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ABSTRACT

This study examined the effects of a schema-based direct instruction strategy on the addition and subtraction word problem solving performance of three third- and fourth-grade students with learning disabilities. An adapted multiple probe across subjects design was used. The intervention involved training students to distinguish "change," "group," and "compare" problems and to label problem components using schemata diagrams for these problem types. Results indicated that the intervention was successful in increasing the percentage of correct word problems for all three students. In addition, maintenance and generalization of word problem solving was seen 2 to 3 weeks following the study. Student interviews also indicated that the strategy was beneficial. Contains seven references, three figures, and two tables. (DB)

# Schema-Based Instruction on Word Problem Solving Performance of Students with Learning Disabilities

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## Abstract

This study examined the effects of a schema-based direct instruction strategy on the word problem solving performance of three third and fourth grade students (2 girls, 1 boy) with learning disabilities. An adapted multiple probe across students design was used. Results indicated that the intervention was successful in increasing the percentage of correct word problems for all three students. In addition, maintenance and generalization of word problem solving was seen two to three weeks following the study. Student interviews indicated that the strategy was beneficial. Further research with different students and problem types (e.g., multistep) and an investigation of the long-term effects of the strategy and its use in novel settings appear warranted.

# Schema-Based Instruction on Word Problem Solving Performance of Students with Learning Disabilities

At least one-fourth of students with learning disabilities are identified for special education services because of significant discrepancies in mathematics performance (Brian, Bay, Lopez-Reyna, & Donahue, 1991). Although these students may exhibit problems in quantitative concepts and relations and basic facts, many also have difficulty solving word problems (Mercer & Miller, 1992). However, a major emphasis (80%) of mathematics instruction involves computation usually at the expense of attaining higher order skills such as reasoning and problem solving (Cawley & Parmer, 1992). Given the poor performance of students with learning problems and calls for mathematics instruction to better address higher order thinking, there is a clear need to design effective instructional sequences that promote understanding for these students.

The purpose of the present study was to investigate the effects of an explicit schema-based direct instruction strategy on the acquisition, generalization, and maintenance of addition and subtraction word problem solving by students with learning disabilities. We predicted that the schema-based strategy would facilitate word problem solving for students with learning disabilities.

## Methodology

### Subjects and Setting

Three students from a Northeast private elementary school for students with learning disabilities were selected for participation in the study (see Table 1 for student description). They ranged in age from 8 years, 10 months to 10 years, 10 months and were enrolled in the third and fourth grades. All were white and were from middle to upper middle income homes. Students were selected based on their teachers' judgments to possess adequate addition and subtraction computational skills, but to be poor word problem solvers.

### Measures

Prerequisite Skills Test and Pretest. Screening measures were used to ensure that the students' possessed the prerequisite skills necessary to solve word problems. They were required to complete 20 two digit by two digit addition and subtraction computational problems with 90% accuracy. In addition, they were required to complete simple action problems that involved phrase by phrase translation (see Silbert et al., 1990) with 90% accuracy. To ensure that sudents could not succesfully perform the target skills, students were required to complete a test consisting of 15 addition and subtraction word problems (five each of change, group, and compare) with less than 50% accuracy. Students' scores on the criterion test of word problem solving ranged from 33%-50%.

Probes. Sets of simple one-step story situations and word problems were developed for the study. Each set contained instances of three problem types (change, group, and compare) based on Riley, Greeno, and Heller's (1983) categorization scheme (see Table 2). All probe sets were parallel forms; the only difference in the parallel sets were the contexts and specific numerical values used.

Student Interviews. Following the intervention, an interview was conducted about what students liked most and least about the strategy. In addition, students were asked to state if they would recommend the strategy to a friend and how they would rate the strategy on a scale of 1 to 5 in terms of mapping information from the problem onto schema diagrams, labeling parts of the diagrams, and using the statement cards to find the solution.

