A Comparison of Two Approaches for Teaching Complex, Authentic Mathematics Problems to Adolescents in Remedial Math Classes

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ABSTRACT: Two groups of adolescents with learning difficulties in mathematics were compared on their ability to generate solutions to a contextualized problem after being taught problem-solving skills under two conditions, one involving standard word problems, the other involving a contextualized problem on videotape. All problems focused on adding and subtracting fractions in relation to money and linear measurement. Both groups of students improved their performance on solving word problems, but students in the contextualized problem group did significantly better on the contextualized problem posttest and were able to use their skills in two transfer tasks that followed instruction.

Since U.S. Secretary of Education Terrel Bell declared the United States a "nation at risk" in a report by the National Commission on Excellence in Education (1983), a steady stream of evidence has supported his contention. In mathematics, verification has come primarily from national and international assessments showing that U.S. students lack necessary skills for solving multistep problems required to function in the context of everyday situations and work settings (Dossey, Mullis, Lindquist, & Chambers, 1988; Lapointe, Mead, & Phillips, 1989).

Responding to these findings, groups such as the National Council of Teachers of Mathematics (NCTM) (1980, 1989) have issued position statements emphasizing that students should have opportunities for solving problems that resemble those encountered in real-life settings. Most recently, mathematics was one of two content areas emphasized in former President Bush's education reform strategy, America 2000 (U.S. Department of Education, 1991).

For adolescents already identified as "at risk," the seriousness of the problem is likely magnified. By the time students with learning disabilities reach secondary school, they not only lag behind their peers in basic skills, but also lack proficiency in higher order skills (Schumaker & Deshler, 1988). Special characteristics attributed to students with learning disabilities, such as weaknesses in deliberate memory tasks, reduced motivation, and the lack of social skills and self-efficacy, contribute to the difficulty of teaching adolescents with learning disabilities (Reschly, 1987).

Numerous studies have investigated ways to bolster students' performance in complex prob-
lems. For example, Carnine (1989) combined Direct Instruction with mastery learning principles, presented in a videodisc format, to provide a "comprehensive" instructional intervention in math and science. The curriculum design is based on the premise that many seemingly unrelated concepts can be organized into a smaller number of rules, thus reducing the memory load required for solving complex tasks (Engelmann & Carnine, 1982). Effectiveness of this method has been demonstrated in studies focusing on chemistry (Hofmeister, Engelmann, & Carnine, 1989), fractions (Hasselbring et al., 1987-1988; Kelly, Carnine, Gersten, & Grossen, 1986), and ratio and proportion word problems (Moore & Carnine, 1989).

Whereas knowing rules may improve students' memory of algorithms and performance on word-problem tasks, students who do not know when and in what situations to use them may still be just as limited when confronted with real-life problems (Hasselbring et al., 1991). This inability to retrieve needed information when the situation calls for it was termed "inert" knowledge more than a half-century ago (Whitehead, 1929) and has been the focus of several recent studies (see Bransford & Vye, 1989).

The inert-knowledge phenomena has been exacerbated by methods frequently employed in today's classrooms. Problem-solving, for example, is often equated with students' ability to solve word problems. But word problems usually found in today's basal texts do not meet the definition of "problem" described by Schoenfeld (1989) as "a task (a) in which the student is interested and engaged and for which he wishes to obtain a resolution, and (b) for which the student does not have a readily accessible mathematical means by which to achieve that resolution" (p. 88). Thus, educators are faced with a dilemma. How can they provide problem-solving situations in contexts that students regard as important? And, how can they arrange the classroom environment so that patterns of knowledge structures match their anticipated uses?

Affording students opportunities to practice relevant knowledge retrieval in contexts they recognize and regard as important may rest in the concept called "anchored instruction." Anchored instruction is a way of transposing semantically rich, shared learning environments into the classroom (Bransford, Sherwood, Hasselbring, Kinzer, & Williams, 1990; Cognition and Technology Group, 1991). When students are placed in real-life, problem-solving contexts, they gain the experience of noticing how new information affects their own noticing and understanding. Not unlike contexts found in the informal learning environments of young children, anchored instruction requires guidance by an effective teacher and a rich, realistic source of information.

