Solving Mathematical Word Problems in Primary Grades
Oral Presentation

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Abstract

Finding ways to help primary grade students overcome difficulties in solving mathematical word problems can be a challenging task for teachers. The focus of this article is to use a graphic organizer and the Mathematician's Chair strategy to enhance student mathematical proficiency in solving mathematical word problems in a regular classroom setting.

Introduction

Finding ways to help primary grade students overcome difficulties in solving mathematical word problems can be a challenging task for teachers. These challenges may include: 1) students having difficulty with vocabulary; 2) students lacking confidence when solving problems; 3) students confused on the proper operation to use when solving a problem; and 4) students lacking the knowledge of various problem-solving strategies.

According to NCTM (2000), the ways in which mathematical ideas are represented is fundamental to how students can understand and use those ideas. "When students gain access to mathematical representations, and the ideas they represent; they have a set of tools that significantly expands their capacity to think mathematically" (NCTM, 2000, p. 67). Many researchers agree that students benefit from active learning, cooperative learning, multiple representations, and sharing and reflecting with peers (Web & Palincsar, 1996; Monk, 2003; Smith, 2003). Along with the strategies listed above, our focus for solving word problems is based on and extended from research by Hildebrand, Ludeman, and Mullin's "Integrating Mathematics with Problem Solving Using the Mathematician's Chairs" (1999) to enhance student proficiency in solving word problems in regular classroom teaching. The process of our problem solving includes four sequential steps: Classroom instruction, student group discussion, student presentation, and student evaluation. In this inquiry learning process, a teacher's role is a facilitator; students take the role of problem solvers, professors, and evaluators. In this article, we'll share how classroom teachers at Gompers Elementary School in Long Beach used the Mathematician's Chair activities to engage students in the active learning of problem solving. Particularly, we will illustrate the detailed process of Mathematician's Chair using examples from our observations and video analysis of a second grade teacher, Mrs. King's instruction to demonstrate how the Mathematician's Chair activity is processed in the real classroom setting.

Classroom instruction

In order to integrate the Mathematician's Chair in problem solving, the teachers first provide a whole classroom instruction of how to deal with the problem. The teachers model the entire process using the graphic organizer (Barell, 1995), guiding students how to: 1) construct the problem; 2) circle the important numbers; 3) identify the key or clue words; 4) use pictures or representations; 5) choose a mathematical operation or number sentence to solve the

problems. Using this systematic format, students cooperatively create and solve word problems with their table groups (See Figure 1, Graphic organizer).

After the students learned how to use graphic organizer for their developing word problem, the teacher provided students with opportunities to apply their own strategies through the use of the Mathematician's Chair, an activity in which students work with their groups to construct a word problem in a real life situation and then proceed to solve the problem. They take turns to share their own word problem with peers, who then attempted to solve it. During the problem sharing phase, students are addressed as "professors" by their teacher. Each week, the teacher provided a topic of problem solving task related to student mathematics learning, which enriched and reinforced their understanding of their current mathematics learning.

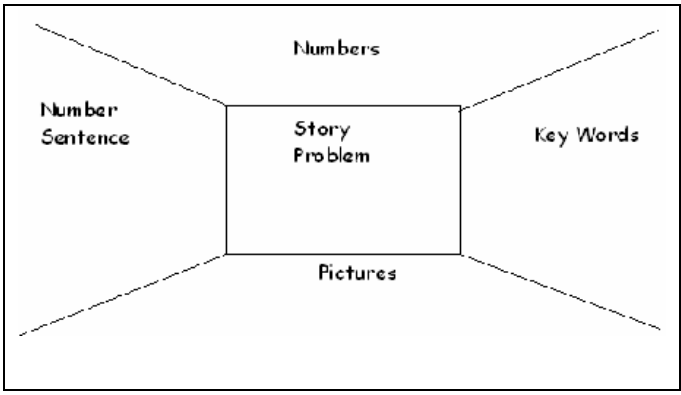

Figure 1. Graphic organizer

Figure 2. Mrs. King works with Plains group

For example, after the week of learning multiplication in spring 2006, Mrs. King engaged her second grade students in the Mathematics Chair activity focused on multiplication. Before the task, Mrs. King discussed the possible applications of multiplication with her students. She gave examples on how multiplication can be applied in real life such as in the time and measurement situations. She then asked her students to discuss with their groups to find out other ways of applying multiplication in real life situations. The students found the examples of multiplication relating to their classroom, sports games, circus shows, and others. Mrs. King then asked students to represent multiplication.

