ADI NEWS

VOLUME 10, NUMBER 3 THE ASSOCIATION FOR DIRECT INSTRUCTION SPRING, 1991

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17th Annual Eugene Direct Instruction Conference

August 5-9, 1991

What's NEW at this year's conference:

Based on your feedback, the ADI Board has redesigned this year's conference:

Keynote Speakers

- ☛ Jean Osborn - Assistant Director, Center for the Study of Reading
- ☛ Barbara Bateman - Professor, University of Oregon
- ☛ Zig Engelmann - Professor, University of Oregon
- ☛ Linda Youngmayr - Visiting Lecturer, California State University, Stanislaus

New Sessions

- ☛ Reasoning and Writing — A new Language program for K - 3rd grade.
- ☛ Connecting Math Concepts — A new math program for K - 3rd grade.
- ☛ Higher Order Thinking Skills
- ☛ Administrative Issues in Instruction
- ☛ Literature and Reading Mastery
- ☛ Applications of Curriculum Based Assessment to Direct Instruction
- ☛ Research on Reading Comprehension
- ☛ Beginning Reading Instruction - What works
- ☛ Design of Direct Instruction Programs

The **ADI News** is published Fall, Winter, Spring and Summer, and is distributed by mail to members of the Association for Direct Instruction. Membership and subscription information may be found on the last page of this newsletter. Readers are invited to submit articles for publication relating to Direct Instruction. Send contributions to: The Association for Direct Instruction, P.O. Box 10252, Eugene, Oregon, 97440.

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Critical Look at New Reading Program*

by Patrick Groff
San Diego State University

Sharp-eyed readers of the recent California Assessment Program (CAP) scores may have noticed that the third-grade children in San Diego usually scored higher in reading than sixth-graders.

Of the 80 elementary schools tested in San Diego Unified School District, in only 16, or 20%, did sixth-graders score as high or higher than the third-graders.

The foremost reason for this poorer performance by sixth-graders, according to the state Department of Education, is that the tests for sixth-graders contain about 40% more critical-reading items. These questions require the student to make inferences about what they have read.

What this would seem to signify is that San Diego sixth-graders have received less than ideal instruction in how to read critically. CAP expects teachers to develop more critical-reading ability in their sixth-grade pupils than they already do.

Critical reading is certainly more difficult than reading literally.

In literal reading, the goal is to comprehend precisely what an author intended. Critical reading, on the other hand, requires the student to evaluate the ideas—to decide whether they are accurate, honorable, relevant, complete, up-to-date, metaphoric or symbolic, accompanied by supporting evidence, or whether they meet a host of other criteria.

But, although critical reading is more complicated than literal reading, its success depends on good literal-reading skills. Only after literal knowledge is obtained, can critical reading commence.

The San Diego city schools and many others around the state have recently adopted a new way to teach reading: the so-called whole-language approach. Under this teaching philosophy, students are no longer grouped by ability; and the reading texts contain a higher quality of literature and less emphasis on word recognition.

But will this new approach produce sixth-graders who are better critical readers? Or is this just another educational fad?

The whole-language theory of reading development has at least five disabling suppositions. Taken together they comprise an invitation for disaster for reading instruction.

1) Whole language insists that children learn to read the same way they learn to speak, that is, with no formal instruction. The reading research, to the contrary, supports direct, systematic and intensive teaching of reading.

2) Whole language de-emphasizes word recognition. Children can comprehend the meaning of a written sentence before they can recognize the words in it, says the state Department of Education's "English-Language Arts Framework," which mandates whole-language instruction for teachers. The truth is that there has been no reading factor more closely related to comprehension than quick and accurate word recognition.

3) Whole language encourages children to omit, substitute and insert words in sentences they read—at will. Students thus are encouraged to make eccentric decisions as to precisely what an author intended to impart. No accurate literal or critical reading is possible under these circumstances.

4) Whole language denies that there is any sequence of reading skills. Everything about reading must be taught simultaneously, whole-langauge proponents maintain. Quite the contrary, says the research. Teaching a hierarchy of reading skills, from the easiest to the more difficult, works best.

5) Since the whole-language theory has fared badly when examined experimentally, leaders in the movement now claim that experimental research findings are fraudulent. According to whole-language proponents, the only proper way to evaluate progress is to write subjective anecdotes of children's reading behavior. It goes without saying that this disavowal of scientific method raises alarms about the merit of its other propositions.

The delivery of critical reading skills is the most important function of the schools. One cannot participate effectively in a democratic society without this ability. People without reading skills often find themselves on welfare rolls or in prison. Poor readers require costly remedial instruction.

The taxpaying public must provide for all these services. It is not only parents, therefore, who have a vital stake in making sure that schools are not indulging in transitory fads and theories, which Harvard President Derek Bok recently chastised them for doing.

A critical question for our school board members therefore should be: "Did you understand what you were approving when you authorized the whole-language approach to reading development?" ◆

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*Reprinted from the *Los Angeles Time, San Diego Edition*, December 9, 1990, with permission.

From Those Who Know...

Dear Mr. Engelmann,

Enclosed is a letter from one of my students, Francisco. When I started teaching here, Francisco was in *Reading Mastery II*, however, he wasn't at mastery. So last year I put him back into *Reading Mastery I* at about lesson 40. He is now on *Reading Mastery II* lesson 130, but doing the Fast Cycle and he is really solid on his skills.

I have been most fortunate to meet and work with Nicci Tucci (I believe her program should be called "the Competent Teacher Model," since I feel I have become more competent and consequently–my students have become more competent!), Kathy Madigan (her techniques in her workshops here at Monterey County Office of Education have enabled me to be a more effective deliverer of Direct Instruction) and Helen Van Heusen (Monterey County SELPA Specialist, who has at times come to coach me in mastery of Direct Instruction delivery). Consequently, I am enjoying the best time I've had in my 15 year teaching career, because my students are the most successful of any class I've ever taught.

So, I too want to thank you for the programs you've developed–we use Arithmetic I & II. I can't yet figure out how to squeeze into the day Language DI, Cursive DI, And Spelling DI, but when I do– I already know my students will be successful.

Thank you,

Anna Mae Gazo
A. B. Ingham School
Salinas, California

P.S. Francisco is a very bright boy who didn't come to the United States until about 5 years ago. His family doesn't speak English, but they've given him great self esteem. Francisco has been writing stories this year, since he is getting skilled at the printed word– at the beginning of last school year he couldn't write a sentence. He just finished a 700 word story about his Christmas Vacation. He started it after the vacation and it's taken almost 2 months. He has a typewriter at home with a small memory. He works on his stories at home. When he brings them in, I help him with spelling, punctuation and grammar and he goes home every day and revises them. He really enjoys this and takes great pride in his work. His letter to you is his; I only helped with spelling, punctuation and grammar.

Francisco is a delight!

Dear Mr. Engelmann,

I am using the reading program. Thanks to you and my teacher I am learning how to read.

Now I can read a couple of stories. I can make my stories now. My teacher said to me, "Do you want to send a card to Engelmann?" I answered, "Who is the man?" My teacher answered, "He is the one who made the reading program."

I answered, "Yes, I will type a card for thanking him." I am doing good in reading thanks to you. Really, I like the reading program because I am learning step by step. I am sending you a picture so you can see how I am doing all my work. Really, I am thankful to you and my teacher.

Sincerely,

Francisco Javier Flores

Francisco Javier Flores

READERS—

WE NEED YOUR IDEAS FOR ARTICLES!

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Effects of Audiotape Self-Monitoring on DI Teacher Presentation Techniques*

by Kay D. Simon Brynildson
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Research on Direct Instruction has clearly demonstrated that it is effective in enhancing academic gains of students. For example, in Project Follow Through, one of the largest social experiments ever conducted, the academic achievement of Direct Instruction students was well above that of students in all of the other instructional models that were compared (see Becker & Carnine, 1981; Gersten, Carnine, & White, 1984; Gersten, Woodward, & Darch, 1986).

To ensure the effectiveness of Direct Instruction, the programs should be carefully implemented following program specific guidelines, procedures, and presentation techniques. Siegel (1974) found a functional relationship between newly trained teachers' behaviors and student academic achievement in a Direct Instruction language program and thereby demonstrated the need for fidelity of implementation of Direct Instruction programs. This necessary condition for program effectiveness has been verified by other researchers who have found considerable variability in implementation among more experienced Direct Instruction teachers (Gersten, Carnine, & Williams, 1982; Gersten, Carnine, Zoref, & Cronin, 1986). These findings strongly suggest the need for monitoring of Direct Instruction teachers in order to ensure fidelity of program implementation and thereby to safeguard program effectiveness.

To deliver Direct Instruction programs as prescribed, a combination of teaching skills is required. The individual skills (i.e., Direct Instruction presentation techniques) that have been shown to be functionally related to student academic performance include: (a) rapid pacing; (b) frequent praise; (c) clear and precise signals; (d) consistent, immediate corrections of incorrect responses; and (e) maintaining high student accuracy rates (see Carnine, 1981; Carnine & Fink, 1978; Gersten, et al., 1982).

Fidelity of implementation of Direct Instruction programs is critical to their effectiveness, yet it is not always found. Therefore, monitoring of Direct Instruction teaching is needed. The present study is concerned with monitoring the skills of Direct Instruction teachers in order to provide for skill correction and maintenance. One efficacious monitoring mechanism is factual (objective) feedback (e.g., Cooper, Thomson, & Baer, 1970; Good & Brophy, 1974).

The data for factual feedback pertaining to Direct Instruction teaching skills can be derived from audiotape recordings. Hosner (1980) demonstrated the effectiveness of feedback from observers in maintaining tutors' Direct Instruction teaching skills. After recording tutoring sessions on audiotapes, observers coded process measures of instruction (teachers' skills) and provided tutors with corrective feedback and praise. In this study, intermittent (once every four sessions) feedback was shown to be equally as effective as continuous (every session) feedback in maintaining tutors' skills. Educationally and statistically significant gains in reading skills were made by students in both the continuous and the intermittent conditions.

Videotape monitoring, has also been shown to be effective in improving the teachers' skill levels (Cottrell, 1986). However, the availability of instructional staff for providing feedback to teachers is typically so extremely low (Alfonso, Firth, & Neville, 1981, chap. 1) that even with the convenience of videotapes it is unlikely that monitoring will take place. Self-monitoring offers an alternative. Thomas (1971), Saudargas (1972), and Rule (1972) provide some evidence that video-tape self-monitoring can be effective.

The present study goes a step further in reducing the "effort demanded" by examining the effectiveness of an audiotape self-monitoring technique to assist Direct Instruction teachers in improving their teaching skills. The study also uses a less costly "intermittent schedule" of self-monitoring in seeking to reduce further the effort required to use monitoring.

Method

Subjects

Two subjects participated in the study. Teacher A was a 44-year-old male middle school special education teacher who used the *Decoding C* materials of the SRA *Corrective Reading Program* (Engelmann, Meyers, Johnson, & Carnine, 1988). Teacher A had been using Direct Instruction teaching methods for 4 1/2 years and had a broad background of training in Direct Instruction presentation techniques. He participated in an earlier study (Cottrell, 1986) four years prior to the present study in which several of the same teaching skills were measured.

