Increasing Student Mathematical Problem-Solving Achievement Through the Use of Exemplars

Ben Hartman
Educational Leadership Program
Georgia State University

Ben Hartman is a fifth-grade teacher at Cedar Hill Elementary School in Gwinnett County, Georgia. Cedar Hill's 1,251 students represent a diverse population. For example, students at Cedar Hill speak nearly 30 different languages. The student population has undergone significant change in the last decade. In 1997, the school was 82% white. In 2005, 15% of the students were white, 28% were African American, 30% were Hispanic, 5% were indicated as multiracial and 13% were Asian. In 1997, the Free and Reduced Meal rate was only 14% of the students in the school. The rate for 2005 was 60%.

Ben, along with some of his colleagues, was concerned about students' ability to solve mathematics problems. "At Cedar Hill Elementary School, one area of mathematics that has historically challenged students is problem solving." This weakness was reflected in the test scores on the Georgia Criterion-Referenced Competency Tests (CRTC), and local school data has consistently shown weaknesses in the area of mathematical problem solving.

The school recognized the problem, but had not taken specific action to address it. "Despite spending the last three years discussing this drop in math achievement as a school-wide focus, we do not have any immediate solutions."

Ben believed that students' low achievement in math,

> stems from two primary causes. First, teachers struggle to make mathematics relevant to the current student population. Many teachers' pedagogical approach leaves gaps in support structures needed for students to move from concrete mathematical thinking to abstract mathematical concepts.
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> Second, real-life mathematics does not happen in seclusion. ...We use mathematical problem solving knowledge in subtle ways numerous times each day. However, much of current math instruction is based largely on computation skills and operational minutia, which has little impact on real-world lifestyles for most people. Students need mathematics instruction that is applicable to their experiences and views.

Cedar Hill had subscribed to Exemplars and Ben felt that the regular use of Exemplars would improve students' performance in mathematics.

> Exemplars is a way of providing students with real-life situational problem-solving opportunities. The multifaceted mathematics Exemplars offers students opportunities to learn and apply problem-solving skills, communicate mathematically and develop self-assessment of mathematical abilities. It is through such opportunities that teachers can aid students in greater mathematic achievement on standardized tests and beyond.

To find out if regular problem solving using Exemplars would improve student performance, he developed a research project as part of his Educational Leadership Program at Georgia State University.

His research question was: "Will students in selected classes at Cedar Hill Elementary show an increase in math achievement in the Problem Solving Strand of the CRCT by using Exemplars on a weekly basis?"

The 18 students in his fifth-grade class comprised the study group. Between October and the end of March students completed an Exemplars task approximately each week. The tasks were used for both assessment and instruction. As he reports:

> Exemplars tasks are not designed to be used in isolation. Students need appropriate instructional support to be successful with Exemplars as with many other mathematical learning methods. Thus, a balance of typical math instructional strategies was used. Common strategies used include the use of manipulatives, reading aloud the Exemplars task, and individual teacher support as needed. A mix of direct instruction with the whole group and small groups was used to help students understand Exemplars use. Cooperative pairs and individual work was used as well. The goal was to use the Exemplars in the most instructionally appropriate way at all times to maximize student learning and mathematical problem-solving abilities.

Change in student achievement was measured in two ways. First, was there an improvement in student performance on the CRCT between 2005 and 2006? Scores were available for 16 of the students for both years. Second, did achievement levels on Exemplars problem solving tasks improve over the study period? To measure achievement, students completed three Exemplars problems before the study began and three problems after the study was completed. Scores were averaged for both sets of results and compared.

Georgia Assessment Results

Students were assessed using the CRCT in 2005 before using Exemplars and in 2006 after using Exemplars. There were data for 16 students.

Of the 16 students:

- 3 Did Not Meet the Standard in 2005. Of those, 2 Met the Standard in 2006 and 1 Exceeded the Standard.

- 12 Met the Standard in 2005. Of these, 8 continued to Meet the Standard in 2006 and 4 now Exceeded the Standard.

- 1 Exceeded the Standard in 2005 and continued to exceed the standard in 2006.

Performance on Georgia CRCT 2005-2006

Level	Before Using Exemplars CRCT 2005	After Using Exemplars CRCT 2006
Did Not Meet the Standard	3	0
Met the Standard	12	10
Exceeded the Standard	1	6
Total	**16**	**16**

Ben concluded, "all students made progress in mathematical achievement and seven of the students made significant progress. 100% of the students in the research group met or exceeded state expectations on the mathematics section of the Spring 2006 CRCT."

Exemplars Results

Improvements on the CRCT are mirrored by improved student performance on Exemplars tasks. Nine students, fully one-half of the class, averaged Novice on the three Exemplars problems used on the pre-test in October. Another eight were at the Apprentice level. This means that 17 of 18 students were not meeting the Exemplars standard of performance. Only one student met the standard by performing at the Practitioner level. There were no Experts; that is, students exceeding the standard.

On the post-test, one student performed at the Novice level and five were at the Apprentice level. Twelve students, two-thirds of the class, met or exceeded the standard; that is, were either Practitioners or Experts.

Individually, of the nine students who had been at the Novice level, one remained a Novice, four had progressed to Apprentice, and four now met the standard—they were at the Practitioner level. Of the eight students who had been Apprentices, one remained an Apprentice, six had become Practitioners and one had become an Expert.

Change in Performance on Exemplars Problems

Level	Before Using Exemplars	After Using Exemplars
Novice	9	1
Apprentice	8	5
Practitioner	1	10
Expert	0	2
Total	**18**	**18**

Conclusion

Ben concluded,

> The CRCT data details growth among all students in overall mathematics scale scores. Coupled with the Exemplars data, I believe the use of Exemplars did contribute to students' mathematical problem solving abilities.
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> I recommend continued use of Exemplars in the classroom as part of the regular mathematics curriculum. While a teacher could just distribute Exemplars to students, I suggest some informal training or collegial discussion with other teachers who have used them successfully in their classrooms. Peer support through discussion and familiarity with scoring procedures can be beneficial for teachers and students alike.