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Metacognition Process in Learning

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ABSTRACT

Metacognitive skills are related to enhancing and managing cognitive abilities, commonly referred to as control or self-regulation. The purpose of the study was to describe the metacognitive self-regulation processes of students in the higher, medium, and lower groups during problem-solving of molecular structure phases of problem analysis, planning, problem-solving, and evaluation. The purpose of this study was to collect data on the planning, monitoring, and reflection components of student metacognitive self-regulation in the context of molecular structure problem-solving. The results of this study suggested that, in a planning dimension, the individuals in the higher group had a deeper groove of metacognitive self-regulation for considering and using fundamental knowledge to solve the problem than those in the middle and lower groups. The subjects in the upper group utilized their information more thoroughly, closely, and precisely than those in the middle and lower groups.
Similarly, the reflection dimension was only completed by the top and bottom groups. Metacognition became the learner's need to comprehend how a task was performed or accomplished, whereas cognition was the desire to simplify the work. Self-regulation of metacognition was required to solve the problem or complete the task.

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INTRODUCTION

In general, there are two primary components of metacognition: knowledge of cognition or metacognitive knowledge and cognitive control or metacognitive skills (Urena, Sandi, 2008). Knowledge of cognition in regards to one's awareness of his cognition or about his thinking procedure, together with: knowledge of something (declarative knowledge), knowledge of how to do things (procedural knowledge), and the know-how of why and when to do something (conditional knowledge).

Metacognitive skills are associated with regulating and improving cognitive abilities that are often referred to as control or self-regulation. Self-regulation includes planning, monitoring, and reflection or evaluation, in which students can plan their thinking activities, monitor their progress, and think about how to be better in the future. Self-regulation metacognitive skills can be taught to students by involving them in self-regulated learning.

North Central Regional Educational Laboratory(NCREL) states that metacognitive skills include activities:(1) developing an action plan; (2) conducting monitoring, and; (3) evaluating the plan. NCREL gives instructions for implementing the three components of metacognition as follows.

First, evolving an action plan (before accomplishing the assignment), comprising the questions: what fundamental knowledge can assist me to do the assignment; in what way will I focus my mind; what should I do first; why I read this section; how long do I have to complete this assignment. Second, conducting monitoring (while working on the assignment), comprising the questions: how do I work; am I on the right track; how should I continue working; what information is important to remember; should I do it differently; should I adjust the steps depending on the level of difficulty; what should I do if I do not understand something. Third, evaluating plan (after completing the assignment), comprising the questions: how well I work; is my thinking less or better than I expected; have I done it differently?To identify the metacognitive self-regulation activities, the author used Dimensional Activity Guidelines of Identification Metacognitive Self-Regulation by Co¬hors-Fresenborg & Kaune (2007) and Pulmones (2007), which were modified according to the research needs for solving the molecular structure in Table 1 (Sugiarto, Prabowo, Suyono, 2014).

Table 1. Dimensional Activities of Metacognitive Self-Regulation

Planning		Monitoring		Reflection	
P-1	Thinking/reading/ writing what one knows and does not know	M-1	Repeatedly reading material until one can understand	R-1	Reflecting on the concepts/objectives that have been achieved
P2	Determining goals	M-2	Using rules, such as molecular formula/structure, equations, diagrams, and graphs.	R-2	Reflecting implementation/ application more efficient strategy
P-3	Determining the problem-solving strategies	M-3	It is monitoring something that is considered an error such as writing, drawing, molecular formula/structure, and others.	R-3	Analyze the text, molecular formula/ structure, and image.
P-4	Determining intermediate results that can be achieved	M-4	Monitoring carefully in problem-solving	R-4	Analyzing the way or structure of decision-making
P-5	Planning a representation (molecular formula/structure, reaction equations, text, images) to support understanding	M-5	Monitoring by arguing	R-5	Choosing intentionally in the form of presentation (molecular formula, structural formula, text, images)
		M-6	Reveals a lack of understanding	R-6	It recognizes the interaction between their presentation and the idea that one as a control theme.
		M-7	Monitor planning deficiencies		

Planning	Monitoring		Reflection
	M-8	Monitoring match between fact and purpose/goal	

METACOGNITION APPLICATION IN LEARNING

The following are some results of qualitative and quantitative research on the process of metacognition in learning. The study aimed to describe the process of student metacognitive self-regulation in the upper, middle, and lower groups in problem-solving of molecular structure corresponding phases of problem analysis, planning, problem-solving, and evaluation. From the above research objectives, the focus of this study was to obtain information about the process of student metacognitive self-regulation of upper, middle, and lower groups in terms of planning, monitoring, and reflection dimensions in problem-solving molecular structure. The findings of this study indicated that in a planning dimension, the upper group had a more careful and thorough metacognitive self-regulation groove for considering and using the fundamental knowledge to resolve the problem rather than the subjects in the middle and lower groups. The upper group in monitoring used more knowledge, more closely, and more specific than the subjects in the group of middle and lower.

