Meta-Cognition and Reflection in Math Problem Solving

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Until this year, Kathy Spruiell was a math specialist and instructional math coach in 75 classrooms at Simonton Elementary School in Gwinnett County, Georgia. Simonton Elementary's diversity is reflected in its 1,500 students representing 40 nationalities and speaking 20 languages.

In reflecting on her experience as an instructional math coach, Kathy writes:

> Mathematical problem solving is an area of struggle for many students with whom I work. It is also an instructional area of struggle for many of the teachers with whom I work. This is true in the first-grade math model classroom where I both teach students and coach the teacher. The students utilize a variety of different intuitive approaches to solving math problems. These vary from applying computational strategies to a fear-induced paralysis producing a blank response. I find that many of the teachers I work with have high expectations of student problem solving but not a great deal of instructional experience in the teaching of problem solving.

Her experience as a math coach led her to wonder if using a meta-cognitive approach and peer reflection with students would lead to improved student performance. A review of several articles and books led her to the following research question: "How can both a meta-cognitive and a collaborative peer-reflection approach to mathematical problem solving increase student achievement?"

> I believe I can increase the student achievement and teacher efficacy in mathematical problem solving in the first-grade math model classroom by teaching the students and coaching the teacher to try a meta-cognitive approach at the beginning of each problem-solving lesson. As part of this approach the students and teacher will consciously focus on the thinking involved in setting up and carrying out the problem. Additionally, I believe it will be helpful to teach the students and teacher to use peer reflection throughout the problem-solving process. In my opinion the increased use of meta-cognition and peer reflection will increase the competence and confidence of both the students and classroom teacher in mathematical problem solving, resulting in increased student achievement.

Kathy was able to pursue this question as part of a collaborative action research project in her Masters degree program. She chose the first-grade classroom where she had been model teaching.

As indicators of performance before using meta-cognitive thinking and peer reflection, she used samples of Exemplars student problem-solving work from the portfolios saved in the first grade math model classroom.

> In the math model classrooms I coach, we primarily utilize questions from the Exemplars (2007) problem-solving program. I will obtain an average benchmark score for the work in the students' portfolios based on an assessment rubric we use at my school to assess student achievement on Exemplar(s).

Another Exemplars problem was assessed at the end of the study to provide post-study data.

The period of study was one month, April 2007. Students completed three Exemplars problems using meta-cognitive problem-solving strategies and peer reflection in April. Students worked in pairs. The meta-cognitive strategies students used included visualization of the problem, Think, Pair, Share and verbally explaining strategies to a partner. Peer Reflection strategies included assessing a partner's problem-solving work, targeting and reflecting on trouble areas in the partner's problem-solving work, and editing and correcting a partner's problem-solving work.

The data show that using these strategies when doing Exemplars problems appear to improve student performance.

Performance on Exemplars Problems

	Pre-Study Average	Post-Study Assessment
Novice	4	1
Apprentice	3	4
Practitioner	8	5
Expert	2	7
Total	**17**	**17**

Before using meta-cognitive strategies and peer reflection four students were at the Novice level. Afterward, only one student remained at the Novice level; the other three had moved to the Apprentice level. Similarly, of the three students who were Apprentices, two moved to the Practitioner level, while one remained at the Apprentice level. Eight students had been performing at the Practitioner level (that is, meeting the standard). Of these, five became Experts, exceeding the standard. The two students who had been Experts, remained Experts.

Kathy comments,

> Reflecting on the data collected I see the relevance and importance of teaching meta-cognitive strategies to use in math problem solving. I was actually surprised at the gains the students were able to make in a relatively short amount of time.