

The Use of Graphic Organizers to Improve Student and Teachers Problem-Solving Skills and Abilities

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Abstract

This paper reports on the use of graphic organizers to improve student mathematical problem solving. Graphic organizers are visual and graphic displays that spatially depict the relationships between facts, terms, concepts and ideas within a learning task. Graphic organizers have widespread, and successful use in the areas language arts and special education in communication skills and comprehensions abilities (Hall & Strangman, 2008; DiCecco & Gleason, 2002; Goeden, 2002; Griffon, Malone, & Kameenui, 2001; National Reading Panel, 2000; Ritchie & Gimenez, 1996; Robinson, 1998). In this manuscript, I coalesce the findings of three separate, but related studies using a graphic organizer, *four-corners-and-a-diamond*, specifically designed to aid students in mathematical problem solving. Results found elementary teachers' comfort and self-confidence levels increased dramatically. Results also found third, fourth and fifth-grade students results on open-ended measurement problems increased. Lastly, results found significant improvement on open-ended geometric and algebraic problems with sixth, seventh and eighth-grade students.

Introduction

Think of how you would begin to put together a commercial bathroom vanity cabinet kit. Would you first read the instruction manual? Or would you check the inventory first to see if all parts were included? Would you begin by studying the picture of the completed cabinet? Would you just ask for help from someone more knowledgeable? Would you not even try? Your response to the problem situation above is analogous to student reactions to problem solving. Your previous experiences greatly influence your persistence and approach to a problem. Similarly, we have to accept and utilize student tendencies to increase their problem-solving skills and abilities.

As problem solving is a major, *if not the major*, goal of learning mathematics, how do we assist students develop their skills and abilities (National Council of Teachers of Mathematics, 1989; 1995; 2000)? One approach is to teach Polya's four-step problem-solving heuristics, namely first understand the problem; devise a plan; carry out the plan; and look back (Polya, 1944). However students, and teachers, many times misinterpret the four-steps to be a linear step-by-step procedure, not a process. So teachers and students try to make problems into sequential procedures, which does not work with most problems. And students quit working on problems if they get stuck on a step. This manuscript describes a specific approach to mathematical problem solving derived from research on reading and writing pedagogy, specifically, research indicating that students use graphic organizers to organize their ideas and improve their comprehension and communication skills (DiCecco & Gleason, 2002; Goeden, 2002; Griffon, Malone, & Kameenui, 2001; National Reading Panel, 2000; Robinson, 1998).

Graphic Organizers

Graphic organizers are visual and graphic displays that spatially depict the relationships between facts, terms, concepts and ideas within a learning task (Ellis, 2004). Graphic organizers have widespread, and successful use in the areas of language arts and special education in communication skills and comprehensions abilities (Hall & Strangman, 2008;

DiCecco & Gleason, 2002; Goeden, 2002; Griffon, Malone, & Kameenui, 2001; National Reading Panel, 2000; Ritchie & Gimenez, 1996; Robinson, 1998). Graphic organizers allow (and even expect) the student to:

- sort information as essential or non-essential;
- structure information and concepts;
- identify relationships between concepts;
- organize communication about an issue or problem; and
- allow students to utilize their previous tendencies and experiences as a starting point of the problem-solving process (Zollman, 2011; 2009a; 2009b).

Figure 1 depicts the *four-corners-and-a-diamond* mathematics graphic organizer. This graphic organizer is modeled after a *four squares* writing graphic organizer described by Gould and Gould (1999). This *four-corners-and-a-diamond* mathematics graphic organizer (Zollman, 2011; 2009a; 2009b) has five areas: What do you need to find? What do you already know? Brainstorm possible strategies to solve this problem. Try your ways here.

What things do you need to include in your response and what mathematics did you learn by working this problem?

Figure 1

Four-Corners-and-a-Diamond Mathematics Graphics Organizer

<p><u>Second Paragraph</u> Write what you know from the problem</p> <p>“What I know from the problem is ...”</p>	<p><u>Third Paragraph</u> Show the strategies you will try.</p> <p>“So what I first try to do is...”</p>
<p><u>First Paragraph of Extended Response</u> Write what you are to find.</p> <p>“First, what I want to find is ...”</p>	
<p><u>Fourth Paragraph</u> Show your solution.</p>	<p><u>Fifth Paragraph</u> Explain your method and answer.</p> <p>“Therefore, to solve this problem I...”</p>

The *four-corners-and-a-diamond* graphic organizer encourages students to begin working on a problem before they have identified a solution method. The extended-response written answer is not begun until there exists information in all five areas. As in the four square writing method, students then organize and edit their thoughts by writing their solution in the traditional linear response, using connecting phrases and adding details and relationships. For the extended-response write up (as used in large-scale assessments) students usually first state the problem, identify the given information, next they propose methods for solving the problem, then show their mathematical work procedures, and finally present their final answer, conclusions and learning. (Zollman, 2011; 2009a; 2009b).

Methodology

These one-year research studies were initiated to improve student mathematical problem solving. There were 240 elementary and 186 middle school students in the studies. The elementary students utilized graphic organizers on the topic of measurement (area and perimeter); the middle school students utilized graphic organizers on the topics of algebra and geometry. None of the students, or their teachers, had previous experience using graphic organizers in mathematical problem solving.

Results

Using the graphic organizer had a substantial impact on the elementary teachers practices. Initially 50% of the elementary teachers reported being uncomfortable teaching problem solving. Afterwards, 100% of the teachers reported being comfortable (80% being very comfortable) teaching problem solving with their students. All the teachers subsequently reported changing their instruction to include much more writing in mathematical problem solving.

On achievement in area and perimeter problem-solving items, the 3rd grade students rose from 55% to 78%. The 4th grade students increased from 40% to 52%. And the 6th grade students improved from 40% to 62% from pretest to posttest scores.

Likewise, the middle school students also significantly improved their achievement scores from pretest to posttest on algebra and geometry problem-solving items. On a four-point scoring rubric, the students went from a pretest score of 0.83 to a posttest score of 2.93 on mathematical knowledge (Z-score -19.8849, $p < 0.001$; effect size 1.94). On strategic knowledge, the student scores rose from 1.52 to 2.79 (Z-score -11.66049, $p < 0.001$; effect size 1.16). Similarly, their explanation scores grew from 0.83 to 2.67 (Z-score -15.3907, $p < 0.001$; effect size 1.51).

Teachers studying their own students reported the use of graphic organizers in mathematical problem solving to be efficient and effective for students at all achievement levels. Teachers saw students who normally would not attempt open-response problems now had partial written solutions. Students who normally did well on problems now had an efficient method of writing and communicating their thinking in logical, complete arguments.

Conclusions

These research studies found that the proper use of the mathematics graphic organizer *four-corners-and-a-diamond* to be an extremely useful instructional method in the middle school mathematics classroom. Students should improve their problem solving abilities with any instructional intervention. The teachers specifically attributed the increase in student performance in mathematical problem solving to the student use graphic organizers. Lastly, the teachers also changed their instructional pedagogy during the study. This may be due to teachers viewing the *four-corners-and-a-diamond* graphic organizer a comfortable method to include writing-across-the-curriculum into their mathematics lessons, and subsequently including more extended-response problem solving into their lessons.

Teaching about problem solving in a hierarchy of procedural steps is neither efficient nor effective. This study concurs with other problem-solving research – teaching *via* a problem solving process is the crucial instructional development (Lester, Masingila, Mau, Lambdin, dos Santon, & Raymond, 1994).

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