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Use of metacognitive regulation strategies to increase student academic achievement in microbiology course

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Abstract. The purpose of this research was to examine the influence of metacognitive regulation strategy to improve students' achievement in microbiology learning. The method used was Quasi-Experimental. Participants of this study were 27 students from Biology Education in a university in West Java. There were two classes used in this research, namely the class using metacognitive regulation strategies as an experimental class consisting of 14 students and the non-metacognitive regulation strategies class as a control consisting of 13 students. In the experimental class, discussion was assisted with questions about subject matters. The instrument was used consist of the concept mastery test and self-reflection questionnaire. Data were analyzed by Analysis of Variance. The results of this research showed that there were differences in student achievement between metacognitive regulation and non-metacognitive regulation strategies. Students who learned with metacognitive regulation strategies was obtained high moderate criteria score ($g = 0.59$), while students who learned with non-metacognitive regulation strategies were obtained low of criteria score ($g = 0.26$). Study on self-reflection after carrying out the test obtained the following results: aspects related to the use of learning resources (21%), time management (29%), learning behavior (36%), attending and concentration in learning (14%). The implementation of the metacognitive regulation strategy was significantly effective to improve academic achievement in a microbiology course, so this strategy is an innovation in learning.

1. Introduction

Metacognitive is the ability of a person to think about himself/herself as an object (thinking about thinking). In the context of learning, students know how to learn, know their abilities and modalities of learning, and know the best strategies for effective learning. Metacognition is a form of an ability to look at oneself then it can optimally control what is being done. Metacognition consists of both metacognitive knowledge and metacognitive experiences or regulation, all forms of self-monitoring activities, self-regulation, and self-efficacy can be considered as a form of metacognition [1]. There are three components of metacognitive knowledge, i.e knowledge of declaration, procedural, and conditional. The four-component of metacognition skills are predicting, planning, monitoring, and evaluating [2]. Metacognitive self-regulation is used to monitor and control student cognition. There are three metacognitive processes of self-regulation i.e planning, monitoring, and regulating [3]. Planning includes the setting of goals and sub-goals. Achievement of goals depends on appropriate learning strategies or methods. Monitoring is carried out to monitor student understanding. When the monitoring



process is carried out, the students will make adjustments to learning strategies and knowledge they have. After that, students do self-evaluation of the effectiveness of the learning process [4].

The use of metacognitive self-regulation strategy in learning is considered important to make students have metacognitive skills. Assessment and Teaching of 21st-Century Skills (ATC21S) classified 21st-century skills consist of 4 categories, i.e. way of thinking, way of working, tools for working and skills for living in the world. Way of thinking refers to creativity and innovation, problem-solving, decision making, critical thinking, learning to learn and metacognition. Based on the statement, the metacognitive ability is one of the abilities that is targeted to be developed because metacognitive ability supports the formation of cognitive processes. Cognitive development is considered as a determinant of intellectual intelligent. There is a high relationship between metacognitive self-regulation and critical thinking. Metacognitive self-regulation gives a high contribution to critical thinking skills [5]. Other studies have shown that metacognitive regulation through the rubric of critical thinking and problem solving processes can improve critical thinking skills [6] Cognitive learning outcomes will certainly be more meaningful if not easily lost immediately from memory. The achievement of cognitive and retention learning outcomes is closely related to students' independence in learning. The students' independence is related to students' metacognitive skills. Metacognitive skills can help students to develop their thinking skills, then it influences student academic achievement. Some research result related to learning independence includes: There is a significant relationship between awareness, learning independence, and student academic achievement [7] There is a relationship between learning independence and students' perceptions of teacher attitudes and leadership [8]. Independence of learning can be improved through the application of problem-based learning [9].

The purpose of this research was to increase student's academic achievement in microbiology courses through the use of regulation metacognitive strategy. Besides, students were expected to reflect on themselves to improve their ability in the learning process. The results of this research were expected to be used in developing microbiology lecture programs that are oriented in various methods or learning models that can empower metacognitive abilities.

