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Using Metacognitive Strategies to Improve Reading Comprehension and Solve a Word Problem

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Abstract. This article describes briefly the theories of metacognition and the impacts of metacognitive skills on learning. The differences between cognitive strategy and metacognitive strategy were mentioned. Some strategies to improve students' metacognition skills in the classroom explored as well. Based on the theories, two models of metacognitive strategies instruction for deeply understanding in reading textbook and for finding a solution of words physics problem solving were developed. These models will enable students to be independent and strategic learners.

Keywords**:** Metacognition; Models of Metacognitive Strategy; Metacognitive Skills Development

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I. INTRODUCTION

One of the central aims of current research is employing a wide range of instructional practices for fostering learners' metacognition. Metacognition is the core objectives of science education [1]. In addition, recent research has shown that some pedagogical approaches to model use have enabled students to develop a metacognitive awareness How the teacher promote active learning with metacognitive processing by both teachers and learners is a major issue in science teaching and learning [2]. Mitchell [3] stated that philosophers and neuroscientists gathered at a recent international workshop to discuss self-awareness and how it is linked to metacognition. Fadel, C. et.al [4] argued that metacognition plays a central role in learning and achievement. metacognitive strategies are powerful tools for any discipline, inter-discipline or for learning in general. Improving metacognitive strategies related to students' schoolwork also provides young people with tools to reflect and grow in their emotional and social lives. Metacognitive ability is one of "core" competency standard in the Curriculum 2013 implemented currently in Indonesia should be developed for senior-high school students.

In this twenty-first century, the world is changing rapidly. It unrealistic to prepare a literate science-information-technology people in the future if only based on facts and concepts of the content areas that students acquired during school years. A new situation and problem they faced in their daily lives are required the appropriate and satisfactory solutions. We engage in metacognitive activities everyday. While life presents situations that can not be solved by learned responses, metacognitive behavior is brought into play. Metacognitive skills are needed when habitual responses are not successful. Metacognitive skills will enable students to successfully cope with new situations [5]. Teachers who use metacognitive strategies can positively impact students who have learning disabilities by helping them to develop an appropriate plan for learning information, which can be memorized and eventually routine. As students become aware of how they learn, they will use these processes to efficiently acquire new information, and consequently, become more of an independent thinker. Below are three metacognitive strategies, which all include related resources, that can be implemented in the classroom:

As students become more skilled at using metacognitives strategies, they gain confidence and become more strategic, more independent as learners. Independence leads to ownership as students realize they pursue their own intellectual needs and discover a world of information at their fingertips [6]. Because of learning how to learn, developing a repertoire of thinking processes to solve a problem, is a major goal of education, the metacognitive strategies will be a critical ingredient to successful learning. In addition, by using metacognitive strategies, students can truly learn. The hub of the school is an ideal place to develop students' metacognitive skills. The task of educators is to acknowledge, cultivate, exploit, and enhance the metacognitive capabilities of all learners [7]. Thus, guidance in recognizing, and practice in applying metacognitive strategies should be executed by teachers of all content area (subjects) since the primary years. It is also argued that metacognitive skills can be taught to students of all ability levels. Spiegel & Barufaldi [8] reported that training students on metacognitives strategies in reading and making self-notes of graphic postorganizers during secondary school physics class could enhance recalls and retentions and students' achievement as well. Koch [9] concluded that the experimental group using the Koch–Eckstein technique with the metacognitive tasks, to be significantly higher score on a test of reading-comprehension physics text than those of the control group after the experimental manipulation. Based on these results, she strongly recommended that the metacognitive technique is developed and applied in teaching reading comprehension of physics texts as an effective self-monitoring device.

Reading comprehension of physics texts is a neglected area in physics curricula. I found that few college instructors explicitly teach strategies for monitoring learning. They assume that students have already learned these strategies in high school. But many have not and are unaware of the metacognitive process and its importance to learning. Rote memorization is usual—and often the only—learning strategy employed by high school students when they enter college.

This paper describes briefly the theory of metacognition and how it differs from cognition and two models of a metacognitive technique for improving student reading comprehension of physics texts and student ability to solve physics word problem as well.