*Presented in partial fulfillment of the requirements for the Degree of Specialist in Education, Department of Psychology, Western Michigan University, Kalamazoo, Michigan, August 1990

Teacher B was a 42-year-old female regular education teacher. She was employed as a special education teaching assistant at the time of the study, and worked several hours each school day in Teacher A's classroom. She used the *Decoding B2* materials of the SRA *Corrective Reading Program* (Engelmann, Meyers, Carnine, et al., 1988). She had been teaching Direct Instruction for the last 2 years of her 12 years of teaching experience. She had much less training with Direct Instruction presentation techniques than Teacher A.

Setting

The study took place in a 7th grade special education classroom in an inner-city middle school in western Michigan. It was conducted with two reading groups of two to six students each during Direct Instruction teaching sessions. The students in both classes ranged in age from 12 to 15 years, and all were labeled either emotionally impaired or learning disabled, the majority being in the former category. All of the students had at least one year prior experience in Direct Instruction programs. An incentive system, beyond the usual grading system found in classrooms, was in effect. It involved administering behavior specific praise and bonus points to students contingent on appropriate behavior and academic achievement. A wide variety of backup reinforcers were available to be traded for the bonus points.

Apparatus and Materials

Each teaching sessions where self-monitoring was to be studied was videotaped. Audiotape recordings were made simultaneously with a cassette tape recorder plugged into the audio out jack on the video recorder. An observation form (see thesis) was used to systematically collect performance data on teacher and student behavior from the recordings of teaching sessions.

For self-monitoring, the teachers were provided with a worksheet that detailed the scoring procedures and provided spaces for recording their skill rates and comparing them to the criterion rate or goals (again, see thesis for details). A troubleshooting checklist was also provided to aid the teachers in self-monitoring.

Dependent Variables

The five dependent variables were Direct Instruction teaching skills that have been shown to be functionally related to student academic performance (see Table 1). Fidelity of implementation of Direct Instruction programs exists, with regard to presentation techniques, when criterion levels (delineated in Table 1) of these performance variables are present (see Carnine, 1981; Carnine & Fink, 1978; Gersten, et al., 1982). Each of the five skills is really a composite of several behaviors that combine to form the skill. The unit of analysis for this study was necessarily the more molar skills rather than their component behaviors. A self-monitoring technique that would require recording the component behaviors would be too time-consuming to have utility for teachers. Typically, during initial Direct Instruction training, teachers are taught to perform the necessary behaviors that combine to result in mastery of the skills. The troubleshooting checklist provided to the teachers during self-monitoring delineated many of these component behaviors.

Three of the behaviors observed—those related to clear signalling, pacing, and student accuracy—were student behaviors. Because this study is concerned primarily with teacher behavior, a rationale for observing student responses rather than teacher behaviors for these variables is provided, as follows:

1. With regard to clear signals, the teacher behavior involved must, by definition, evoke a *simultaneous* group response from students. Therefore, one way to count clear signals is to count simultaneous group responses that follow teacher signals.

2. With Direct Instruction, there should be a direct correspondence between the teacher's rate of task presentation and the rate of student responding. Counting student responses in order to measure pacing provides a means of checking that this correlation exists.

3. Student accuracy, of course, involves recording student responses; however, how it relates to teacher behavior requires explanation. Student accuracy is considered a teaching skill because it can be controlled by the teacher (Gersten, Carnine, et al., 1986; Youngmayr & Madigan, 1985) purportedly through the correct performance of the other four critical teaching skills as well as by using other tactics emphasized by the Direct Instruction model. These tactics include, for example, appropriately placing students in homogeneous (in terms of skill levels) small groups, seating the students so that they all can see the teacher and the teacher can see all of them, seating the lowest performers closest to the teacher, continuously monitoring all the students (see Berliner, 1987) using a scanning technique, and teaching to mastery criterion. These and other components

Table 1. Definition of Variables

Variable	Related Unit of Measurement	Criterion
Clear Signals	Simultaneous student group responses during instruction that are evoked by a visual or auditory antecedent stimulus (e.g., a hand drop signal) provided by the teacher (as prescribed in the teacher's manual) following the presentation of a task.	90% of session signals are clear
Pacing	All student responses (individual and group) that follow a teacher's signal or request for a response, including group responses that are not simultaneous.	9 responses per minute
Corrections	Two types: (1) signal error corrections, which must occur immediately after one or more student respond too early or too late (i.e., before or after the other students) or not at all, and involve the teacher pointing out that an error was made (e.g., "you're late") and re-presenting the task until all students respond together; and (2) content error corrections, which must occur immediately after a student gives an incorrect response or after all students fail to respond, and involve a *model, test, retest* procedure (as prescribed in the teacher's manual) directed toward the whole group.	85% of session errors are corrected
Contingent Reinforcement	Praise statements or expressions of approval (e.g., "That's great," or "Yes!") spoken by the teacher following a correct student response during instruction.	2.8 occurences per minute
Student Accuracy	Group and individual responses during instruction that follow a teacher signal and are both simultaneous among students (if group responses) and contain no incorrect student responses.	85-90% of session responses are correct

skills related to student accuracy were included in the troubleshooting checklist provided to the teachers to use during self-monitoring.

Observation and Scoring Procedures

One observation session of approximately five-minutes duration was conducted each day, one-to-four days a week. The sessions alternated between Teacher A and Teacher B. All sessions were simultaneously video- and audiotaped in order to ensure that any subject reactivity to the recording instruments was held constant throughout the study. After every observation session, the researcher scored the videotape. Frequency counts were used to score the behaviors related to the dependent variables. Each group response was counted as just one response, and each individual response was considered one response. During group responding, if one or more students in the group made an error the response was considered an error response, regardless of how many students responded correctly. Thus, the criteria for student accuracy were quite stringent.

Observer Training and Reliability

An experienced Direct Instruction teacher/trainer was selected as the expert observer for the study in order to assess interobserver agreement and accuracy of the observations made from videotapes. Practice tapes were used for training. Mean agreement for five training sessions between the expert observer and the "primary" observer was 86.3%. For the last two of the five sessions, mean agreement was 88.4%.

During the experiment, observer agreement was assessed by having the expert observer score randomly-selected videotaped sessions. Then, the primary observer's scoring of the same sessions was compared, trial-by-trial, to the expert's. Again, trials had to be scored identically in order for them to be considered in agreement, and agreements were divided by agreements plus disagreements. Agreement was checked for 9 of the 30 experimental sessions, 5 during baseline and 4 during intervention. Total agreement averaged 82.9%: range was: 75.5% to 90.2%).

Experimental Design and Procedures

The study was conducted during the word attack portion of the reading lesson during the second period of the school day for both teachers. The researcher was responsible for operating the recording equipment.

Baseline and intervention conditions were introduced in a multiple baseline across subjects design.

With this design, intervention effects are evaluated by introducing the intervention to different baselines (persons in this case) at different points in time. "If each baseline changes when the intervention is introduced, the effects can be attributed to the intervention rather than to extraneous events".

During baseline sessions the recording equipment, but no other new contingencies, was in place. The researcher began baseline for Teacher B the day after it was begun for Teacher A and recorded 7 sessions of baseline data on Teacher A and 11 sessions of baseline data on Teacher B. For two of Teacher B's baseline sessions the data were discarded because of extraneous variability imposed by the absence of all but one student during those sessions. After baseline performance was stable for both subjects, the self-monitoring intervention was initiated with Teacher A while baseline continued for Teacher B. When Teacher A's performance again stabilized, the same intervention was begun with Teacher B and continued with Teacher A. Intervention was conducted over 8 observation sessions for Teacher A and over 6 observation sessions for Teacher B.

Prior to beginning the intervention with each subject, the researcher spent 1-2 hours training the subject to self-monitor. The Corrective Reading Series Guide (Johnson, 1988) was used to review the critical teaching skills (dependent variables) with the subjects, and then the self-monitoring technique was explained, including: (a) scoring procedures, (b) calculating skill rates, (c) criterion skill levels, and (d) use of the troubleshooting checklist.

During the intervention, the subjects usually scored one 5-minute audiotape of one of their own teaching sessions per week, on randomly alternating days of the week. They then calculated their rates for each of the dependent variables for that session. The troubleshooting checklist was used at their own discretion to aid them in identifying ways of improving their teaching skills. The researcher told the teachers which sessions to self-monitor, *after* those particular teaching sessions were completed. The teachers were requested to complete scoring each self-monitoring session within 24 hours of the teaching The researcher then collected their completed data collection form. The teachers kept a running record of their progress throughout the self-monitoring intervention.

Following each self-monitoring session, the rates the subjects recorded for their teaching skills were compared to the rates the researcher obtained by scoring the videotape of the same session. This was done in order to assess whether or not the subjects were receiving accurate feedback about their skill levels through self-monitoring.

Results

Table 2 presents rate data for the five dependent variables for Teacher A and Teacher B (all rates except those for contingent reinforcement are rounded to the nearest whole number). During self-monitoring, Teacher A's mean skill rates increased by 19 percentage points for clear signals, 65 percentage points for corrections, and 12 percentage points for student accuracy; they decreased by .4 occurrences per minute for contingent reinforcement; and they stayed the same for pacing. Teacher B's mean skill rates during self-monitoring also increased for clear signals, corrections and student accuracy by 35, 70, and 23 percentage points respectively. Unlike Teacher A, Teacher B's mean rate for contingent reinforcement also increased—by 2.2 occurrences per minute—and her mean pacing rate decreased—by 6 responses per minute.

Figures 1 to 5 illustrate the changes in skill rates for the five dependent variables across baseline and self-monitoring phases for Teachers A and B.

For the percentage of clear signals per observation

Table 2. Means and Ranges of Teaching Skill Rates During Baseline and Self-Monitoring

Teaching Skill	Teacher A				Teacher B			
	Baseline		Intervention		Baseline		Intervention	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Clear Signals	68%	39-89%	87%	63-93%	48%	26-65%	83%	72-89%
Pacing	13	10-17	13	9-17	19	13-24	13	11-16
Corrections	5%	0-13%	70%	50-88%	0	0-3%	70%	56-87%
Cont. Reinforcement	3.3	1.8-4.5	2.9	1.8-4.4	2.2	1.3-3.4	4.4	3.4-5.8
Student Accuracy	70%	62-76%	82%	62-90%	52%	41-70%	75	59-85%

Figure 1. Percentage of Clear Signals per Observation Session for Teachers A and B.

