The relationship between habits of mind and metacognition in solving real analysis problems

R Y Tyaningsih\(^*\), T W Triutami\(^1\), D Novitasari\(^1\), N P Wulandari\(^1\) and Y M Cholily\(^2\)

\(^1\)Mathematics Education Department, Universitas Mataram, Indonesia
\(^2\)Mathematics Education Department, Universitas Muhammadiyah Malang, Indonesia

*Corresponding author’s email: ratnayulis@unram.ac.id

Abstract. The habits of mind are often associated with metacognition because both are related to human thinking. Metacognition skills focus on how a person manages his thoughts, whereas habits of mind focus on one's ability to think and make conclusions about one's thoughts. The purpose of this research was to determine the relationship between habits of mind and metacognition of students in solving real analysis problems. Sampling is done by purposively. The subjects in this study were students of Mathematics Education in Semester 5 Academic Year 2019/2020. This type of research is quantitative with data collection techniques using test and online surveys. The data obtained were analyzed by Correlation Analysis. The results of data analysis show the relationship between habits of mind and metacognition in solving mathematical problems is a very strong positive, for metacognition-problem solving and habits of mind-problem solving. Positive means the unidirectional relationship between habits of mind and metacognition, the purpose of unidirectional is the better the habits of the mind, the better the metacognition and vice versa. Based on the results of this study, it can be concluded that there is a significant relationship between habits of mind and metacognition of students in solving mathematical problems.

1. Introduction
The term metacognition first appeared in the 1970s which examines one's awareness of the cognitive processes that occur when solving a problem. Metacognition is often interpreted as “thinking about thinking”. It is considered as a type of person's thinking to express what is desired to show their ideas and achievements in various contexts [1]. Metacognition is an awareness of the cognitive processes experienced and skills in monitoring and controlling cognitive processes [2]. Awareness of their thought processes will guide students in developing, monitoring, and evaluating the learning strategies that have been used.

Metacognition is divided into three components, namely metacognitive knowledge, metacognitive experience, and metacognitive skills. Metacognitive knowledge includes information stored in long-term memory that refers to three domains, namely oneself, the tasks performed, and the accompanying strategies [3]. Whereas metacognitive experiences include cognition and feelings followed by intellectual processes. Meanwhile, metacognition skills are one's ability to regulate and control cognitive activity. Cognitive activities include mental activities related to intellectual abilities. Of the three types of metacognition, which is closely related to the ability to solve problems is metacognitive skills.
Metacognition skills are important for students to have because they help students to exchange new information/knowledge with others so that they arouse curiosity and interest in new things and make them lifelong learners [4]. Therefore, this study will further explore the relationship between metacognition and problem-solving.

In connection with problem-solving, metacognition skills are divided into two interrelated abilities, namely knowing self-expertise, strategies, and resources needed in completing tasks and the ability to determine in what ways and when to use them to make sure the task can be completed perfectly [5]. Stages of students' metacognition processes in solving problems, including identifying problems to find out what is known and what is asked, then formulating an appropriate strategy, implementing the strategy chosen procedurally, and finally evaluating the final answer. This process is included in metacognition skills in solving problems. Metacognition skills help students to 1) realize that there are problems to be solved, 2) find out what the problem is, and 3) understand how to reach a solution [6]. When involved in problem-solving, students need to apply certain metacognition skills, such as monitoring the thought process that occurs, checking whether progress is being made toward the right goals, ensuring accuracy, and making decisions about the use of time and effort made [7].

There are five dimensions of learning, namely 1) attitudes and perceptions, 2) acquire and integrate knowledge, 3) extend and refine knowledge, 4) use knowledge meaningfully, and 5) habits of mind [8]. Students have negative perceptions about learning, they will likely be lazy to learn and be learning less, whereas students have positive perceptions about learning, they will be eager to learn and learn more. The same thing applies to the 5th dimension when students use habits of mind productively so that they will be easier to learn. Therefore, dimensions 1 and 5 are the determining factors in the learning process [8][9].