Recently the Cognition and Technology Group at Vanderbilt University (1990) conducted a series of studies that used instructional video anchors. The 15-25 min anchors combined video and audio in a narrative format that pose a multistep problem in which students first have to identify pertinent information and then formulate strategies they expect will lead to its overall solution. Students are challenged to solve the problem as they identify with the protagonist's attempts to reach a solution. Studies with high-achieving, intermediate-grade students and general education, middle school students have shown video anchors to be effective in solving problems involving distance, elapsed time, rates, fuel consumption, and money (Cognition and Technology Group, 1992).

For adolescents with a history of difficulties with mathematics, national and international achievement trends portray a gloomy picture. This group of students is at greater risk of finishing school without the skills necessary to function in everyday life. There is evidence that direct mathematics instruction, in combination with media, can be effective in teaching students certain kinds of skills, such as basic computation and standard word problems (Hasselbring et al., 1987-1988; Moore & Carnine, 1989); but few studies have investigated the impact of this instruction on real-world tasks. Further, using video anchors in combination with teacher coaching has shown promise for regular education students, but no research has suggested that video anchors could be an effective instructional tool for high school students experiencing special difficulties in learning mathematics.

We conducted the first phase of this study to gauge the effectiveness of a videodisc program, Mastering Fractions (Systems Impact, 1985), to improve students' ability to add and subtract fractions and to determine whether this procedural knowledge transferred to students' problem-solving performance. The second phase compared students' ability to generate solutions to contextualized problems after being taught problem-solving skills under two conditions. In one condition, a teacher mediated students' efforts to
solve a contextualized problem presented via videodisc. In the other condition, teachers guided instruction and provided practice in standard word problems.

**METHOD**

**Subjects**

Subjects were 36 9th-grade students in two remedial math classes from a high school in the upper Midwest. The high school contained Grades 9-12, with 400 students per grade level. It was one of two public high schools serving a community of about 50,000 people and a total student population of approximately 12,000. The primary objective of the remedial classes was to strengthen computation and functional math skills. Both classes were taught by a regular education teacher with more than 20 years of teaching experience.

Students in these two classes had experienced significant academic and behavioral problems. Of the 36 students who began the study, 17 had qualified for and received special education services. To qualify for direct special education services in the school district, students must have attained an ability-achievement discrepancy Relative Performance Index (RPI) of 39 or below on the Woodcock-Johnson Psycho-Educational Battery (WJPEB) (Woodcock & Johnson, 1978). Six of the 17 students were currently enrolled in special education programs, 2 were in the referral process, and 9 had been terminated from special education service for having met the goals of their individualized education programs. The 19 students who had never received special education services were considered at-risk of failure in mathematics and hence had been placed in this class.

Every spring the Comprehensive Test of Basic Skills (CTBS) (CTB/McGraw-Hill, 1982) is administered to district students in Grades 1-6. Sixth-grade math scores were available for 19 of the students in the study and indicated a median national percentile rank of 33 and a median local percentile rank of 11. Although scores were almost 3 years old, they added supportive evidence to rationalize the referrals of these students to the remedial classes by their 8th-grade mathematics teachers.

School records kept by the principal indicated that 15 of the 36 students had been suspended from school for at least 1 day during the 4 months preceding the study. Three students had been suspended for only 1 day, 6 students for more than 5 days, and 1 student for 29 days. In all, students in these classes had been suspended a total of 73 days during the first 4 months of the school year before the study began. Students had been sent home for a variety of reasons, such as starting fires in garbage cans, theft, smoking, and aggressive behavior. The most common reason for school suspension was skipping class. Counselor records indicated that 28 of the 36 students had skipped at least one class since the beginning of the school year. Of these 28, 16 students had skipped five or more classes.