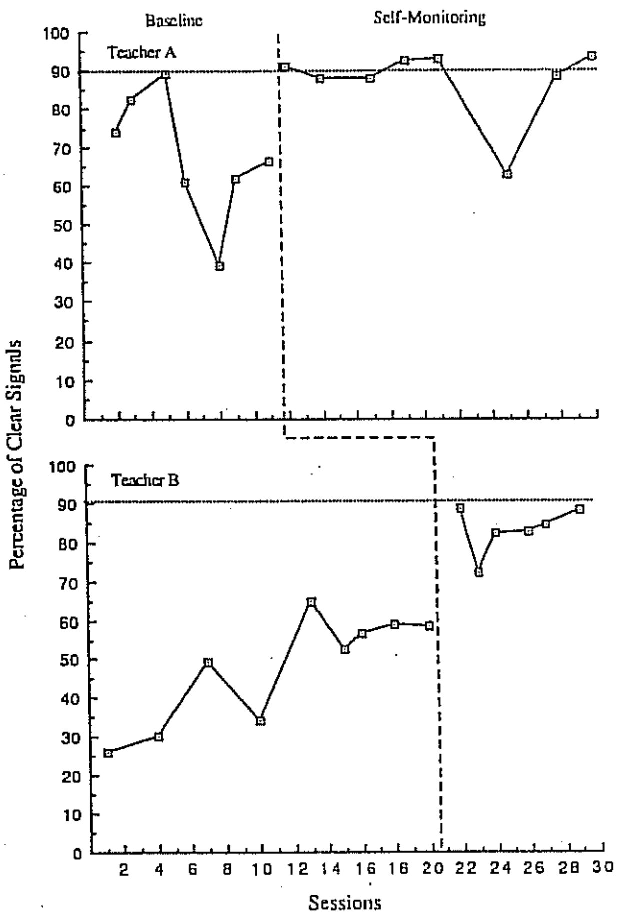
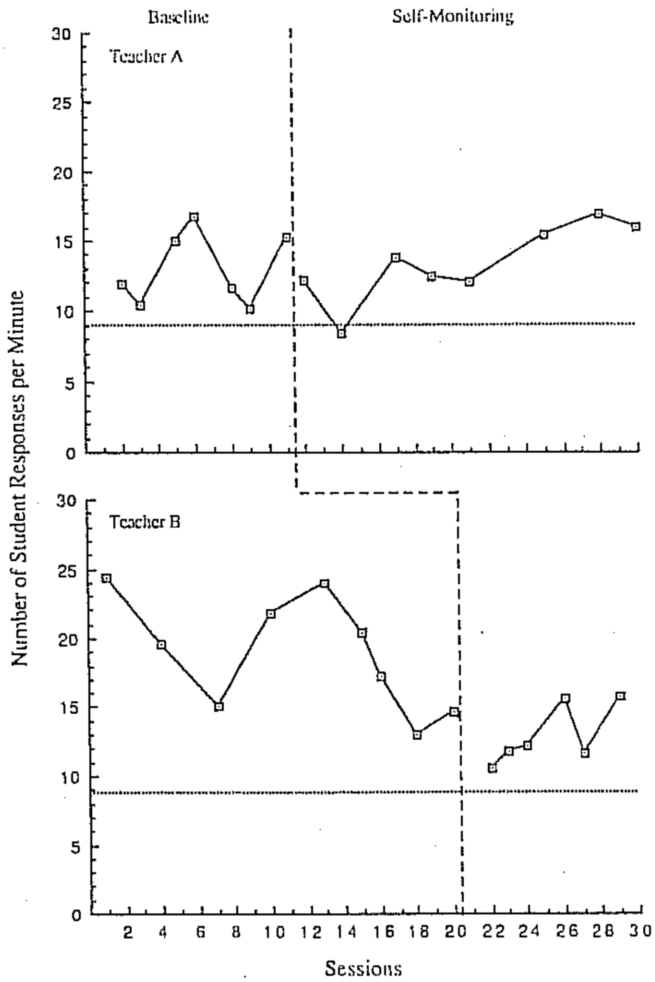


Figure 2. Number of Student Responses per Minute (Pacing) per Observation Session for Teachers A and B.



session (Figure 1), there was a great deal of variability in Teacher A's performance during baseline followed by an immediate rate increase at the onset of self-monitoring with subsequent generally stable, criterion level performance thereafter in this phase. Teacher B's clear signalling performance began far below the criterion during baseline and was followed by an upward trend in this phase, but immediately increased substantially to near criterion level at the onset of self-monitoring and remained near that level thereafter in Phase 2.

For the number of student responses per minute (pacing) per observation session (Figure 2), Teacher A's rate was about the same, and was generally above the criterion level, during both baseline and self-monitoring; however, during self-monitoring there was a gradual upward trend in the rate with less variability. Teacher B's pacing rate was also above the criterion level during both phases of the experiment; however, it was highly variable during baseline and lower, but much less variable and in an upward trend, during self-monitoring.

For the percentage of student errors corrected per observation session (Figure 3), both teachers' rates were stable at near zero levels during baseline and both increased dramatically at the onset of self-monitoring. The rates generally continued in an upward trend during this phase, approaching and exceeding the criterion level at several points.

For the number of occurrences of contingent reinforcement per observation session (Figure 4), Teacher A's rate was usually close to or above the criterion level during both baseline and self-monitoring. Teacher B's rate was usually below the criterion level during baseline. It immediately increased at the onset of self-monitoring and remained consistently above criterion level performance thereafter.

For the percentage of correct student responses (student accuracy) per observation session (Figure 5), both subjects' rates were fairly stable and below the criterion level during baseline, both immediately

Figure 3. Percentage of Student Errors Corrected per Observation Session for Teachers A and B.

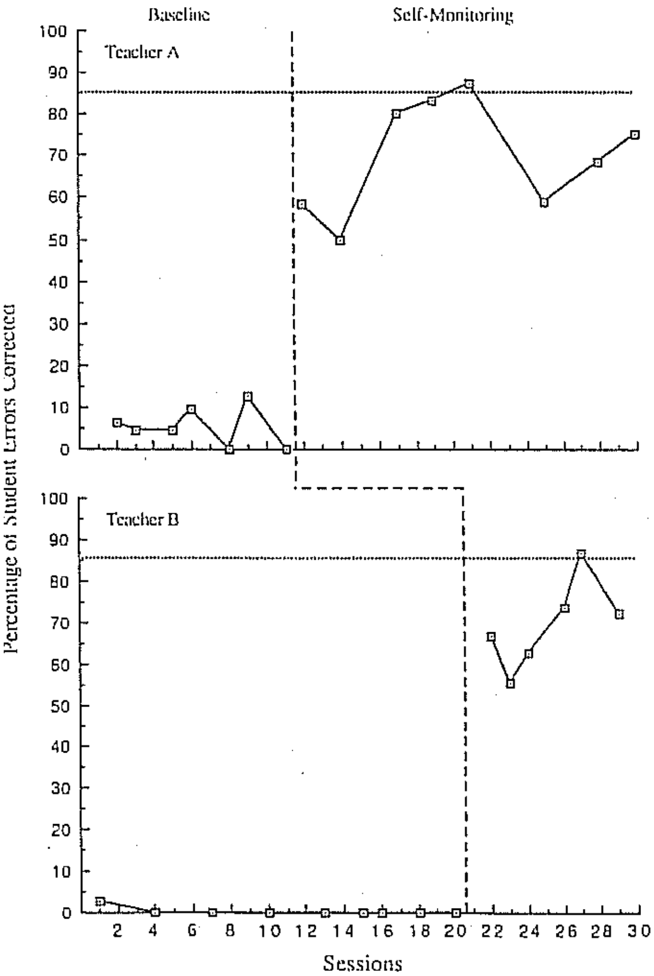
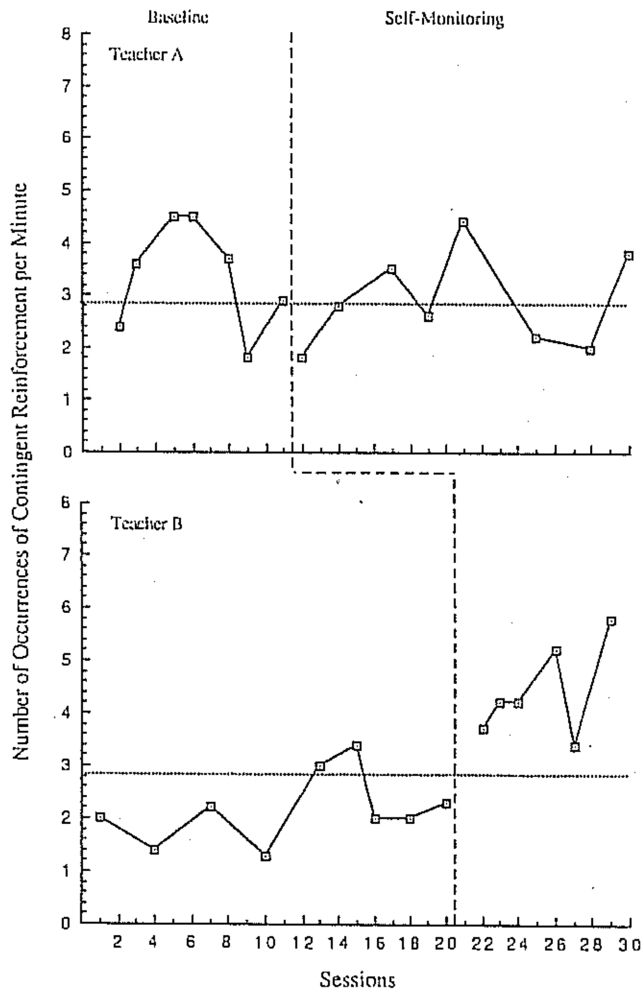


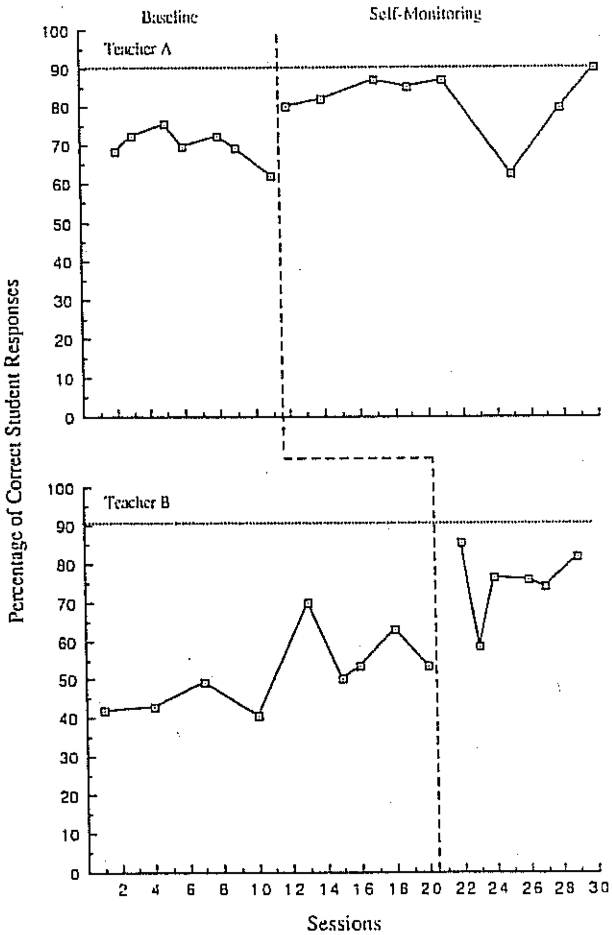
Figure 4. Number of Occurrences of Contingent Reinforcement per Minute per Observation Session for Teachers A and B.



increased to near criterion upon onset of self-monitoring, and both remained fairly stable for the duration of Phase 2.

Teacher A self-monitored 6 teaching sessions and Teacher B self-monitored 4. Table 3 presents the mean *absolute differences*(+ or –) and the range of differences *between the subjects' recorded rates and the experimentally observed rates. Negative range amounts indicate subject-recorded rates that were lower than experimentally observed rates,* and positive amounts indicate the opposite. With contingent reinforcement and pacing, the subjects usually scored themselves lower; with clear signals and student accuracy, they scored themselves higher and lower approximately an equal number of times. The major discrepancy between subject-derived and experimentally-derived rates was with *corrections.* The subject-derived rates were usually much higher, particularly in the earlier sessions. Therefore, the decision was made to give the subjects feedback regarding this discrepancy following the first two sessions of self-monitoring for each subject (i.e., after Session 14 for Teacher A and after Session 24 for Teacher B). It was thought to be unlikely that the subjects' skill with corrections would improve more if they did not see the need for more improvement. The feedback consisted of informing the subjects of the discrepancy and reminding them of what constituted a proper correction. This, of course, added another component to the self-monitoring technique.

