Analysis of Metacognition Ability in Solving Environmental Mathematics Problems

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Abstract. This study aims to analyse the metacognition abilities of students in 18 ving environmental mathematical problems. The method used is the descriptive qualitative method. The research instruments used were ability tests, questionnaires, and interview guidelines. The subjects included 18 students of Mathematics Education. The students were chosen randomly from the group of students' interests in algebra. The results showed that there were three groups of students based on metacognition abilities, aware, reflective, and strategic learner. The first group is aware learner who are knows about some of the kinds of thinking they do. The second group is strategic learner, who are knows the strategies to help them learning something. The last group is reflective learner who are able to reflect upon their thinking in progress, ponder their strategies and revise them. These results prove that environmental education can be integrated in mathematics through the use of environmental mathematics problems. Integrating environmental education and mathematics can improve students' metacognitive abilities as well as increase students' awareness of environmental problems.

1. Introduction

Sustainable development in Indonesia should be implemented in all aspects of life, including education. The development of education in Indonesia has the mission of preparing human resources as objects and subjects of development. Therefore, the development of education is always pursued by the demands of the times. If the times are changing, it is still going to bring up new issues that was thought before.

The environment is one of the main problems challenging the people of Indonesia today, which was previous was not put into consideration. Environmental awareness and environmental quality are essential aspects of assessing how civilized a nation is. To raise environmental awareness and improve environmental quality, environmental education is an obligation. One of the important approaches is to integrate environmental education in the classroom [1].

Environmental education does not need to be implemented through the application of new subjects. Environmental education can be applied through the integration with the existing subjects. Some subjects that have been integrated with environmental education are mathematics and science [1], [2]. The integration of mathematics, science, and environmental education permits the students to gain from all three areas simultaneously.

Mathematics is a subject directly associated to the environmental of human life. Students who studied mathematics must think and learn mathematics by/for themselves [3, 4], must think mathematically [5, 6]. So, the development of students' mathematical thinking ability on the environment can be assessed. The students' thinking ability should be in line with their understanding and attitude towards the environment.

There are several types of thinking skills, including higher-order thinking skills (HOTS) and metacognitive. HOTS are unusual thinking abilities, are activated when students encounter unfamiliar problems, uncertainties, questions, or dilemmas, whereas [7-10], while metacognitive is an ability to control thinking process through variation strategy, such as organizing, monitoring, and adapting [11]. Metacognition refers to "thinking about thinking," and is considered as important component of successful in learning [12].

Furthermore, the crucial purpose of mathematical instruction is not only to equip students with a collection of skills and procedures but also to facilitate them to think for themselves. The value of skills and processes instruction should be judged by the extent to which the skills and processes enhance flexible, independent thinking [13].

Students' abilities to think flexibly can be developed and enhanced by teachers modelling their own thinking processes, giving students opportunities to problem solve, and helping students become aware of their own thought processes as they solve mathematical problems. This process of analysing our own thought processes is called metacognition and includes thinking about how we are approaching a problem, the strategies we choose to use to find a solution, and the questions we ask ourselves about the problem are all part of metacognition [13].

One of the learning approaches implemented to improve students' metacognitive thinking skills also increases student awareness of environmental problems is through the application of mathematical problems that contain environmental problems

Is it true that environmental education has been integrated in mathematics in Indonesia? Can the instrument used measure the student's metacognitive level? What is the metacognitive level of mathematics students? Thus, the purpose of this study is to analyse the metacognitive abilities of mathematics students in solving environmental math questions.

2. Method

The study was conducted on 18 students who took algebra course. Algebra is a compulsory lesson that implemented in Mathematics Education Department the University of Papua in the academic year 2019/2020. They are students who are studying in the third year, so they has enough mathematical knowledge.

There are three sequences of activities to conduct this research; students work on tests; researchers evaluate test results, and conduct interviews. Students work on test instrument which consist of seven items for 90 minutes. The test instrument used refers to problems solving environmental problems involving five topics: Plant trees to keep the environment green, Conserve resources and develop "clean energy", Utilize land resources wisely, Construct water conservation projects to save water, and Control population growth by family planning [1].

Student test results are evaluated to determine students' metacognitive levels. The metacognitive abilities of students were analysed using the metacognitive classification proposed by Perkins. There are four metacognitive levels of students, namely: tacit, aware, strategic, and reflective.