Mrs. King: In what ways can multiplication be represented?
Student 1: It can be represented by an array.
Student 2: Array is a good way to represent multiplication.
Student 3: We can use the inverse of division to represent multiplication.

Mrs. King understood that it was a challenge to 2nd graders to use the inverse of division to show multiplication, so she asked a probing question to promote student understanding of the meaning of the inverse of division.

Mrs. King: How do you use the relationship between multiplication and division?
Student 4: We can use the division to check if we did multiplication right or not.

With above discussion, Mrs. King was sure of her students' readiness of using multiplication in problem solving. She provided 25 minutes for her students work with their groups to construct and solve their own multiplication word problems.

Student group discussion

Following the classroom instruction, the students worked with their groups to construct and solve their own problems**.** All teachers use creative ways to group students. For example, Mrs. King used flags and geographic figures to name the groups of her second grade students: Northwest Coastal, Southwest Coastal, River, Grassland, and Plains Groups. Each group had its own flag representing the meaning of the group's name.

During the group discussion and the word problem group activity, students physically put their heads together and got up from their seats to collaborate and share ideas on writing the word problem. Afterwards, the students were given the graphic organizer to transcribe and solve their problem systematically in different ways, and to use it for sharing with and engaging in the entire class. The students were assigned roles at each table to share the duties. Those duties were: 1) finding and writing down the numbers used in the problem; 2) finding and writing down the clue words; 3) drawing pictures or representations; and 4) writing the equations or number sentences used to solve the problem.

The following example demonstrates how Mrs. King facilitated her students in their group discussion on constructing word problem for multiplication and shows how she engaged her students in playing their roles in the Mathematician Chair activity (See Figure 2).

In the Plains Group, students were interested in the break times during the school day.

Mrs. King: How many break times do you have in each school day?
Students: Three.
Mrs. King: Can you use the number of break times to construct a multiplication word problem? Remember you need to use multiplication.
Students: … (Students seemed to be puzzled as to how to do it)
Mrs. King: How long is your break? (Mrs. King tried to direct students to think).
Student 1: 15 minutes from 10:30 am to 10:45 am.
Mrs. King: How many breaks do you have during the school day? You can start from here (Mrs. King provided students with an opportunity to think).

Mrs. King walked to the Southwest Coastal Group and participated in their discussion:

Student 1: We are thinking to use the flag in each group in our problem.
Mrs. King: Very good idea. How will you do it?
Students: … (Students seemed to be bewildered).
Mrs. King: How many flags in our classroom? (Mrs. King started to promote the students to think).
Student 2: Five.
Mrs. King: How do you connect it with the multiplication?
Students: … (Students were still baffled).
Mrs. King: If a flag pole is 2 feet long, how many feet is a total length if five flag poles are put altogether?

With Mrs. King's enlightening questions, the students in the Southwest Coastal got an idea and started to develop their problem.

Mrs. King joined the Northwest Coastal Group's discussion:

Mrs. King: How is your discussion?

Students: We do not know how to start it.
Mrs. King: What is happening? You can look at your surround area: there are pictures, flower pots, and others. Do these items have a relationship to multiplication? You can count these items first.
Student 1: There are 21 flower pots in our classroom.
Mrs. King: Look at how many groups in our classroom? Think if there is any multiplication relationship in it? (provided a hint to the students).
Student 2: If using 21 to divide 5 groups, it has a reminder.
Mrs. King: Do not forget that the teacher should have one flower pot.

Mrs. King said it humorously and enlighteningly. The students in the Northwest Coastal got an idea and started to construct their problem.

Mrs. King walked to the River Group and asked a question:
Mrs. King: Do you have a good idea for your problem?
Student 1: Daniel said that his family's dogs can be used in our problem.
Mrs. King: Daniel, would you please tell us your idea on how to use your dogs?
Daniel: I want to use my family's dog mom and baby dogs as an example.
Student 2: I am not sure if I understand Daniel's idea.
Mrs. King: Daniel, please discuss your idea with your group.
Daniel: Ok, I'll do it.

The River Group started their discussion on Daniel's idea.