II. COGNITIVE AND METACOGNITIVES STRATEGIES

Nelson [10] refers to metacognition as "the scientific study of an individual's cognitions about his or her own cognitions". Therefore, metacognition can be considered as a subset of cognition, better to say, a certain kind of cognition. Broadly defined, cognition is a general term for thinking, while metacognition is thinking about thinking. Cognitive strategies differ from metacognitive strategies. It is often difficult to distinguish between what is metacognitive and what is cognitive. There is also much debate over what metacognition is. These terms, are sometimes, confusing. At least, there are two sources of confusion. The first is concerning the interchangeability of cognitive and metacognitive strategies. The second source of confusion concerning the wide spread use of the term metacognition is that, within the psychological literature. According to Weinert & Kluwe [11], a cognitive strategy is one designed simply to get the individual to some cognitive goal or subgoal. Here I present the simplest instances. A cognitive strategy for getting the sum of a list of numbers would be to add them up. The goal is to find the sum, in order to do so the numbers are added. In the same situation, a metacognitive strategy might be to add the numbers a second time to be sure the answer is correct. Similarly, sometimes one reads things slowly simply to learn the contents (cognitive strategy); other times one reads through things quickly to get an idea of how difficult or easy it is going to learn the content (metacognitive strategy). Cognitive and metacognitive strategies may overlap in that the same strategy. A strategy could be regarded as either cognitive or metacognitive depending on what the purpose of using that strategy may be. For example, you may use a self-questioning while reading as a means of obtaining knowledge (cognitive), or as a means of overseeing what you have read. In short, one learns cognitive strategy for making cognitive progress and about metacognitive strategy for monitoring the cognitive progress [12]. So, one learns cognitive strategy for making cognitive progress and about metacognitive strategy for monitoring the cognitive progress. Stated briefly, cognitive strategies are used to help individual achieve a particular goal, while metacognitive strategies are used to ensure that the goal has been reached or completed.

A cognition is generally assumed to be thinking, a mental act by which knowledge is acquired [13]. By using a variety of cognitive strategies (processes of thinking), the objectives or goals of learning tasks could be performed. Bloom's taxonomy includes the six basic or essential categories of cognitive or thinking skills, they are; knowledge, comprehension, application, analysis, synthesis, and evaluation. Each of these categories indicates the kind of behavior students are to perform as the objectives or goals of specific learning tasks.

Metacognition is thinking about your thinking as you are thinking to improve your thinking [14]. The metacognitive strategies represent the awareness and control of all the cognitive processes. Metacognition is thinking about thinking, knowing "what we know" and "what we don't know" and is a process of management of thinking. Dirkes [5] argued that the metacognitive strategies are; (1) connecting new information to former knowledge; (2) selecting thinking strategies deliberately; and (3) planning, monitoring, and evaluating thinking processes. Winn & Synder [15] stated that metacognition is an important concept in cognitive theory. It consists of two basic processes occurring simultaneously: monitoring your progress as you learn, and making changes and adapting your strategies if you perceive you are not doing well. Metacognitive skills include taking conscious control of learning, planning and selecting strategies, monitoring the progress of learning, correcting errors, analyzing the effectiveness of learning strategies, and changing learning behaviors and strategies when necessary [16]. Therefore, constructing understanding or comprehension requires both cognitive and metacognitive strategies. Livington [12] stated further that because cognitive metacognitive strategies are closely interlinked and dependent upon each other, any attempt to examine one without acknowledging the other would not provide an adequate picture.

According to Flavell [17], a wide range of intellectual activities will be monitored by means of the actions and interactions among four basic elements: a) metacognitive knowledge, b) metacognitive experience, c) goals (or tasks), and d) actions (or strategies) as shown in Figure 1. *Metacognitive knowledge* refers to one's knowledge or beliefs about person, task, and strategy variables. He has affirmed that metacognitive knowledge is not basically different from other kinds of knowledge in the long-term memory. *Metacognitive experiences* are the segments of this stored knowledge, metacognitive knowledge, that have entered into consciousness, that is, "any conscious cognitive or affective experiences that accompany and pertain to any intellectual enterprise". Metacognitive experiences are very likely to take place in circumstances which require a great deal of careful, highly 'conscious thinking'. Metacognitive knowledge can be added, deleted, or revised through metacognitive experiences. The *goals or tasks* have to do with the actual objectives of a cognitive endeavor. And finally, *actions or strategies*, as the name indicates, are some ways and techniques that may assist in reaching those goals. According to Flavell [18], acquiring metacognitive strategies as well as cognitive ones is viable.

