
| Statistic       | Df | Sig. | Statistic | Df | Sig. |
| Score           | .171 | 24 | .062 | .894 | 24 | .027 |

\(a\). Lilliefors Significance Correction

The data normality testing hypothesis is:

\( H_0 \): Variance is normally distributed

\( H_1 \): Variance is not normally distributed

Test criteria accept Ho if the significance value > 5%. Based on the table above, a significance value of 0.062 or 6.2% > 5% is obtained. So Ho's conclusion is accepted, it means that the Higher Order Thinking Skills (HOTS) ability variable in class VIII B is normally distributed.

The metacognitive skills questionnaire given to students was not only tested whether the students 'metacognitive skills affected the ability of students' Higher Order Thinking Skills (HOTS). But the researchers also tested whether the achievement of metacognitive skills indicators and
conducted data linearity tests of metacognitive skills on the ability of Higher Order Thinking Skills (HOTS) students.

Based on the questionnaire data with 3 indicators of metacognitive skills that are spelled out in 25 assessment items and the metacognitive skills questionnaire is given after the end of the Higher Order Thinking Skills (HOTS) ability test. Achievement of indicators of metacognitive skills classically obtained an average of 74.250 means that metacognitive skills possessed by students are quite high. The instrument metacognitive skills variables used in this study consisted of 25 items. Grouping students' answers are divided into four ranges of scores with categories 1, 2, 3, and 4. So the average results of students' metacognitive skills both classically and individually show enough categories.

3.1.1. Effects of metacognitive skills on students' Higher Order Thinking Skills (HOTS) abilities

Simple linear regression test to determine the effect of metacognitive skills on students' Higher Order Thinking Skills using SPSS version 25.0 obtained the following results:

**Table 4. Simple linear regression test results coefficients**

| Model | Unstandardized Coefficients | Standardized Coefficients | t       | Sig.  |
|-------|-----------------------------|---------------------------|---------|-------|
|       | B                           | Std. Error                | Beta    |       |
| 1     | (Constant)                  | -11.710                   | 14.972  | -.782 | .442 |
| keterampilan metakognitif | 1.123                       | .194                      | .777    | 5.782 | .000 |

Dependent Variable: Higher Order Thinking Skills (HOTS) capabilities

Based on the Coefficient table above, it can be determined the linear regression equation, namely $y = -11.710 + 1.123X$. Furthermore, before determining how much influence the independent variable (metacognitive skills) has on the dependent variable (the ability of Higher Order Thinking Skills (HOTS)), the linear equation regression test is first performed.

**Linearity Test of Metacognitive Skill Variables on Mathematical Critical Thinking Ability**

Test the linearity of the data used a regression equation with a simple regression model that is estimation with the formula $Y = a + bX$

$H_0$: Model regresi linear

$H_1$: Model regresi non linear

With the test criteria $H_0$ is accepted if the significance value <5%.

Based on Table 4 can be read on the t distribution of the significance of metaognitive skills (X) $t_{count} = 5.782 > t_{table} = 2.074$ with a significance of 0.000 < 0.005, then $H_0$ is accepted, meaning that the metacognitive skills variable has a linear relationship to the ability of Higher Order Thinking Skills (HOTS). It can also be said that the coefficient $\beta$ for the variable X is positive, each 0.777, it can be said that the relationship is positive. Positive means that metacognitive skills have a linear relationship to the ability of Higher Order Thinking Skills (HOTS). By looking at the standardized $\beta$ (Beta) coefficient, the value is theoretically the same as the correlation coefficient. The above shows that the metacognitive skills (X) towards the ability of Higher Order Thinking Skills (HOTS) (Y) are linear means and the magnitude of the correlation coefficient is 0.777.

To see the magnitude of the influence or contribution of metacognitive skills to the ability to think critically mathematically can be seen the value of R Square (coefficient of determination) in the following Table 5.
Table 5. Contribution of metacognitive skills to Higher Order Thinking Skills (HOTS)

| Model | R   | R Square | Adjusted R Square | Std. Error of the Estimate |
|-------|-----|----------|-------------------|---------------------------|
|       | .777a| .603     | .585              | 10.838                    |

a. Predictors: (Constant), metacognitive skills
b. Dependent Variable: Higher Order Thinking Skills (HOTS)

From the above data obtained R Square value of 0.603 = 60.3% this means that variations that occur in Y can be explained by X through the model Y = -11,710 + 1,123X while 39.7% are influenced by other variables.

