

Promoting Mathematical Problem Solving and Explanation at Home

Abstract

Generating explanations, particularly for another person, is associated with greater learning (Teasley, 1995; Rittle-Johnson et al., 2008). Additionally, Van Voorhis (2011) found that family involvement in homework increased student motivation and achievement. Using weekly homework assignments, we investigated the effectiveness of second graders solving word problems and explaining their thinking to a family partner, compared to independently solving and explaining. Requested family involvement improved accuracy and explanation quality on homework, but had no effect on independent performance on an in-class posttest. Results from an exploratory follow-up on a classroom that continued to use the family homework assignments for another semester showed that extended use of the homework greatly improved explanation quality but did not improve word-problem accuracy.

Keywords: mathematics education, instructional practices, parent involvement

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Objectives

In psychology and education, the benefits of encouraging students to generate explanations as part of learning activities has gained broad endorsement (e.g., Rittle-Johnson, Saylor, & Swygart, 2008; Wong, Lawson, & Keeves, 2002; Renkl et al., 2008; Boaler, 2002). The goal of the current study was to increase opportunities for children to make sense of problems and explain their mathematical thinking. We used weekly homework assignments to investigate the effectiveness of second graders solving challenging word problems and explaining their solutions to a family partner, compared to independently explaining in writing. A secondary goal of this study was to help teachers and children meet Common Core State Standards (CCSS) in mathematics.

Theoretical Framework

Prompting students to generate explanations as a means to make sense of new information (e.g., “self-explanation”; Chi, 2000) has been recognized by both teachers and researchers as a worth-while learning tool. The U.S. Department of Education (2003) published a brochure with suggestions for ways parents can help their children with homework, including encouraging children to explain how they solved a math problem as a way to check for understanding. This is in line with a push from the Common Core standards to increase opportunities for children to explain their mathematical thinking. Research in psychology has shown that providing explanations for another person seems to be particularly important for learning (Teasley, 1995). In fact, Rittle-Johnson et al. (2008) found that children who explained correct solutions to their moms had greater problem-solving transfer compared to those who explained to themselves.

While homework is a less studied context, it may provide a good opportunity for children to generate explanations, supplementing classroom efforts. The majority of research investigating homework is concerned with the benefits of family involvement (e.g., Epstein & VanVoorhis, 2001; Balli, Demo, & Wedman, 1998). In a 2-year homework intervention study (Teachers Involving Parents in Schoolwork; TIPS), Van Voorhis (2011) found that family involvement in homework increased student motivation and achievement. Additionally, those who participated in the TIPS program reported more positive feelings and attitudes about math homework. Thus, by combining the benefits of explanation and family involvement through homework, student learning could be improved.

Homework that is an introduction of material not yet covered in class and/or a review of past material has been found to be more effective than homework that is on same-day-content (Cooper, 2001). Therefore, we specifically choose more difficult, challenging word problems to maximize homework’s utility. Word problems provide a setting that could encourage more explanation. As outlined in the Common Core Content Standards for second grade, children are expected to represent and solve problems involving addition and subtraction, so we used addition and subtraction word problems.

Current study. In an attempt to harness the benefits of both family involvement and explanation, we investigated the effectiveness of second graders solving word problems and explaining their thinking to a family partner, compared to independently solving and explaining in writing. Specifically, we were interested in the effects of requested family

involvement on children's word-problem performance, their use of correct number sentences to represent the problem, and ability to provide valid explanations.

Method

Participants were 60 2nd graders from four classrooms at a local metropolitan elementary school. This excludes 3 students who did not complete at least half of the homework assignments and 7 students in the family involvement condition whose parents did not initial at least half of the homework assignments.

Procedure. To assess students' prior knowledge of word problems, all children completed a pretest in their classrooms. The homework intervention occurred over a span of 8 weeks. Children completed two homework assignments a week for a total of 16 homeworks. Two teachers volunteered to participate in the *parent explain condition* (n=26) and two volunteered to participate in the *independent explain condition* (n=34).