Similarly, the dimension of reflection was only done by the upper and lower group. Metacognition became a learner's need to understand how a task was done or completed, while cognition was the need to make a task more manageable. Metacognitive self-regulation capacity was needed to solve the problem or task.

A study was performed to identify student metacognition in solving chemical problem based on reflective and impulsive cognitive styles. Reflective cognitive style is a characteristic of students' cognitive style in solving problems with a long and accurate time. Therefore, the generated answers tend to be correct. In contrast, the impulsive cognitive style is a cognitive style students have in solving problems in a short but less accurate time, so the answers tend to be wrong. This study obtained findings as follows:

1. Students with reflective cognitive style performed metacognition activities, i.e., planning, monitoring, and evaluating.
    a. In developing planning, reflective students wrote what was known and what was asked by using the correct notation and could determine the purpose of the problem. Reflective students could gain valuable something from the data and determine the initial knowledge needed for each problem. Reflective students also obtained a solution plan, prescribed the formula applied in every step correctly, and arranged the following steps to determine the results obtained from the calculations. In addition, reflective students took steps steadily, were more cautious in solving problems, and could change anonymous data to close to what was known. Thus, reflective students were easier to solve problems because the method of solving was systematic.
    b. In monitoring implementation, reflective students checked the conformity of the notation used with what was known and asked, controlled the possibility of errors in a step, verified the accuracy of calculation step by step, check the correctness of results, and re-examined the truth of the work before being collected. Reflective students were quick to solve problems. They considered all alternatives before making a decision, so mistakes made tend to be few, and they could also make improvements if something went wrong.
    c. In evaluating action, reflective students analyzed the conformity of results with the objective and convinced themselves that the evaluation was correct. If they could not solve the proposed problems, they would try to solve the related problems first and evaluate the achievement of the objective. So, reflective students tended to be cautious in making decisions

because they concentrated on solving problems and checking first the activities they had performed.

2. Students who had impulsive cognitive styles did not carry out evaluation metacognition activities. Impulsive students only performed metacognition activities which included planning and monitoring, namely:
   a. In developing a plan, impulsive students wrote what was known and what was asked but had yet to apply the appropriate notation, determined the objective of the problems, obtained a solution plan, arranged the following steps, and settled the results. Impulsive students did not recognize the mistakes they had made in solving problems, resulting in not corrective from the mistakes made.
   b. In monitoring, impulsive students scrutinized the step-by-step calculation even though they had not controlled for the error possibility instep. Impulsive students had not analyzed the conformity of results with the objective and needed to be more careful in solving problems, so they tended to make more mistakes. In addition, impulsive students cannot recognize errors that might be made while not correcting them since they need to consider the alternatives in making a decision.
   c. Impulsive students could not commit to the evaluation activity in solving problems because they did not re-examine their work. Also, impulsive students needed to recognize any step mistakes that had been made.

Other studies aimed to 1) explore the metacognitive self-regulation activities of students in the upper, middle, and lower groups for solving chemical problems and 2) determine students' metacognitive levels based on their metacognitive activities. The metacognitive level is one's awareness of his process and the results of thinking, which consist of:

- Tacit use. Sort of deciding without thinking about the decision.
- Aware use. Kind of thinking represents someone realizing "what" and "when" he is carrying out something.
- Strategic use. Sort of thinking that shows someone organizes the thought by being aware of the specific strategies to improve thinking accuracy.
- Reflective use. Kind of thought showed someone reflecting on their idea by considering the acquisition and how to improve it.

FINDINGS AND DISCUSSION

The results of the research are disclosed below:

1) Students of the upper group occupied the metacognitive level of reflective use.
   Metacognitive activities of this group consisted of planning that was thinking/reading/writing what was known and unknown, setting strategies for solving problems, and planning representation in the form of equations or images to support understanding. The monitoring activities used the equation rule, monitored something considered a mistake, closely monitored the problem-solving, and observed by arguing. The reflection activities were in the form of reflecting on the already achieved concepts/purposes and the efficient strategies application/use.
2) Students of the middle group occupied the metacognitive level of strategic use.
   These group metacognitive activities consisted of planning that was thinking/reading/writing what was known and unknown, setting strategies for solving problems, and planning a representation in the form of images to support understanding. The monitoring activities were monitoring something considered wrong and thoroughly monitoring the problem-solving. Unfortunately, this group did not perform the reflection activity.