Habits of mind are the ability of students to control positive behaviour so they have confidence and a steady personality [10]. Habits of mind empower students to explore and find solutions to complex problems both in school and in everyday life [11]. Habits of mind imply that behaviour requires a disciplined and trained mind so that it becomes a habit to keep trying to act wiser and smarter [12]. There are 16 indicators of habits of mind, namely 1) persisting, 2) managing impulsivity, 3) being empathetic and willing to listen to others, 4) thinking flexibly, 5) thinking about thinking (metacognition), 6) attempting for accuracy, 7) questioning and posing problems, 8) accommodating past knowledge to new situations, 9) Thinking and communicating clearly and precisely, 10) collecting data through all senses, 11) creating, imagining, innovating, 12) responding with enthusiasm, 13) taking responsible risks, 14) finding humour, 15) thinking interdependently, and 16) remaining open to continuous learning [13][14][15][16][17]. In this study, the habits of mind questionnaire used only contained 14 indicators adjusted to the characteristics of students in a Real Analysis lecture.

Students who have good habits of mind will behave and behave smartly in dealing with problems in various situations even for problems that have not found a solution [18]. The habits of mind will guide students' interpretations of overcoming problems so that cognitive activity will go well. To support this, metacognition skills are needed to manage cognitive activities based on thinking. Students who get learning with the metacognition approach have better habits of mind compared to conventional learning. There is a positive influence between habits of mind and student learning outcomes [19]. Therefore, one of the approaches that can accommodate the development of students' habits of mind in solving mathematical problems is metacognition [17].

Habits of mind are part of the theory of mind and are often interpreted with the character of thought [20]. The habits of mind are often associated with metacognition because both are related to human thinking. Metacognition skills focus more on how a person manages his thoughts, whereas habits of mind focus more on one's ability to think and make conclusions about one's thoughts. However, this research will not contradict the first time between metacognition and habits of mind. But rather to test the correlation of metacognition and habits of mind on students' problem-solving abilities.
Figure 1 shows that student learning outcomes in Real Analysis lectures are quite low with 35.71% failing to pass, 34.8% obtaining a C-C+ score, 26.79% obtaining a B-B+ grade, and 2.68% obtaining an A. This means that the Real Analysis course has a fairly low passing rate. Thus, it is necessary to study the factors that influence the achievement of student learning outcomes in the Real Analysis subject. Based on this description, researchers are interested in knowing the correlation between metacognition and habits of mind in solving real analysis problems.

2. Methods

This type of research is quantitative with correlational descriptive type. The subjects in this study were students of Mathematics Education in semester 5 of the 2019/2020 academic year who took the Real Analysis course. Data collected in the form of a questionnaire. The steps taken in descriptive-correlational research are 1) testing the validity and reliability of research instruments, 2) testing data normality, 3) testing linearity between research variables, 4) analyzing data using Correlation Analysis techniques with variable metacognition skills ($X_1$) and habits of mind ($X_2$) as criteria ($X$) and problem-solving as predictors ($Y$). This study aims to determine the description of the correlation between metacognition and habits of mind of students in solving mathematical problems. The metacognition and habits of mind are presented questionnaire in table 1 and table 2 as follows.

Table 1. Metacognition questionnaire.

| No. | Statements                                                                 |
|-----|---------------------------------------------------------------------------|
| 1   | I read the question more than once to understand the purpose of the problem. |
| 2   | I check what problems are asked to me.                                    |
| 3   | When solving a problem, I don't know where to start.                     |
| 4   | I like to describe the problem schematically                              |
| 5   | I encountered some difficulties when solving problems                     |
| 6   | I am interested in developing possible strategies for solving a problem   |
| 7   | I try different strategies or approaches to solving problems              |
| 8   | I try to remember whether I solved the same problem before or not         |
| 9   | I found one of my mistakes while resolving the problem and fixing it      |
| 10  | I immediately thought about how to find a solution to a new problem I had found |
| 11  | I evaluate how much time I need to solve this kind of problem             |
| 12  | I ask myself whether my answer is meaningful or not.                      |
| 13  | I checked my calculations to make sure everything was correct.            |
| 14  | I think there is something I should pay attention to or not in the information provided |
Table 2. Habits of mind questionnaire.

| No. | Statements                                                                 |
|-----|---------------------------------------------------------------------------|
| 1.  | I am a persistent person. If I did not succeed on the first try, I kept trying until I succeeded. |
| 2.  | I can manage my desires and not be complacent to achieve long-term goals. |
| 3.  | I empathize and openly listen to the opinions of others.                   |
| 4.  | I am a flexible thinker. I am looking for new and different perspectives and can change my mind. |
| 5.  | I realize how I think when I try to solve a problem.                       |
| 6.  | I check my work to get quality results                                    |
| 7.  | I ask questions, look for data to support conclusions, and submit interesting ideas. |
| 8.  | I use what I have learned and apply it to new situations to solve problems.|
| 9.  | I learned a lot of new vocabulary to be used to convey ideas well.         |
| 10. | I know how to come up with ideas and manage them.                          |
| 11. | I am willing to take calculated risks in choosing a strategy and take responsibility for finding solutions to problems |
| 12. | I can laugh at myself and find humour in many situations.                  |
| 13. | I collaborate with others, contribute, and learn cooperation.              |
| 14. | I reflect and learn from my experience and am willing to admit what I don't know. |