Figure 5. Percentage of Correct Student Responses (Student Accuracy) per Observation Session for Teachers A and B.



Subject Satisfaction

Assessment of the teachers' satisfaction with the self-monitoring technique was done using a questionnaire which asked them the following questions:

1. What are your likes and dislikes regarding the self-monitoring technique?
2. Did you find the troubleshooting checklist to be helpful in self-monitoring or did you rarely or never use it?
3. Was self-monitoring too time-consuming?
4. Are you still using the technique, or, if not, do you plan to use it again in the future?

The teachers reported that the technique is fast, easy to use and "keeps you consistent with the format." They said the scoring worksheets made it easy to observe progress and focus on areas that needed improvement. The only dislike mentioned was that the technique "points out how difficult it can be to stay with the format when you have resistant learners." Both teachers reported that they used the troubleshooting checklist and one said it made improvement easier. One teacher stated that the technique was not overly time-consuming and the other reported that at the beginning it was too time-consuming, but took less time with practice. To date, neither teacher has self-monitored since the study ended because of "time and equipment constraints at the end of the school year." However, both teachers reported that they plan to use the technique at the beginning of the next school year and thereafter.

Discussion

The results of the present study indicate that audiotape self-monitoring is a viable method of assisting teachers in improving and maintaining teaching skills that are critical to the effectiveness of Direct Instruction programs. Both teachers improved all of the skills they were performing at below-criterion levels prior to beginning self-monitoring. With corrections, both teachers improved dramatically.

The teachers were able to measure most of their teaching skills fairly accurately using audiotapes of their teaching sessions. This is a noteworthy finding considering the relative ease of using an audiotape recorder versus using videotaping equipment. The data also indicate that there is some room for error within the teachers' scoring of their skills. Self-monitoring was effective despite discrepancies between subject-derived and experimenter-derived rates. However, it is unlikely that this would be as true had the experimenter not given the subjects feedback about their substantial scoring discrepancy on the corrections skill continued. It appears necessary to have an outside observer monitor the accuracy of the teachers' scoring after

Table 3. Means and Ranges of Differences Between Subject-Reported Skill Rates After Self-Monitoring and Experimentally Observed Rates for the Same Sessions

	Teacher A		Teacher B	
Teaching Skill	**Mean**	**Range**	**Mean**	**Range**
Clear Signals (%)	2.7	-7.0 to +3.0	5.9	-5.5 to +8.9
Pacing (Rep. per min)	3.2	-5.6 to +1.7	3.1	-5.5 to -1.1
Corrections (%)	34.8	-42.8 to +75.0	10.5	-6.7 to +22.3
Cont. Reinforcement (Per min.)	0.7	-1.7 to +0.5	0.4	-0.6 to +0.6
Student Accuracy (%)	5.1	-6.4 to +16.1	5.2	-8.6 to +4.9

Effectiveness of Visual Imagery Versus Rule-based Strategies in Teaching Spelling to Learning Disabled Students*

by Craig Darch
Robert Simpson, Auburn University

There is a growing awareness that for instructional models to be effective with learning disabled students in rural settings, academic programs must be tailored specifically to meet the needs of those students. Parks, Ross, & Must (1982) assessed the current research in rural education and concluded that it is important to "develop distinctly rural models for providing students with adequate curricula and service" (p. 185). Because the development of rural special education programs present educators with a unique set of curriculum design problems, studies are needed that evaluate the effectiveness of various instructional approaches for learning disabled students in rural areas.

Teaching spelling to students in the elementary grades is an instructional area that has received considerable attention in the literature in recent years (Graham, 1983). Unfortunately, much of this work has been non-experimental in nature. Authors have often recommended spelling-instruction approaches without research studies to support their claims of effectiveness. In response to this paucity of instructional research, both researchers and practitioners have emphasized the need for carefully controlled studies designed to evaluate the effectiveness of various approaches to spelling instruction (Englert, Hiebert, & Stewart, 1985).

The interest in spelling research is particularly lively in the area of learning disabilities. Although most students with learning disabilities have difficulty with all forms of written expression, spelling problems rank as some of the most difficult to remediate and are common among learning disabled students (Demaster, Crossland, & Hasselbring, 1986). In fact, several researchers (Deshler, Schumaker, Alley, Warner, & Clark, 1982) have indicated that problems with spelling effectively discriminate between learning-disabled adolescents and other low-performing students. Although, as Graham and Freeman (1985) state, "spelling instruction has received little attention in the research literature" (p. 267), descriptive studies have been published in which the spelling abilities of learning disabled and non-learning disabled students have been addressed and compared.

Several researchers have focused on the performance deficits of learning disabled students and have suggested that the spelling problems exhibited by these students can be attributed to structural or ability deficits (Graham & Freeman, 1985). Recently, however, studies have indicated that LD students' spelling difficulties are a function of strategy-production deficits (Gerber, 1986; Nulman & Gerber, 1984). Research that evaluates the types and causes of strategy deficits are important to the development of an effective technology of spelling instruction. For example, if the problems learning disabled students exhibit in spelling are a function of strategy deficits, then effective spelling instruction should include teaching students specific spelling strategies, and then provide practice in applying these strategies to a variety of words. Indeed, Bailet and Lyon (1985) asserted that "deficient rule application, either alone or in combination with other processing difficulties, can cause spelling difficulties" (p. 164). If this assertion is correct, then more studies that evaluate the effectiveness of various strategy approaches to spelling instruction are sorely needed. Unfortunately, few have been reported to date.

The purpose of the present study was to investigate the relative effectiveness of two different approaches for teaching spelling to rural fourth grade learning disabled students. One group of students was taught spelling with a visual-imagery mnemonic, while the other group was presented with rule-based spelling strategies. Both of these approaches were designed to teach students a spelling strategy; however, the two strategies differed greatly. A visual-imagery strategy is a generic method that can be applied to any word-type that students are taught. If found to be a successful technique, visual imagery would be a relatively cost-effective instructional method to implement in most classrooms. In addition, teachers would find it appealing because visual imagery is easy to implement. Several researchers have suggested that because of the cognitive deficits exhibited by LD students, techniques like visual imagery, which help the student focus his/her attention to a task, may be helpful (Rose, Cundick, & Higbee, 1983). To date, no spelling research investigating the effectiveness of visual imagery with el-

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ementary grade LD students has been reported. However, Sears and Johnson (1986) investigated the effects of using a visual-imagery strategy for spelling instruction of non-handicapped fourth to sixth graders. Results of this study indicated that a visual-imagery approach was superior to an auditory treatment in which students were taught to focus on the relationship of the sounds in each word. Sears and Johnson suggested that, because spelling is a visual activity, approaches to spelling instruction which are primarily auditory in nature will not be as effective as visually based approaches.

If this conjecture is true, it is suggested that teaching students with explicit rule-based strategies may be less effective than imagery-based mnemonics. Recently, however, results of studies designed to evaluate the effects of strategy training with learning disabled students have been reported that suggest otherwise. In one study, Graham and Freeman (1986) examined strategy training in the context of several experimental conditions. The results of their study indicated that LD students who were taught a five-step study strategy spelled more accurately than did control subjects. These authors concluded that "LD students' spelling difficulties are associated with problems in self-regulation of organized, strategic behavior" (p. 15). It should be noted that the Graham and Freeman study did not compare the effectiveness of teaching LD students different spelling strategies.

Robinson and Hesse (1982) studied the differential effectiveness of the Spelling Through Morphographs Program with low, average, and high performing seventh graders. Spelling Through Morphographs (Dixon & Engelmann, 1979) involves a rule-based strategy approach that is similar to the structure of the spelling approach used in the Spelling Mastery treatment utilized in the present study. Results of their study indicated that low and average ability students who received instruction based on a rule-based strategy approach displayed significant spelling achievement gains when compared to controls. When the performance of the high-achieving students was evaluated, less success was found. The results of this study have implications for designing spelling programs for learning disabled students and led to the design of the present study.

Method

Subjects and Setting

The subjects for this study were 28 learning disabled students who attended a university-based summer program located in the rural southeast. Each of the students participating in this study had a history of low-academic achievement. In the summer program, the students received remedial instruction in a variety of academic areas.

Of the 28 subjects, 7 were black and 21 were white. Twelve females and 16 males participated in the study. The mean age of the entire sample was 10 years, 6 months. The mean full scale IQ for the entire sample was 92. The subjects had been placed in programs in their local districts based on both federal and state guidelines for learning disabilities. These guidelines required that identified students demonstrate at least average potential as measured by a standardized intelligence test and exhibit a significant discrepancy in one of the major academic areas.

All subjects were administered the spelling subtest of the Wide Range of Achievement Test (Jastak & Jastak, 1984) as a pretest. This test was individually administered approximately 1 week before beginning the experimental interventions. Relative to grade placement, the spelling achievement of the total sample of students was low (spelling grade level mean = 3.7). Although there were slight differences in spelling achievement between the two group the result of a t-test for independent samples indicated that these differences were not significant ($p > .05$).

Four graduates students completing their training program served as examiners and experimental teachers. To control for potential teacher bias effects, teachers were randomly assigned to either the Spelling Mastery Group or the Visual Imagery Group. After the teachers had been randomly assigned to their instructional group, each teacher met individually with the senior author for training in how to implement their respective spelling program. The senior author met with each teacher twice for approximately 1 hour each time. During these training sessions, the correct instructional procedures for the appropriate spelling program were modeled. Through role playing, the teachers practiced the instructional procedures and were critiqued by the senior author. All teachers were judged to have mastered their respective instructional strategies.

Subject Assignment, Instructional Materials, and Procedures

In order to compare the relative effectiveness of two different approaches for teaching spelling, fourth grade LD students were randomly assigned to either a group which received instruction involving visual imagery or a group receiving rule-based spelling instruction. To increase the external validity of this study, each instructional intervention lasted for approximately 6 weeks, and instruction was provided to students in groups.

To ensure internal validity of this study, certain aspect of the instructional presentation were controlled across both groups. For example, students in both treatment groups received instruction for 25 days. Length of these daily instructional sessions was also comparable, about 25-30 minutes per treatment group. Additionally, the spelling words used in each of the treatment groups were identical, consisting of the practice words that were presented in the Spelling Mastery Program. Lessons for the Visual Imagery group were developed around these words. Lessons for both the Spelling Mastery Group and the Visual Imagery Group were scripted which allowed for the individual treatments to be implemented uniformly and appropriately.

In spite of the similarities, there were several critical curriculum design differences between the two instructional groups. In the Spelling Mastery Group, the students were taught spelling with the use of explicit rule-based strategies. The three major strategies taught to this group of students were: (a) morphemic analysis, (b) phonemic analysis, and (c) spelling rules. In addition, students in the Spelling Mastery group were provided with specified teacher-directed corrections during spelling instruction.

Spelling instruction in the Visual Imagery Group was vastly different and was based on the visual imagery model presented by Sears and Johnson (1986). In this approach students were not provided with the strategy training that students in the Spelling Mastery Group received. Instead, these students were taught a generic visual imagery framework that could be applied to words of any type. In addition, students in this group did not receive the systematic strategy based corrections utilized in the Spelling Mastery Group.

