Metacognitive Abilities in Physics Problem Solving

Emma Jiménez Cisneros
Colegio de Bachilleres México
subdlabs@cbachilleres.edu.mx

Pilar Segarra Alberú
Facultad de Ciencias, UNAM
mpsa@hp.fciencias.unam.mx

Abstract

In a two year study with 240 fifteen years students, it was shown that they increased their performance in mechanics problem solving when metacognitive abilities were developed during five month training. This one was 'blended' with the normal course time in about: 25% metacognitive abilities and 75% normal activities. In comparison with normal courses, the students that developed metacognitive abilities tried to solve mechanic problems in about three times more than the formers, and in about the same rate they were successful. In addition the students that get trained, increased their homework delivery and developed alternative methods for problem solving.

Introduction

Although problem solving is a very important line in physics education, there is not yet a complete answer to the continuous failure of our students. Since the 70', education researchers [1] point out that a main ingredient for proper problem solving consists in solver reflection of how he/she employs his/her cognitive resources. This includes not only physics concepts, but abilities to identify relevant information, to make schemas, to make plan solutions, to be able to follow the plan and to change it when it is necessary, among others. Metacogniton precisely focus in the way the students handle their cognitive resources to achieve specific tasks like mechanics problem solving [2, 3].

1 Metacognitive abilities

Metacognition, metacognitive knowledge and metacognitive abilities are often employed in the same way. Metacognition refers to cognition about the proper cognitive resources, the possibility to supervise and control them, and the willingness to employ them in a specific task [4]. Metacognitive knowledge is just like others knowledge, it can be declarative or procedimental, increased, stored, activated.... and in the metacognitive way it refers to the learner cognition, the tasks he has to solve and the available strategies to confront them. Yet these two notions occur in learners' mind, for this research it was chosen the metacognitive abilities notion [5]. This one is linked to a particular action. When someone displays certain ability something specific is done, so it can be studied by an observer. Since each ability is grounded in knowledge; metacognitive abilities are grounded in metacognition, specifically in the situated one [6].

2 What students do + what students say

Metacognition emphasizes the planning, supervision and control of the proper cognitive resources, for this reason it is not enough to study what students do when they solve problems. It is necessary an approach to what is occurring in their minds [7], so it is important to analyze what they say about the way they solve problems, as an evidence of what they are thinking [8]. To gather information for this research two instruments were designed to collect problems solved by students (portfolios) and to know what they say about the way they solved them. So it was possible to link what students do + what students say.

3 What is the effect of metacognitive abilities development?

To **identify the effect of metacognitive abilities development in problem solving** (research problem), it was designed a metacognitive abilities training program embedded with problem solving of a normal mechanics course. Then, it was selected a sample of 80 fifteen years students conformed by an experimental group of 40 students and a control group of 40 students. The metacognitive abilities that were developed consist in: making solution plans, supervising and controlling the plan execution and evaluating solving procedures and results.

During five months normal course the training program was worked out with the experimental group. To analyze the results of its operation it was considered the two kinds of instruments described above and it was compared with the achievement of both experimental and control group.

This procedure was repeated tree times with equivalent samples in a research cycle way. During each one, the instruments were refined and the identified effects were confirmed.

4 Problem solving improvement

It was found that the students in the experimental group attempted to solve the mechanics problems of the monthly test in about three times more than the control group students do. And that they were successful, in about the same rate the students. Besides in the experimental

groups the total scholar works delivery increased from 15% to 45%. Finally, the experimental group students got problem solving through alternative methods (not reviewed in classes) and center their achievements in themselves. Meanwhile the control group students repeated only the solving method proposed by the teacher and center their achievements in him.

5 Gradual development

During the third cycle, a four student's team of the experimental group was tape recorded to identify their display of cognitive and metacognitive abilities when they solved mechanics problems. During this cycle the solving of three problems was recorded: at the beginning, in the middle and at the end. The record was analyzed with the written solution of the student's team. Figures 1, 2 and 3 show how the students improved their procedure. In this figures: 1 = organizing, 2 = understanding, 3 = planning, 4 = solving, 5= supervising, 6 = finding results, 7 = procedure revising, 8 = results revising.

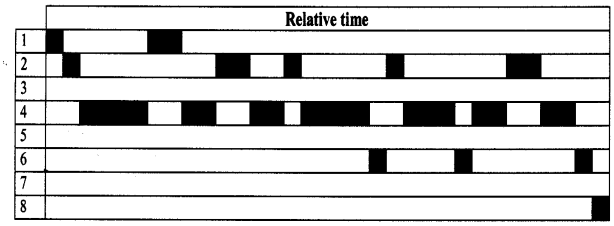

Figure 1. At course beginning

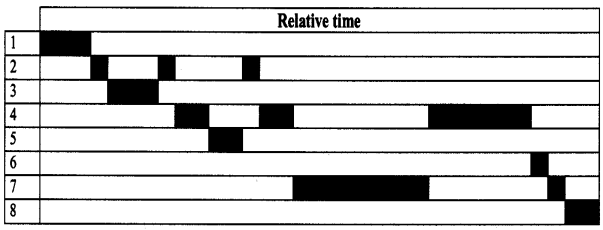

Figure 2. At the middle of the course

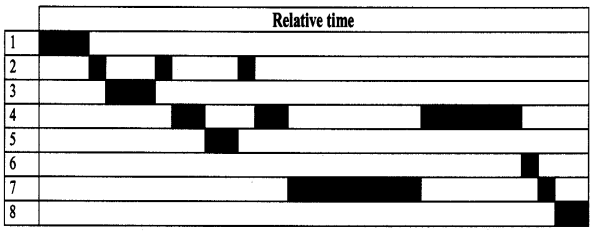

Figure 3. At course ending

Conclusions

To invest time for metacognitive abilities development in problem solving during a normal physics course increased the students' success in this activity. This research showed that it is due to the development of problem solving cognitive abilities like identifying relevant information, making connections with physics concepts and making drawings or schemas, among others. It also increases the students' success expectations since they try to solve more problems and they feel responsible with the activity.

References

[1] FLAVELL, J. Metacognitive aspects of problem solving in *The Nature of Intelligence*, 1976. I.B. Resnick (Ed.), New Jersey: Erlbaum.

[2]. NICKERSON, R., PERKINS, D., and SMITH, D. *Enseñar a pensar. Aspectos de la aptitud intelectual*, 1987. España: Ediciones Paidos.

[3] WOODS, D. *Problem solving in practice*, 1989. United States of America: National Science Teachers Association.

[4] SHOENFELD, A. Learning to think mathematically: Problem solving, Metacognition and sense making in Mathematics in *Handbook of research on Mathematics Teaching and Learning,* 1992. D. Grows (Ed.). Toronto: Macmillan Publishing Company.

[5]. JIMENEZ, E. *Desarrollo de habilidades metacognitvas en la solución de problemas de mecánica,* 2004. Ph. D. Dissertation, Universidad Pedagógica Nacional: Unpublished.

[6] GEORGHIADES, P. Making pupils' conceptions of electricity more durable by means of situates metacognition. *International Journal of Science Education* 2004, 26 (1), 85–99.

[7] KUO, V., HELLER, K., HELLER, P. HENDERSON, C. and YERUSHALAMI, E. (2004). *Instructors´ View on what Students should Think About when Solving Physics Problems.* AAPT Winter 2004 Conference. Florida. Downloaded: 2004 February 28 from: http://groups.physics.umn.edu/physed/

[8] NELSON, T. Consciousness and Metacognition. *American Physiologist*, 1996, 15(2), 102-106.