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# THE EFFECTIVENESS OF VIRTUAL METACOGNITIVE LEARNING TO ANALYZE STUDENT METACOGNITION PROCESSES IN PROBLEM-SOLVING

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## Abstract

This article is the result of virtual learning research with research subjects of two groups of students and aims to determine the effectiveness of metacognitive learning so that the components of metacognition in solving problems can be analyzed. The research begins with a pre-test followed by virtual learning and ends with post-test and metacognition questionnaires. During the post-test, students' activities in solving them were observed through awareness, evaluation, and regulation while the metacognition questionnaire consisted of questions about metacognition components. The results of the data analysis show that students who do metacognition, their learning outcomes increase so that there is a relationship between the components of metacognition and the ability to solve problems. This relationship is expressed by the correlation coefficient $r_{xy}$ = 0.419 with the regression equation y = 61.02 + 0.287x. This means that each metacognition independent variable can increase the average problem solving dependent variable by 0.287 units. Statistically, metacognitive learning is quite effective in solving problems. Based on these final results it can be recommended that virtual learning with a metacognitive model can be used as a new way and becomes a strong motivation for students to improve their ability to solve problems.

**Keywords**: Effectiveness, metacognition questionnaire homogeneous, interpretation, virtual learning.

## *Abstrak*

*Artikel ini merupakan hasil penelitian pembelajaran virtual dengan subjek penelitian dua kelompok mahasiswa dan bertujuan untuk mengetahui efektivitas pembelajaran metakognitif sehingga komponen metakognisi dalam memecahkan masalah dapat dianalisis. Penelitian diawali dengan pre-test yang dilanjutkan dengan pembelajaran virtual dan diakhiri dengan pemberian post-test dan angket metakognisi. Selama post-test, diamati aktivitas mahasiswa dalam menyelesaikannya melalui kesadaran, evaluasi, dan regulasi sedangkan angket metakognisi berupa pertanyaan tentang komponen metakognisi. Hasil analisis data menunjukan mahasiswa yang melakukan metakognisi, hasil belajarnya meningkat sehingga ada hubungan antara komponen metakognisi dengan kemampuan menyelesaikan masalah. Hubungan tersebut dinyatakan oleh koefisien korelasi rxy = 0,419 dengan persamaan regresi y = 61,02 + 0,287x. Hal ini berarti bahwa setiap variabel independen metakognisi dapat meningkatkan rata-rata variabel dependen pemecahan masalah sebesar 0,287 satuan. Secara statistika pembelajaran metakognitif cukup efektif dalam pemecahan masalah. Berdasarkan hasil akhir tersebut dapat direkomendasikan bahwa pembelajaran virtual dengan model metakognitif dapat digunakan sebagai cara baru dan menjadi motivasi yang kuat bagi mahasiswa untuk meningkatkan kemampuan dalam menyelesaikan masalah.*

***Kata kunci**: Angket metakognisi, efektivitas, homogen, interpretasi, pembelajaran virtual.*

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## INTRODUCTION

The Covid-19 virus pandemic that occurred in Indonesia caused face-to-face restrictions in lecture activities. Meeting restrictions led to the choice of a virtual learning model as a replacement Virtual learning is a learning model through the use of internet media which aims to keep lecturers and students together so that all planned goals are achieved. The virtual learning used in the research carried out is by using the zoom cloud meeting application so that all teaching materials are presented as usual, only that lecturers and students are in different places.

In virtual learning, there are goals to be achieved on each topic or material presented. These goals can be grouped and formulated in the realm of attitudes, knowledge, and skills. Anderson and Krathwohl stated the domain of knowledge involves students' knowledge which can be distinguished into factual knowledge, conceptual knowledge, procedural knowledge, and metacognitive knowledge (Anderson & Krathwohl, 2001). The types and kinds of knowledge that students do show that metacognition is the highest level of thinking of students and plays a very important role in every learning (Purnomo, 2017). In other cases, metacognition skills have a dominant contribution to students in terms of planning skills, monitoring or monitoring skills, and evaluation skills. Students have a low level of metacognition components, especially in terms of planning skills (Arkham, 2014)