3. Results and discussions
This study aims to examine the relationship between metacognition skills and habits of mind variables in problem-solving skills using Pearson Bivariate Correlation Analysis. The data generated in this study are metacognition questionnaire, habits of mind questionnaire, and the value of students’ problem-solving. Some requirements that have been made are as follows: (1) the data of each variable must be on the ratio or interval scale, namely by changing from an ordinal scale to an interval scale using the Successive Interval Method (MSI) (2) data with a normal distribution (table 7), (3) there is a linear relationship between the variables of metacognition skills and habits of mind with a linearity test (table 8).

3.1. The results of the validity of the instruments of metacognition and habits of mind questionnaire
The following are the results of the analysis of the validity of the metacognition questionnaire presented in table 3 and the habits of mind questionnaire in table 4 using the Pearson Product Moment correlation.

Table 3. Correlations of metacognition skills.

| No. Item | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 | 11 | 12 | 13 | 14 | Tot |
|----------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|-----|
| Pearson  | .635 | .481 | .548 | .516 | .633 | .639 | .674 | .645 | .527 | .693 | .610 | .538 | .550 | .489 | 1  |
| Correlation | **| ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | **  |
| Sig. (2-tailed) | .000 | .010 | .003 | .005 | .000 | .000 | .000 | .000 | .000 | .004 | .000 | .001 | .003 | .002 | .008 |
| N        | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28  |

Table 3 shows that the Pearson Correlation output of each item starting from items 1 to 14 (r-count) > 0.374 (r-table), meaning that each item is valid. Decision making can also be seen from all values of Sig. (2-tailed) each item starting from item 1 to 14 < 0.05 = α then based on decision making in the validity test it can be concluded that items 1 to item 14 on the metacognition questionnaire are valid.

Table 4 shows that the Pearson Correlation output of each item starting from items 1 to 14 (r-count) > 0.374 (r-table), meaning that each item is valid. Decision making can also be seen from all values of Sig. (2-tailed) each item starting from item 1 to 14 < 0.05 = α then based on decision making in the validity test it can be concluded that items 1 to item 14 on the habits of mind questionnaire are valid.
Table 4. Correlations of habits of mind.

| No. | Item | 1     | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    | 11    | 12    | 13    | 14    | Tot  |
|-----|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------|
| Pearson Correlation | .661 | .435  | .548  | .437  | .746  | .508  | .609  | .581  | .652  | .664  | .491  | .511  | .521  | .460  | 1     |
| Sig. (2-tailed)  | .000 | .021  | .003  | .020  | .000  | .006  | .001  | .001  | .000  | .000  | .008  | .005  | .004  | .014  |       |

N 28 28 28 28 28 28 28 28 28 28 28 28 28 28 28 28

3.2. The results of the reliability of the instruments of the metacognition and habits of mind questionnaire

Then the instrument reliability testing was carried out with Cronbach's Alpha. The results of the reliability data analysis for the metacognition questionnaire are presented in Table 5 and habits of mind are presented in Table 6.

Table 5. Reliability of metacognition.

| Case Processing Summary | N     | %     | Reliability Statistics | Cronbach’s Alpha |
|-------------------------|-------|-------|------------------------|------------------|
| Valid                   | 28    | 100.0 |                        | .851             |
| Excluded*               | 0     | .0    |                        | .810             |
| Total                   | 28    | 100.0 |                        | 14               |

*Listwise deletion based on all variables in the procedure.

Table 5 shows that the number of respondents analyzed was N as many as 28 students. Because there is no blank data (all respondents' answers are filled in) the amount is 100% valid. In the reliability statistics, the number of items in the analyzed metacognition questionnaire is 14 items with a Cronbach’s Alpha value of 0.851 > 0.60, so as a basis for decision making in the reliability test, it can be concluded that all items of the questionnaire statement for variable metacognition skills are reliable or consistent.