For the homework, children solved a variety of challenging word problems and either independently explained their solution in writing (*independent explain condition*), or solved a word problem and explained their solution to a family partner before writing (*parent explain condition*). Children were instructed to spend no more than 10 minutes on each homework, and teachers reviewed the problems in class the following week. Parents in the *parent explain condition* were instructed to listen and encourage, prompt children to show their work and explain their thinking, help children write their explanation after they explain verbally, and communicate issues and/or comments to the teacher. Parents in the *independent explain condition* were instructed to let their child work on the homework on their own and to not provide solutions but to remind their child that they would go over the problems in class.

After the last week of homework assignments, all children completed an in-class posttest to measure learning.

Upon study completion, one teacher from the *parent-explain condition* continued using the homework approach the following semester on her own. This classroom (n=13), as well as a comparison classroom (n=16), agreed to administer a brief follow-up test at the end of the school year. Thus, we were able to explore the effects of prolonged homework use on children's explanations and word-problem performance.

Data Sources

Assessment. The assessment was adapted from the Second-Grade Vanderbilt Story Problems (VSP; Fuchs & Seethaler, 2008) to assess children's word-problem-solving skills. VSP consists of 18 word problems of varying problem types and difficulty. As identified by the Common Core content standards, problem types include total, difference, change, two-step, and multiplication. The VSP also includes transfer problems that present a graph or chart and require the student to ignore irrelevant information unnecessary to solve the problem. We added one additional change problem and two multiplication problems to the assessment. At pretest, we only administered a subset of 12 items. These same 12 items plus 3 transfer items were administered at posttest.

On the assessment, children were instructed to show their work and write a number sentence for each problem. In order to explore explanation quality, at posttest, children were prompted to explain on two problems. The end of year follow-up test included the two posttest explain problems, one two-step problem, and one transfer item. Explanations

were scored according to whether or not the student provided a valid explanation (e.g., explained a correct procedure for the problem).

Homework. Homework problems were selected from the Level 1 Singapore Math Word Problems workbook (Frank Schaffer Publications, 2009). While all problem types from the assessment were included, the majority of the problems selected represented the more difficult problems types to assure the homework was challenging. Additionally, prompts to explain were added to each homework sheet. See Figure 1 for an example homework sheet and student work.

Results

Homework Assignments. Requested parent involvement improved accuracy on the homework assignments. Controlling for pretest accuracy, children in the *parent explain condition* solved more of the homework problems correctly, compared to children in the *independent explain condition*, $F(1,57) = 9.66, p < 0.01, \eta^2 = 0.15$. Children in the *parent explain condition* also provided more valid explanations, compared to children in the *independent explain condition*, $F(1,57) = 8.52, p < 0.01, \eta^2 = 0.13$. Further, homework accuracy ($r = 0.30, p = 0.03$) and explanation scores ($r = 0.24, p = 0.08$) were predictive of performance on the posttest. Table 1 presents mean accuracy scores by condition for the homework, as well as pretest and posttest performance.

Pretest and Posttest. There were no differences in overall pretest word-problem accuracy by condition. No reliable differences were found for solution accuracy on the in-class posttest ($F(1,57) = 0.02, p = 0.90, \eta^2 = 0.00$), or in writing correct number sentences ($F(1,57) = 0.24, p = 0.63, \eta^2 = 0.00$). Most children also struggled to provide a valid explanation when prompted on two posttest problems, again with no reliable difference between conditions ($F(1,57) = 0.01, p = 0.94, \eta^2 = 0.00$). However, students who explained to family partners were more likely to at least attempt to provide an explanation on the posttest (44% of children in *independent explain* did not attempt to explain vs. 24% in *parent explain*), which is a step in the right direction.

Follow-up Test. Recall that one teacher continued to have her students complete homework assignments with a parent the following semester. There were no differences in overall pretest word-problem accuracy between the groups. Compared to standard classroom practice, extended use of homework improved children's use of valid explanations, $F(1, 26) = 4.32, p = 0.05, \eta^2 = 0.14$. Extended homework use also supported children's use of correct number sentences, $F(1, 26) = 8.66, p = 0.01, \eta^2 = 0.25$. However, extended homework use did not seem to have much impact on word-problem accuracy, $F(1, 26) = 0.21, p = 0.65, \eta^2 = 0.01$. Table 2 presents pretest, posttest, and follow-up test means for the follow-up subsample.