**Measures**

*Fractions Tests.* A fractions-computation test and a fractions word-problem test were developed by the experimenters. The 18-item, fractions-computation test was used to measure students’ performance before and after instruction with the Mastering Fractions (Systems Impact, 1985) videodisc program. Test items were graduated in difficulty from simple addition with like denominators and no rewriting to subtraction of mixed numbers with unlike denominators. Two points were possible for each problem; 1 point was awarded for showing correct calculations and 1 point for the correct answer displayed in simplified form.

The 18-item, word-problem test involved single-step and multistep word problems requiring addition and subtraction of fractions. Problems encompassed a range of measurement questions and required the same level of computation skills as the fractions-computation test. As in the computation test, 2 points were possible for each problem. Students could earn 1 point for selecting the appropriate numbers to add and subtract and 1 point for the correct answer represented in simplified form.

We administered both tests to three classes of regular education 6th-grade students (N = 84) in one of the school district’s elementary schools to assess internal consistency reliability. Cronbach’s coefficient alpha was .98 for the fractions-computation test and .95 for the fractions word-problems test.

*Contextualized Problem Test.* An 8-min video anchor, *Bart’s Pet Project*, written and produced by the experimenters, required a solution based on the calculation of several subproblems involv-
ing buying a small pet and building a home for it. To solve the main problem, students had to add and subtract money, add and subtract fractions, and convert simple measurement equivalents such as inches to feet.

To determine scoring criteria for the Bart test, students in two 9th-grade advanced geometry classes \((N = 53)\) served as “experts.” First, we asked these students to pay close attention to the video as it was shown the first time. Then, we gave them data sheets with all the numbers and quantities mentioned in the video, although not all the information was necessary for solving the problem. Next, we gave the students blank worksheets on which they were to show their work, and we showed them the video again.

At the end of the 40-min class period, we collected and inspected the protocols to identify procedures used by students who had successfully solved the problem. This sifting process yielded 10 procedures involving computation and problem representation that successful problem solvers had employed. For example, students had to show that it was possible for Bart to be able to purchase enough wood to build the animal cage and buy one of the pets shown in the pet store. Students demonstrated this by adding together combinations of wood lengths that left very little scrap wood. Successful problem solvers showed their attempts to find combinations of lengths that led to solving the problem.

After we identified problem-solving patterns, our next step was to determine whether the criteria were actually defined well enough to produce reliable ratings. Accordingly, about one fourth of the protocols were randomly selected, photocopied from the originals, and scored by a secondary observer. Interobserver agreement was calculated by dividing the number of agreements by the number of disagreements and agreements and multiplying by 100 to yield percentage of agreement (Sulzer-Azaroff & Mayer, 1977). Interobserver agreement was 94% \((\text{range} = 63\%-100\%)\) for the selected samples.

**Transfer Tasks.** After instruction, we administered two transfer tasks. The first transfer task, a text-based problem, required students to demonstrate that, with a limited amount of money, they could afford to build a kite frame from a plan and a materials list. The problem included several steps involving the computation of money, fractions, and measurement.

This task resembled both the video problem and the multistep word problems used during instruction in several ways. It was like the video problem because there was limited text, and the materials list gave no clues as to how students should proceed. It resembled the word problems because all the information necessary for successfully solving the problem was provided in text rather than video format. Calculations for the transfer task were similar to those required by both the Bart video and the word problems because students needed to add and subtract fractions to arrive at the correct solution.

Scoring criteria for the text-based problem followed closely those identified for the Bart video except that there were fewer steps needed for solving the transfer problem. Students were given credit for using correct procedures and for arriving at correct answers to subproblems.

