Journal of Education and Learning (EduLearn)
Vol.12, No.3, August 2018, pp. 501~509
ISSN: 2089-9823 DOI: 10.11591/edulearn.v12i3.7209

Preparing A Strategic Learner by Using Metacognitive Strategies: from Theory into Practice

Tomo Djudin
Department of Physics Education of Education and Teacher Training Faculty, Tanjungpura University of Pontianak, Indonesia

Article Info

Article history:

Received Sep 05 2017
Revised Apr 28, 2018
Accepted May 12, 2018

Keywords:

Metacognition
Metacognitive skill
Metacognitive strategy
Reading
Word problem

ABSTRACT

It is unrealistic to expect students to have future literacy about science, information, and technology if their education includes only facts and concepts relevant during the school years. While life presents situations that cannot be solved by learned responses, the metacognitive strategy 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. The main purpose of this paper is to propose a practical model of implementing strategies to increase students' ability to comprehend texts and find solutions to word problems based on the theories and empirical background of metacognition. In addition, the distinction between metacognition and cognition and explicit instruction on the learning strategies to develop students metacognitive skills were discussed. It concludes that teachers can raise the level of metacognitive thought in their classrooms by modeling the processes. The use of metacognitive strategies will enable students to be independent and strategic learners.

Corresponding Author:

Tomo Djudin,
Department of Physics Education of Education and Teacher Training Faculty,
Tanjungpura University of Pontianak, Jl. Purnama,
Jl. Perintis No. 8-Z RT 06/RW15, Kel. Akcaya, Pontianak-Kalimantan Barat, Indonesia
Email: lsntl@ccu.edu.tw

1. INTRODUCTION

Metacognition is a core objective of science education [1, 2]. How the teacher promotes active learning with metacognitive processing by both teachers and learners is a major issue in science teaching and learning [3, 4]. Typically, the metacognitive ability is one of the "core" competency standards in the Curriculum 2013 currently implemented in Indonesia for senior high school students. Mitchell stated that philosophers and neuroscientists gathered at a recent international workshop to discuss self-awareness and how it is linked to metacognition [5]. In addition, recent research has shown that some pedagogical approaches to model use have enabled students to develop metacognitive awareness. Fadel et al.argued that metacognition plays a central role in learning and achievement.Metacognitive strategies are powerful tools for any discipline, interdiscipline, or for learning in general. Improving metacognitive strategies related to students' school work also provides young people with tools to reflect and grow in their emotional and social lives [6].

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 made routine. As students become aware of how they learn, they will use these processes to efficiently acquire new information, and consequently, become more independent thinkers. As students become more skilled at using metacognitive strategies, they gain confidence and become more strategic and more independent as learners. Independence leads to ownership as students realize that they pursue their own intellectual needs and discover a world of information at their fingertips [7].

Because of the need to learn how to learn, developing a repertoire of thinking processes to solve a problem is a major goal of education, and metacognitive strategies will be critical ingredients 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 [2]. Thus, guidance in recognizing and practice in applying metacognitive strategies should be executed by teachers of all content areas (subjects) beginning with the primary years. It is also argued that metacognitive skills can be taught to students of all ability levels. Spiegel and Barufaldi reported that training students on metacognitive strategies in reading and making notes of graphic postorganizers during secondary school physics class could enhance recall and retention as well as students' achievement [8]. Koch concluded that the experimental group using the Koch-Eckstein technique with metacognitive tasks achieved significantly higher scores on a test of reading-comprehension of a physics text than those of the control group [9]. Based on these results, she strongly recommended that the metacognitive technique is developed and applied in teaching reading comprehension of texts as an effective self-monitoring device.

Reading comprehension of learning texts is a neglected area in curricula. Only 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 they are unaware of the metacognitive process and its importance to learning. Rote learning is the usual and often the only learning strategy employed by high school students when they enter college. Learning in the schools simply overemphasizes the acquisition of subject matter. Based on a systematic analysis of 178 studies published in peer-reviewed journals in the ERIC database, Zohar and Barzilai concluded that the development of learners' metacognitive knowledge is receiving less attention in science education. Furthermore, there are very few studies of teachers' knowledge and professional development regarding metacognition [1].

This paper proposes two practical models of metacognitive strategies for improving student reading comprehension and ability to solve a word problem. In addition, it briefly describes the theory of metacognition and how it differs from cognition and provides explicit instruction on the learning strategies to develop student's metacognitive skills.