Significance

We found that requested family involvement improved accuracy and explanation quality on homework, which was predictive of performance on an in-class posttest. However, requested family involvement did not reliably lead to better posttest performance, although it did increase attempts to provide an explanation. Given the difficulty second graders have in writing explanations, this is a step in the right direction. In line with past research, family involvement seemed to impact student motivation to explain (VanVoorhis, 2011). In a subsample, extended use of the weekly homework assignments

improved children's use of valid explanations and correct number sentences, compared to standard classroom practice. Still, word problem accuracy was not impacted by extended word-problem homework use with family involvement.

While homework and family involvement had no effect on word-problem-solving accuracy, teachers were still encouraged and enthusiastic about its utility as a learning tool. All teachers agreed that the weekly homework assignments were a good idea. Indeed, one teacher felt the weekly homework assignments with family involvement were so useful that she continued to implement them on her own and plans to use them again next year. This extended use of word problem homework with family involvement did seem to support improved explanations. Teachers considered the in-class review of the problems to be a particularly helpful learning activity, and many students discussed multiple strategies and explanations for the problems. However, due to the large variability across classrooms pertaining to how this review was handled, we are limited in our ability to draw conclusions from the data.

Teachers were encouraged by the impact of homework on student's abilities to provide explanations and represent word problems using number sentences, especially during classroom discussions. The homework assignments provided a desirable situation for children to persevere in solving problems and explain their mathematical thinking, helping teachers and students meet Common Core standards and practice skills for constructed-response tests that require students to explain their answer or show their work. Future studies should further explore the role of explanation in weekly homework by specifically contrasting homework with and without prompts to explain. Overall, explaining homework to a family member shows some potential for improving aspects of student learning and is deserving of consideration by teachers as a learning tool used to supplement classroom efforts.

References

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Figure 1. Student work from a homework assignment.

There are 14 apples in a basket. Mr. Goldberg puts some more apples into the basket. Now there are 19 apples. How many more apples did Mr. Goldberg put in the basket?

a

Write a number sentence for this problem:

$$\boxed{19} - \boxed{14} = \boxed{5}$$

Mr. Goldberg put $\boxed{5}$ more apples in the basket.

Explain how you figured out this answer:

Because $14 + 5 = 19$

HOME-TO-SCHOOL COMMUNICATION

Dear Family Partner,

Please give me your reactions to your child's work on this activity by checking one of the following:

- 1. O.K. My child seems to understand this problem.
- 2. PLEASE CHECK. My child needed some help on this, but seems to understand it.
- 3. PLEASE HELP. My child still needs instruction on this kind of problem.
- 4. PLEASE NOTE (other comments). _____

Any other comments:

First, he gave an incorrect solution. But then figured it out. Had difficulty to explain how he got the solution.

Parent Initials: MS

Date: 10/22

Table 1. Homework, pretest, and posttest means by condition.

	Parent Explain	Independent Explain
Homework		
Accuracy	.88* (.03)	.74 (.03)
Explanation score	.58* (.04)	.41 (.04)
Pretest		
Accuracy	.56 (.05)	.52 (.05)
Posttest		
Accuracy	.57 (.04)	.56 (.04)
Number sentence score	.40 (.05)	.37 (.04)
Explanation score	.38 (.08)	.37 (.07)

Note. * $p < .05$; With the exception of pretest accuracy, all means are estimated marginal means controlling for pretest accuracy. Standard errors are reported in parentheses.

Table 2. Pretest, posttest, and follow-up test means for the follow-up subsample.

	Extended Family Homework Use	Standard Classroom Practice
Pretest		
Accuracy	0.66 (.05)	0.60 (.07)
Posttest		
Accuracy	0.74 (.04)	0.72 (.04)
Number sentence score	0.42 (.05)	0.46 (.05)
Explanation score	0.45 (.11)	0.51 (.11)
Follow-up test		
Accuracy	0.66 (.06)	0.62 (.06)
Number sentence score	0.52* (.08)	0.20 (.08)
Explanation score	0.92* (.08)	0.69 (.08)

Note. * $p < .05$; With the exception of pretest accuracy, all means are estimated marginal means controlling for pretest accuracy. Standard errors are reported in parentheses.