The second transfer task was a video-based contextualized problem, *Bart’s Museum Adventure* similar in format but different in content from the Bart video. The problem employed an embedded data design like the Bart video. That is, students first had to retrieve relevant information from context to begin solving the problem. The content of the transfer video, however, differed considerably from the Bart instructional video. The transfer video asked students to solve a money and time problem using whole-number operations, whereas the emphasis of the Bart video was on linear measurement requiring operations with fractions. Because students were able to compute several of the subproblems without showing their work on paper, they were not given credit for showing their work but only awarded 1 point for the correct solution to each of the two main problems.

**Instructional Materials**

*Mastering Fractions Interactive Videodisc Program, Mastering Fractions* (Systems Impact, 1985) was used to strengthen the students’ fractions-computation skills before beginning the problem-solving phase of the study. The videodisc program consists of three double-sided discs that contain 35 lessons including mastery tests, quizzes, reviews, and remedial exercises. Each instructional sequence is characterized by a presentation of a concept by a narrator. Students respond to questions either orally or by writing the answer on their papers. The pace of the lesson is controlled by the classroom teacher who ad-
vances the video with a remote control unit. Special graphics and sound hold students' attention.

**Contextualized Problem.** An 8-min contextualized problem presented via videotape called *Bart's Pet Project* served as an instructional anchor for facilitating students' ability to solve a real-world problem. The design of the video was guided by principles of the Learning Cognition and Technology Group at Vanderbilt University (1990). These principles set forth conditions favorable for learning that include guidance by an effective teacher; a rich, realistic source of information; and a meaningful problem-solving context.

The video employs an "embedded data design" (Cognition and Technology Group, 1991) where the mathematics problems are not explicitly stated or well formulated as they are in standard word problems. Rather, information is included in scenes that will be relevant as the viewer becomes better able to define the problem. To illustrate, the cage plan shown in the video shows that a certain dimension of lumber is required. This dimension is among several heard on a television advertisement in the background in one scene of the video. The viewer must notice that this is a useful piece of information, determine how it can be integrated with other relevant data, and then perform the appropriate calculations.

**Word Problems.** A series of standard word problems that paralleled the content of the sub-problems in the contextualized video problem was written by the experimenters. These single-step and multistep problems of the type typically found in many basal mathematics textbooks focused on calculations of money, linear measurement requiring addition and subtraction of fractions, and a combination of money and measurement problems. Several problems dealt with charts indicating the amount of material needed to make a product. Students were required to add and subtract appropriate measurements in the chart to arrive at the correct solution. Each of the problems was copied to overhead transparencies suitable for showing to the whole instructional group.

**Procedures**

Before the study began, we administered the fractions-computation test to students in the two remedial mathematics classes and all 9th- through 12th-grade students in general mathematics and prealgebra classes. Errors made by the remedial students were categorized and then matched with chapters in *Mastering Fractions* (Systems Impact, 1985) that addressed the concept. The most predominant error among remedial students was in renaming and simplifying fractions.

We then organized selected chapters of the videotape program into a 5-day instructional plan that included instructional presentation and worksheet completion. The regular classroom teacher was primarily responsible for teaching the chapters. One of the experimenters was present in the classroom at all times to help if the teacher was unable to successfully manipulate the videotape equipment.

Each student was provided with a folder that contained blank pieces of paper for the computation required by the videotape lessons. They also were furnished with a packet of workbook exercises to reinforce chapter objectives. During each 40-min class period, students watched the videotape program and responded either orally or in writing to the narrator's directions. Then students checked their own work and completed the workbook exercises. After each class period, the experimenter and the teacher checked workbook exercises before planning the next day's lesson. An average of two chapters per instructional period were taught. No subject matter other than the *Mastering Fractions* program was presented during the 5 instructional days. At the conclusion of fractions-computation instruction, the fractions-computation test was readministered to students to assess improvement in computation skills before beginning the problem-solving phase of the study.