When someone performs metacognition, it can be seen that there are activities related to awareness, evaluation, and regulation (Desmita, 2017). Purnomo in his research states that during metacognition, students perform 5 awareness activities that can be detected through 30 indicators, 5 evaluation activities through 23 indicators, and 4 regulation activities through 19 indicators (Purnomo et al., 2016)

Zuhriati et al (2021) in their research supported the opinion of Flavell, a psychologist from the United States, who stated that metacognition is knowledge and a person's cognition of his cognitive phenomena. In other hand Purnomo et al have corroborated the research opinion of Schneider and Artelt (2010) which stated that the metacognitive process refers to a person's knowledge of skills, wanting to know one's own information, as well as knowledge of cognitive tasks in nature, strategies for coping with tasks, and related skills. with monitoring and self-regulation (Purnomo et al, 2016). Likewise Setyaningrum provides support for Guratt and Medulla's theory which states that metacognition is a thinking process someone about how it is develop the strategy to be used solve the problem (Setyaningrum, 2020).

Although there are various opinions about the metacognitive component, in essence the experts argue that the componentor metacognitive indicators consist of three elements in dealing with problems, namely developing a strategy or action plan; monitoring actions; and evaluating actions (Hartin et al., 2020). Ozoy & Ataman (2013) argue that metacognition is a person's awareness of his thinking processes and his ability to control these processes.

The process of metacognition plays an important role in creating a person's success in solving mathematical problems, besides that metacognition which is a person's awareness of cognition and its regulation in learning mathematics is

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very necessary so that awareness, evaluation and regulation are carried out as supporting elements in learning (Anggo, 2011). Before the study, the research subjects were given a pre-test that aimed to determine the homogeneity of the subject's initial ability. After knowing the subject's initial ability, the researchers carried out the teaching and learning process with the virtual learning method. After completing the research, subjects were given a metacognition questionnaire and post-test. The metacognition questionnaire aims to determine the metacognitive activities carried out by the subject, while the post-test aims to determine the ability of the research subject to solve problems.

## RESEARCH METHODS

### a. Subjects and Instruments

The research conducted was qualitative research using a fixed comparison method design. The comparison method is still carried out by comparing research data that originates from the subject's performance in solving problems using *think-alloud*, metacognition questionnaire results, interviews conducted and subject observation sheets while solving the given problem. Based on the results of the data comparison, it was found that activities showed indicators of the process of awareness, evaluation and regulation of students as research subjects.

The subjects of this study were students of IKIP Budi Utomo Malang who were taking a Differential Equation course which consisted of 19 students in group A and 17 students in group B. Before the study, the research subjects were given a pre-test that aimed to determine the homogeneity of the subject's initial ability. After completing the research, subjects were given a metacognition questionnaire and post-test.

The metacognition questionnaire aims to determine the metacognitive activities carried out by the subject, while the post-test aims to determine the ability of the research subject to solve problems. The questionnaire on metacognition is based on the indicators of awareness, evaluation, and regulation (Purnomo, 2018).

Awareness raises 14 indicators so that the metacognition questionnaire relating to awareness activities. The indicators of the awareness process are: Re-read the problem repeatedly and mark the words that are considered as keywords in the questions (A1). Record important things in the math problem by giving underlines to words that are considered as keywords (A2). Re-think the important things on a mathematical problem by giving underlines to words that are considered as keywords (A3). Make note after thinking about things that are known as conditions in determining the completion of the problem (A4). Conclude the question after thinking about things that are known as a condition in determining the completion of the problem (A5). Re-thinkk the relationship between things that are known in mathematical problems with each question to be taken (A6). Read each of the questions of repeated mathematical problems and relates them to previous statements on mathematical problems as things are known (A7). Mark the words that are considered important and as keywords for each question on a mathematical problem and think about things asked in mathematical problems (A8). Conclude the things asked in mathematical problems (A9). Look back at the things known in mathematical problems

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(A10). Think back to choose the method used to solve mathematical problems (A11). Try another way to answer mathematical problems that have not been done before (A12). Repeat new ways and check with things known to be in the problem (A13). Compare the description of the answers between the one and the other ways that have been done before (A14).