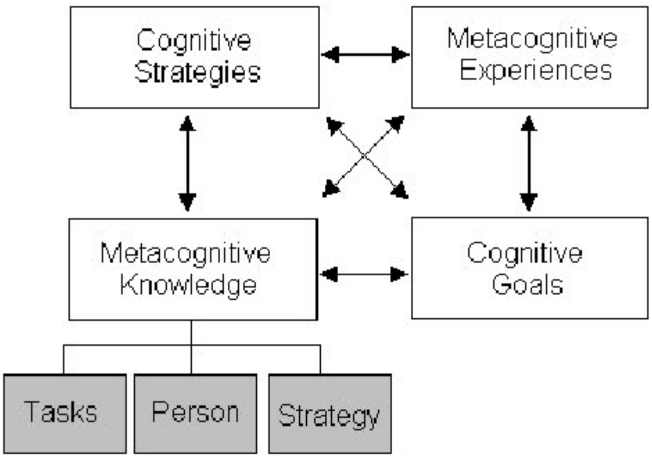

Fig. 1 Flavell's Model of Metacognition [17]

III. HOW TO DEVELOP STUDENTS' METACOGNITIVE SKILLS?

Experts in the cognitive theory agreed that metacognition, like everything else, undoubtedly improves with practice or training. Simpson and Nist [19], in a review of the literature on strategic learning, emphasize that instructors need to provide explicit instruction on the use of study strategies. Abromitis [6] argued that teachers can raise the level of metacognitive thought in their classroom by modeling the processes themselves. Thinking aloud when solving the problems, mirroring students' ideas back to them or rephrasing them to include specific thinking words (such as planning, strategy, steps to be taken, etc.), clarifying responses and questions, and having students include the " how they did it" as a part of larger assignments are all ways to encourage metacognitive thinking.

Flavell [18] a pioneer in the field of metacognition, mentioned a number of experiences or activities that might assist metacognitive development. *First*, experience may be supplied by parents. Parents may unintentionally model metacognitive activity for their children. They may also deliberately demonstrate and teach it, helping the child to regulate and monitor his/her actions. *Second*, teachers in schools may sometimes model, as well as teach and encourage, metacognitive activity including reading, writing, and learning mathematics or any subjects as well. In the course of learning to read, the child gets practice in scrutining messages in isolation from context, and in evaluating the possible intended meanings and implications. Bond, *et.al.* [20] argued, "learning to read and reading to learn should develop together throughout the school years ". Writing allows one critically inspect one's own thoughts and also encourages the individual to imagine the thoughts of others. Similarly, learning mathematics or any subject provides opportunities for monitoring all sorts of activities. Palinscar, *et.al.* [21] stated that during problem-solving situations, teachers should think aloud so that students can follow demonstrated thinking processes. This talking about thinking strategy is important because students need a thinking vocabulary. Modeling and discussion develop the vocabulary students need for thinking and talking about their thinking. Labeling thinking processes when students use them is also important for student recognition of thinking skills. Fogarty [7] stated that modeling through think-aloud is the best way to teach all comprehension strategies. By thinking aloud, teachers show students what they should do. Think-aloud s can be used. Another useful strategy during problem-solving situations is paired problem solving. One student talks through a problem, describing his/her thinking processes. His/her partner listens and asks questions to help clarify thinking. Similarly, in reciprocal teaching, small groups of students take turns playing teacher, asking questions and clarifying and summarizing the material being studied.

Good schools should be hotbeds of metacognition development. In school, children have repeated opportunities to monitor and regulate their cognition, as they gradually pass from novice status to (semi) experts status. Ertmer & Newby [22] stated that the novice learners don't stop to evaluate their comprehension of material. They generally don't examine the quality of their work or don't stop make revisions as they go along, and satisfied with just scratching the surface as well. They also don't attempt to examine a problem in depth. Novice learners don't make connections or see the relevance of the material in their lives. On the contrary, expert learners are more aware than novices of when they need to check for errors, why they fail to comprehend, and how they need to redirect their efforts. Taking reading for example. we've all experienced the phenomenon of reading a page or a whole of chapter in textbook and then realizing we haven't comprehended a single thing. A novice learner would go on to the next page, thinking that merely reading the words on a page is enough. An expert learner would re-read the page until the main concept is understood, or flag a difficult passage to ask for clarification from teacher or peers later.