Before problem-solving instruction, students were administered the word-problem test and the video-problem test in their regular classrooms. A matching procedure recommended by Borg and Gall (1989) was employed to assign students in each class to one of two instructional groups based on student performance on the fractions-computation posttest. Test scores were first ranked from highest to lowest. Students who had the top two scores were randomly assigned to either the contextualized problem (CP) or the word problem (WP) group. Then, the next pair of scores from the rank list was selected and randomly assigned to a group. This procedure resulted in four instructional groups, with a total of

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15 students in the CP group and 14 students in the WP group.

The regular classroom mathematics teacher and the first author, each with more than 20 years of teaching experience, shared instruction. To help reduce systematic teacher effects, each teacher taught both conditions. The mathematics teacher instructed WP students in the morning class and CP students in the afternoon class. Conversely, the experimenter taught the CP group in the morning and WP group in the afternoon.

**Contextualized Problem Instruction.** During the 5-day instructional period, CP students were guided through a series of lessons intended to help them solve the problem on their own. Students were provided with a folder that contained blank paper for problem calculations and a packet of worksheets. Daily lesson plans were reviewed by both teachers at least 1 day before classroom implementation.

The methodology of Rosenshine and Stevens (1986) was used as a guide to help ensure that there was equivalence of instruction across groups:
1. review (check previous day’s work and reteach, if necessary);
2. presentation of new content/skills;
3. guided student practice (and check understanding);
4. feedback and correctives (and reteach, if necessary);
5. independent student practice; and
6. weekly and monthly reviews. (p. 379)

An observer completed a curriculum implementation checklist for one third of the instructional sessions. In addition, six of the instructional periods were videotaped. These filmed segments helped document procedures used across each of the instructional groups.

During the first day of instruction, students were shown the video problem one time with no interruption and then asked to describe the challenge presented by the video. Next, the teacher solicited ideas about elements in the video that could better define the problem. As students gave their suggestions, the teacher replayed segments of the video. For the last 10 min of the period, students completed a worksheet that reviewed the video’s content.

At the beginning of the second day, students corrected their own worksheets from Day 1, reviewed the important elements discussed the day before, and were given time to calculate solutions to subproblems. Procedures and answers were discussed to help clarify steps in the problem-solving process. Near the conclusion of the instructional period, students again completed a worksheet requiring them to calculate solutions to subproblems on their own.

After correcting the worksheet from Day 2, students on Day 3 were administered a teacher-guided quiz to check their understanding of relationships between the subproblems and the challenge problem. First, the video was shown in its entirety. At any time, students could request that the video be stopped to allow them to take notes. Then, students were asked to solve the challenge problem and share their ideas with other students.

The first 10 min of the fourth day were devoted to discussing how students worked the previous day’s challenge problem. Students were encouraged to generate several ways of solving the problem, because the correct solution could be gained by a variety of methods. Suggested alternatives were summarized on the chalkboard and then reviewed on a worksheet given to students at the end of the class period.

After the worksheets from Day 4 were corrected, the main focus of the last day’s instruction centered on a series of “what if” questions. For example, students were asked: What if Bart had not spent $3 at the arcade the day before? or What if one of the sides of the mammal cage plan had called for a piece of wood 1/2 inch longer? These questions helped focus on the main problem yet invited students to think about how solutions would be altered, given new information.

**Word-Problem Instruction.** Students in the WP group were guided through a series of word problems about money and linear measurement involving fractions. As with the CP group, teachers had detailed lesson plans for each of the 5 instructional days. (Detailed instructional plans are available from the first author.)

Although there was no reference made to the contextualized problem in any of the word problems, they were parallel in the required procedural steps. That is, the subproblems that the WP group solved required identical mathematical procedures although problem contexts were largely unrelated. For example, one word problem showed a drawing of a garden and asked how much total landscape material was needed to go around it. The text of the problem stated that land-
scape material was sold only in certain lengths, and the cost was provided for each length. The problem’s main question was whether the garden border could be built with the money available, given the cost of the border material. The teacher guided students through the steps or subproblems for solving the main problem.