Mrs. King walked to the Grassland Group:
Mrs. King: What is your example?
Student 1: We would like to use a baby as an example.
Mrs. King: How?
Student 2: We are thinking: There are 5 babies in the nursery's room in a hospital (the student seemed to be confused and could not clearly express his idea). We would like to use the half of 5, but it is an odd number; we could not divide it into two equal whole numbers.
Mrs. King: The important part is that can a baby be divided into two parts?
Student 2: No
Mrs. King: So you may need to change this number.
Student 3: How about 16?
Mrs. King: How do you relate 16 with multiplication?
Students: … (The Grass Land students seemed to be puzzled).
Mrs. King: Usually a hospital has more than 16 babies (Mrs. King provided help to students).
Students 4: Ok, but… (This student seemed to get idea).
Mrs. King: Think about how many nursery rooms the hospital has? Discuss it (Mrs. King provide further hints to promote the student thinking).

Mrs. King walked to the Plains Group again. The students had a draft of the problem already. Student 1 read the problem: Our first break starts at 10:30 am; second stats from 11:55 am. How long is it from the first break time to the second break time?
Mrs. King: Are you doing multiplication?

Student 2: … (Student 2 is thinking).
Mrs. King: This is a very good subtraction problem, but it is not about the multiplication.
Mrs. King participated in the students' discussion.
Mrs. King: You need to think about the problem again. You had a very good subtraction problem, but did not use multiplication concept in the problem.
Student 3: You want us to start it over?
Mrs. King: I don't think so. Let's make some changes in the draft of the problem.
Students: … (Students were confused)
Mrs. King: How many breaks do you have during a school day? (Mrs. King provided a hint).
Students: Three.
Mrs. King: So how many minutes of your break time in a total?
Student 1: The total is 45 minutes of break time in a school day.
Obviously, Mrs. King's inspiring questions sparked the students' thinking in this group.

With Mrs. King's probing questions and support, all groups developed their clear ideas of constructing their problems. Mrs. King went around the classroom and stopped at different groups to answer students' questions, to use the question strategy to direct students to think about relationships and multiplication concepts, and to find their misconceptions while they were constructing the problems.

As Mrs. King was walking from one group to another, she made sure all groups completed their tasks of constructing and solving the world problems, and then she went to each group again to check their work.

Mrs. King first came to the Grassland Group and asked, "Did you finish it? Please read it to me." Students in the Grassland Group read their problem simultaneously: "There were 16 babies in each nursery room. If there were 10 nursery rooms, how many babies are in all?" Mrs. King looked at the Grassland's graphic organizer that showed five parts of student work with their word problem in the center (See Figure 3, Grassland group's work).

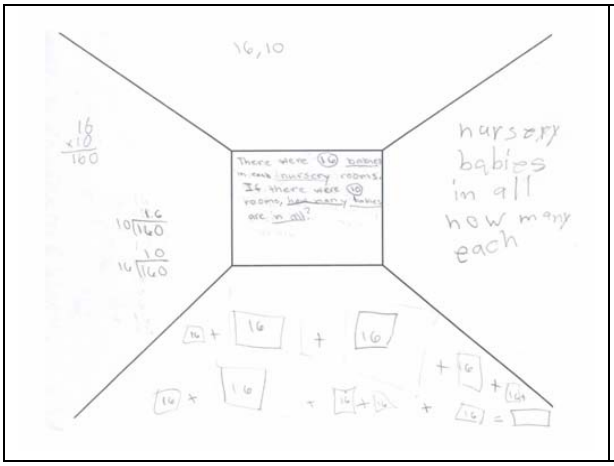

Figure 3. Grassland group's work

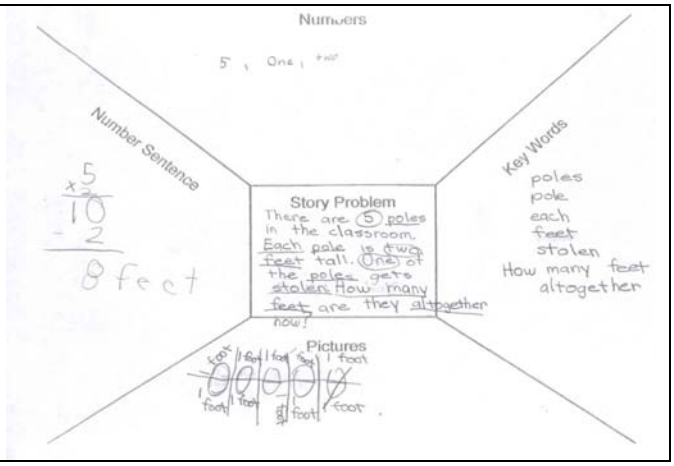

Figure 4. River group's work

Mrs. King returned to the River Group again to check their work. Mrs. King praised their problem for the meaningful mathematics application because it involved not only multiplication but also addition. The River Group's problem (See Figure 4, River group's work): Emily has 8 dogs. 7 of them are puppies. One of them is the mother. Each puppy weighs 8 pounds. The mother weighs 10 pounds. How do they weigh in all?