2. METHOD AND RESULTS

To develop a practical model of implementing metacognitive strategies that can be used to increase students' ability to comprehend texts and find a solution of word physics problems, a initial review of the theoretical perspectives and empirical background from the results of previous studies of metacognition was conducted. Through a content analysis of the perspectives studies, a simple and practical strategy was intended to be developed explicitly regarding applicability for students at the secondary school level. In developing a model of metacognitive strategies for increasing students' ability to comprehend texts, I used the perspectives of Fogarty and Costa, which state that a good reader must (1) develop a plan before reading, (2) monitor their understanding of the text, and (3) evaluate their thinking after reading. In developing a model of metacognitive strategies for solving a word problem in physics, I modified the strategies proposed by Dirkes: 1) connecting new information to former knowledge; 2) selecting thinking strategies deliberately, and 3) planning, monitoring, and evaluating thinking processes.

A model of implementing strategies to increase students' ability to comprehend texts and find solutions to word problems developed in this paper is described as follows.

2.1. Metacognitive Strategies for Deeper Comprehending of Text

To increase students' ability to comprehend texts, a teacher might model explicitly the learning activities as shown in Figure 1.

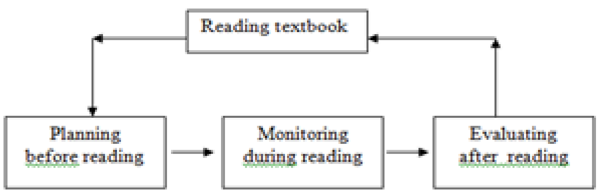

Figure 1. A model of metacognitive strategies in reading text

a. ***Planning***
- Think about the text's topic.
- Think about how text features can help in understanding the topic.
  - Read the title, author, and table of contents.
  - Study illustrations, photos, and graphics, including labels and captions
  - Skim for boldfaced words, headings 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.

b. ***Monitoring during Reading***

Good readers take charge of their reading by monitoring their own comprehension. Do students need direct instruction on how and why to do this, for instance by asking *Do I understand what I just read*? Readers 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 and 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 whether 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.

2.2. Metacognitive Strategies for Solving a Word Problem of Physics

To improve students' ability to solve a word problem, a teacher might model or guide students to apply the learning strategies as shown in Figure 2.

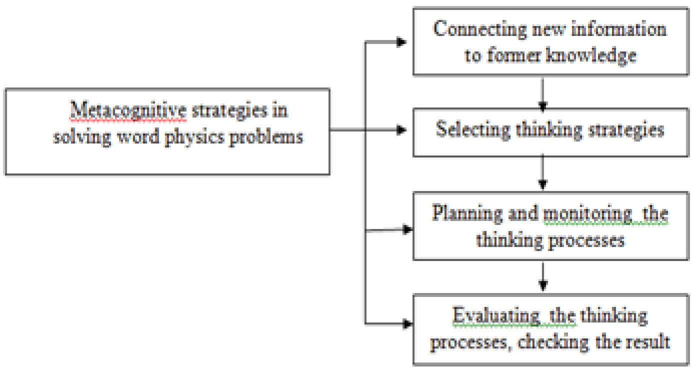

Figure 2. A model of metacognitive strategies for solving word problems

Here is an example of word problems of physics:

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 car as it passes the worker?

a. ***Strategy 1*****:** ***Connecting new information to former knowledge***

Teacher asks studen*ts*:

Try to comprehend the problem by reading carefully to identify what basic concepts are involved. (The *teacher tries to cultivate students' self-awareness.*)

Intended answers:
1. Constant-accelerated motion
2. Train (particle) is in rest at the initialcondition

Teacher asks students:
What is the initial information (our existing knowledge) that might be used to connect to the concept (problem) we are facing?
Intended answers:
There are three basic formulas in uniform-accelerated motion.

$$v = v_0 + at$$

$$s = v_0 t + \frac{1}{2} a t^2$$

$$v^2 = {v_0}^2 + as$$

b. Strategy 2: Selecting thinking strategies
Teacher asks students:
What are you supposed to do to find a correct 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 deeply comprehend the problem and find the solution, we first sketch a free diagram, as follows:

