ANALYSING THE ROLE OF METACOGNITIVE SKILLS INVOLVED IN THE PROCESS OF PROBLEM SOLVING IN PHYSICS AMONG HIGHER SECONDARY STUDENTS

Research Paper

ABSTRACT

This paper provides an overview of research into metacognitive skills that are involved in physics problem solving and how these skills affect the performance of problem solvers. Based on an analysis of 12th standard public examination problems (Tamil Nadu state board exam) with 150 students , this paper presents how students learn to solve problems in the higher secondary level.

INTRODUCTION

One of the vital goals of education is to enable people to utilize their knowledge in problem solving. Bascones et al (1985) believed that worthwhile learning enables people to adopt situations , to identify and deal with problems as they arise. Cumulative learning ultimately results in the establishment of capablilities that allow individuals to solve a wide variety of novel problems (Elby 2001). In physics education according to Veeman, M.V.J.et all (2005), "learning physics is equated with developing problem solving abilities and achievement is measured by the number of problems which a student has correctly solved on the test".

METACOGNITION IN PHYSICS EDUCATION AND PROBLEM SOLVING

Students learning physics at the school level have difficulty with the mathematical problem solving that is an integral part of physics classes.

The research trend in studies of physics problem solving seems to have focused on cognition and subsequently metacognition (Park.J. & Lee.L.2004. Mestre (2001) argued that metacognitive skills should be taught to students to help them solve physics problems.

The role of metacognition in problem solving has been demonstrated by many researchers (Ref.6,7,9) . But almost all of the efforts have been on mathematical problem solving among mathematics students at the college level. There has been little development of approaches for physics problem solving on how metacognitive skills can be affected by instructional activities (Ref.5,8). These studies also focus on college students.

The present study is an attempt to investigate the role of metacognitive skills in assisting higher secondary students in schools to solve physics problems individually.

METACOGNITION

Metacognition refers to thinking about cognition (memory, perception calculation , association , etc) itself or thinking about one's own thinking. 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 so well. It's about self-reflection, self-responsibility and initiative, as well as goal setting and time management.

Metacognitive skills include taking conscious control of learning, planning and selecting strategies, monitoring the process of learning, correcting errors, analyzing the effectiveness of learning strategies and changing learning behaviours and strategies when necessary.

Metacognition refers to learners' automatic awareness of their own knowledge and their ability to understand, control and manipulate their own cognitive processes.

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METACOGNITIVE SKILLS

METAMEMORY

This refers to the learners' awareness of knowledge about their own memory systems and using their memories effectively.

PLANNING

It involves metacognition that is related to starting a problem and organization of knowledge.

SELF-MONITORING

It involves metacognition that is related to checking the progress of a solution to a problem. Its focus is on the ability of a student themselves to monitor their solving process and to maintain the attitude necessary to solve a problem.

SELF-EVALUATION

It involves metacognition that is related to checking the reasonableness of a solution to a problem.

PROBLEM SOLVING ASSESSMENT

STRATEGIES

How is problem solving performance measured? In most introductory physics courses, students' problem solutions on exams are given a score based on the correctness of numerical solution (Heller et al 1984). Research into problem solving has used different means to measure problem solving performance. One method used by Stillman et al (1988) involves measuring the time it takes a problem solver to write down each quantitative expression in their solution and recording the total time to reach a solution. Some researchers have investigated problem solving using think-aloud protocols or interviews in which students engage in conversation to explain their thinking processes as they attempt a physics problem. A difficulty with these methods is that it is time consuming since data analysis is complicated. In order to compare problem solving performance for XII standard students, five general criteria are selected.

(i) Understanding the problem

(ii) Organization of information

(iii) Developing and executing the problem

(iv) Monitoring the process

(v) Verifying final results

The investigator adopted the above skills for the present study.

SAMPLE

Since problem solving is an essential aim of education, at the final stage of secondary education (i.e. XII standard) it is assumed that the students have gained some adequate skills in problem solving. By random sampling technique 150 XII standard students studying physics in Govt.Hr.Sec.School, Kalakad, Tirunelveli District, Tamil Nadu were selected as sample for the study.

TOOL

The tool consisted of a questionnaire comprising of 10 physics problems. The problems are taken from XII standard public examination question papers of March-2006, September-2006 and March-2007 of TamilNadu State Government Examinations. The metacognitive skills used in the solution process of each student are quanitatively analysed and interpreted by the investigator.