Table 6. Reliability of habits of mind.

| Case Processing Summary | N     | %     | Reliability Statistics | Cronbach’s Alpha |
|-------------------------|-------|-------|------------------------|------------------|
| Valid                   | 28    | .810  |                        | .829             |
| Excluded*               | 0     | .0    |                        | 14               |
| Total                   | 28    | 100.0 |                        |                  |

*Listwise deletion based on all variables in the procedure.

Table 6 shows that the number of respondents analyzed was N students, 28. Because there was no blank data (all respondents' answers were filled in) the number was 100% valid. In the reliability statistics, the number of items/statement items in the habits of mind questionnaire analyzed was 14 items with a Cronbach Alpha value of 0.810 > 0.60 so that as a basis for decision making in the reliability test it could be concluded that all questionnaire items were due to habits of mind variables that were reliable or consistent.

3.3. The results of data normality test

To test data with normal distribution or not, the data were analyzed using Shapiro-Wilk because there were 28 respondents (< 50). The results of the data normality test are presented in Table 7. It shows the value of Sig. metacognition = 0.335 > 0.05 = α means that the data for the metacognition variables are normally distributed. The value of Sig. habits of mind = 0.213 > 0.05 = α means that the data for habits of mind variables are normally distributed. Furthermore, the value of Sig. problem solving = 0.372 > 0.05 = α means that the data for problem solving variables are normally distributed.
### Table 7. Tests of normality.

|                      | Kolmogorov-Smirnova | Shapiro-Wilk |
|----------------------|----------------------|--------------|
|                      | Statistic  df   Sig. | Statistic  df  Sig. |
| Problem-solving      | .113  28   .200* | .961  28   .372  |
| Habits of mind       | .125  28   .200* | .951  28   .213  |
| Metacognition        | .153  28   .093 | .959  28   .335  |

*a* This is a lower bound of the true significance.

*b* Lilliefors Significance Correction

#### 3.4. The results of the linearity test between metacognition, habits of mind, and problem-solving variables

The following linearity test results are presented to find out whether there is a linear relationship between the research variables. The results of the linearity test between problem-solving and metacognition are presented in Table 8 while problem solving and habits of mind are presented in Table 9.

### Table 8. The results of the linearity test between metacognition and problem-solving.

|                      | Sum of Squares | df | Mean Square | F      | Sig.  |
|----------------------|----------------|----|-------------|--------|-------|
| Problem-solving      |                |    |             |        |       |
| Metacognition        | Between Groups | (Combined) 5022.679 | 21 | 239.175 | 5.618 | .020  |
|                      | Linearity      | 3932.390 | 1   | 3932.390 | 92.372 | .000  |
|                      | Deviation from Linearity | 1090.288 | 20  | 54.514 | 1.281 | .405  |
|                      | Within Groups  | 255.429 | 6   | 42.571  |       |       |
|                      | Total          | 5278.107 | 27 |       |       |       |

Table 8 shows that deviations from linearity between the problem-solving and metacognition variables have Sig. = 0.405 > 0.05 = α. This means that there is a significant linear relationship between the metacognition variable \(X_1\) and the problem-solving variable \(Y\).

### Table 9. The results of the linearity test between habits of mind and problem-solving.

|                      | Sum of Squares | df | Mean Square | F      | Sig.  |
|----------------------|----------------|----|-------------|--------|-------|
| problem-solving      |                |    |             |        |       |
| habits of mind       | Between Groups | (Combined) 5040.607 | 20 | 252.030 | 7.428 | .006  |
|                      | Linearity      | 4633.614 | 1   | 4633.614 | 136.570 | .000  |
|                      | Deviation from Linearity | 406.994 | 19  | 21.421 | .631 | .800  |
|                      | Within Groups  | 237.500 | 7   | 33.929  |       |       |
|                      | Total          | 5278.107 | 27 |       |       |       |

Table 9 shows that deviations from linearity between problem-solving variables and habits of mind have Sig. = 0.800 > 0.05 = α. This means that there is a significant linear relationship between habits of mind variables \(X_2\) and problem-solving \(Y\).