Spelling Mastery Program

Students in this treatment group received spelling instruction based on Level C of the Spelling Mastery Program (Dixon & Engelmann, 1979). This commercial program contains 137 lessons and is designed to improve the spelling skills of fourth grade students by teaching curriculum based spelling strategies. Students in this treatment group received instruction on selected lessons through lesson 40 in the program. The Spelling Mastery Program, like other similarly designed direct instructional programs (Gersten, Woodward, & Darch, 1986), has scripted lessons, so that the teacher is provided specific directions concerning how to implement the lessons and what to say to the students. The most significant curriculum feature of this instructional treatment is the teaching of spelling via carefully crafted learning strategies. In all, three salient strategies were taught to students in this group. Students were first taught the meaning of a morphograph and then were instructed to identify the component morphographs in words. Once this skill was developed, students were presented with extensive practice spelling words composed of these morphographs. In Table 1 an example of one of the lesson formats designed to teach students a morphographic analysis strategy is presented. As can be observed, students are presented with words which are composed of at least two morphographs. The students are asked to first identify each of the morphographs in the word and then to spell the complete word. This basic strategy was applied to several words.

Figure 1. Sample Spelling Mastery Strategy for Teaching Morphographic Analysis

1. Find Part D on your worksheet. Get ready to write some words that have more than one morphograph.
2. First word: breakable. What's the first morphograph in breakable? *Signal*. Break. Next morphograph? *Signal*. A-b-1-e.
3. Write breakable.
4. Next word: restlessness.
   What's the fist morphograph in restlessness? *Signal*. Rest.
   Next morphograph? *Signal*. Less.
   Next morphograph? *Signal*. Less.
5. Write restlessness.
6. For misjudge, refillable, unkindness, and charming, have students identify each morphograph and write each word.
7. Correct Part D.

Taken from Dixon & Engelmann (1979, Level C, *Spelling Mastery Program*).

Another strategy used with this treatment group was teaching students to apply phonemic analysis to spelling. With this strategy a student was first provided a rule and then was asked to apply this rule to a carefully sequenced group of practice examples. Finally, students were taught several spelling rules that allowed for systematic application of spelling rule taught to students is the rule for dropping the final e in a word (e.g., value/valuing)

Visual Imagery Group

Students in this treatment group received spelling instruction based on the visual imagery model discussed by Sears and Johnson (1986). Students were presented with the same practice words that the students received in the Spelling mastery group, about 15 words per lesson. Because instruction occurred in groups, an overhead projector was used to present spelling words to the students. When a word was presented, the students were directed to look at the word and apply a four step visual imagery model. This was done by the teacher who implemented the following procedure: (1) after covering the word the teacher asked the students if they could see the image of the word in their mind; (2) the students were then directed to imagine the word displayed on a large outdoor screen; (3) next, the students were asked to imagine each letter of the word pasted onto the screen; and (4) finally, the students were told to help themselves to remember the word by visualizing themselves nailing the letters of the word onto the screen.

This procedure was used with the first several words presented to the students. Once the students had completed the teacher guided part of the lesson they were asked to apply the visual imagery strategy, without teacher assistance, to several words from a list that had been passed out by the teacher. Typically, the list contained five to seven words. This independent practice was closely monitored by the experimental teacher and typically required 5 to 8 minutes. Once the students had completed this independent activity, and if there was still time left in the session, the students were directed to practice the visual imagery model on the words that appeared on the overhead screen.

Dependent Measures

There were three types of dependent measures used for this study. First, spelling was assessed with three unit tests that were administered approximately every 8 to 10 lessons. The purpose of these short tests was to evaluate the student's ability to spell a selected set of words presented in the lessons. The second measure was a posttest, comprised of words from the entire instructional unit. The third measure, *The Test of Written Spelling* (Larsen & Hammill, 1986), was administered to evaluate whether there were differences in the two instructional approaches on a broader, more comprehensive measure of spelling achievement. These dependent measures are discussed in more detail below.

Unit tests

At the end of approximately every 9 lessons a 10-item test made up of randomly selected words from the unit, was administered to all subjects. These tests were administered to the students as a group. All students had as much time as necessary, the rate of presenting the words was slowed to allow students to have time to apply their particular strategy to a test word. In total, there were three unit spelling tests administered during this study.

Posttest

After completion of the entire instructional program, students in both groups received a comprehensive posttest consisting of the words the students learned in each spelling program. In order to ensure that students were tested on a representative range of word-types presented in the programs, 25 words were randomly selected for inclusion on this posttest. The test was administered on the day following the last day of instruction. The testing procedure for the posttest was the same as that used for the unit tests. Testing was done in groups with students given as much time as necessary to apply their particular strategy to a test word. Students were not assisted by the teacher if they had difficulty with a word. If students asked for help, they were told to attempt to apply the techniques they had learned in the spelling group.

Test of Written Spelling

The Test of Written Spelling (*TWS*) (Larsen & Hammill, 1986) was administered to students in each of the instructional groups the day following the last day of intervention. The *TWS* was chosen for this study because the test is designed to assess students' spelling performance on both predictable words (e.g., rule-governed) and unpredictable words (e.g., not rule-governed). Therefore, it was possible to determine if there existed an interaction between word-type (predictable vs. unpredictable) and type of strategy instruction. Students were tested as a group by their respective teachers.

Results

Examination of Table 1 indicates clear differences between the performances of the two experimental groups. The students taught in the Spelling Mastery Group performed similarly on each of the probe measures. The range of performance for this group

Table 1. Means and Standard Deviations for Number of Correct Spelling Words on the Probe Measures

	Treatment			
	Spelling Mastery		Visual Imagery	
Test	M	SD	M	SD
Probe 1a	7.9	1.5	4.7	2.0
Probe 2a	7.2	1.3	5.0	1.6
Probe 3a	7.8	1.2	4.6	2.0

Probe test scores are based on 10 possible items

was 70% to 78% words spelled correctly. The Visual Imagery Group performed consistently as well, however, their performance was appreciably lower. The Visual Imagery Group scored at 47% correct on prove 1, 50% correct on probe 2, and 46% on probe 3. Results of a 2 x 3 (group x test) repeated measures ANOVA indicated a significant main effect favoring the Spelling Mastery group, $F(1, 26) = 33$, $p < .01$. There was no significant test effect, nor was there a significant interaction.

The results of each group on the 25-item posttest along with the scores on the Test of Written Spelling for the subtests of predictable words (e.g., rule-governed words) and unpredictable words (e.g., irregular words) are presented in Table 2. The results of the posttest are consistent with the results of the probe measures. As can be seen in Table 2, the average score on the posttest was 17 words correct (68%) for the Spelling Mastery Group, while the Visual Imagery group averaged 11 words correct (44%). There was a similar pattern of results on each subtest on the *Test of Written Spelling*. When the groups' performance on the Predicted Words subtest is considered, the Spelling Mastery Group scored higher than the Visual Imagery Group (29 words correct for the Spelling Mastery Group versus 24 words correct for the Visual Imagery Group). Similar results, favoring the Spelling Mastery Group, occurred on the Unpredictable Words subtest (15 words correct vs. 11 words correct). Multiple Analysis of Variance (MANOVA) procedures were used to evaluate the effect of student performance on the three dependent variables: (a) the 25-item posttest, (b) the predictable words subtest form the TWS, and (c) the unpredictable word subtest form the TWS. The results of the MANOVA indicated that there were significant differences between the Spelling Mastery Group and the Visual Imagery Group, $(2, 24) = 9.87$, $p < .01$. Separate one-way analyses of variance were calculated for each of the three dependent variables to determine where these differences occurred in each analysis ($p < .01$) there was a significant difference favoring the Spelling Mastery Group on each dependent measure.

Table 2. Means and Standard Deviations for Number of Correct Spelling Words for the Posttest and Predictable, Unpredictable for the Test of Written Spelling

	Treatment			
	Spelling Mastery		Visual Imagery	
Test	M	SD	M	SD
Post test	17.5	3.8	11.7	4.1
Predictable words	29.2	4.2	24.0	4.2
Unpredictable words	15.2	4.2	11.2	2.0

Posttest scores are based on 25 possible items.
Predictable word subtest scores are based on 35 possible items.
Unpredictable word subtest scores are based on 25 possible items.

Discussion

Results of the present study indicate that the students taught with an explicit rule-based strategy approach outperformed students who were presented with a visual imagery spelling strategy. This finding is important for two reasons. First, it will help teachers in rural settings make informed instructional decisions when developing new spelling programs for disabled students. Rule-based spelling strategies, when presented with explicit teacher modeling and detailed correction procedures, are superior to approaches that fail to teach students how to use a specific approach for different word-types. Because rural school districts serve a disproportionate number of special education students, effective and cost efficient instructional models are desperately needed so that teachers can improve the academic performance of learning disabled students. The results of the present study suggest a model of curriculum design teachers in rural programs can use to modify existing commercial instructional programs.

The outcomes on the three probe measures allow a comparison between the treatment groups on a short-term recall measure. The students who taught to use rule-based spelling strategies performed in the 75% correct range (see Table 1). Conversely, the students who were taught to use a visual imagery strategy scored much lower, in the 50% correct range. Although the students in the rule-based strategy group scored higher, it is important to note, however, that they did not perform at a mastery level. Several researchers have demonstrated that for learning disabled students to apply learning strategies effectively, in unprompted contexts, these students must be given extensive practice in applying these strategies. Although the *Spelling Mastery Program* provides practice in the application of spelling rules, the amount of practice that was provided in the present study was inadequate. The typical learning activity in the *Spelling Mastery Program* requires that the students work with that teacher on several words, practice applying the appropriate rule, then work independently on three to five words. Learning disabled students will likely require many more practice examples to achieve mastery.

Analysis of the posttest results also for a comparison between the experimental groups on a measure that was designed to assess spelling retention across 25 days of instruction. Because previous researchers have confirmed the memory problems of learning disabled students (Geizheiser, Solar, Shepard, & Wozniak, 1982), the performance of each group was expected to be lower on the posttest than on the Probe measures. Although each group did perform at a lower level on the posttest (see Table 2), these differences were slight. What is important to recognize, however, is that the students who were taught with rule-based strategies significantly outperformed the students in the Visual Imagery Group. This result supports the assertion that teaching LD students rule-based spelling strategies, in a direct instruction format, is a superior instructional method when long-term retention is evaluated. Students in the Spelling Mastery Group were able to apply spelling strategies to new, untaught words. Even though rule-based strategies can be rather detailed, and may sometimes be difficult for learning disabled students to apply, this approach was still superior to the visual imagery method.

Research in memory performance of learning disabled children has shown that these students often exhibit retrieval, organizational, and/or selective attention deficits (Tarver, Hallahan, Kauffman, & Ball, 1976). Results of the present study indicate that providing learning disabled students with explicit rule-based strategies enhances the ability of these students to perform on memory tasks. It also seems clear that packaged programs, like the *Spelling Mastery Program*, will probably benefit greatly from modification. Teachers will need to include more guided practice when a strategy is first introduced so that learning disabled students can efficiently apply strategies when working independently. One possible explanation as to why the visual imagery approach may have been less effective is that during the instructional sessions the teacher could not be sure whether the students were actually using the imagery model when they were spelling practice words. In contrast, the students who were taught rule-based strategies were required to apply spelling rules in an overt, observable manner. This allowed the teacher to closely monitor the students and to ensure that they were actually applying the specified strategies. Also, the teacher was able to provide corrective feedback during the learning process, not just correction as to whether a word was spelled correctly. Other researchers have shown the effectiveness of process feedback during instruction (Gersten et al., 1986).