Materials

The materials for the study included student worksheets of word problems. One-step addition/subtraction word problems were constructed. Three semantic relations, change, group, and compare, that characterize most addition and subtraction word problems presented in commercial basal mathematics were used to develop items for the probes and student worksheets (See Table 1). Diagrams were also used to illustrate the three problem types (see Figure 1).

Experimental Design

An adapted multiple probe design across students was employed to assess the effectiveness of the schema-based direct instruction strategy in facilitating the solution of one-step addition and subtraction word problems.

Experimental Procedures

Probe Conditions

The probe conditions consisted of a 15-item worksheet with five each of change, group, and compare problem types. Students were allowed as much time as they needed to complete the probes, and were encouraged to call on the examiner if they had difficulty reading.

Instructional Procedures

Scripted lessons were developed for the study. Student instruction was based on principles of direct instruction: explicit explanation of rules, modeling, guided practice, monitoring, corrective feedback, and guided practice.

Problem Schemata Condition. In the problem schemata training phase, students were taught to recognize features of the semantic relations in the problem, and discern the different problem types (change, group, compare). Instruction was in a group format, and consisted of teacher-led demonstration and modeling along with frequent student exchanges. For each problem type, students read the story situation and mapped features of the situation onto the appropriate schemata diagrams (see Figure 2).

At the end of each training session, students completed a worksheet containing 12 story situations. Initially, worksheets included story situations of a single problem type. When students learned to identify and map subsequent problem types, worksheets included each of the remaining problem types until all three problem types were included. This phase continued until every student reached 100% mastery on two consecutive days in discerning the three different problem schemata. Training in this condition ranged from five to eight days. When students reached 100% mastery in identifying and representing problem schemata, they completed a single probe (P2).

Intervention Condition. Following the probe, the schema-based direct instruction strategy was introduced to teach word problems; participants were introduced to the strategy one at a time (intervention condition). Instructional conditions lasted an average of eight days. This phase began with a review of the problem schemata. The only difference was that problems rather than story situations were presented. Students were shown how critical elements of the specific problem were mapped onto the schemata diagrams, while the missing element was flagged using a question mark. Next, instruction in the remaining step (action schema and strategic knowledge) of the strategy was presented. The instructor explained how to find the total in the word problem by focusing on the specific information in the verbal text. For example, to find the total in the change problem required reading the change word (i.e., verb) to determine whether an increase or decrease occurred to the beginning amount causing the problem to end up with more or less. When the change caused the ending amount to be more than the beginning amount, the word total was written under the ending amount in the schema diagram; otherwise the word total was written under the beginning amount. Once the total was determined, the student was taught a simple rule based on the number family relationship (Silbert et al., 1990) to determine whether to add or subtract. When the total and one of the other numbers was known, subtraction was the choice of operation. When the total was unknown and the other two numbers were known, the problem required addition.

At the end of each training session, the student completed a worksheet containing nine word problems with problem schemata diagrams. Instructions for completing the worksheet were similar to those given during the probe conditions, except that initially the student was working on only one type of problem. When the student had completed instruction in the combined use of the strategy steps for all problem types, worksheets with 12 word problems that included all three problem types were presented. The student completed the worksheets until an evaluation of word problem solving indicated that mastery (100% accuracy for two consecutive days) on all three schemata was reached. Upon completion, the worksheet was checked and appropriate feedback was provided. Students were also informed about the usefulness of the strategy based on a comparison of his or her performance during baseline and intervention, and were encouraged to use the strategy in the future to solve word problems.

Maintenance and Generalization Procedures

Two maintenance probes consisting of parallel sets (generalization) of previous probe items were obtained for each student 2 to 3 weeks after the last probe was completed to assess maintenance and generalization of the word problem solving strategy.