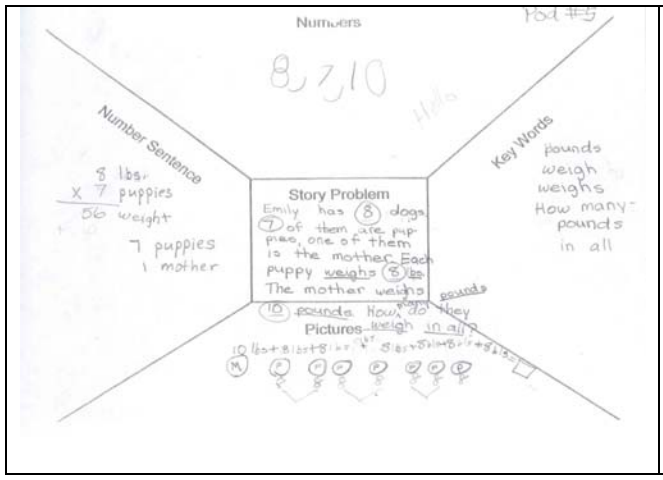

Figure 5. Southwest Coastal group's work

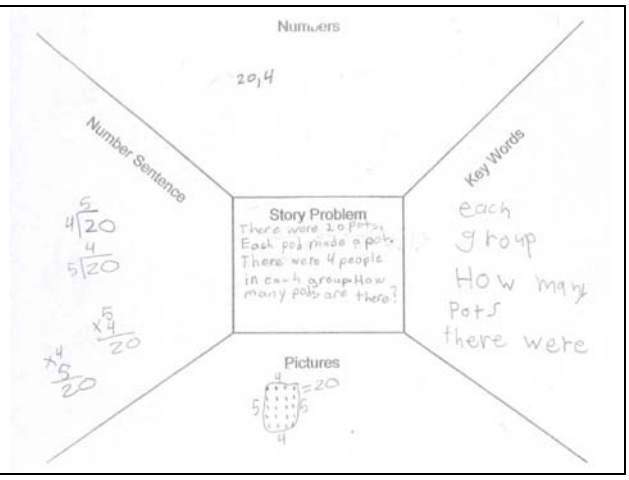

Figure 6. Northwest Coastal group's work

Mrs. King walked to the Southwest Coastal Group. This group not only constructed a word problem, but also added an interesting story (See Figure 5): There are 5 poles in the classroom. Each pole is 2 feet tall. One of poles gets stolen. How many feet are they altogether now?

Mrs. King came back to the Northwest Coastal Group again to check the progress on their developing problem. The group used an example with flower pots (See Figure 6): There were 20 pots. Each group made a pot. There were 4 people in each group. How many pots are there?

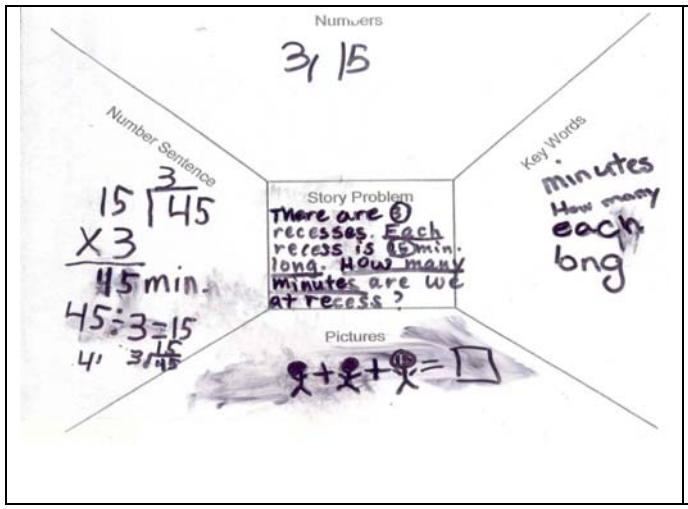

Figure 7. Plains group's work

Name _____

Mathematician's Chair Rubric

4	○ I can read it. ○ I can understand it. ○ It has more than one step to solve it. ○ I can solve it.
3	○ I can read it. ○ I can understand it. ○ It has one step to solve it. ○ I can solve it.
2	○ I can read it. ○ I can not understand it. ○ I can not solve it.
1	○ I can not read it. ○ I can not understand it. ○ I can not solve it.