Carpenter and Miller (1982) reported that learning disabled students have difficulty spelling both regular and irregular words. It is therefore important to study whether certain spelling approaches are differentially effective with various types of words. Student performance on the subtests of the *Test of Written Spelling* allow for such an analysis. Because both regular and irregular words were assessed on this instrument, it is possible to determine if an interaction existed between instructional approach and word type. As can be noted in Table 2, the Spelling Mastery Group outperformed the Visual Imagery Group on both subtests; regardless of whether students were assessed on regular or irregular words, the students who learned rule-based strategies performed higher, although the scores for both groups dropped appreciably when irregular words wee assessed (61% correct for the Spelling Mastery Group and 45% for the Visual Imagery Group). When discussing how teachers can help teach LD students to memorize, Gelzheiser, et al. (1983) commented: "...if the goal of the training is generalized improvement in the ability to memorize, simply teaching children a fixed mnemonic will not be adequate" (p. 423). As the results of the present study indicate, teachers who decide to use visual imagery because they think that students will be able to successfully apply this general technique likely will be disappointed in the outcome. ◆

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Linking Special and General Education Services Through Direct Instruction
Moss Point School District
Moss Point, Mississippi

Certainly one of the more common themes in special education is the potential linkage of special and general education services. Consultation models, peer collaboration between teachers, a common curricula, and adaptive teaching strategies are but a few of the proposed solutions to what is, at times, a marriage of inconvenience. Too often, where there is the promise of a meaningful dialogue between special and general education there is also a relentless and mundane exchange of paperwork — referrals, reports from school psychologists, IEPs, letters to parents, and so forth.

But there are occasions when special and general education services are unified, and the two do work in concert. There are even instances where the district's *special education program* dramatically influences its general education practices. Such is the case in the Moss Point School District.

You have to look closely to find Moss Point on the map. This Mississippi gulf coast town, about 30 miles east of Biloxi on the Alabama border, has a handful of elementary schools, two junior highs, and one high school. Of the 6,000 students, almost ten percent of them receive some kind of special education services.

Direct Instruction has been used in Moss Point for over a decade in special education. The reasons for this — and the levels of success — have been fairly typical. Special educators chose an array of DI programs to remedy deficiencies in reading, mathematics, and language. The *Reading Mastery* series, *Corrective Reading* (Decoding and Comprehension), *Spelling Mastery, DISTAR® Arithmetic* and the *Corrective Mathematics* modules, and the *DISTAR Language* programs have been used throughout the day in special education classrooms.

Easing Transfer to the Mainstreamed Classroom

Special educators in Moss Point always have been pleased with the Direct Instruction programs. In a few cases, however, they were perplexed with the performance of a few students. According to Ginger Hollimon, the district's special education director, "Every once in a while one of our special education students was reading just fine in the *Reading Mastery* programs, but had a harder time than the others adjusting to the mainstreamed classroom. The kinds of interactions expected of these few students in the regular classroom made transfer [of reading skills] difficult."

In pull-out classes, the special education students had been taught in very small groups, with ample feedback and direct contact. Naturally, this teacher-student ratio could not be maintained in the mainstreamed class. Deborah Millender, a special education teacher at the time, noted, "They didn't volunteer; they felt intimidated at asking questions; and when they didn't know a word, they just froze."

Special educators addressed this problem by working directly in mainstreamed classrooms as assistants to the regular teacher. They spend most of their time with mainstreamed students and others who were having academic difficulties.

Millender felt that this cooperative assistance helped in many ways. Obviously, the teachers appreciated the assistance during their reading period. But they also began to see how much progress the special education students had made in their Direct Instruction pull-out classes. The recurrent message was that Direct Instruction was effective in teaching low achieving students. Eventually, many saw that the DI curricula addressed *their* needs. As a result, several elementary schools in Moss Point have shifted to a Direct Instruction emphasis in their *regular* primary grades.

Enhancing the Mainstreamed Classroom Through Direct Instruction

In 1978, the general success of the Direct Instruction programs in special education caught the attention of Mary Alfred, principal of East Park Elementary School. Most of her students, although mainstreamed, were academically at-risk. She instituted *DISTAR Reading I, II,* and *III* (the precursors of SRA's *Reading Mastery* series) in the primary grades. Teachers were reluctant to use the new program at first, but the systematic phonics and the obvious student growth by the middle of the year convinced teachers at East Park that Direct Instruction was the best program for their students.

Success in the primary grades carried over into the upper grades. Fifth grade teachers were impressed with the change in the younger students. They too had many students who couldn't read, or whose

Percentile Growth on the California Achievement Test

	Reading		Mathematics		Language	
	4th	6th	4th	6th	4th	6th
1978	12	9	15	1	18	12
1984	45	42	63	51	53	40

reading was borderline. Mary Alfred suggested that the fifth grade teachers use the *Corrective Reading Program.* However, she offered it only under the condition that, if the teachers liked it, they needed to make a commitment to it. In requesting financial support from the superintendent, Alfred told him, "If you give me the funds for the DI programs, I'll guarantee success."

The chart above shows the dramatic change in student performance at East Park for fourth and sixth graders in reading, mathematics, and language. The school once had the lowest level of achievement in the district. Now, Alfred notes, "the majority of the high school honor students come from East Park. We feel that the programs build success, and that students *know* what they can do. It changes their self-esteem. Part of this has to do with the way the programs have taught teachers how to give praise."

In 1985, Moss Point changed its standardized tests to the Stanford Achievement Test. Taking the change in measures into consideration, performance levels have remained the same, or slightly higher.

In the last few years, East Park has implemented even more Direct Instruction. *DISTAR Arithmetic* is used in the first grade and SRA's *Corrective Math* modules are used selectively through the end of the third grade.

Last year another Moss Point school—Kreole Elementary School—followed East Park's model. Most of the students at Kreole, while not as low academically as East Park, still qualified for Chapter I services. *Reading Mastery* was chosen as the core reading program for the first three grades. In the combination third and fourth grade classroom, teachers also use *Spelling Mastery* and *Corrective Math.*

Mary Alfred has good reason to be pleased with the influence she—and in no small way, the district's special education program—has had in the Moss Point Schools. The PTA at East Park has grown from virtually nothing to a vital community organization. Alfred attributes this change to the SRA programs.

"Through the student achievement, we showed parents that school wasn't a place to fear, a place to avoid. Parents are proud in sending their children to East Park. Before, they used to send them to other schools in Moss Point. I think all of this came about through our commitment to kids and changing their self-esteem through better academic abilities."

As a fitting touch to these many accomplishments, Mary Alfred was nominated by her fellow principals for the National Distinguished Principal Award for the State of Mississippi, an honor which she won in 1989. This award was in recognition of her decade of service and accomplishments at East Park.

Against all Odds—*Edison Elementary School Dayton, Ohio*

Remember the late 1960's and early 70's—bell-bottom pants, VW vans, and men on the moon? There were other important events of the day — especially ones in education. Beginning in 1968, a select number of schools throughout the country were participating in what was called Project Follow Through.

This project, one of the most important educational experiments for its size in U.S. history, was an attempt to compare dramatically different approaches to early education for disadvantaged children. The endeavor was an extension of Lyndon Johnson's Great Society and the Head Start Program. One Follow Through site was the inner city schools of Dayton, Ohio.

Direct Instruction, was one of several instructional models studied in the Follow Through Project. It was implemented in three Dayton elementary schools — Edison, Greene, and Louise Troy. In its heyday, the Dayton Follow Through schools had Direct Instruction throughout its K-3 program and a multitude of other services. Community assistance programs taught parents discipline techniques and how to help their children with academics. There were classes on nutrition, exercise, first aid, and drug abuse. Federal monies also sponsored extensive health screening and dental care for school children, as well as an array of other social services (counselors, social workers, day care facilities, and outreach centers).

The impact of the Direct Instruction practices and programs on these three inner city Dayton Schools was considerable. The graphs on the next page show its effect on second and third grade reading scores once full implementation was achieved in the three Direct Instruction schools (Edison, Greene, and Louise Troy) and six other Title I schools in Dayton used as comparisons in Follow Through. The mean percentile growth in reading from 1970 to 1972 for the DI schools consistently exceeds that of the comparison schools.

Equally impressive was the impact of these academic programs on teachers and parents. Thirty-one teachers were interviewed in 1975, seven years after Direct Instruction was introduced to the Dayton schools, and more than enough time had passed for the halo effect of this innovation to have worn off. The chart opposite shows teacher sentiments, which were consistently positive. They saw it as a primary program, not just a supplement to traditional basals. More than anything else, they all saw the value in continuing the program after the Follow Through funding ended.

Parents were equally supportive of the programs. Almost 90% of them felt that the teachers were doing either an excellent or a very fine job. Unsolicited comments recorded in a parent survey attested to the Direct Instruction approach.

"Being in the Follow Through Classes has helped Jackie to improve in her academic progress. It also provided enjoyment while learning, which has helped her to obtain a healthy attitude towards her school studies."

"She [her daughter] feels good. Simply because she is praised for her learnings. She knows more than the others [her siblings] when they were in the first and even third grade."

"Personally speaking, it is a wonderful, wonderful program. I hope my child will be able to stay with it."

"I want to say congratulations on a well needed project. For helping it to work and giving the children their lessons in such a way they enjoy doing them. Keep up the good work and thank you for helping my child."

Since 1975, we've seen the rise and fall of jogging, racquetball, pet rocks, and leveraged buyouts on Wall Street. Fads in education also have come and gone. American education has explored open education, quality circles, LOGO, assertive discipline, learning styles, basic skills, writing across the curriculum, and whole language, to name a few. As one innovation after another passed through Dayton schools, Edison Elementary stuck with Direct Instruction. *Reading Mastery, DISTAR ®Language,* and *DISTAR Arithmetic* have been at the core of their K-3 program for 22 years.

Twice since 1975, Edison has been so successful that the US Department of Education has validated the school as a resource center — eligible for over $90,000 per year in funding for dissemination as an exemplary program. Their years of effort and persistence culminated in 1985, when William Bennett, then Secretary of Education, visited Edison in recognition of its award as a National School of Excellence.

Gail Rowe, Follow Through Director in Dayton since 1968, has been instrumental in keeping Direct

The 1975 Survey of Dayton Follow Through Teachers	percent
Are the curricula [Reading, Language, Arithmetic] adequate?	86*
Are the curricula diagnostic/prescriptive?	100
Does the program provide the teacher adequate assessment procedures for problem identification and correction?	100
Do the programs challenge/ interest the child?	97
Would you select the programs [Reading, Language, Arithmetic] as basic instructional materials if given the choice?	100
If other instructional programs are used as basic materials, would you want to continue using some of the programs for:	
Initial Presentation	93
Supplementary Materials	6
Remediation	53
Do you see a value in continuing to use the materials as the basic instructional programs after Follow Through has phased out?	100

**Percent who rated the programs good, very good, or excellent*

level that attests to the success of Direct Instruction at Edison. Three employees at the school, one teacher and two paraprofessional aides, have been with Direct Instruction since 1968. The story of Euladean Jones, now an Edison teacher, is particularly compelling.