3.1.2. The Effect of Metacognitive Skills Based on Indicators (Awareness, Regulation, Evaluation) Against the Abilities of Higher Order Thinking Skills (HOTS)

Simple linear regression test to determine the effect of metacognitive skills based on indicators such as awareness (self awareness) on the ability to think critically mathematical students using SPSS version 25.0 obtained the following results:

Table 6. Simple Regression Linear Test the results

| Higher Order Thinking Skills (HOTS) (Y) | B        | Std. Error | Beta | t_count | Sig |
|----------------------------------------|----------|------------|------|---------|-----|
| Konstanta                              | 2.310    | 16.804     | .677 | .137    | .892|
| Awareness (X₁)                         | 2.817    | .653       | 4.312| .000    |     |
| Regulation (X₂)                        | -5.506   | 11.913     | -.462| .649    |     |
| Evaluation (X₃)                        | -12.298  | 15.224     | -.808| .428    |     |
|                                        | 3.605    | .630       | .774 | 5.725   | .000|

Based on the above Table 6, it can be determined a linear regression equation for awareness (self awareness), namely Y = 2.310 + 2.817 X₁. The table above also shows awareness t_count = 4.312 > t_table = 2.074 so that the two constants are declared significant and the significance value (0.000 < 0.005) then H₀ is accepted. This means that the linear model between awareness (self awareness) and the ability of Higher Order Thinking Skills (HOTS) is significant. The linear regression equation for regulation (self regulation) is Y = -5.506 + 3.767 X₂. Furthermore, the table above also for regulation shows t_count = 6.763 > t_table = 2.074 so that it can be stated that the two constants are significant with a significance value (0.000 < 0.005) then H₀ is accepted. In accordance with the above table, we also see a linear regression equation for evaluation, namely Y = -12.298 + 3.605 X₃ and t_count = 5.725 > t_table = 2.074. The two meanings are significant with a significance value (0.000 < 0.005) then H₀ is accepted.

To find out the effect of awareness (self awareness) on the ability of Higher Order Thinking Skills (HOTS) can be seen from the value of R Square in the following table.

Table 7. Contribution of awareness, regulation, and evaluation of the ability of (HOTS)

| Model           | R       | R Square | Adjusted R Square | Std. Error of the Estimate |
|-----------------|---------|----------|-------------------|---------------------------|
| Awareness (X₁)  | .677a   | .458     | .433              | 12.665                    |
| Regulation (X₂) | .822a   | .675     | .660              | 9.805                     |
| Evaluation (X₃) | .774a   | .598     | .580              | 10.904                    |
From the Table 7 obtained R Square value of 0.458 = 45.8% means that the variation that occurs in Y can be explained by X through a linear regression model that is Y = 2,310 + 2,817 X₁ while 54.2% is influenced by other variables. In the regulation obtained R Squares value of 0.675 = 67.5%. This means that variations that occur in Y can be explained by X through a linear regression model Y = -5.506 + 3.767 X₂ whereas 32.5% is influenced by other variables. While the evaluation obtained R Square value of 0.598 = 59.8% means that the variation that occurs in Y is explained by X through the model Y = 12,298 + 3,605 X₃ while 40.2% is influenced by other variables.

1) The effect of metacognitive skills on the ability of Higher Order Thinking Skills

The mean result of classical metacognitive skills is 74.250%. This means that the students 'metacognitive skills in working on the problems are overall positive and show a fairly high category. The average results of individual students' metacognitive skills reflect an adequate category of 24 students. The amount of the contribution of metacognitive skills to the ability of Higher Order Thinking Skills can be read from the value of R Square (determination index) that is equal to 0.603 = 60.3%, meaning that the metacognitive skills affect the ability of Higher Order Thinking Skills (HOTS) of students by 60.3% while there are other variables which affects 39.7%. Metacognitive skills affect the ability of students to Higher Order Thinking Skills (HOTS) in accordance with research conducted by [12,13,14] that in general metacognitive can be strengthened leading to the development of critical thinking, reasoning, and problem solving actions. It is very necessary that the trials cognitively influence high level capability.