2. Methods

This research used the method of Quasi-Experimental with a type of Non-equivalent Control Group Design. Students involved in this research were Biology Education students in a university in West Java. The participants in this research were 27 students and divided into two classes, i.e. the experimental class and the control class. The experimental class is a class applies a metacognitive regulation strategy which consisting of 14 students. While the control class is a class does not apply metacognitive regulation strategies which consisting of 13 students. An instrument used was the concept mastery test and self-reflection questionnaire. The data analyzed by Analysis Variance. The research was carried out with the following procedure: The experimental class and control class carried out the pre-test with the material of Role Microorganism on Health and Microorganism Ecology on Food. The experimental activities carried out refer to the activities according to Nathan (2018). In the experimental class, a treatment before the lecture was started in the classroom was given at the planning stage. The treatment was conducted by giving the assignment to set goals, set strategies to achieve that goal, learn the material that will be taught through reading assignments with the strategies they like. Then, students were given the task to make a summary or concept map. Those tasks were collected to be assessed. In the control class, there are no assignments were given before the lecture was started in class. Furthermore, learning is carried out by the group discussion method. In the experimental class, each group of students was given the task of making the questions of the subject matter under study, then the answers to the questions were presented in class discussions. When the learning activity is going on, students take notes the concepts that they do not understand than explain those concepts through the strategies they choose. The post-test was carried out after completed the class. After that, monitoring and evaluation were carried out through reflective questions about learning a subject that is considered difficult, correcting the answers of questions that are not answered on their exam, explain and diagnose the incorrect answer, identify learning strategy or behavior used.

3. Result and Discussion

Metacognitive regulation strategies are used to monitor and control student cognition. There are three metacognitive processes of self-regulation, namely planning, monitoring and regulating. Planning includes setting the goals and sub-goals. Achieving the goals depends on the appropriate learning strategy or method. Monitoring in the form of monitoring of understanding. When monitoring the process was carried out, the students make adjustments to the learning strategies undertaken and the knowledge they have. Then the students conduct a self-evaluation of the effectiveness of the learning process.

Figure 1 shows the results of data analysis on the measurement of achievement students between the experimental classes using metacognitive regulation strategies and control classes that do not use metacognitive regulation strategies.



Figure 1. The Differences in the average pre-test and post-test student achievement between class using metacognitive regulation strategies with class using non-metacognitive regulation strategies

Figure 1 shows the difference in the average pre-test and post-test between learning using metacognitive regulation strategies and learning that do not use metacognitive regulation strategies. The results of the data analysis show that there are differences in the increase in student academic achievement between learning using metacognitive regulation strategies and learning that does not use metacognitive regulation strategies. The value of n -gain in learning using the metacognitive regulation strategies is $g = 0.59$, this indicates a moderate increase. The value of n gain in learning that does not use the metacognitive regulation strategies is $g = 0.26$, this indicates a low increase. Based on these results it can be stated that student academic achievement in learning that uses metacognitive regulation strategies is better than those that do not use metacognitive regulation strategies. Some reasons that support the achievement of better academic achievement are supported by expert opinions and some of the results of previous studies, among others: the metacognitive regulation strategies carried out stages of planning, monitoring and evaluating.

These stages will support learning independence to achieve successful learning. In the learning that has been done in this study, the planning phase includes setting goals and determining strategies to achieve that goal. Awareness and desire to be an active learner, act independently, make decisions related to what and how to learn, set goals, and control achievement are factors that can increase independence in a person [10]. There are three phases in the cyclic self-regulatory process consisting of the forethought phase, performance or volitional control phase and the self-reflection phase. In the forethought phase, students who have high independence will make learning goals and planning strategies with how to achieve these goals. Goals refer to the learning goals. Goals are processes that are specifically oriented at the initial stage of learning, more effective than the goals set at the end of learning

[11]. Planning strategy refers to decisions about how a person can achieve specific goals such as choosing a strategy to solve a problem. In the forethought phase, it is focused on the actions of students' beliefs that influence their preparation in learning. This phase consists of task analysis and self-motivation. Task analysis includes goal setting and planning strategies. Goals setting is an activity to determine learning goals and if necessary modify these goals so that they can be achieved.

Besides, before the implementation of learning in the classroom, students were given the task of reading subject matter through reading strategies according to their likes. Then students are given the task of making a summary or concept map or mind map. The use of reading strategies will help students improve their learning outcomes. A study on the strategy of reading has been done on gender differences. Reading strategies consist of problem-solving strategies, supporting strategies and general strategies. The results showed that men and women preferred the problem-solving reading strategy where the results were 212 students, consisting of 139 female and 73 male students. Supporting reading strategies were 69 students (59 female, 13 male). The least used strategy is the general reading strategy of 31 people (20 female, 11 male) [12]. Many studies on metacognition only pertains to one specific task or domain, such as reading and text studying [13,14]. The same study concludes that metacognitive skills and reading strategies can improve the introductory learning outcomes of Biology [15]. Giving assignments such as summarizing, creating a concept map or mind map will help students to develop self-regulated learning. In face-to-face learning, self-regulated learning, can be developed through developing time management skills, understanding texts and summarizing, recording, anticipating tests and writing [16]. The study on the effects of writing essays on lectures on short-term and long term-retention showed the results that the task of writing essays can increase short-term and long-term retention. Writing assignments with the metacognitive component can enhance learning in introductory biology courses [17].