# Results

Percentage of Math Word Problems Correctly Completed

| Students | Probe 1 (Baseline) | Probe 2 (Following Problem Schemata) | Probe 3 (Following Intervention) | Probe 4 (Maintenance) |
|---|---|---|---|---|
| Kelly | 20; 6; 27 | 46 | 93; 93; 80 | 73; 67 |
| Laurie | 27; 27; 46 | 46 | 87; 53; 93 | 80; 93 |
| Scott | 33; 20; 27 | 33 | 87; 87; 93 | 73; 93 |

Student Interview Results

When asked what they liked the most about the schema-based strategy, a common answer was learning to solve the problems by figuring out where to put parts of the word problem into the schemata diagrams. When asked what they liked the least, two of the three students answered having to do so many word problems. Another student felt that finding the total was the least liked because of having to go back and read the problem. When asked if they would recommend this strategy to a friend, they all answered in the positive. Student ratings regarding the benefits of the strategy, from the most useful (5) to the least useful (1), averaged 4.5, 4.5, and 4.6 for Students 1, 2, and 3 respectively.

# Discussion

The present study provides preliminary findings regarding the utility of the schema-based strategy as a valuable instructional technique in facilitating word problem solving. The positive results with the three students regarding acquisition, maintenance, and generalization support the earlier research on schema-based instruction with college students in improving word problem solving (Marshall, 1991). The findings have implications for instruction because students with learning disabilities often do not generalize and maintain skills and strategies that they learn. In fact, one of two teachers interviewed in the study indicated that Student 1, who evidenced some math phobia prior to the intervention, showed increased confidence in her math performance. The student was also more consistent in labeling her work while doing word problems. Although both Student 1 and Student 2 did not improve in their computational skills, the teacher reported that these students' understanding of word problems was enhanced as a result of the intervention.

Several considerations limit the generalizability of the findings in this study. Our results are limited to individuals with learning disabilities. Consequently, further investigation is needed to determine if these results hold when other students are involved. Another limitation is that this study focused only on addition and subtraction one-step word problems. Future research should examine the effects of the schema-based instructional package in the area of maintenance and generalization on solving advanced multistep word problems and problems that involve all four operations (addition, subtraction, multiplication, and division). A final limitation of this study is that the long-term effects of the strategy (i.e., more than 2 or 3 weeks) and the use of the strategy in novel settings were not addressed.

## References


Brian, T., Bay, M., Lopez-Reyna, N., & Donahue, M. (1991). Characteristics of students with learning disabilities: A summary of the extant data base and its implications for educational programs. In J. W. Lloyd, N. Nirbhay, & A. C. Repp (Eds.) The regular education initiative: Alternative perspectives on concepts, issues, and models. Sycamore, IL: Sycamore Publishing Co.

Carnine, D. (1991). Curricular interventions for teaching higher order thinking to all students: Introduction to the special series. Journal of Learning Disabilities, 24, 261-269.

Cawley, J. F., & Parmer, R. S. (1992). Arithmetic programming for students with disabilities: An alternative. Remedial and Special Education, 13(3), 6-18.

Marshall, S. (1990). The assessment of schema knowledge for arithmetic story problems: A cognitive science perspective. In G. Kulm (Ed.) Assessing higher order thinking in mathematics. American Association for the Advancement of Science. Washington, DC.

Mercer, C. D., & Miller, S. P. (1992). Teaching students with learning problems in math to acquire, understand, and apply basic math facts. Remedial and Special Education, 13(3), 19-35, 61.

Riley, M.S., Greeno, J.C., & Heller, J.I. (1983). Development of children's problem-solving ability in mathematics, in The development of mathematical thinking by H. P. Ginsburg (Ed.), Academic Press.

Silbert, J., Carnine, D., & Stein, M. (1990). Direct instruction in mathematics. Columbus, OH: Merrill.