Tacit learners are unaware of their metacognitive knowledge. They do not think about strategies for learning and merely accept if they know something or not. Aware learners know about some of the kinds of thinking that they do – generating ideas, finding evidence, etc. Strategic learners organise their thinking by using problem-solving, evidence seeking, decision making, etc. They know the strategies to help them learn something. Reflective learners are not only strategic about their thinking but they also reflect upon their thinking in progress, ponder their strategies and revise them [14].

Further analysis to determine the metacognitive level of students based on the results of their work. Determination of students' metacognitive levels is based on the dominant level obtained on the whole item of the test instrument.

3. Result and Discussion

The results of the analysis of students' answers show that students' metacognitive abilities are distributed at all metacognitive levels, except at the Tacit level. Examples of student answers at each metacognitive level are presented in Figure 1, Figure 2, and Figure 3.

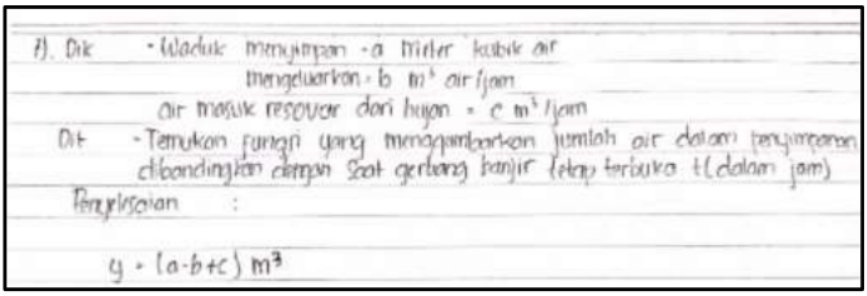

Figure 1. Student answers belonging to the metacognitive level, AWARE

In Figure 1, it appears that students are able to identify what is known, asked and able to develop mathematical models for problems. This shows that he has used his metacognitive abilities even at a low level.

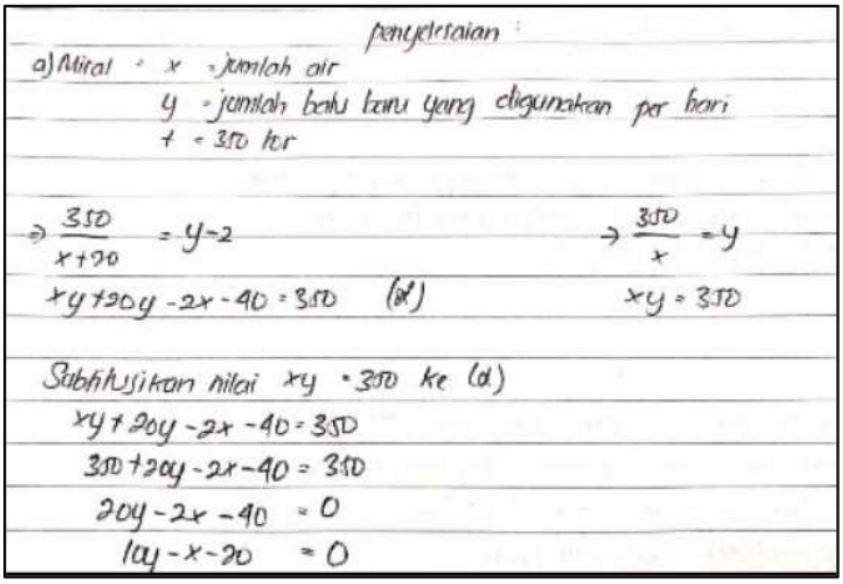

Figure 2. Student answers belonging to the metacognitive level, Strategic

Figure 2, shows that students who solve this problem are able to organize their thinking skills. The student is able to use the information contained in items, and use them to solve the problem. However, these students have not been able to make decisions on the results they have achieved. Therefore, the metacognitive level of the students is strategic.