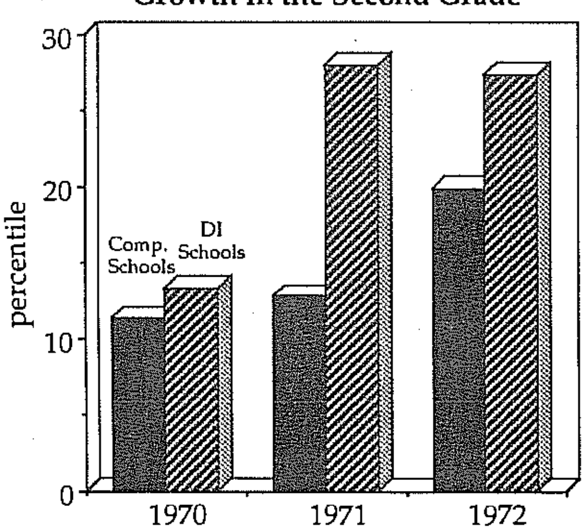
In 1968, Euladean was a parent volunteer at Edison with three children in the primary grades. That year she was hired as an instructional aide, a job she kept for the next 17 years. At first, she didn't know what to expect, "but I was excited to be a teacher. I had always wanted to be a teacher or a nurse." The career development plan in Follow Through allowed her to attend college and in 1985, she received her bachelor's degree and teaching credential from Central State University in Xenia, Ohio.

Today, Euladean still teaches Direct Instruction programs at Edison. In fact, she has seen six of her grandchildren learn to read with Reading Mastery. For Jones, "It's the best program I've ever seen. I still have parents who come back years later to say 'thank you.' For these children to go out of here reading makes all the difference. I am still very excited about Direct Instruction." ◆

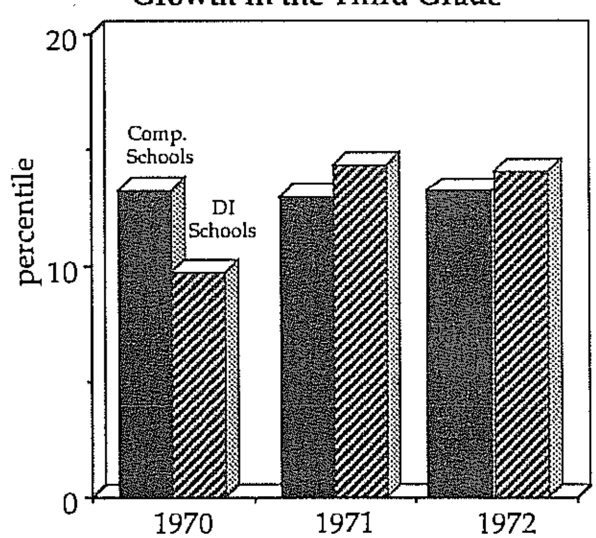
Instruction at Edison Elementary over the last 22 years. She is strongly committed to staying with programs that are effective, ones that she *knows* will improve a student's abilities in reading, mathematics, and language. "We've been able to keep Direct Instruction at Edison in spite of every educational fad that's been in the Dayton schools, not to mention decreased federal funds. Even though the school system [Dayton] has a regular basal program, it realizes that the basal doesn't work for everyone. In fact, sometimes psychologists feel Direct Instruction is a better fit for some students."

Rowe points to other evidence at a more personal

1970 - 1972: Stanford Reading Achievement Growth in the Second Grade



1970 - 1972: Stanford Reading Achievement Growth in the Third Grade



Little Haiti's New Elementary School—Francoise Dominique Toussaint L'Ouverture Miami, Florida

It's natural for school openings to be a bit chaotic, but not many create as much of a stir as Toussaint L'Ouverture Elementary School, in the Miami district known as Little Haiti. Before the school opened, city officials, at the urging of the L'Ouverture Beautification Committee, demolished rundown buildings in the neighborhood, removed abandoned cars, and even cited landlords for zoning violations. With work on the six million dollar building nearly complete, administrators scrambled on the first of July to order literally everything — chairs, desks, books, PE equipment — for the first day of school in September.

The rush to get everything 'just right' was fueled by intense community excitement over the school and its historic namesake. Francoise Dominique Toussaint was an 18th century emancipated slave and Haitian freedom fighter. Rising to the rank of general, Toussaint was given the surname L'Ouverture ("the opening") for the many doors he opened for his people through the successful liberation of Haiti from France. Now, a new school and a statue commemorate this cultural hero.

Toussaint L'Ouverture's facilities are striking. A light and airy courtyard, reminiscent of Haitian schools, complements the school's tropical colors of pastel blue, peach, and yellow. There are special areas for music and art, a computer lab and media center, and spacious patios that give a relaxed feeling to a school of 1000 elementary aged students. Over 85 percent of these students are Haitian, with another 10 percent Hispanic. A child is likely to be bilingual, speaking English and the native language of Creole.

For a community whose parents are largely immigrant and illiterate, but who have high expectations for their children, Toussaint L'Ouverture is a symbol of social advancement. It is a source of community pride. As one parent commented, "This school is very, very good. It's important. It's good for the Haitian people."

Choosing a Reading Curriculum Based on Research

Marietta Mischia, the principal of Toussaint L'Ouverture, has been an educator for 24 years. One might expect her to be only modestly innovative, with a deeper connection to the past, to what has become second nature in over two decades of work in public schools. But this is hardly the case. Mischia chose the school's reading curriculum not by looking back at Earlington Heights, where she was previously a principal, or to what is typically used in Dade County. Instead, she worked with teachers and parents, using research as a basis for their final decision.

"I looked into the research on teaching models and methods. I read about an array of programs, and I'm always looking for new techniques that are effective. The academic performance [at Toussaint L'Ouverture], like so many other inner city schools, is much lower than the norm.

I believe that in the planning process, it's important to involve teachers and parents. I brought in [research] literature that compared different reading programs for our kinds of students, and we concluded that the Direct Instruction Model offered the most."

Mischia orchestrated this decision in the context of a new building, a new staff, and new students. She began staff training in *Reading Mastery* and *Distar Language* in the early fall, and by November, teachers were fully implementing the programs. Kindergarten students began in *Reading Mastery I* and *Language I*. First through fifth grade teachers used the remaining levels in the *Reading Mastery* series.

After seven months, the results are consistent with what Mischia expected — a steady growth toward the norm. While Stanford Achievement Test scores are below average (what one would expect with less than a year of implementation) individual gains have been significant. Mischia notes that over 50 percent of the students dramatically improved in their reading. She plans to track student progress systematically over the next few years, looking at the implementation at Toussaint as a "major applied research project." This attitude toward research as an applied activity, and the belief in curriculum as a key variable in school change, are commendable. They make Marietta Mischia a natural leader among public school administrators. ◆

Effective Instruction in Mathematics—the Role of Basal Programs: A Case Study of Fifth Grade Fractions*

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In 1990 and 1991, nearly all publishers of basal math programs are releasing new editions of their math programs. These new editions reflect the publishers' reaction to the recent furor in math education, crystalized by the new NCTM standards.

This paper compares basal instruction in 1980 editions that did not have time to digest the new NCTM standards and in 1990 editions that reflect the new standards. Two basals, a higher-approval basal and a stronger-pedagogy basal, were selected. We selected the higher-approval basal because it was the only publisher to have its late 1980 versions approved in the three largest adoption states—California, Texas, and Florida. We selected the stronger-pedagogy basal because its 1980 version best exemplified the criteria for instructional effectiveness at the Center for Improving the Mathematics Curriculum for differently-abled students (Dixon, 1990). The criteria have to do with the sequence for introducing concepts, the rate of introducing new concepts, or clarity of teacher communication, the provision of guided practice, and practice opportunities and review.

The purpose of the present paper is to evaluate the pedagogical effectiveness of both versions of these two basals. The question is whether these revisions are effective, professional tools for teachers who are expected to serve an increasingly diverse student population.

First, we compared the 1988 edition of the higher-approval basal and the 1989 edition of the stronger-pedagogy basal. Then we examined the corresponding chapters in the 1991 editions. We studied the teaching of adding and subtracting fractions in the fifth-grade text of each publisher, because understanding of a variety of demanding concepts is assumed and because the algorithm is usually difficult for teachers to teach and for students to learn.

A step-by-step review of the algorithm for adding mixed numbers with fractions that have different denominators reveals a number of component concepts.

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1. Students determine that the fractions cannot be added because the have unlike demoninators. Students determine the lowest common denominator of the fractions. The lowest common denominator of 4 and 6 is 12.

$$\begin{array}{r} 5\frac{3}{4} \\ +\,2\frac{5}{6} \\ \hline \end{array}$$

2. Students rewrite the fractions as equivalent fractions with denominators of 12:

$$\begin{array}{rcr} 5\frac{3}{4} & = & 5\frac{9}{12} \\ +\,2\frac{5}{6} & = & +\,2\frac{10}{12} \\ \hline \end{array}$$

3. Students add the fractions, then the mixed numbers:

$$\begin{array}{r} 5\frac{9}{12} \\ +\,2\frac{10}{12} \\ \hline 7\frac{19}{12} \end{array}$$

4. Students rewrite the answer so the fraction is not an improper fraction:

$$7\frac{19}{12} = 8\frac{7}{12}$$

Student understanding of this algorithm depends on their conceptual grounding in equivalent values. Addition and subtraction of whole numbers are quite different than addition and subtraction of fractions. With whole numbers, the units are always equivalent. With fractions, the units are defined by the denominators and are not always equivalent. Students must understand that such an equivalency must be established before addition and subtraction can take place.

Denominators for the equivalent fractions can be determined by finding the lowest common multiple. This requires the student to know the multiples of each number and find the lowest number that is a multiple of both the numbers. For example, the multiples of 4 are 4, 8, 12, 16...The multiples of 6 are 6, 12, 18, 24 ... The lowest common multiple of 4 and 6 is 12. Finding the lowest common multiple is used to find the lowest common denominator of two fractions.

Once a common denominator has been identified, each fraction must be rewritten as an equivalent fraction, e.g., with $\frac{3}{4}\ \frac{(3)}{(3)} = \frac{9}{12}$, $\frac{3}{4}$ must equal $\frac{9}{12}$ because $\frac{3}{4}$ was multiplied by a fraction equal to one, $\frac{3}{3}$. Fundamental to an understanding of the creation of equivalent fractions is knowing that a fraction multiplied by a fraction with the same numerator and denominator yields a fraction equal to the original fraction.

Other types of equivalency skills are involved in simplifying answers with fractions. In the example above, the original answer was 7 and 9/12, which is equivalent to 7 and $\frac{12}{12}$ and $\frac{7}{12}$. By applying the concept that a fraction with the same numerator and denominator equals one, students rewrite 7 and $\frac{12}{12}$ and $\frac{7}{12}$ as 7 and 1 and $\frac{7}{12}$ or 8 and $\frac{7}{12}$.

Yet another type of equivalency comes into play with a fraction answer such as $\frac{6}{12}$, which equals $\frac{1}{2}$. Two, three, and six are factors of six; two, three, four, six, and and twelve are factors of 12. Six is the greatest common factor of 6 and 12. So the fraction $\frac{6}{12}$ equals another fraction times 6; $\frac{6}{12} = \frac{\square}{\square}\ \frac{6}{6}$. That fraction is $\frac{1}{2}$. Because $\frac{1}{2}$ is multiplied by a fraction equal to one, $\frac{6}{12} = \frac{(1)}{(2)}\ (1)$, or just $\frac{1}{2}$. Six-twelfths is equivalent to one-half.

Sequence of Concepts

The order in which concepts are introduced affects their difficulty for many students.

A sequencing oversight concerning equivalent fractions appeared in both editions of both programs. Equivalent fractions were introduced in the first chapter dealing with fractions; the students must learn to multiply a fraction by a fraction equaling one whole, $\frac{3}{5}\ \frac{4}{(4)} = \frac{12}{20}$. However, in neither program do the students learn about multiplying fractions until a later chapter.