For each of the 5 days, the instructional method followed the same routine. First, as the problem appeared on the overhead projector screen, one student was asked to read it aloud to the other students. Then the teacher asked students to identify any extraneous information. Students identified “key” words such as “in all” or “how much more” in the text of the problem that might help provide clues about which mathematical operation (i.e., adding or subtracting) to employ. Once students could explain how to solve the problem, they computed the answer on their papers.

For the last 10 min of each instructional period, students were given a worksheet that contained one or more practice problems similar to the ones they had worked together in class. Students worked independently, but were allowed to ask the teacher for help. At the beginning of the next instructional period, the worksheets were corrected and areas of misunderstanding were retaught.

Following the last day of instruction, students were recombined into their regular mathematics classes. Students were given the contextualized problem posttest and the word-problem posttest to assess performance following the 5-day instructional period. The text transfer task was administered 1 day following administration of the two posttests. The contextualized problem was shown to students 3 weeks later.

RESULTS

Fractions-Computation Instruction

A paired samples t-test on pretest (M = 20.65) and posttest scores (M = 24.10) before and after instruction with the Mastering Fractions videodisc program indicated the amount of performance gain was significant, t(30) = 3.12, p < .01.

Comparisons of computation test scores of the remedial students following instruction with the Systems Impact program and prealgebra students who had taken the test during the same time period indicated almost identical achievement, 24.10 and 24.03, respectively. It appeared that the remedial students, before the second phase of the study, had attained a similar level of fractions-computation skills as their grade-level peers in prealgebra. Results of the word-problem test, however, showed significantly greater performance of prealgebra students (M = 23.75) than remedial students (M = 17.16), t(117) = 4.69, p < .001. Although equally proficient in adding and subtracting fractions, the remedial students still lagged behind their peers in the ability to solve word problems.

Problem-Solving Instruction

Formation of Instructional Groups. Before instruction, students were matched and randomly assigned to the word problem (WP) or the contextualized problem (CP) group, based on their fractions-computation performance. This procedure resulted in 14 WP students and 15 CP students. The mean score on the computation posttest of the WP group was 21.93, compared to the CP group mean score of 22.93. A paired samples t-test on computation posttest scores revealed no significant difference between groups, t(14) = .302, p = .767.

Performance on Two Problem-Solving Measures. A word-problem test and a video-problem test were administered to students before and following instruction. The highest possible score for each test was 36. Table 1 shows means and standard deviations for WP and CP students.

A 2 x 2 repeated-measures analysis of variance (ANOVA) was used to analyze data from each test. The between-subjects factor was the type of instruction (word problem or contextualized problem) and the within-subjects (repeated) factor was the time of test (pretest and posttest). Table 2 shows the repeated-measures analysis.

Results of the ANOVA for the word-problem test revealed a statistically significant main effect for pretest to posttest scores, F(1,27) = 11.46, p < .01, but not for Type of instruction or Time of test x Instruction interaction.

Analysis of video test scores showed a significant interaction between time of test and type of instruction, F(1,27) = 7.59, p < .01. A one-way ANOVA on posttest scores of each group yielded a significant difference in favor of the CP group, F(1,27) = 8.79, p < .01.

Fidelity of Instruction. An experienced staff development trainer observed four instructional
TABLE 1
Mean Performance of Students in Word-Problem and Video Contextualized Problem Groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Pretest</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Mean</td>
</tr>
<tr>
<td><strong>Word-Problem Test</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Word problem</td>
<td>14</td>
<td>15.43</td>
</tr>
<tr>
<td>Contextualized problem</td>
<td>15</td>
<td>19.47</td>
</tr>
<tr>
<td><strong>Contextualized Problem Test</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Word problem</td>
<td>14</td>
<td>1.21</td>
</tr>
<tr>
<td>Contextualized problem</td>
<td>15</td>
<td>1.80</td>
</tr>
</tbody>
</table>

TABLE 2
Univariate Repeated-Measures Analysis of Variance for Word-Problem Test and Contextualized Problem Test