Figure 1. Schemata Diagrams for Change, Group, and Compare Problem Types

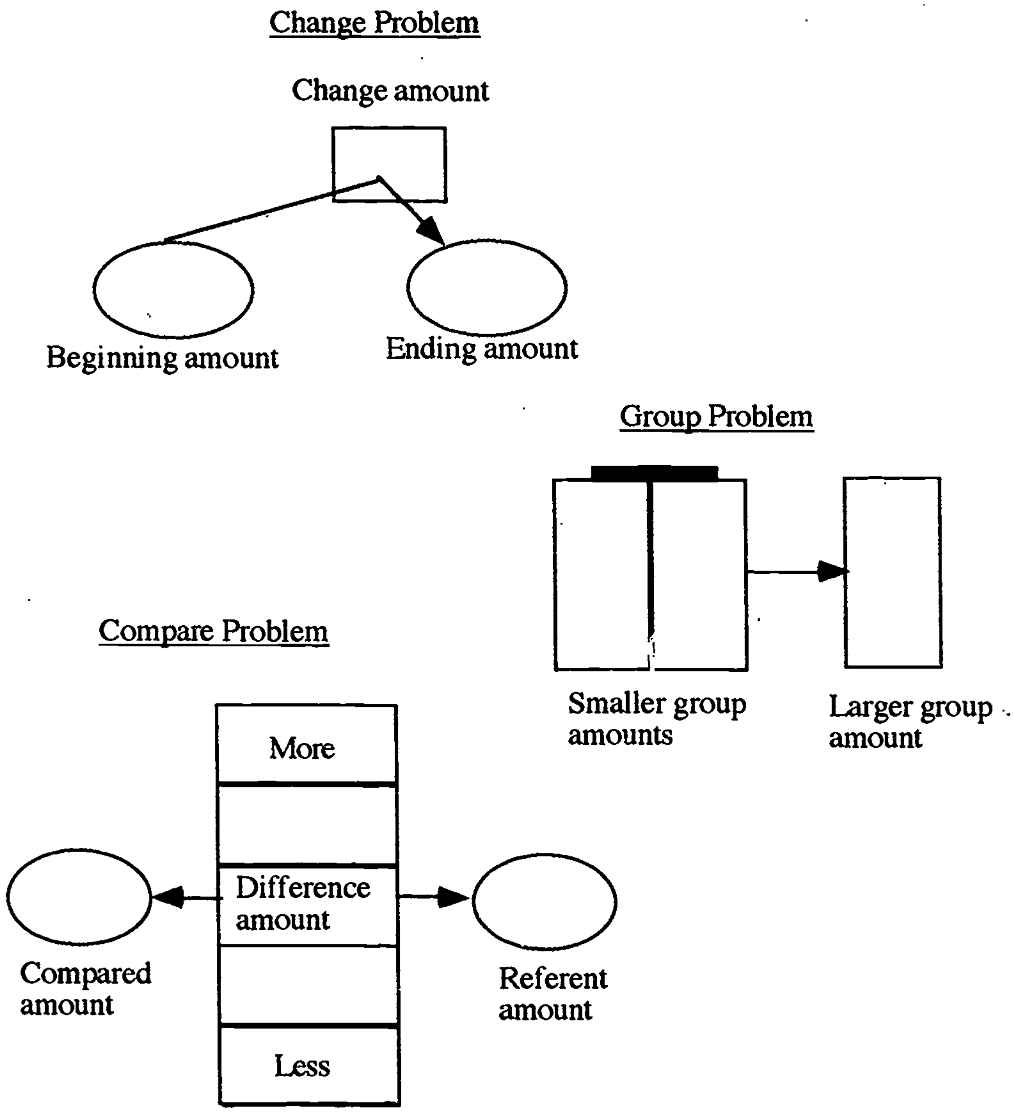

Figure 2. Problem Schemata Instruction

Change Story Situation. Mario had 58 stamps in his collection. He bought 24 more stamps at the new store and now has 82 stamps in his collection.

The teaching procedure required students to understand that the change relation started with a beginning state (e.g., 58 stamps) in which the object identity (e.g., stamps) and the amount of the object was defined (e.g., 58). A change in possession then occurred as indicated by the verb, bought, inferring more stamps than he had before. Based on the position of the statements and the phrase bought more, the student was taught to infer the time constraints (past to present). After the change occurred, the situation resulted in an ending state (82 stamps) in which the new amount (i.e., 82) was defined. The situation clearly indicated that both the beginning and ending states could not occur at the same time; either there were 58 stamps or 82 stamps.