Mitchell [3] recommended 7 strategies to improve students' metacognition skills in the classroom, as follows:

a. *Teach students how their brains are wired for growth.* Teaching kids about the science of metacognition can be an empowering tool, helping students to understand how they can literally grow their own brains.

b. *Give students practice recognizing what they don't understand.* The act of being confused and identifying one's lack of understanding is an important part of developing self-awareness.
c. *Provide opportunities to reflect on coursework.* Higher-order thinking skills are fostered as students learn to recognize their own cognitive growth.
d. *Have students keep learning journals.* One way to help students monitor their own thinking is through the use of personal learning journals. Assign weekly questions that help students reflect on *how* rather than *what* they learned. Encourage creative expression through whatever journal formats work best for learners, including mind maps, blogs, wikis, diaries, lists, e-tools, etc.
e. *Use a "wrapper" to increase students' monitoring skills.* A "wrapper" is a short intervention (give a few tips) that *surrounds* an existing activity and integrates a metacognitive practice. When used often, this activity not only increases learning but also improves metacognitive monitoring skills.
f. *Consider essay vs. multiple-choice exams.* While it is less time consuming to grade multiple-choice questions, even the addition of several short essay questions can improve the way students reflect on their learning to prepare for test taking.
g. *Facilitate reflexive thinking.* Reflexivity is the metacognitive process of becoming aware of our biases -- prejudices that get in the way of healthy development. Teachers can create a classroom culture for deeper learning and reflexivity by encouraging dialogue that challenges human and societal biases. When students engage in conversations or write essays on biases and moral dilemmas related to politics, wealth, racism, poverty, justice, liberty, etc., they learn to "think about their own thinking." They begin to challenge their own biases and become more flexible and adaptive thinkers.

IV. THE MODELS OF METACOGNITIVE SKILLS DEVELOPMENT

Costa [13] argued that metacognitive instruction would include learning how to learn; how to study for a test; how to use strategies of asking before, during, and after reading. It might include how to learn best—visually; diagrammatically; auditorily—and what strategies to use when you find yourself in a problem-solving situation that does not match your best learning modality. In this paper, relevant to Costa, I would like to figure diagrammatically the first model consist of the three basic strategies of metacognition in favor of developing metacognitive skills in reading the text that they can be adopted and applied explicitly, as shown in Figure 2.

A. Reading for Deeper Understanding of Text

According to Fogarty [7], a good reader must; (1) develop a plan before reading; (2) monitoring their understanding of text, and (3) evaluate their thinking after reading. Through modeling and practice, a teacher should teach students to:

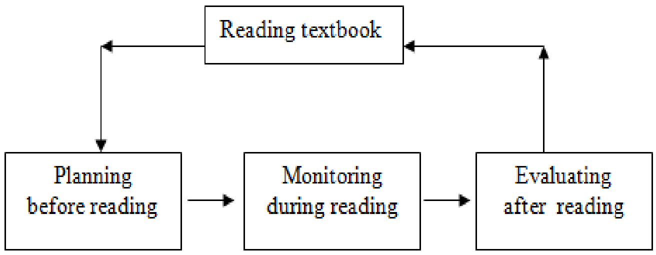

Fig. 2 Models of Metacognitive Strategies in Reading Textbooks

a. *Planning* :

- Think about the text's topic.
- Think about how text features can help in understanding the topic.
  - Read the title and author, and table of contents.
  - Study illustrations, photos, and graphics, including labels and captions
  - Skim for bold-faced words, heading and subheadings, and summaries
- Think about what they know, what connections they can make, and what questions they might want to be answered.
- Think about the way the text might be organized. There are six types of text structures; (1) cause and effect; (2) compare and contrast; (3) sequence of events; (4) problem and solution; (5) description; and (6) a combination of these text structures [8].

b. Monitoring during Reading:

The good reader takes charge of their reading by monitoring their own comprehension. Students need direct instruction on how and why to do this, for instance, by asking *Do I understand what I just read*? The reader who take responsibility for their own comprehension constantly question the text and their reaction to it. Other ways that readers monitor comprehension during reading are to:

- Make connections predictions or inferences
- Use context clues, text features
- Identify text structures
- Use graphics organizers to pinpoint particular types of text information
- Write comments or questions on self-stick notes or in the margins

c. Evaluating:

When students finish reading, students reflect on a reading strategy they used to determine their plan worked or whether they should try something else next time. Generally, students are asked to answer questions posed, relating answers to headings or subheadings.

B. Solving The General Word Problems in Physics

In this section, I will model explicitly teaching processes that implement metacognitive strategies in solving a senior high school physics problem. The strategies I employed to guide students are derived from Dirkes [5] figured as follows:

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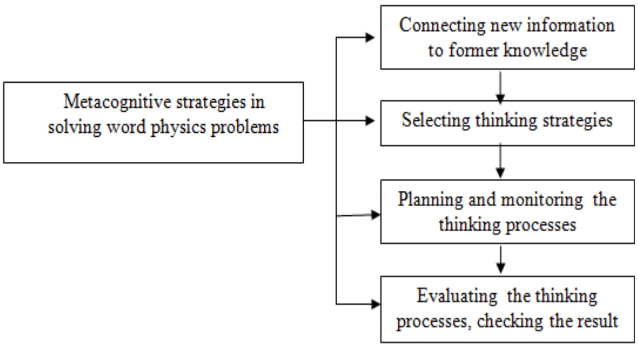