<table>
<thead>
<tr>
<th>Source</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Word-Problem Test</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instruction (I)</td>
<td>1.148</td>
<td>.293</td>
</tr>
<tr>
<td>Time of test (T)</td>
<td>11.459</td>
<td>.002</td>
</tr>
<tr>
<td>1 × T interaction</td>
<td>2.009</td>
<td>.168</td>
</tr>
<tr>
<td><strong>Contextualized Problem Test</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instruction (I)</td>
<td>9.359</td>
<td>.005</td>
</tr>
<tr>
<td>Time of test (T)</td>
<td>19.986</td>
<td>.000</td>
</tr>
<tr>
<td>1 × T interaction</td>
<td>7.588</td>
<td>.010</td>
</tr>
</tbody>
</table>

sessions. In all but 1 of a total of 52 procedures, teachers were following the procedures indicated on the instruction checklist. Videotaped instructional sessions gave a visual account of how teachers' styles differed, but confirmed that the lesson plans and teaching procedures were being followed.

Transfer

**Text Transfer.** The first transfer was a text-based, multistep problem that required subproblem resolution. A paired-samples t-test on mean scores of the CP group (M = 9.07) and the WP group (M = 6.00) showed no significant differences between groups, t(13) = 1.44, p = .174. However, Pearson correlations revealed a significant relation in scores on the contextualized problem posttest and the transfer task of CP students, r(12) = .66, p < .05.

**Contextualized Transfer.** Another contextualized problem was shown to students in both groups 3 weeks after the first transfer task. The number of correct answers attained was compared to determine whether they differed significantly by instructional group. A total of 28 points was possible for the CP (14 students × 2 points = 28) and 24 points for the WP group (12 students × 2 points = 24). CP students earned 15 of 28 possible points compared to 5 of 24 points for WP students. A chi-square analysis performed on the number of correct answers showed that CP students solved significantly more questions than did WP students, χ²(1, N = 52) = 5.85, p < .05.

**Interobserver Agreement.** One fourth of the samples of the fraction computation, word problem, contextualized problem, and text-based transfer test were randomly selected, photocopied from the original, and scored by a secondary observer.

Exceptional Children
Interobserver agreement was 97% (range = 83%-100%), 96% (range = 83%-100%), 98% (range = 94%-100%), and 94% (range = 85%-100%), respectively. Because the contextualized-problem transfer test involved simple right or wrong answers, one scorer calculated number of correct responses.

**DISCUSSION**

National commissions and teacher organizations have recommended emphasizing problem-solving instruction in today’s classrooms. However, missing from these exhortations are suggestions about how this might be accomplished, especially with students already experiencing difficulty in mathematics. Results of this study showed that students with a history of learning difficulties can learn how to solve complex, meaningful mathematics problems and, further, can transfer these skills to other real-world tasks.

**Fractions-Computation Instruction**

The first part of the study was devoted to strengthening students’ skills in adding and subtracting fractions before beginning the problem-solving phase and to determine whether this procedural knowledge transferred to students’ performance on a traditional word problem and a contextualized video problem. Although the mathematics teacher had reviewed fractions at the beginning of the school year, results of the fractions-computation pretest revealed weaknesses in computation skills, especially in renaming. To help remediate this deficiency, the mathematics teacher selected and taught relevant chapters of the interactive videodisc program, *Mastering Fractions* (Systems Impact, 1985). Posttest results indicated that use of the videodisc program increased average student performance of the remedial students to that of regular education, prealgebra students.

Though the videodisc program was effective in improving fractions-computation skills, there was evidence that the program did not result in these students’ being able to completely solve word problems requiring the fractions computation skills. For example, although average computation test scores of remedial students following instruction and regular education prealgebra students were almost identical, the performance of prealgebra students in solving word problems was significantly higher than that of remedial students. These findings seem to support those of Hasselbring et al. (1991), who found that better computation skills do not necessarily translate into competence in solving word problems that require the use of those computations.