2) The Effect of Metacognitive Skills Based on Indicators (Awareness, Regulation, Evaluation)

Against the Mathematical Critical Thinking Ability

| Metacognitive Skills | Higher Order Thinking Skills (HOTS) |
|----------------------|-------------------------------------|
| Awareness = 45.8%    | Analyze                             |
| Regulation = 67.5%   | Evaluate                            |
| Evaluation = 59.8%   | Create                              |

**Figure 1.** The Effect of Metacognitive Skills

3.2. Qualitative research

Examples of new Arithmetic Higher Order Thinking Skills (HOTS) used:

| Barang | Harga       | Diskon                  |
|--------|-------------|-------------------------|
|        | Toko Rame   | Toko Damai              | Toko Seneng | Toko Indah |
| Baju   | Rp 80,000,00| 25%                     | 20%         | 15%        | 10%        |
| Celana | Rp 100,000,00| 10%                     | 15%         | 20%        | 25%        |

Anam akan membeli sebuah baju dan celana di toko yang sama. Di toko manakah Anam berbelanja agar diperoleh harga yang paling murah? Jelaskan alasannya!

**Figure 2.** Example of new Arithmetic Higher Order Thinking Skills
Error Analysis about HOTS which is affected by metacognition abilities

Errors occur if students are wrong or do not determine conclusions (set of completion) because students do not understand the meaning of the command matter, so students have not been able to regulate self-awareness, how the desired goal in the problem.

Figure 3. Student Work

In Figure 3, the students are correct in the process of counting but it is still wrong in concluding which store's store should be chosen, not those that have the least amount of discount as offered by a beautiful store that is the price of a shirt of Rp 8,000 and Rp 15,000, but the most discounted price should be chosen like the one offered by the crowded store, that is, the price of clothes is Rp 20,000 and pants Rp 10,000. Based on interviews with students, students are not careful enough to understand the purpose of the command matter, that the discount is a discount rather than the value that must be paid.

It can be concluded that students are still not able to use self-awareness properly about what should be done in the problem. So the ability of metacognition needs to be considered to train students' self-awareness between being able or not in selecting important information used in problem solving, especially on HOTS. Because in the HOTS problem itself needs to use high reasoning in problem solving, so the ability of metacognition is important for students to use in improving the ability of HOTS.

4. Conclusion and suggestion

Based on the results of research and discussion about the effect of metacognitive skills on the ability of Higher Order Thinking Skills (HOTS) students obtained the conclusion that; 1) There is a significant influence of metacognitive skills on the ability of Higher Order Thinking Skills (HOTS) with a linear regression model \( Y = -11.710 + 1.123X \). The magnitude of the effect of students' metacognitive skills on the ability of Higher Order Thinking Skills (HOTS) students is known from...
the value of $R^2$ (index of determination) of 60.3% while other variables that affect the ability of Higher Order Thinking Skills are 39.7%. 2) There is an effect of metacognitive skills based on indicators (awareness, regulation, and evaluation) on students' mathematical thinking ability with a regression equation model for awareness that is $Y = 2.310 + 2.817X$, for regulation that is $Y = -5.506 + 3.767X$, while for evaluation that is $Y = -12.298 + 3.605X$. The magnitude of the effect of the three indicators of metacognitive skills is that each gained awareness = 45.8%, regulation = 67.5%, and an evaluation of 59.8%. The rest of each indicator is influenced by other variables.

Based on the three indicators of the metacognitive skills obtained information that regulation (self-regulation) is higher in influence than the other indicators and student awareness (self-awareness) is the lowest compared to other metacognition indicators and from the findings of student work analysis, students lack knowledge of conditional knowledge in understanding maximal the purpose of the problem command is to select important information used in problem solving. So that student awareness in learning or in working on questions needs to be developed to be able to produce better Higher Order Thinking Skills (HOTS).

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