Group Story situation. Ken sold 37 Kit-Kat bars and Art sold 53 Hershey bars at a fund-raiser. Ken and Art together sold 90 candy bars.

Unlike the change relation, instruction in the group relation emphasized that the passage of time was irrelevant and that there was no change or permanent alteration of object amounts. Instead, instruction indicated that a grouping (e.g., hierarchical) of objects into superordinate and subordinate categories must be present and that subordinate categories should have semantic ties to the superordinate category. For example, the student was made aware of the common attributes of the three elements, "Kit-Kat bars", "Hershey bars", and "candy bars" and the relationships among them. Although "Kit-Kat" and "Hershey" bars were shown to be instances of candy bars with similar properties, they were seen as distinct in that a Kit-Kat bar was not equivalent to a Hershey bar.

Figure 2 (Continued)

Compare Story situation. Michael has 43 music records and Emily has 70. Emily has 27 more music records than Michael.

Instruction focused on the presence of two elements (Michael's and Emily's music records), each associated with a smaller or larger value (i.e., 43 and 70) and both having the same semantic features (e.g., music records). Generally, the semantic features included the units in which the elements were measured (e.g., number of music records). One of the elements served as the comparison object (Emily) and the other as the referent object (Michael). The two sets were compared by contrasting their values using the more than or less than concepts and the amount left was noted as the difference between the two sets. In the compare relation, time was not a distinguishing characteristic because the comparison occurs at a single point in time; both individuals currently have the music records stated in the above story situation.

Figure 3. Percentage of math word problems completed correctly for the three students. Note: P = Probe Conditions.