Evaluation process raises 11 indicators. These indicators are: Compare the results of each method that has been done (E1). Mark the important things in the ways used to solve mathematical problems (E2). Note the important thing is the difference between the methods that have been used in solving the problem (E3). Make a connection between things that have been known by the methods used in solving mathematical problems (E4). Check the relationship between things that are known to things asked in mathematical problems (E5). Check the description of the answers that have been written in the way that has been done (E6). Re-examine the writing of the relationship between the known and question (E7). Re-reading the answers to each question to find out the truth (E8). Check the final answer of each question (E9). Re-reading the answer to know the truth value (E10). Re-calculating the answer to each given problem (E11).

Regulation process raises 10 indicators. These indicators are: Re-checking the answers to the mathematical problems repeatedly (R1). Specify the method that will be used to answer questions in mathematical problems (R2). Sort the answers from each question based on previously known conditions (R3). Mark errors in the calculation of mathematical problem answers. (R4). Check the method used to answer mathematical problem questions (R5). Compare the methods used to solve mathematical problems (R6). Sort the answers to questions in mathematical problems (R7). Mention the differences in the methods used in solving the given mathematical problem (R8). Check the level of difficulty of the answers that have been done (R9). Re-examine the written answers (R10).

**b. Data Collection Procedures**

Data collection begins with determining the subject of 36 students and the subject is given a pre-test to find out the homogeneity of the initial ability. Homogeneity test is done by t test. After knowing the initial homogeneous abilities, it is continued with virtual-based metacognition learning.

The next procedure in the research is Giving metacognitive questionnaires to research subjects, giving a post-test in the form of math problems is used to determine the ability of research subjects in solving problems, changing the questionnaire scores of each research subject on the variable x and post-test scores respectively. each research subject on the variable *y*. Based on these changes, the relationship was analyzed using Pearson's product-moment correlation test statistic.

The research step ends with comparing the results of the pre-test and post-test to determine the effectiveness of virtual learning-based metacognitive learning, in this case, the t-test is used, dan concluding learning outcomes based on data analysis and discussion of learning outcomes

**c. Data Analysis**

All data obtained in the study were analyzed to obtain conclusions. The pre-test data were analyzed to determine the initial ability

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homogeneity of each subject in group A and group B, initially determined by the mean and standard deviation of each group, and the combined standard deviation. Finally, the pre-test data were analyzed using t-test statistics so that the homogeneity was known. Furthermore, research data in the form of questionnaire scores and post-test results were analyzed using the Pearson product-moment correlation formula. The post-test scores and the metacognition questionnaire scores of each subject experienced variable changes. *y* and *x*. Thus, *y* as the dependent variable is the student's ability to solve problems, while *x* is the activity of mathematical metacognition.

After the correlation coefficient is obtained, then a regression analysis is carried out, this is done to determine the form of the regression equation and determine the change in the unit value of the *x a*nd *y* variables. The regression equation uses the formula $y = ax + b$. Finally, the learning outcomes of research subjects at pretest and post-test were compared to determine the effectiveness of virtual-based metacognitive learning on the process of student awareness, evaluation, and regulation in solving problems.

## RESULTS AND DISCUSSION

### a. Results

The results of the study are divided into 4 parts, namely research findings related to pre-test results, metacognition questionnaire scores, post-test results of research subjects, and comparing the results of the initial and final tests to determine the effectiveness of the virtual metacog-nitive learning model to know the process of awareness, evaluation, and evaluation. and regulation in solving problems. The pre-test results of group A averaged 71.04 with a standard deviation of 5.33 while group B averaged 71.39 with a standard deviation of 5.09. Based on the pre-test data, the average group A and B was 71.26 with a combined standard deviation of 5.21.

The second result of the study was the results of metacognition questionnaire in the form of a statement of awareness, evaluation, and regulation statements for each statement and overall. Completely, several research subjects do awareness, evaluation, and regulation in solving problems given and the number of research subjects who do not carry out awareness, evaluation, and regulation through questionnaires can be seen in Table 1.