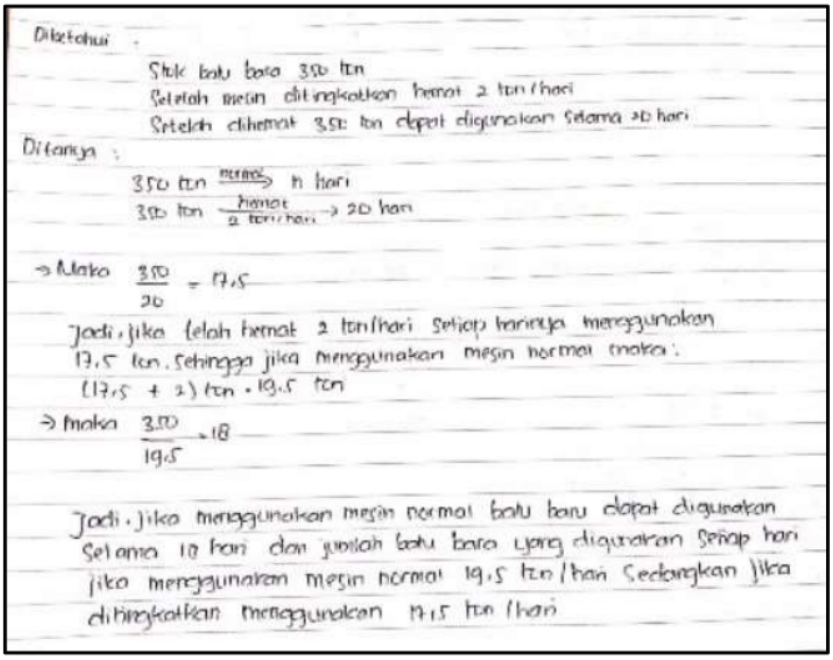

Figure 3. Student answers belonging to the metacognitive level, Reflective

Students who work on the problems in Figure 3 are students who have the highest metacognitive level, namely reflective. Reflective learners are not only strategic about their thinking but they also reflect upon their thinking in progress, ponder their strategies and revise them [14].

The following are the results of further analysis about the level of metacognition of mathematics students, as presented in Table 1.

Table 1. Distribution student's metacognition

Level of Metacognition	Number of Students	Percentage
Tacit	0	0.00
Aware	3	16.67
Strategic	10	55.56
Reflective	5	27.78
Sum	18	100.00

Table 1. presents some important things, especially about the integration of environmental education in mathematics.

The First, the integration of environmental education can be achieved through the use of environmental mathematical problems. The lack of students at the tacit level shows that the problems of mathematics provided can be understood. In this case, the student used his thinking skills to solve the problems of mathematics.

The Second, students were able to use the metacognitive ability to recall math concepts previously learned. In this case metacognitive skills can be used properly by the students.

Cognitive processes activated in a student's mind while solving a problem depends on the student's prior knowledge and experience. Prior knowledge is found to be one of the important prerequisites for learning [15], and affects mathematical performance [16]. Consequently, one question could activate recalling a type of knowledge for one student, while for another who has not seen similar questions, creativity could be activated as the student needs to construct new knowledge. Even within each cognitive process, different subcategories may be activated by students, depending on their prior knowledge and experience. For instance, in terms of applying, if a student has previously solved a similar question to one being answered, executing could be involved; however, if they have not solved similar questions before, implementing might be activated for solving the problem [17].

The Third, by solving mathematical problems concerning the concept of environmental education, students will simultaneously store various environmental problems in their minds. Automatically awareness of the environment and students' concern for the environment will arise.

Environmental education is a model for encouraging student to consider how their behaver affects other people and conditions of the environmental. Student should have an opportunity to be educated so that they can properly respond to environmental problems that will arise in their lives, and to do so they need to be taught the environmental. If students are to help protect the environment, they need not only a willingness to act but also an understanding of ecological and scientific fundamentals [18].

The Forth, metacognitive abilities of students can still be improved using math problems integrated with environmental education. Problem-based test instruments should be developed to improve students' metacognitive abilities. Specifically, by integrating environmental education into mathematics.

Metacognition is necessary for students to succeed in problem-based learning (PBL). Without adequate metacognition, learners may have difficulty understanding complex topics in learning environments [19]. PBL is a learner-cantered constructivist instructional method, which embeds student learning processes in solving real-life problems [20]. There is a relationship between students' metacognitive abilities and academic achievement [21]

Furthermore, to develop the learners' critical thinking, they should be given opportunity to construct their own knowledge through active learning [22, 23]. The teacher should predict learning difficulties, mistakes, and obstacles of students to find some approaches to improve their critical thinking [24].

4. Conclusion

Environmental education can be integrated in mathematics through the use of environmental math problems. Integrating the environment in mathematics can be used to improve students 'metacognitive abilities as well as to increase students' awareness of environmental problems. In order to integrate environmental education into mathematics, it is necessary to develop instruments for HOTS math problems that contain environmental issues.

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