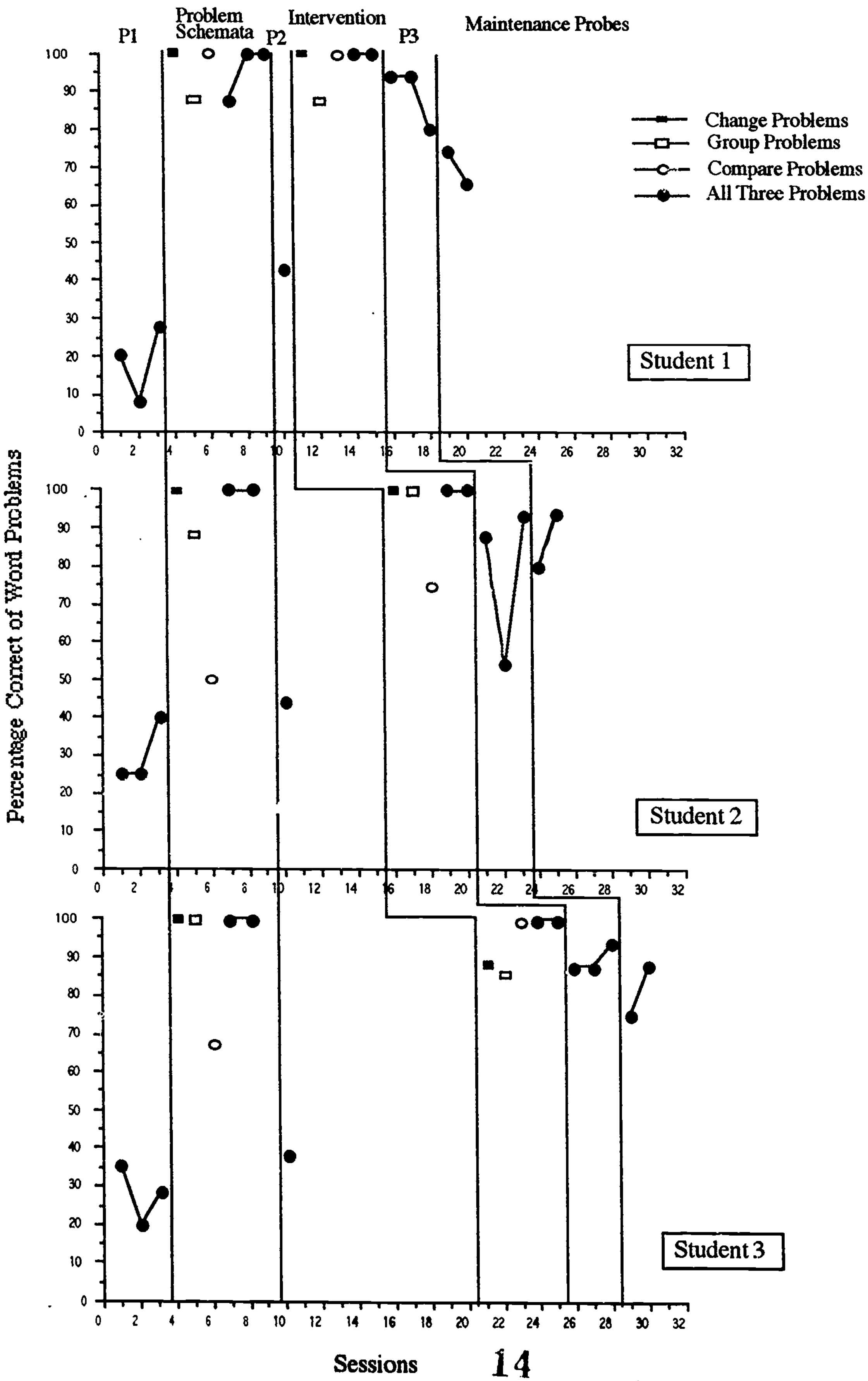

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Table 1

Student Characteristics

| Gender | Age in Years/ Months | Grade | Full Scale IQ | Test | Math Operation Scores (grade level) | Test | Medication | Years in Special Education |
|---|---|---|---|---|---|---|---|---|
| Female | 10/10 | Fourth | 84 | WISC-R | 2.5 | WIAT | None | 3.5 |
| Female | 10/6 | Third | 88 | WISC-R | 1.4 | CAT | Ritalin | 0.5 |
| Male | 8/10 | Third | 101.5 | K-ABC | 3.0 | Key Math | None | 2.5 |

Note: WISC-R = Weschler Intelligence Scale for Children-Revised; K-ABC = Kauffman Assessment Battery for Children; WIAT = Weschler Individual Achievement Test; CAT = California Achievement Test

Table 2

Classification of Addition/Subtraction Word Problems

| Problem Type | Example |
|---|---|
| **Change** | |
| Ending Quantity Unknown | Jane had 3 marbles. Then Ted gave her 5 more marbles. How many marbles does Jane have now? |
| Change Quantity Unknown | Jane had 3 marbles. Then Ted gave her some more marbles. Now Jane has 8 marbles. How many marbles did Ted give her? |
| Beginning Quantity Unknown | Jane had some marbles. Then Ted gave her 5 more marbles. Now Jane has 8 marbles. How many marbles did Jane have in the beginning? |
| **Group** | |
| Whole (Superordinate or Larger Group) Quantity Unknown | Jane has 3 marbles. Ted has 5 marbles. How many marbles do they have? |
| Part (s) (Subordinate or Smaller Groups) Quantity Unknown | 1. Jane and Ted have 8 marbles altogether. Jane has 3 marbles. How many marbles does Ted have?<br>2. Jane and Ted have 8 marbles altogether. Ted has 5 marbles. How many marbles does Jane have? |
| **Compare** | |
| Difference Quantity Unknown | Jane has 8 marbles. Ted has 5 marbles. How many more marbles does Jane have than Ted? |
| Compared Quantity Unknown | Jane has 3 marbles. Ted has 5 more marbles than Jane. How many marbles does Ted have? |
| Referent Quantity Unknown | Jane has 8 marbles. She has 5 more than Ted. How many marbles does Ted have? |

Note: Representation adapted from "Development of children's problem-solving ability in mathematics" by M.S. Riley, J. G., Greeno, and J. I. Heller, 1983, in The development of mathematical thinking (p. 160) by H. P. Ginsburg (Ed.), Academic Press. 