Figure 8. Score rubric

Finally Mrs. King visited the Plains Group and found that students correctly completed the problem related to the break times There are three break times in our school during a school day. Each break time is 15 minutes. How many minutes of the break time do we have (See Figure 7)?

Student presentation

After each table group cooperatively wrote and solved their own problem (25 minutes), each table group was invited to take turns to come to the front of the room to share their problem and engage the whole class to solve it. They used the overhead projector where the "Number Professor" circled the important numbers in the word problem and wrote on the designated area of the graphic organizer transparency. Then the "Key Word Professor" underlined the key words in the word problem and then re-wrote the words in the designated area of the graphic organizer. The "Picture Professor" drew the representation or pictures to represent the numbers in the problem. The "Number Sentence Professor" chose the operation, wrote the number sentence and solved the problem.

Mrs. King respected and encouraged her students by addressing them as "Professors" during their presentations. For example, when the Plains Group came up to the front to present their problem, Mrs. King addressed them as Professor Jones, Professor David, Professor Robert, and Professor Susan. The Plains Group was the first group to share their problem solving:

First, the group copied their problem on a transparency, and used the overhead projector to show it to the whole class. They read their problem aloud to the whole class, and then they asked the whole class to solve it in their own groups. Just as the group presenting, each student in their individual groups had a different role: Identify important number, find key words, draw a picture or a representation, and solve the problem. The students from the Plains group, acting as mathematics professors in the classroom, frequently walked around the classroom to provide support to each group and to answer questions. Mrs. King observed the students' actions and behaviors, controlled the time and pace of this activity, and provided help if it was needed.

After the entire class had time to solve the problem being presented, the "Professors" of the Plains Group then proceeded to demonstrate their method on how to solve it correctly. Professor Robert told the important numbers of 3 and 15 to the class and wrote these numbers down in the "important numbers" section in the graphic organizer. Professor David wrote "minutes, how many, each, and long" in the "key words section" in the graphic organizer. When he attempted to put "break time" as a key word, Mrs. King asked him, "Professor David, do you think the 'break time' can be a key word in this problem?" She then asked the whole class to provide feedback to Professor David. Everyone had their own views. Finally, the whole class agreed that "break time" should not be considered as a key word because it only is an event and it does not represent the meaning of a mathematical idea in this problem.

Professor Joan drew a little person figure to represent time: each figure represented 15 minutes; she used 3 person figures to show the total break time. Professor Susan summarize their group's problem solving by multiplication. She used a vertical form to show their solution.

To test their grasp of the understanding of the concept, Mrs. King asked a challenge question to the Plains Group, "How did you know your answer is correct?" All mathematics Professors in the Plains Group confidently answered, "We used division to verify the answer." Professor Jack showed their checking expression in division (See Figure 7).

This activity was done through out the week. One table group each day had an opportunity to present their problem to the entire class. Great mathematical discussions were generated while different table groups discussed with the "Professors" that their solutions to find the answer were different from the "Professors."

Student evaluation

Finally, the entire class scored the group's the word problem using the Mathematician's Chair Scoring Rubric with four levels, each level consisting of four parts: 1) readable, 2) understandable, 3) number of steps of problem solving and 4) solvable (See Figure 8, Score rubric). Each group provided their scores with justifications. The Plains Group got a score of three out of four because most groups believed that their problem was too simple and it consisted of only one step.

Conclusion

As a result of using the Mathematician's Chair, we found that it was important to give additional support, time, and strategies to alleviate the frustrations that are commonly encountered when solving mathematical word problems. With the use of the Mathematician's Chair, students became much more confident, not only in writing and problem solving, but also in representing their mathematical word problems with their understanding and sharing their ideas of solving with their peers, which promoted a higher order of thinking and developed a connection between mathematics ideas and real life situations, and a connection between mathematics concepts and language development. Importantly, it met diverse student learning needs by providing them with multiple methods to construct and solve a problem. By using the Mathematician's Chair in their instruction, the teachers became more confident in their instructional methodology. They experienced more enthusiasm and fun in teaching the concept of word problems and believe that the student learning outcomes implementing the Mathematician's Chair was worth the time and effort.

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