Table 1. Number of the subjects who answered each statement of the metacognition questionnaire

| No. | Questionnaire Statement | Number of | ∑ | Average | Percentage |
|---|---|---|---|---|---|
| 1. | A1-A14 | Statement | 14 | - | - |
| | | Yes | 258 | 18,43 | 51,19 |
| | | Unsure | 134 | 9,57 | 26,59 |
| | | No | 112 | 8,00 | 22,22 |
| | | Total | 504 | - | - |
| 2. | E1-E11 | Statement | 11 | - | - |
| | | Yes | 221 | 20,09 | 55,81 |
| | | Unsure | 113 | 10,27 | 28,54 |
| | | No | 62 | 5,64 | 15,66 |
| | | Total | 396 | - | - |

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| No. | Questionnaire Statement | Number of | ∑ | Average | Percentage |
|---|---|---|---|---|---|
| 3. | R1-R10. | Statement | 10 | - | - |
| | | Yes | 185 | 18,50 | 51,39 |
| | | Unsure | 111 | 11,10 | 30,83 |
| | | No | 64 | 6,40 | 17,78 |
| | | Total | 360 | - | - |
| 4. | All of the questionnaire statements (A1-R10) | Statement | 35 | - | - |
| | | Yes | 664 | 18,44 | 51,23 |
| | | Unsure | 358 | 9,94 | 27,62 |
| | | No | 238 | 6,61 | 18,36 |
| | | Total | 1260 | - | - |

The questionnaire score results in addition to producing data as in Table 1, were obtained by the average and standard deviation of each group and the group combination. The results of group A questionnaire scores obtained an average score of 46.95 with a standard deviation of 7.98. Group B obtained an average score of 46.88 with a standard deviation of 6.61. Overall 36 research subjects who answered 35 metacognitive questionnaire statements averaged 46.92 with a standard deviation of 7.26.

The third finding of this study is the post-test results of all research subjects. In Group A the average post-test result was 73.08 with a standard deviation of 5.49. The post-test results of group B averaged 75.81 with a standard deviation of 4.7. Based on the combined standard deviation formula, the standard deviation of the post-test results of groups A and B was 5.07 and the post-test average of both groups was 74,445. Because the metacognition questionnaire scores were changed in the x variable and the post-test results were changed by the y variable, then based on the results of the second and third studies in groups A and B the correlation coefficient rxy and the constants a and b for the regression equation were y = a + bx. By using the described formula, the correlation coefficient $r_{xy}$ = 0.421 and the constants a = 60.83 and b = 0.292. Based on the results of these calculations obtained linear regression equation $y = 60.83 + 0.292\ x$. By comparing the results of the pre-test and post-test with a t-test, the hypothesis that the virtual-based metacognitive learning method is effective for measuring the awareness process, evaluation, and regulation is accepted. In other words, virtual-based metacognitive learning is effectively used to measure the awareness, evaluation, and regulation activities of students in solving problems.

**b. Discussion**

Comparing the results of the initial test of research subjects between group A and group B, the average for group A was 71.04 and the standard deviation was 5.33 while group B had an average of 71.39 and a standard deviation of 5.09 showed that the initial ability of the two groups was homogeneous. Statistically using the t-test obtained $t_{hit}$ = -0.184 and $t_{table}$ = 2.01 with a significance level of 5%. Furthermore, by comparing the two values of thit and table and citing the opinion Sudjana (2014) obtained $t_{hit} < t_{table}$ so that statistically it shows the initial ability of research subjects between groups A and B is homogeneous. The homogeneity of the

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initial abilities of research subjects is a strong enough reason for researchers to carry out a metacognition-based classroom learning model as a treatment in research. Based on this treatment, the research subjects were finally given a metacognition questionnaire and post-test which aimed to determine the student's ability to solve mathematical problems through metacognitive activities.

Table 1 shows that 51.19% of research subjects carried out awareness activities, 55.81%, carried out evaluation activities, and 51.39% of research subjects carried out regulatory activities in solving problems. Overall, 51.23% of the research subjects performed metacognition in solving problems that were given through the post-test. In addition to these facts, 26.59% of research subjects are not confident in carrying out awareness activities, 28.54% are not confident in carrying out evaluation activities, and 30.83% are not confident in carrying out regulatory activities. Overall, 27.62% of research subjects are not confident in carrying out metacognitive activities. The remaining 22.22% of research subjects did not carry out awareness activities, 15.66% did not carry out evaluation activities and 17.78% did not carry out regulatory activities. Overall 18.36% of the research subjects did not perform metacognitive activities in solving the given mathematical problems. Thus, if we compare the emergence of awareness, evaluation, and regulation with the results of the initial and final tests, research subjects who have high metacognitive activity result in high scores on the initial and final tests. This finding supports the results of research conducted by Biryukov (2003) stated that student metacognition can be measured by metacognition questionnaires. Sengul & Katranci (2012) which states that a person's good metacognitive ability can lead to high problem-solving abilities. The same thing was stated by those who stated that metacognitive learning strategies Karan & Irizarry (2014) were very effective in improving students' abilities.

