Metacognition and Problem Solving Strategies

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Metacognition

Metacognition is thinking about thinking. Although metacognition was recognized four centuries ago, it was emerged more in the studies of 20th century. Flavell (1976) describes metacognition as one's knowledge concerning one's own cognitive process and regulating one's own cognitive process with to help of this knowledge. According to Brown (1978), metacognition is an executive control, which can be seen as the control people have over their own cognitive process. Metacognition is generally defined as the activity of monitoring and controlling one's cognition (Young & Fry, 2008). It refers to higher-order mental process involved in using appropriate skills and strategies to solve a problem (Coutinho, 2007).

Metacognition is comprised of two components: knowledge about cognition (metacognitive knowledge) and regulation of cognition (metacognitive regulation) (Schraw & Dennison, 1994) (see Figure 1). There are three components of knowledge about cognition called: declarative knowledge, procedural knowledge, and conditional or strategic knowledge. Declarative knowledge was found to be what is known in a proportional skill or the assertions about the word and the knowledge of the influencing factors of human thinking (Deseote, Roeyers & Buysse, 2001). Procedural knowledge refers to knowledge about the execution of procedural skills (Schraw & Moshman, 1995). Conditional or strategic knowledge is considered to be which the awareness of the conditions that influence learning such as why strategies are appropriate (Deseote et al., 2001). Regulation of cognition, on the other hand, refers to activities that control one's thinking and learning such as planning, monitoring, comprehension, and evaluation (Schraw & Dennison, 1994). From Brown (1980)'s point of view, it can be seen as the voluntary control that people have over their own cognitive process. There are five components of regulation of cognition called: Planning, information management, monitoring, debugging, and evaluation. According to Schraw and Dennison (1994), planning refers to planning, goal setting, and allocating resources prior to learning; whereas, information management is skills and strategy sequences used on-line to process information more efficiently. Monitoring is assessment of cognitive processing plans (Efklides, 2009). Debugging is strategies used to correct comprehension and performance errors (Schraw & Dennison, 1994). Evaluation is self-judging of the answer and of the process of getting to this answer (Deseote et al., 2001). According to Kuhn

(2000), there would seem few more important accomplishments than people becoming aware of and reflective about their own thinking and able to monitor and manage the ways in which it is influenced by external sources, in both academic, work, and personal life settings. Metacognitive development is a construct that helps to frame this goal (Kuhn, 2000).

This study engages with the Brown (1978)'s framework of metacognition as the theoretical foundation since the Brown framework provides direct application to academic learning settings (Baker & Brown, 1984).

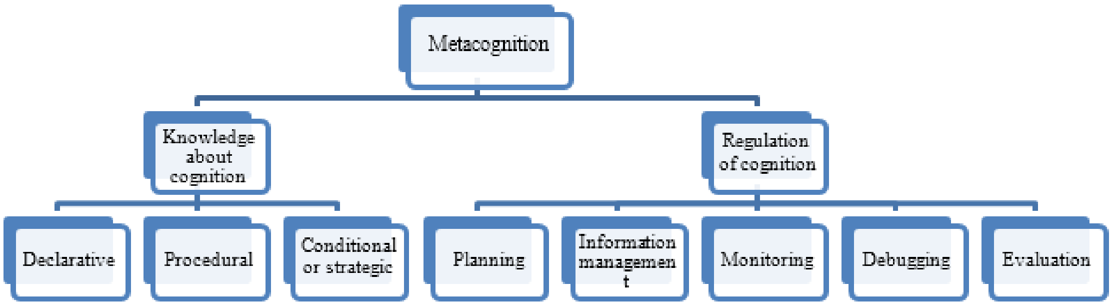

Figure 1. Components of Metacognition

Problem Solving

Problem solving is one of the most significant factors in the cognitive process. Problem-solving strategies play a central role in education because many tasks performed in professional and daily life require such strategies, which we define as planned sequences of activities leading to a goal, the solution of the problem (Taconis, Ferguson-Hessler & Broekkamp, 2001). Cause of problem solving involves the cognitive representation of prior experience and gives an overview of the students' plan of action in their cognitive process (Dhillon, 1998). The procedure in problem solving is to analyze the problem into the students' cognitive skills needed for solution (Mayer, 1998). According to Polya (1945), problem solving strategies consist of the following four major steps: description, planning, implementation, and checking (see Figure 2). Description is listing explicitly the given and desired information or drawing a diagram of solution. That is, it's a clear formulation of the problem. Planning is doing the basic relations and making outline for solving the problem. Implementation is executing the plan by doing calculations. Checking is controlling each of the steps as valid and if the final answer makes sense. In order to be successful in problem solving, students need to have ability to reflect upon, understand, and control their learning.