Using the fractions videodisc program before the problem-solving phase of the study served another purpose in addition to improving basic skills. Clark’s (1983) review of early media studies found that novelty of media had a major impact on the performance of media-instructed groups. It was hoped that presenting instructional lessons in videodisc format to all study participants before the problem-solving phase would lessen possible novelty effects.

**Problem-Solving Instruction**

The main purpose of the study was to compare two methods of problem-solving instruction requiring computation of fractions involving money and measurement. Students in one condition learned how to solve single-step and multi-step problems using standard word problems (WP group). In the other condition, students were guided through a series of problems via videodisc that led to a solution of a contextualized problem (CP group). Both methods taught the same level and types of procedural skills. The primary difference was that the CP group was taught procedural skills within a larger contextualized problem, whereas the WP group received instruction within a set of decontextualized problems.

As was expected, CP students outscores WP students on the contextualized problem test. However, performance on the word-problem test improved significantly for students in both groups, regardless of type of instruction. These findings support the contention that direct instruction in solving word problems can lead to improved performance in solving word problems. But if expertise in solving word problems is the desired goal, this can also be achieved by using contextualized problems. Both methods seem to lead to similar results.

Teaching contextualized problems rather than standard word problems provides the additional benefit of learning transfer. More CP students were able to notice critical features of transfer problems and organize them in ways that led to solutions of both the text-based and the contextualized video problems. Not surprisingly, inspection of protocols of the text-based problem revealed that both instruction groups correctly
calculated the total amount of money available for purchasing kite materials. However, there appeared to be important differences between the groups in their ability to shift from the materials list in the contextualized problem to the one provided in the text-based problem. Almost two thirds of the WP students persisted in calculating lengths of wood of 96 inches required for solving the contextualized problem rather than the 48-inch lengths needed for solving the kite problem. This inability to shift from one problem to the other was less noticeable among CP students. Less than one fourth of these students persisted in calculating to 96 inches rather than 48 inches.

Perhaps the most encouraging finding occurred 3 weeks following instruction. CP students did significantly better on the second video problem than WP students even though its content was unrelated to the content of the instructional video. The instructional video involved money and measurement and required successful computation of fractions, whereas the transfer problem required students to add and subtract whole numbers related to money and time. Thus, CP students who had successfully solved the transfer problem did not narrow their focus only to fractions and measurement, but they seemed to view the problem as a more general representation of how problems naturally occur in real-life settings. If one of the major reasons for students' inability to solve problems is their lack of skill in noticing critical features of a problem, then findings of this study would suggest that instruction using contextualized video anchors can help improve this skill.

The successful use of contextualized problems with high-risk students is encouraging. Instruction for these students usually does not change significantly from what they receive in general education classes. Often, accommodations in curriculum and instruction are made in terms of topic density with emphasis on review rather than focusing on more complex, meaningful problems (Means & Knapp, 1991). Several students in this study were able to solve problems that the mathematics teacher did not think possible, considering their prior history. For example, one student who had attended a special education resource room for several years because of poor mathematics performance obtained a perfect score on the contextualized posttest and both transfer tasks. At the conclusion of the study, he asked if we had more problems he could solve.

Limitations of this study involve the use of only one contextualized video problem for instruction and transfer. Although skills of students in the video-instructed group appeared to transfer to two other tasks, neither of these tasks required students to solve a problem in exactly the same manner as the video used for instruction. Second, the study was conducted with only two classes. To further reduce possible teacher effects and increase statistical power, a similar study should be conducted with at least four classes and two teachers rotated among instruction groups.

Modern cognitive theory recommends that ways be found to afford learners practice in applying previously unused knowledge in meaningful contexts (Resnick & Klopfner, 1989). Results of this study suggest that merging their recommendations with technological capabilities can be powerful motivational and instructional tools for enhancing the problem-solving skills of students with serious learning problems.

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