#### 3.5. The results of the analysis of correlation of metacognition and habits of mind in problem-solving

The main thing in this research is to analyze the correlation between metacognition and habits of mind in solving problems as presented in Table 10.
Table 10. Output analysis of correlation of metacognition and habits of mind.

|                     | Metacognition | Habits of Mind | Problem Solving |
|---------------------|---------------|----------------|-----------------|
| Metacognition       |               |                |                 |
| Pearson Correlation | 1             | .738**         | .842**          |
| Sig. (2-tailed)     |               | .000           | .000            |
| N                   | 28            | 28             | 28              |
| Habits of mind      |               |                |                 |
| Pearson Correlation | .738**        | 1              | .900**          |
| Sig. (2-tailed)     | .000          |                | .000            |
| N                   | 28            | 28             | 28              |
| Problem-solving     |               |                |                 |
| Pearson Correlation | .842**        | .900**         | 1               |
| Sig. (2-tailed)     | .000          | .000           |                 |
| N                   | 28            | 28             | 28              |

Table 10 shows that Sig values. (2-tailed) between the metacognition and problem-solving variable is 0.000 < 0.05 = α means that there is a significant correlation between the metacognition skills and problem-solving. The same thing can also be seen from Sig. (2-tailed) between habits of mind and problem-solving variables is 0.000 < 0.05 = α means that there is a significant relationship between habits of mind and problem-solving. If observed further, based on Table 10 also seen the correlation between metacognition and habits of mind variables with Sig. (2-tailed) of 0.000 < 0.05 = α means that there is a significant correlation between metacognition and habits of mind.

4. Conclusions

Based on the results of research and discussion, it was concluded that there was a significant correlation between metacognition skills and the ability to solve mathematical problems in strong and positive categories. There is also a significant correlation between habits of mind with the ability to solve mathematical problems in the strong and positive categories. Thus it can be stated that there is a significant relationship between metacognition abilities and habits of mind with the ability to solve mathematical problems. Based on the results of this study, it becomes the basis for researchers to develop learning with characteristics that can accommodate and support the development of metacognition abilities and students' habits of mind to achieve learning goals that are by the demands of the 21st century.

References

[1] Sanium S and Buaraphan K 2019 J. Phys.: Conf. Ser. 1340 012014
[2] Ridlo S and Lutfiya F 2017 J. Phys.: Conf. Ser. 824 012067
[3] Jankowski T and Holas P 2014 Conscious. Cognit. 28 64-80
[4] Chatzipanteli A, Grammatikopoulos V and Gregoriadis A 2014 Early Child Dev. Care 184 1223-32
[5] Anwarudin M and Dafik D 2019 IOP Conf. Ser.: Earth Environ. Sci. 243 012051
[6] Metcalfe J and Shimamura A P 1994 Metacognition : Knowing About Knowing (Cambridge, MA, US: MIT Press)
[7] Magno C 2010 Metacognition Learn 5 137-156
[8] Marzano R J et al. 2009 Dimensions of Learning, Teacher’s Manual 2nd Edition (Alexandria, Virginia USA: ASCD)
[9] Susilowati E, Hartini S, Suyidno S, Mayasari T and Winarno N 2018 J. Phys.: Conf. Ser. 1120 012055
[10] Widodo S, Sari D P, Hikmawan R and Majid N W A 2020 Int. Conf. on Elementary Educ. (Bandung: Universitas Pendidikan Indonesia) pp 1165–76
[11] Wible S 2020 Coll. Compos. Commun. 71 399-425
[12] Asria V Z and Wahyuadin W 2019 J. Phys.: Conf. Ser. 1157 042085
[13] Costa A L and Kallick B 2008 Learning and Leading with Habits of Mind : 16 Essential


Characteristics for Success (Alexandria, Virginia USA: ASCD) p 458
[14] Dwirahayu G, Kustiawati D and Bidari I 2017 J. Phys.: Conf. Ser. 895 012013
[15] Handayani A D, Herman T, Fatimah S, Setyowidodo I and Katminingsih Y 2018 J. Phys.: Conf. Ser. 1013 012115
[16] Hafni R N, Sari D M and Nurlaelah E 2019 J. Phys.: Conf. Ser. 1211 012074
[17] Sugandi A I, Maya R and Hutajulu R 2019 J. Phys.: Conf. Ser. 1315 012030
[18] Gloria R Y, Sudarmin S, Wiyanto W and Indriyanti D R 2018 J. Phys.: Conf. Ser. 983 012158
[19] Sari R P, Hasibuan M P, Haji A G, Nahadi N and Sofiyan S 2020 J. Phys.: Conf. Ser. 1460 012096
[20] Murti H A S 2011 J. Psikol. Pitutur 1 53-64