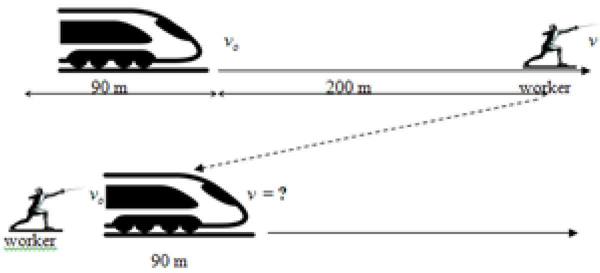

Figure ?

c. Strategy 3: Planning and monitoring the thinking processes
Teacher guides students:
In this problem, we can separate the problem into two situations. In the first situation, the initial speed is zero, the final speed is 25 m/s, and the distance is 200 m long. In the second situation, 25 m/s will be the initial speed and the rest distance is 90 m long. We are asked to find the *final speed*. So we can make two equations derived from the third equation above, namely:

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

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 will find:

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

Thus, the speed of the last train car as it passes the worker is 31.5 m/s.

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

3. DISCUSSION

3.1. The Difference between Cognitive and Metacognitive Strategies

Nelson referred to metacognition as “the scientific study of an individual’s cognitions about his or her own cognition.” Therefore, metacognition can be considered as a subset of cognition, or rather a certain kind of cognition. Broadly defined, cognition is a general term for thinking, while metacognition is thinking about thinking[10]. 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. There are at least two sources of confusion with these terms: the interchangeability of cognitive and metacognitive strategies, and the widespread use of the term metacognition within the psychological literature [11]. According to Weinert and Kluwe, a cognitive strategy is one designed simply to get the individual to some cognitive goal or subgoal. 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, and 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 [11]. Similarly, sometimes one reads things slowly simply to learn the contents (cognitive strategy); at other times one reads through things quickly to get an idea of how difficult or easy it is going to be to learn the content (metacognitive strategy).

Cognitive and metacognitive strategies may overlap. A strategy could be regarded as either cognitive or metacognitive depending on the purpose of using the strategy. For example, you may use 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 a cognitive strategy for making cognitive progress and a metacognitive strategy for monitoring the cognitive progress [12]. In brief, cognitive strategies are used to help the individual achieve a particular goal, while metacognitive strategies are used to ensure that the goal has been reached or completed. Cognition is generally assumed to be thinking, a mental act by which knowledge is acquired. 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: 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 [13].

Metacognition is thinking about your thinking as you are thinking to improve your thinking. Metacognitive strategies represent awareness and control of all the cognitive processes. Metacognition is thinking about thinking, i.e., knowing “what we know” and “what we don’t know,” and is a process of thinking management [14]. Dirkes argued that metacognitive strategies involve (1) connecting new information to former knowledge; (2) selecting thinking strategies deliberately; and (3) planning, monitoring, and evaluating thinking processes [15]. Winn and Synder stated that metacognition is an important conceptin 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 [11]. 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 stated further that because cognitive and 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 [12].

According to Flavell, 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 3. Metacognitive knowledge refers to one’s knowledge or beliefs about a person, task, and strategy variables. Flavell affirmed that metacognitive knowledge is not essentially different from other kinds of knowledge in terms of long-term memory. Metacognitive experiences are the segments of this stored, metacognitive knowledge that have entered 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 that 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. Finally, actions or strategies, as the names indicate, are techniques that may assist in reaching those goals [17]. According to Flavell, it is viable to acquire metacognitive strategies and cognitive ones.

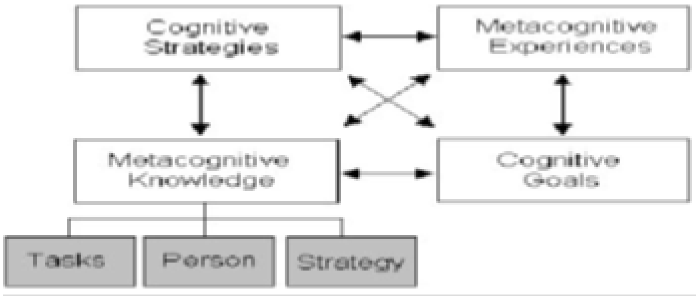

Figure 3. Flavell's model of metacognition (Mahdavi, 2014, p.530)

As students develop, they rely increasingly on internal, self-regulatory skills. At the self-regulatory level, individuals possess strong self-efficacy beliefs, as well as a repertoire of cognitive strategies, that enable them to self-regulate their learning [18]. According to Zimmerman [19], self-regulated learning consists of three main components: cognition, metacognition, and motivation. Each component is necessary but not sufficient for self-regulation. For example, individuals who possess cognitive skills but are unmotivated to use them do not achieve the same level of performance as individuals who possess skills and are motivated to use them. Similarly, those who are motivated but do not possess the necessary cognitive and metacognitive skills often fail to achieve high levels of self-regulation.

