Metacognitive Instruction with Cooperative Learning

Why Is This Strategy Useful?

Authentic tasks in mathematics are those which portray common contexts and for which there are no ready-made algorithms. Additionally, low-achieving students struggle with seeing abstract problems as whole problems. In authentic mathematic tasks, the focus is on the relationship between the problem-solver and the problem. Metacognitive instruction with cooperative learning focuses on the use of authentic tasks to provide the context for students learning mathematics. The strategy may be effective with middle school students and improves outcomes for all students, but particularly low-achieving mathematics students.

Description of Strategy

A major common element of metacognitive instruction is training students who work in small groups to reason mathematically by formulating and answering a series of self-addressed metacognitive questions. These questions focus on:

(a) *comprehending* the problem (e.g.,"What is the problem all about"?);
(b) *constructing connections* between previous and new knowledge (e.g., "What are the similarities/differences between the problem at hand and the problems you have solved in the past? and why?");
(c) *using strategies* appropriate for solving the problem (e.g., "What are the strategies/tactics/principles appropriate for solving the problem and why?")
(d) *reflecting* on the processes and the solution (e.g., "What did I do wrong here?"; "Does the solution make sense?", "What difficulties/feelings do I face in solving the task?"; "How can I verify the solution?"; "Can I use another approach for solving the task?").

Each teaching period included three parts:

(a) teacher's introduction to the whole class (about 10 minutes);
(b) practicing activities in small heterogeneous groups of approximately four students (about 30 minutes); and
(c) teachers' review of the main ideas of the lesson with the whole class (about 5 minutes).

In the small groups, each student, in his/her turn, reads the task aloud and tries to solve it and explain his or her mathematical reasoning. Whenever there is no consensus, the group discusses the issue until the disagreement is resolved. Students are encouraged to talk about the task, explain it to each other, and approach it from different perspectives. Students use the metacognitive questions during their discourse in small group activities and in their written explanations when they solve the mathematical tasks. When all students agree upon the solution, they write it down in their notebooks.

Research Evidence

At least one quasi-experimental design study supports the use of this strategy. Ninety-one seventh-grade students from two schools participated in a control and treatment group. The control group was involved in cooperative education and the treatment group participated in classrooms that combined metacognitive instruction with cooperative education. Findings indicate that students in the treatment group significantly out-performed those students in the control group. Low-achieving students in the treatment group showed the greatest gains in comparison to those students in the control group.

Sample Studies Supporting this Strategy

Kramarski, B. Mevarech, Z. and Arami, M. (2002). The effects of metacognitive instruction on solving mathematical authentic tasks. *Educational Studies in Mathematics (49* 2, 225-250.

The present study investigates the differential effects of cooperative-learning with or without metacognitive instruction on lower and higher achievers' solutions of mathematical authentic tasks. Participants were 91 seventh graders who studied in three classrooms. Data were analyzed by using qualitative and quantitative methods. Results indicated that students who were exposed to the metacognitive instruction within cooperative learning (COOP+META) significantly outperformed their counterparts who were exposed to cooperative learning with no metacognitive instruction (COOP). The positive effects of COOP+META were observed on both authentic and standard tasks. In addition, the findings show the positive effects of COOP+META method on lower and higher achievers. The practical implications of the study are discussed.

Additional Resources

Forman, S.L. & Steen, L.A. (2000), *Making Authentic Mathematics Work for all Students*, ERIC ED. 440848.

Hembree, R. (1992), Experiments and relational studies in problem solving: A meta-analysis, *Journal for Research in Mathematics Education 23*(3), 242–273.

King, A. (1991), Effects of training in strategic questioning on children's problem-solving performance, *Journal of Educational Psychology 83*, 307–317.

Lester, F.K., Garofalo, J. & Kroll, D.L. (1989), *The Role of Metacognition in Mathematical Problem Solving: A Study of Two Grade Seven Classes*, (Final Report), Indiana University, Mathematics Education Development Center, Bloomington.

Mathematics instruction for secondary school students with learning disabilities. Available at: http://www.frostconcepts.com/pedagogy/MathInstructionLearningDisabilities.pdf