STATISTICAL TOOLS USED

1. Mean
2. Standard Deviation

   and
3. 't' test

Table 1

VARIOUS STAGES OF IMPLEMENTATION

Phases	Activity	Duration
Phase I	Motivating students in learning physics concepts	One day
Phase II	Teaching physics concepts – Lecture method	2 months
Phase – III	Students allowed to study and memorize the concepts	2 months
Phase –IV	Pre-test	1 hour
Phase –V	Teaching physics concepts – Using power point presentation- To activate knowledge orientation	1 month
Phase –VI	Explaining how to organize , access and use their existing knowledge in the problem solving process	1 week
Phase –VII	Giving home-work, Group discussion, Doing laboratory experiments.	2 weeks
Phase –VIII	Group problem solving	1 week
Phase –IX	Post-test-1	1 hour
Phase – X	Identifying the individual difficulities among the metacognitive skills.	1 week
Phase – XI	Giving more practice in the weak area	1 week
Phase – XII	Post-test-2	1 hour

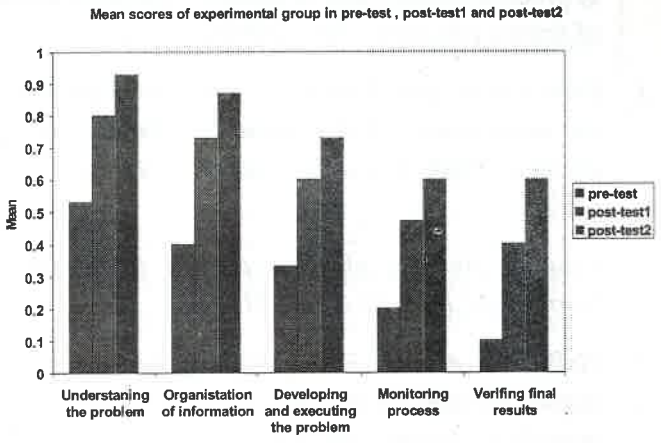
Table 2

't' TEST SHOWING THE DIFFERENCE BETWEEN THE MEAN SCORES OF PRE-TEST AND POST-TEST.

Metacognitive skills	Test	N	MEAN	S.D.	't' value	Remark
Understanding the problem	Pre-test	150	0.53	0.73	--	Significant
	Post-test1	150	0.8	0.89	2.83	
	Post-test2	150	0.93	0.97	4.05	
Organization of information	Pre-test	150	0.4	0.63	--	Significant
	Post-test1	150	0.73	0.86	3.83	
	Post-test2	150	0.87	0.93	5.08	
Developing and executing the problem	Pre-test	150	0.33	0.58	--	Significant
	Post-test1	150	0.6	0.8	3.4	
	Post-test2	150	0.73	0.86	4.74	
Monitoring process	Pre-test	150	0.2	0.4	--	Significant
	Post-test1	150	0.47	0.68	4	
	Post-test2	150	0.6	0.77	5.48	
Verifying final results	Pre-test	150	0.1	0.4	--	Significant
	Post-test1	150	0.4	0.6	4.5	
	Post-test2	150	0.6	0.8	6.7	

The mean scores in all the metacognitive skills in post-test1 and post-test2 are significantly greater than the mean scores in the pre-test. From the data it is observed that "t" value in post-test1 and post-test2 are highly significant. This shows the positive effect of the experimental inputs.

RESULTS AND DISCUSSION



It is observed from the figure that there is continuous and steady increase in the mean scores of the experimental group in pre-test, post-test1 and post-test2 in all the metacognive skills. This shows that changing the learning environments, conducting group discussions and laboratory activities enhance the problem solving skills in physics.

The following study further strengthens our results. In Bascones et al's(1985) study states " Interactive learning instruction promoted cognitive development more than the verbatim memorization of definition states used in traditional instruction". Robertson's (1990) study states "If a student has done a wide range of exercises on physics he/she can generate a solution for a familiar question without necessary understanding :", The skill in problem solving depends on the effective implementation of metacognitive variables. Inorder to improve problem solving skills, the approach is to look at the metacognitive variables and processes involved in skilled problem solving performance and then to give instructions to assist the students.

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Owned & Published by Rev. Dr. S. Sebastian,S.J. from St. Xavier's College of Education, Palayamkottai, Tirunelveli -2. Printed by G. Kanagasabapathi at Muthuletchumi Press, 123-G, Trivandrum Road, Palayamkottai - 627 002.
Editor : **Rev. Dr. S. Sebastian, S.J.**

Research Paper

Statement Regarding Ownership and other Particulars of the Journal.

1. Title of the Journal	:	Research and Reflections on Education
2. Registration Number	:	TNENG/2003/10220
3. Language and Periodicity	:	English and Quarterly
4. Publisher's Name and Address	:	Rev. Dr. S. Sebastian S.J. Indian St. Xavier's College of Education Palayamkottai Tirunelveli - 627 002.
5. Printer's Name and Address	:	G. Kanagasabapathi Indian, Muthuletchumi Press 123-G, Trivandrum Road Palayamkottai - 627 002.
6. Editor's Name and Address	:	Rev. Dr. S. Sebastian S.J. Indian St. Xavier's College of Education Palayamkottai Tirunelveli - 627 002.

I, S. Sebastian, hereby declare that the particulars given above are true to the best of my knowledge and belief.

S. Sebastian