Furthermore, by analyzing the results of the post-test and questionnaire metacognition score by changing the $x$ variable for the metacognition questionnaire score and the $y$ variable for the post-test results for each research subject, the $r_{xy}$ correlation coefficient = 0.421. Because the number of research subjects was 36 students and chose a 5% significance level obtained *r-table* = 0,329. By comparing the $r_{xy}$ coefficient and $r_{\text{-}table}$ obtained by $r_{xy} > r_{\text{-}table}$. So statistically there is a positive and significant relationship between the ability of students to solve mathematical problems with metacognition activities carried out in learning. In other words, the more complex metacognitive activities carried out by students, the better the student's ability to solve mathematical problems.

Finally, because there is a significant positive relationship between students' ability to solve given mathematical problems and metacognitive activities in classroom learning, the large contribution given by metacognitive activities to students' problem-solving abilities. The amount of the donation is seen by using the linear regression equation $y = a + bx$. Statistical calculations for both variables $x$ and $y$ obtained linear regression equation $y = 61.02 + 0.287x$. This can be interpreted that for each independent variable $x$ increasing by one unit will cause an average increase

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in the dependent variable *y* of 0.287 units. Furthermore, based on the results of these studies according to the author that by comparing the post-test scores of the research subjects which are better than the pretest results, it means that statistically, metacognitive learning is most effective in problem-solving. By comparing the results of the pre-test and post-test with the t-test, the hypothesis that the virtual-based metacognitive learning method is effective for measuring the processes of awareness, evaluation, and regulation is accepted. In other words, virtual-based metacognitive learning is effectively used to measure students' awareness, evaluation, and regulation activities in solving problems.

By comparing previous research conducted by Setyaningrum (2020) and Zuhriati et al (2021) it can be argued that the metacognition carried out by students in solving problems can be identified through the activities that arise when performing in solving these problems. Even though learning is carried out virtually, the process of metacognition through the process of awareness, evaluation and regulation has clear differences and each of these components of metacognition can describe activities in virtual-based metacognition learning.

Based on the findings of researchers in research that has been done that metacognition occurs through a process of thinking repeatedly about an activity that has been done. These results support the opinions and statements made by Fitri (2017) which states that children's metacognition is more focused on aspects of how they think and they work, not based on their beliefs about other people's thinking.

## CONCLUSION AND SUGGESTION

Based on the data analysis and research conducted, it can be concluded that the ability of students to solve problems has increased when using metacognition-based learning, this is indicated by an increase in the average ability of students in completing the pre-test and post-test. test questions that are 4.38%.

Another conclusion in the research that has been done are there is a positive and significant relationship between students' problem-solving abilities and metacognitive activities in virtual mathematics learning, this is indicated by the correlation coefficient $r_{xy} = 0.419$ this means that if complex metacognitive activities are carried out in learning mathematics in the classroom, the student's ability in solving the problem is getting better. With regard to the correlation coefficient, it can be shown that the relationship between students' problem-solving abilities and metacognitive activities in mathematics learning is shown by the regression equation $y = 61.02 + 0.287\ x$. The regression equation shows that if the variable *x* (metacognition) increases by one unit, the average variable y (problem-solving) increases by 0.287 units.

In the end, a conclusion was reached virtual-based metacognitive learning is effective for measuring students' awareness, evaluation, and regulation processes in solving problems. It is shown that learning outcomes after using virtual-based metacognitive learning methods are more than previous learning outcomes.

With regard to the conclusions of the study, the authors recommend that given the relationship between students' metacognitive abilities and their ability to solve problems, it is necessary to

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examine further how each component of metacognition consisting of awareness, evaluation and regulation can contribute. In other cases, as long as students solve the problems given in virtual learning, it is very different when learning is carried out face-to-face directly inside.

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