The metacognitive component is students' skills in understanding and monitoring their cognitive processes. Students involve self-observation by self-monitoring. Self-monitoring techniques include recording diaries, journals or using visuals such as graphics. In learning that has been done in the study, self-monitoring and self-assessment are trained through the activities of making their questions and answering those questions, then students record concepts that they do not understand, they are given the task of explaining concepts that they do not understand through their chosen strategies. The aspect of self-monitoring and self-assessment can determine the level of self-regulated learning of students. Relevant study results indicate that self-assessment gives affects to the metacognitive abilities and self-regulated learning of students. The factors that influence the instructor directly face to face with sents and allow students to develop and assess themselves in building their metacognitive skills. Self-assessment activities in the classroom will help students move toward a regular self, lifelong learning that can face various challenges [18].

Furthermore, self-reflection is done through reflective questions. Self-reflection ability is measured after carrying out a post-test. Reflection is focused on the ability to reflect on the answers to the wrong test questions. Table 1 shows the results of measuring the ability of self-reflection on the wrong answers to test questions. Focus assessment is carried out on aspects use of learning resources, time management, learning behavior, attending and concentration at the time of learning.

Table 1. The results of measuring the ability of self-reflection to the wrong answer of test questions

Aspects assessed	Number of students in the category (%)
Use of learning resources	21
Time management	29
Learning behavior	36
Attending and concentration on instruction	14

Table 1 shows the results of measuring the ability of self-reflection to the wrong answer to test questions. Reflections on questions that are considered difficult, so students answer wrongly or cannot answer. This reason is focused on aspects of the use of learning resources, time management, learning behavior and concentration at the time of learning. Referring to the results of the questionnaire analysis that in the use of learning resources, students feel that the available learning resources are limited, students feel less appropriate between the learning resources used and the subject matter, assessing there are differences in the content of learning resources. In terms of time management, students feel a lack of time in working on the problem, in learning behavior, students learn not deeply, learning methods are compacted on one night, learning time is too late. The concentration of thinking when the test affects student academic achievement. Some students felt that they were not concentrated because they were thinking about other subjects' assignments.

On self-reflection, students can carry out self-assessment, self-evaluation, and self-reaction. In this study, self-reflection was carried out in this learning through reflective questions about reflecting on subject matter that was considered difficult, correct answers to questions that are not answered on their exam, explain incorrect answers or diagnose reasons for errors, identify learning strategies or behaviors used. The relevant research about the effect of written correction (exam correction) on the results of the final exam assessment shows that Exam correction can improve student academic achievement. During an examination of the exam, students must explain the reason why the chosen answer is wrong and explain the answer chosen is correct [17]. Relevant research results regarding metacognitive arrangements show that in monitoring the results of Exam Learning Strategy 1: students can explain why the approach they are using is successful or not. (49 %), students do not provide evidence that they monitored the effectiveness of the individual strategies they used (51%). Evaluate the exam results 1 and study plan when planning exam 2: students can evaluate their study plan on exam 1 and adjust plans for exam 2 (44,9 %), change their plans for the exam 2 (55,1%) [19].

Relevant study on the use of metacognitive strategies in an introductory biology course, the results of the study show that assignments designed to improve metacognition can have an impact on students for one semester and can provide the greatest benefits for low-performing students [20]. The assignment given is needed to improve the learning process that can build self-regulated learning. The aspects that support self regulated learning consists of processes such as making learning goals, engaging and concentrating in learning, using an effective learning environment, implementing strategies that are effective in organizing, mark and process information to be remembered, utilize learning resources, monitor performance, seek help when needed, have positive trust in their own abilities.

4. Conclusion

The results of the study showed that there were differences in the increasing of student academic achievement between those using metacognitive regulation and nonmetacognitive regulation strategies in Microbiology course. In learning with a metacognitive regulation strategy obtained an increase in the moderate criteria score ($g = 0.59$), while the non-metacognitive regulation strategies obtained an increase in the low criteria score ($g = 0.26$). Study on self-reflection after carrying out the test obtained the following results: aspects related to the use of learning resources (21%), time management (29%), learning behavior (36%), attending and concentration in learning (14%). Most of the difficulties are caused by learning behavior.

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