Fig. 3 Models of Metacognitive Strategies in Solving Words Physics Problems

Let's follow this direct instruction of the model!
A general of senior high school physics problem;

A 90-m long train begins accelerating uniformly from rest. The front of the train passes a railway worker, who is standing 200 m from where the front of the train starts at the speed of 25 m/s. What will be the speed of the last train as it passes the worker!

a. Strategy 1: Connecting new information to former knowledge

Teacher ask students:
Try to comprehend the problem by reading carefully, what the basic concepts are involved? (*teacher try to cultivate students' self-awareness*)

Intended students' answers:
1. A constant-accelerated motion
2. Train (particle) is in rest initial-condition

Teacher ask students:
Well, what is the initial information (our existing knowledge) might be used that connected to the concepts (problem) we are facing?
Intended students' answers:
(There are three basic formulas in uniform-accelerated motion)

$$v = v_0 + at$$
$$s = v_0 t + \frac{1}{2}at^2$$
$$v^2 = v_0{}^2 + as$$

b. Strategy 2: Selecting thinking strategies

Teacher ask students: (Strategy 2: *selecting thinking strategies*)
Good, what is suppose to do for finding a right solution? Keep silent for a moment while waiting for students' responses. If no response, the teacher should guide students to select the best strategies.

To comprehend deeply the problem and find the solution, because of no picture presented, we first to sketch the free body-diagram, as follows:

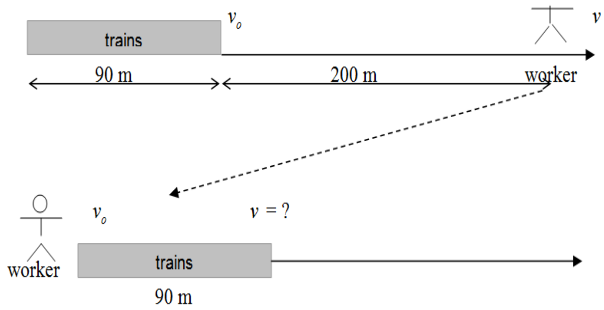

Fig. 4 Free Body Diagram

c. Strategy 3: Planning and monitoring the thinking processes

Teacher guide students:
In this problem, we can separate the problem into two situations. The first is initial-speed is zero, and the final speed is 25 m/s and the distance is 200 m long. In the second situation, 25 m/s will be initial-speed and the rest distance is 90 m long. We ask to find the *final speed*? So, we can make two equations derived from the third equation above, namely:

$$a_1 = \frac{v^2 - v_o^2}{2s_1} \qquad \text{and} \qquad a_2 = \frac{v^2 - v_o^2}{2s_2}$$

What about the value of a_1 and a_2 in the two equations above, are they equal. Why explain your answer! Yes, they have equal values.
Then, we find:

$$\frac{(25)^2 - (0)^2}{2(200m)} = \frac{v^2 - (25)^2}{2(90m)}$$

, so the final solution is 31,5 m/s.
Thus, the speed of the last train as it passes the worker is 31,5 m/s

d. Strategy 4: Evaluating the thinking processes, checking the result
Teacher ask students:
Is it the correct solution? Is it intelligible? Explain your answer!

V. CONCLUSIONS

To help students achieve science-information-technology literacy, an instructional processes through school years should be based on "*hands-on* " activities. These "*hands-on* " activities will promote students' "*minds-on*" activities. The "*minds-on*" activities lead to students' development of the strategy of thinking processes. Developing students' metacognitive strategies in any content areas play a powerful role in the learning processes in order to assist students to be independent and strategic learners. Teachers should model and train explicitly their students of these metacognitive strategies during classroom periods. Students should be guided gradually to comprehend the new situation they faced, to make connection new information to former knowledge, to select thinking strategies, and also to monitor and evaluate the thinking processes. In addition, the teacher might create a various class or school experiences for the students that may increase the growth of metacognitive skills, including reading, writing, and problem-solving situations. A number of strategies can be used by the teachers that enhance students' metacognitive skills while problem-solving situations, such as think-aloud procedure, think-paired technique, and reciprocal teaching. Hence, if we all agreed that the essential goal of education is also to enhance the quality of students' thinking, we should move outside of traditional instruction that simply overemphasizes on the acquisition of subjects matter.

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