3) Students of the low group occupied the metacognitive level of aware use. Metacognitive activities of this group comprised planning to think/read/write what was known and unknown, and establish strategies for problem-solving. Planning representation in the form of images to support understanding. The monitoring activities thoroughly monitored the problem-solving, and this group did not pull off the reflection activity.

The subsequent research was about identifying the students' thinking patterns in solving chemical problems according to the metacognitive activity of different gender. The male subjects in the upper group were superior to the female subjects from the same group. This is because the males were more analytical in thinking. The male subjects in the upper group applied metacognitive activities of planning, monitoring, and evaluating. On the contrary, the middle group employed the metacognitive skill activities of planning, monitoring, and a little evaluating. In contrast, the lower group employed metacognitive planning and monitoring activities in answering the chemical problem-solving test questions.

The female subjects in the upper group thought more imaginatively. They applied metacognitive activities of planning, monitoring, and evaluating. Conversely, the middle group used the metacognitive activities of planning, monitoring, and a little evaluating. In contrast, the lower group used metacognitive planning and monitoring activities in answering the chemical problem-solving test questions.

A study had also been conducted to explore the students' metacognitive skills for solving chemical problems of higher-order thinking domain analysis, evaluating, and creating, which included planning, monitoring, and reflecting activities. The findings revealed that metacognitive activities carried out by the upper group were more varied than the middle and lower groups. The upper group planned, monitored, and reflected on problem-solving activities. The middle and lower group only planned and monitored solving problems.

The exploration of the Proactive Decision Making (PDM) level is a search to find and analyze the characteristics of a person's thinking ability to find out where his thinking ability level is so that he has a proactive attitude. The proactive Decision Making (PDM) level comprises the object, alternative, information, and decision radar. The Proactive Decision Making (PDM) level is expressed below.

1) Object. It is the basis for making alternatives, guiding the method to find information, and deciding on a plan. If the individual does not understand the object precisely, they will generally be unable to make a proactive decision.
2) Alternative. It is a continuation of the object in which the already found object will be utilized for systematic identification. The individual needs to understand the option made to be able to be proactive in making such a decision.
3) Information. It is a continuation of the object and alternative levels. The individual evaluates the alternative with more relevant value. The individual who only collects the existing information unsystematically, but does not seek conformity, will not be able to decide proactively.
4) Decision radar. It is the highest level of the Proactive Decision-Making level. The individual can decide what to do when experiencing obstacles, wherein the individual can predict what obstacle will be encountered. At this level, students can take a proactive manner. The carried-out decision radar has surpassed the object, alternative, and information levels.

The findings of the Proactive Decision Radar level of students in solving chemical problems concerning metacognitive activities are as follows. At the planning stage, the upper group occupied the decision radar level, the middle group occupied the information level, and the lower group occupied the alternative level. These three groups occupied the decision radar level at the monitoring stage, and at the reflection stage, they occupied the object level. Those results were tabulated in Table 2.

Table 2. The Proactive Decision Making (PDM)level of the upper, middle, and lower groups

The students' group	***Level Proactive Decision Making (PDM)***		
	Planning	***Monitoring***	***Reflection***
Upper	*Decision Radar*	*Decision Radar*	*Object*
Middle	*Information*	*Decision Radar*	*Object*
Lower	*Alternative*	*Decision Radar*	*Object*

Before, it was revealed that self-regulated metacognitive abilities can be taught to students by involving them in self-regulated learning. The following is exemplified in learning that applies the cooperative model of Think-Pair-Share. The activities of metacognitive skills were trained in each phase.

- Phase 1: delivering goals and motivating students
  In this phase, students were asked to recall the material explained in previous learning (planning skill). Students were allowed to express what had been remembered/known (planning skill). From now on, the teacher will give feedback to the students and allow students to ask questions (planning skills).
- Phase 2: providing information (**Think**)
  The teacher conveyed brief details on the material that would be studied, and students were allowed to ask about the concept the teacher had explained. Next, the teacher gave the question examples. Students, with the teacher's guidance, determined the strategies used to solve problems(planning skill), wrote what was known and unknown from the questions (planning skill), addressed the problems in a planned way (monitoring skill), and reflected the results of problem-solving (evaluating skill). Students were then given the time to reread the summary of the material on Lembar Kegiatan Siswa (LKS). They did the exercise questions independently (planning skills, monitoring skills, and evaluating skills).
- Phase 3: organizing students into the studying group(**Pair**)
- Phase 4: guiding the working and studying group
  The students, in pairs with the guidance of teachers, matched each student's answers. Hereafter, students in pairs worked on the problem exercises on Lembar Kegiatan Siswa (LKS) (*planning skill, monitoring skill, evaluating skill)*
- Phase 5: evaluation**(Share)**
  The teacher allowed the group who wanted to present the results of the work in the class. Students worked and presented the results of group discussions in the class (planning skills, monitoring skills, evaluating skills). The teacher asked students from the other group to give comments or ask questions about what had been said and done by the group that presented the discussion results (monitoring and evaluating skills). Then, students in one class matched the correct answers from the exercise questions that had been given and worked on LKS (planning skills, monitoring skills, and evaluating skills). The teacher assessed the results read by the presenter group (monitoring skills, evaluating skills).
- Phase 6: rewarding
  The teacher rewarded the group of students who had the most point. Then, together with the students, the teacher concluded the learning results which had been pulled off (evaluating skill).