Some previous studies have concluded that students who receive teachers' intervention will show positive perceptions for metacognitive strategies and enhanced achievement in science [8, 9],[20]. Seraphin et.al. confirmed that metacognitive strategies coupled with disciplinary inquiry have the potential to effect change in the teaching of the scientific process and scientific thought, with the result that students become better critical thinkers, strategic learners, and more scientifically literate [4].

3.2. Developing Students' Metacognitive Skills

The 21st-century world is changing rapidly. It is unrealistic to expect students to have future literacy about science, information, and technology if their education includes only facts and concepts relevant during the school years. New situations and problems they face in their daily lives require appropriate and satisfactory solutions. While life presents situations that cannot be solved by learned responses, the metacognitive behavior is brought into play [17]. Metacognitive skills are needed when habitual responses are not successful. Metacognitive skills will enable students to successfully cope with new situations [1, 15].

Experts in cognitive theory agree that metacognition, like everything else, undoubtedly improves with practice or training. Simpson and Nist, in a review of the literature on strategic learning, emphasized that instructors need to provide explicit instruction on the use of study strategies [11]. Abromitis argued that teachers can raise the level of metacognitive thought in their classrooms by modeling the processes themselves. Methods to encourage metacognitive thinking [7] include 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 how they solved the problems as a part of larger assignments.

Flavell, 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, or they may 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 during the teaching of reading, writing, mathematics, or other subjects. In the course of learning to read, the child gets practice in scrutinizing messages in isolation from context and in evaluating the possible intended meanings and implications [21]. Modeling is an effective means of building self-regulatory and academic skills and raising self-efficacy[19]. Bond, etal. argued that "learning to read and reading to learn should develop together throughout the school years"[22]. Writing allows one to 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. (in Weiner tand Kluwe) 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 [21],

[23]. Fogarty 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. Another useful strategy for 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 [2].

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-) expert status[13]. Ertmer and Newby stated that novice learners don't stop to evaluate their comprehension of thematerial. They generally don't examine the quality of their work or stop to make revisions as they go along, and they are satisfied with just scratching the surface. 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. In contrast, 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 as an example, we've all experienced the phenomenon of reading a page or a whole chapter in a textbook and then realizing we haven't comprehendedanything. 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 later from a teacher or peers [24]. Mitchell recommended seven strategies to improve students' metacognition skills in the classroom:

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 (providing 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 [5].

4. CONCLUSION

Metacognition can be considered as a subset of cognition, a certain kind of cognition.Stated briefly, cognitive strategies are used to help individuals achieve a particular goal, while metacognitive strategies are used to ensure that the goal has been reached or completed. In connection with the reading activity, for gaining deeper textual comprehension students must; 1) develop a plan before reading, 2) monitor their understanding of the text, and 3) evaluate their thinking after reading. Metacognitive strategies for solving a word problem in physics involve; 1) connecting new information to former knowledge; 2) selecting thinking strategies deliberately, and 3) planning, monitoring, and evaluating thinking processes. The teachers can raise the level of metacognitive thought in their classrooms by modeling the strategies. Metacognitive strategies have the potential to effect change in the teaching of the scientific process and scientific thought, with the result that students become better critical thinkers, strategic learners, and more scientifically literate.

ACKNOWLEDGEMENTS

I would like to thank my colleague, Drs. Luwandi, M.Pd, and Clinical Journal CAPA for his helpful and meaningful feedback and revision of the manuscript.

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BIOGRAPHY OF AUTHOR

Tomo Djudin was born on June 3, 1963 at Simpang Empat, a village in Sambas District of West Kalimantan. He was a lecturer of Physics Department of Education and Teacher Training Faculty of Tanjungpura University of Pontianak since 1990 until now.

He graduated his higher educations and received degrees as follows;

1. Sarjana (Drs) in Mathematics Education from Tanjungpura University of Pontianak (1984)
2. Master of Education (M.Pd) in Science Education graduated from Teacher and Education Institute (IKIP) of Bandung (1995)
3. Doctor (Dr) in Science Education graduated from Indonesia Education University (UPI) of Bandung (2003)

He published some Physics supplementary books, conducted science educational researches, and was a speaker on seminars of science education.