Does the Use of Metacognitive Strategies Influence Students’ Problem Solving Skills in Physics?

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I. Problem solving in Education

Problem solving is the most important learning outcome of educational endeavors (Gagne, 1980). All the sciences, both pure and applied, are centrally concerned with developing and systematizing knowledge that is useful for solving various kinds of problems. Problem solving as a goal-directed behavior requires an appropriate mental representation of the problem and the subsequent application of certain methods or strategies in order to move from an initial state to a desired goal state (Metallidou, 2009).

Problem solving is viewed as a fundamental part of science education in regular schools (Reif, Larkin & Brackett, 1976; Larkin & Reif, 1979; Chi, Feltovich & Glaser, 1981; Reif, 1981; Bascones, Novak & Novak, 1985; Amigues, 1988; Robertson, 1990; Savage & Williams, 1990; McDermott, 1991; Heller, Keith & Anderson, 1992; Henderson, Heller, Kuo & Yerushalmi, 2001; Kuo, 2004; Pol, 2005; Yerushalmi & Magen, 2006; Loucks, 2007). Academic problems in this context follow some well-defined criteria: all information needed to solve the problem is given; a limited set of rules are needed to solve the problem; in many cases, only one procedure leads to the right answer; and there is only one correct answer.

Many of the researchers examined general (Polya, 1945; Dewey, 1910; Kneeland, 1999) and specific problem solving strategies. In addition to these strategies, numerous problem-solving methods were developed to help students improve their understanding and problem solving skills in physics in particular. Some such strategies involve the didactic approach (Bagno & Eylon’s, 1997); the collaboration method (Harskamp & Ding, 2006); the computer-assisted instruction model (Bolton & Ross, 1997; Pol, 2005); the translating context-rich problem approach (Heller, Keith & Anderson, 1992; Heller & Hollabaugh, 1992; Yerushalmi & Magen, 2006); the creativeness approach in problem solving (Johnstone & Otis, 2006; Walsh, Robert & Bowe, 2007; Cooper, Cox, Nammouz & Case, 2008; Bennett, 2008) and the epistemic games (Tuminaro & Redish, 2007). Recent studies examine how metacognition helps problem-solving (Anderson & Nashon, 2005).

II. Metacognitive Strategies in Problem solving

The term metacognition refers to a students’ knowledge about his/her processes of cognition and the ability to control and monitor those processes as a function of the feedback received via outcomes of learning. Metacognitive activity can be specified in terms of its components namely planning, monitoring and evaluation (Van Hout-Wolters, Simons, & Volet, 2000). According to Flavell (1979) they are the main components at the highest hierarchical level of metacognitive activities before commencing a task, during execution of the task, and upon completion of the task, respectively.

Recent studies on enhancing domain specific problem-solving strongly recommend the use of metacognitive strategies. They argue that students may not know how to use the instruction effectively, thus they might benefit from metacognitive instruction on how to learn (Roll, Aleven, McLaren, Ryu, Baker & Koedinger, 2006). When new information and domain specific knowledge are held constant, reflective thinking processes that encourage elaboration on a problem are instrumental in providing the most efficient problem-solving. This is because high metacognitive skills can compensate for deficit in overall ability by providing knowledge about their own cognition.

III. Influence of Metacognitive Strategies on Problem Solving

Although the relation of metacognition with learning results is the subject of many educational studies (Sperling, Howard, Miller, & Murphy, 2002; Veenman, Elshout, & Meijer, 1997; Wang, Haertel, & Walberg, 1990), it is by no means clear which particular metacognitive activities are related to problem solving skills particularly to physics. Identifying these activities may render suggestions for metacognitive training. Present study explores the metacognitive strategies adopted by higher secondary school students and investigates how the strategy is related to their problem solving skills in physics, especially mechanics.
IV. Methodology

The study employs a survey to assess the extent of use of metacognitive strategies by higher secondary school students. It also examines how far the use of such strategies influences the problem solving skills of students.

Objectives of the Study
1. To find out the extent of specific metacognitive activities adopted by higher secondary school students
2. To find the relationship between metacognitive learning strategies and problem solving skills in physics among higher secondary school students

Sample
The sample consists of 104 higher secondary school students. There were 64 boys and 40 girls. Three schools were selected from Kozhikode district in Kerala state in India. All the three schools were government managed and were from urban area.

Tools
The study employs the following tools developed by the researchers.
1. Scale of Metacognitive Strategies
   This tool consists of 20 items to assess the various metacognitive practices related to planning (6 statements), monitoring (7 statements), and evaluation (7 statements). The statements were rated on a five point Likert-type scale.
2. Test on Problem solving In Mechanics
   This tool consists of 36 problems from mechanics taught at higher secondary level. The students have to choose the solution from four alternatives. This particular domain was selected because though related to everyday life enabling concrete thinking, mechanics is often perceived difficult and students seems reluctant to attempt to solve problems from mechanics.

V. Results

Analysis of metacognitive learning strategies
Analysis of responses on Scale of Metacognitive Strategies reveals that there is a fair practice of metacognitive strategies by the students. Most of the students (about 75%) have set an academic goal. Only half of them (about 50%) have planned a route to attain the goal.

About 50% of the students prepares a timetable for study purpose, identifies their strength and weaknesses, give more concentration towards important concepts while learning, adopt varying and appropriate methods for learning different subjects, voluntarily seeks the help of teachers and other friends. As far as the use of metacognitive strategies in problem solving is concerned, about 50% of the student’s attempts to solve problems themselves, check the feasibility of the attained solution.

Only very few (less than 25%) students believe that they can attain anything they aspire with hard work. Only very few evaluate whether they have completed the tasks as per the plan. Students rarely make memory tips while learning.

Relationship between metacognitive strategies and problem solving
There is a positive correlation between metacognitive strategies and problem solving (r=0.78).

![Variation of problem solving ability with metacognitive strategy](image)
The figure visually represents the variation of problem solving skill with the practice of metacognitive strategies. Though there is no perfect correlation, except for a few there is increase in problem solving skills with the use of metacognitive strategies.

VI. Conclusion

The study reveals that there is positive influence of the use of metacognitive strategies on problem solving skills. Though students practice regular academic planning, they rarely monitor their learning activities and seldom evaluate learning outcomes. One reason for students to be better in planning than the other components, the investigators assume, is that goal setting, planning, motivating are subject matter of programmes conducted by guidance and counseling cell in every school. There is further need to motivate students more rigorously monitor and continuously self evaluate their learning while solving problems. This will require subject teachers to help in planning, to provide continuous feedback based on the monitoring of problem solving process and to adopt classroom strategies that enhance peer and teacher evaluation of student progress in the initial phase of training for problem solving. Teachers have to take care that they progressively withdraw this facilitation process as students increasingly become fluent on metacognitive strategies.

References

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