The following are presented several teaching and learning models and strategies used to practice the metacognitive self-regulation activities.

Table 3. The relationship of models of teaching and learning with the metacognitive self-regulation activities that are trained

Models of teaching and learning	Phases	*The trained activities*
Cooperative (Think-Pair-Share)	Phase 1: delivering goals and motivating students	*Planning skill*
	Phase 2: providing information (Think)	*Planning skills Monitoring skill Evaluating skill*
	Phase 3: organizing students into the studying group (Pair)	*Planning skill, Monitoring skill, Evaluating skill*
	Phase 4: guiding the working and studying group (Pair)	*Planning skill, Monitoring skill, Evaluating skill*
	Phase 5: evaluation (Share)	*Planning skill Monitoring skill Evaluating skill*
	Phase 6: rewarding	
Cooperative STAD Type (Student Teams Achievement Division	Phase 1: delivering goals and motivating students	*Planning skill*
	Phase 2: Provide information	*Planning skill, Monitoring skill*
	Phase 3: organizing students into the studying group	*Monitoring skill*
	Phase 4: guiding the working and studying group	*Monitoring skill*
	Phase 5: Evaluation	*Monitoring skills, Evaluating skill.*
	Phase 6: rewarding	*Evaluating skill*
Guided Inquiry	Phase 1: observation for finding out a problem.	*Planning skill*
	Phase 2: formulating problems.	*Planning skill*
	Phase 3: Submitting a hypothesis.	*Monitoring skill*
	Fase 4: planning a problem-solving	*Monitoring skill*
	Phase 5: experimenting.	*Monitoring skill*
	Phase 6: observing and collecting data.	*Monitoring skill Evaluating skill*
	Phase 7: analyzing data	*Evaluating skill*
	Phase 8: Concluding	*Evaluating skill*
Direct Instruction *(Problem Posing Strategy)*	Phase *1:*delivering goals and preparing students	*Planning skill*
	Phase *2:* explaining the material or demonstrating skill with the problem-posing strategy	*Planning skill*
	Phase *3:* giving guided exercises with Problem Posing strategy	*Planning skill*
	Phase *4:* Checking to understand and giving feedback	*Monitoring skill*
	Phase *5:* allowing advanced training and application	*Evaluating skill*

Models of teaching and learning	Phases	*The trained activities*
Inductive	Phase *1: Open Ended*	*Planning Skill*
	Phase *2: Konvergen*	*Planning Skill. Monitoring Skill*
	Phase *3: Closure*	*Evaluating skill*
	Phase *4: Aplikasi*	*Evaluating skill*
Learning Cycle 7E	Phase: *Elicit*	*Planning skill*
	Phase: *Engage*	*Planning skill*
	Phase: *Explore*	
	Phase: *Explain*	*Monitoring skill*
	Phase: *Elaborate*	*monitoring skill*
	Phase: *Evaluate*	*evaluating skill*
	Phase: *Extend*	*evaluating skill*

CONCLUSION

Students of the upper group occupied the metacognitive level of reflective use. Students of the middle group occupied the metacognitive level of strategic use. Students of the low group occupied the metacognitive level of aware use. The ensuing research focused on determining pupils' chemical problem-solving thinking patterns based on their metacognitive activities. The male individuals in the upper group were superior to their female counterparts. This is because men have a more analytical mindset. The male subjects in the superior group engaged in planning, monitoring, and evaluating as metacognitive processes. In contrast, the middle group utilized the metacognitive skill activities of planning, monitoring, and a small amount of assessing to answer the chemical problem-solving exam questions. The lower group utilized the metacognitive skill activities of planning and monitoring.

The female individuals in the upper group demonstrated greater creativity. They engaged in metacognitive planning, monitoring, and evaluation. In contrast, the middle group used metacognitive planning, monitoring, and a small amount of evaluation to answer the chemical problem-solving test questions, and the lower group employed metacognitive planning and monitoring.

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