Gagne believed that "the central point of education is to teach people to think, to use their rational powers, to become better problem solvers" (1980, p. 85). Problem-solving plays a crucial role in the science curriculum and instruction in most countries, and is reported by many authors as a very difficult task for students (Mettes, Pilot, Roossink & Kramers-Pals, 1980).

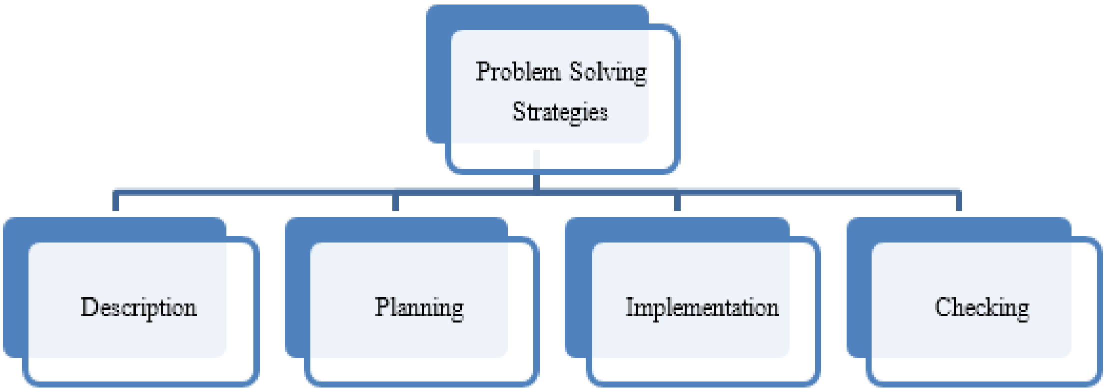

Figure 2. Components of Problem Solving Strategies

Metacognition and Problem Solving

Since metacognition refers to higher-order mental process involved in using appropriate skills and strategies to solve a problem (Coutinho, 2007), learners' metacognitive ability allows them solving of problems successfully (Eric & Mansoor, 2007). Several cognitive processes and metacognitive strategies are integral to problem representation and problem execution and underlie successful problem solving (Mayer, 1998).

Metacognitive training programs were found effective for problem-solving strategies regardless of learning aptitude or achievement (Delclos & Harrington, 1991). Swanson (1990) indicated that metacognitive skills helped children of lower aptitude compensate on problem-solving tasks. In addition, Sperling, Howard, Miller and Murphy (2002) showed significant correlations between children's metacognitive awareness and problem solving strategies.

Reviewing of the literature shows that research has examined a possible relationship between metacognition and problem solving strategies in diverse domains such as mathematics (Daniel, 2003; Desoete, Roeyers & Buysse, 2001; Eric & Mansoor, 2007; Montague, 1992; Rosenzweig, Krawec & Montague, 2011; Schonfeld, 1992), chemistry (Sandi-Urena, Cooper & Stevens, 2012; Rickey & Stacy, 2000; Tosun & Senocak, 2013), and history and physics (Meijer, Veenman & van Hout-Wolters, 2006). For example, Desoete, Roeyers and Buysee (2001) worked with 165 children in Grade 3 to determine the relationship between metacognition and mathematical problem solving. Relationship between metacognitive skills and mathematical problem solving was found in this study. Rosenzweig, Krawec and Montague (2011) studied metacognitive awareness in problem solving in mathematical education. In their study, participants were 73 eighth-grade middle school students in a large metropolitan school district in the southeastern United States. Results of this study suggested that when one did not discriminate between the types of metacognitive verbalizations, students across ability groups looked relatively equivalent in the quantity of verbalizations regardless of the problem difficulty. The aim of the research done by Tosun and Senocak (2013) was to reveal the effects of Problem Based Learning (PBL) on the metacognitive awareness of chemistry teacher candidates with different academic backgrounds. The sample of the study was 70 first-year undergraduate students at a state university. Findings showed that PBL was more effective in developing metacognitive awareness levels of students with weak science background knowledge compared to those with strong science backgrounds. However, research looking for a significant correlation between metacognition and problem solving strategies in physics is not ample. Moreover, research examining students' metacognitive behaviors during solving of physics problems are needed.

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