Rate of Introduction of Concepts

The rate of introduction refers to how much new material is presented in the individual lessons in a chapter and in the chapter as a whole. If too much new material is presented in a lesson, the probability of students encountering failure will be high. Likewise, if lesson after lesson presents new, difficult material, students will also have difficulty. The rate of introduction for the two versions of the two programs is portrayed in Tables 1-4.

Multiplication and division. The 1989 and 1991 versions of the stronger-pedagogy basal and the 1991 version of the higher-approval basal introduced a great deal of information in the initial lesson that taught finding the missing number in a pair of equivalent fractions. The lessons in each program presented problems in which the students had to *multiply* by a fraction equal to one to find the missing number and problems in which the students had to *divide* by a fraction equal to one to find the missing numerator.

Multiply	Divide
$\frac{3}{4} = \frac{\square}{20}$	$\frac{8}{12} = \frac{\square}{3}$

The inclusion of both multiplication and division is apt to make the lesson more difficult because it significantly increases the concept load. Introducing just problems with multiplication would significantly simplify the lesson.

Renaming with mixed numbers. Another component concept that is difficult is renaming with mixed numbers.

$$\begin{array}{r} 4\frac{3}{8} \\ -\ 2\frac{5}{8} \\ \hline \end{array} \qquad \begin{array}{r} 3\frac{11}{8} \\ -\ 2\frac{5}{8} \\ \hline 1\frac{6}{8} \end{array}$$

The 1991 version of the stronger-pedagogy basal presented renaming problems in a manner significantly more difficult than the '89 version. In the '89 version of the stronger-pedagogy basal a full page, including 20 practice examples, was devoted to renaming (e.g., $4\frac{3}{8} = 3\frac{11}{8}$) before subtraction problems with renaming were introduced. The next two lessons taught subtracting mixed numbers with renaming. The first lesson had only problems with like denominators. The second lesson introduced problems with unlike denominators.

The '91 version of the stronger-pedagogy basal changed significantly. The page on renaming was eliminated as well as the lesson in which all problems had a like denominator. All that is left in the 1991 edition is the lesson on renaming mixed numbers with unlike denominators. Without the two prepa-

Table 1. The Stronger-Pedagogy Basal—Fraction Concepts

Overview – '89 Version	'91 Version
• To write fractions for parts of objects and parts of sets.	• To review the region and set interpretations of a fraction.
• To find a fraction equivalent to a given fraction.	• To understand equivalent fractions. fraction. To find equivalent fractions by multiplying or dividing.
• To find the greatest common factor of 2 numbers.	• To find the greatest common factor of 2 or more numbers.
• To give the lowest terms fraction for a given fraction.	• To express fractions in lowest terms. To use a variable for a range of numbers. To use the strategy, Use Logical Reasoning.
• To compare and order fractions using fraction bars. To solve problems involving all operations. To find the sum or difference of two fractions with like denominators.	• To compare and order fractions.
• To write improper fractions for mixed numbers. To write mixed numbers for improper fractions.	• To use objects to develop an understanding of improper fractions. • To write improper fractions as mixed numbers and vice versa.

Table 2. The Higher-Approval Basal—Fraction Concepts

Overview – '89 Version	'91 Version
• Write a fraction for part of a whole. Write a fraction for part of a set.	• Write a fraction for part of a whole, part of a set, or a point on a number line.
• Write equal fractions for pictured situations. Find missing numerators or denominators in equal fractions by multiplying or dividing.	• Write equal fractions by multiplying numerator and denominator by the same non-zero number.
• Write fractions in lowest terms.	• Write fractions in lowest terms.
• Write mixed numbers for pictured situations.	• Write mixed numbers for pictured situations and for number-line models.
• Compare fractions and mixed numbers with with the same denominator.	• Estimate with fractions and mixed numbers.
• Use number lines to compare fractions with different denominators and to tell if a fraction is less than 1, equal to 1, or greater than 1.	• Solve problems by working backward.
• Find the least common denominator for two or three fractions.	• Find the least common denominator for two or three fractions.
• Compare fractions and mixed numbers with different denominators.	• Compare and order fractions and mixed numbers with different denominators.
• Write fractions or mixed numbers to give the lengths of objects to the nearest half, fourth, or eighth inch.	
• Divide whole numbers and give the answer as a mixed number.	
• Solve problems by interpreting remainders.	• Solve problems by interpreting remainders.
• Write improper fractions for mixed numbers.	
• Write mixed numbers for improper fractions.	
• Write decimals for fractions or mixed numbers and write fractions or mixed numbers for decimals.	• Write decimals for fractions or mixed numbers, and write fractions or mixed numbers for decimals.

Table 3. The Stronger-Pedagogy Basal—Addition and Subtraction of Fractions

Overview – '89 Version	'91 Version
	• To add and subtract fractions with like denominators.
• To find the least common multiple of two fractions.	• To find the least common multiple of 2 or more numbers.
	• To add and subtract unlike denominators, using objects.
• To find the sum of two fractions with unlike denominators. To find the difference of fractions with unlike denominators.	• To add and subtract fractions, unlike denominators.
	• To recognize problems that have no solution.
	• To choose techniques for estimating with fractions.
• To add and subtract mixed numbers without renaming.	• To use objects to add and subtract mixed numbers. To add mixed numbers. To subtract mixed numbers.
To rename a mixed number with a fraction part that is an improper fraction. To add mixed numbers and rename the sum in lowest terms.	To add and subtract fractions and mixed numbers
To rename a mixed number as a whole number and improper fraction.	To select a method for fraction computations.
To subtract mixed numbers with renaming of fractions with like denominators.	To collect, organize, and present data.
To subtract mixed numbers with renaming of fractions with unlike denominators.	
To add and subtract whole numbers, mixed numbers, and fractions.	

ratory lessons in the 1989 version, the lesson that introduced subtracting mixed numbers with renaming will be much more difficult in the '91 version.

LCM and GCF. Lowest common multiple and greatest common factor are two concepts that can be easily confused. To find the lowest common multiple of two numbers, the students say the multiples of each number and examine both sets of multiples to find the lowest number in both. To find the greatest common factor of two numbers, the students must determine the factors of each number and select the largest. The least common multiple of 8 and 12 is 24. The greatest common factor of 8 and 12 is 4.

In the '88 version of the higher-approval basal, only three lessons separated the lesson that introduced GCF and the lesson that introduced LCM. In the '91 version of the higher-approval basal, an additional lesson was added, resulting in a separation of four lessons. Introducing LCM and GCF in such proximity increases the likelihood of confusion.

In the '89 version of the stronger-pedagogy basal program, there were five lessons between the introduction of GCF and LCM. In the '91 version of the stronger-pedagogy basal, the number of lessons between the introduction of GCF and LCM increased to eight.

Mixed numbers. The '89 version of the the higher-approval basal program precedes adding and subtracting fractions with mixed numbers with a lesson in which students are taught to add fractions with the same denominator, not a very hard skill. The second lesson introduces another relatively easy skill,

Table 4. The Higher-Approval Basal—Addition and Subtraction of Fractions

Overview – '89 Version	'91 Version
• Add two fractions with the same denominator.	• Add two fractions with the same denominator.
• Add two mixed numbers with the same denominator.	• Subtract fractions with the same denominator.
• Add two mixed numbers with the same denominator and rename the sum.	• Add and subtract two mixed numbers with the same denominator.
• Add two fractions with different denominators.	• Add mixed numbers with the same denominator and rename the sum.
• Add two mixed numbers with different denominators.	• Subtract a mixed number or a fraction from a whole number.
• Add three fractions and/or mixed numbers.	• Subtract mixed numbers with the same denominator, using renaming.
• Subtract fractions or mixed numbers with the same denominator.	• Add and subtract fractions for which one denominator is the least common denominator.
• Subtract fractions or mixed numbers from whole numbers.	• Solve problems by using more than one strategy.
• Subtract mixed numbers with the same denominator, using renaming.	• Add two or more fractions with different denominators.
• Subtract fractions with different denominators.	• Subtract fractions with different denominators.
• Subtract mixed numbers with different denominators.	• Add mixed numbers with different denominators.
• Solve word problems by choosing addition, subtraction, or multiplication of fractions and mixed numbers.	• Subtract mixed numbers with different denominators. Solve problems by solving simpler problems.

adding mixed numbers in which the fractions have the same denominator. The third lesson, however, introduces a skill that is more difficult. The students have to add two mixed numbers, then simplify the sum, e.g.,

$$3\frac{2}{5} + 5\frac{4}{5} = 8\frac{7}{5} = 9\frac{2}{5}$$

In the fourth lesson, adding fractions with unlike denominators is presented, a difficult skill. In the fifth lesson, another very difficult skill is presented, adding mixed numbers with unlike denominators and simplifying the sum, e.g.,

$$28\frac{1}{2} + 6\frac{5}{6} = 35\frac{1}{3}$$

Unless a teacher has been quite careful in providing adequate practice and very carefully monitoring of students, it's likely that a significant portion of the students would be overwhelmed at this point in the program.

The sequence in the 1991 version of the higher-approval basal is even more challenging. The chapter began with a lesson on adding fractions with the same denominators followed immediately by a lesson on subtracting fractions with the same denominator. Moving up the lesson on subtracting fractions allows for earlier discrimination practice between adding and subtracting; however, this positive aspect is negated by what comes next. After a rather simple lesson on adding and subtracting fractions with like denominators, the next lesson adds mixed numbers with carrying, which is immediately followed by two lessons on working subtraction problems with borrowing, e.g.,

$$12\frac{3}{5} - 8\frac{4}{5}$$

Then adding and subtracting fractions with different denominators is introduced and taught over three lessons. Finally, addition and subtraction of mixed numbers that have fractions with unlike denominators is presented. By his time it is likely that many students may be quite confused.

Clarity of Teacher Communication

The role of the teacher's manual is to help the teacher explain new concepts in a clear, concise manner. Teachers need a tool that will prompt them as to what to say and do to ensure that they are communicating in a clear manner that facilitates student understanding. Neither program provides specific suggestions.

Explanations. The 1989 version of the stronger-pedagogy basal program relied mainly on the teacher explaining problems that were illustrated in the student text. A typical direction to the teacher appears below. It's taken from the page on which the algorithm is first introduced.

> **Lesson Development.** Write the problem
>
> $$\frac{7}{8} - \frac{2}{3}$$
>
> on the chalkboard and work through each step of the procedure for finding the difference. Point out that the procedure for subtracting fractions is like adding fractions except that after the equivalent fractions are found the numerators are subtracted rather than added. Have students read the complete statement that shows the answer to the problem. Then have them read the original problem and check to see if the answer 5/24 seems reasonable.
>
> **Other Examples.** Work through these examples with students. In the first and second examples, note that the denominator of one fraction is a multiple of the denominator of the other. In the second example, students must reduce the answer to the lowest terms.

The 1991 stronger-pedagogy basal version took much of the responsibility from the teacher for explaining concepts clearly, in what appears to be the hope that students will be able to explain the concepts to their peers more clearly than the teacher is able to. At the beginning of each lesson in the '91 edition are sections entitled *Communication and Prior Skills.* In many of these exercises, the teacher has the students hypothesize how to solve a problem before the teacher actually presents the strategy. Below is an exercise that appeared before the introduction of problems in which the students had to rename

$$6\frac{1}{2} - 2\frac{3}{5}$$

to subtract mixed numbers.

> **Communication**
>
> **Prior Knowledge.** Write $\frac{3}{5} - \frac{1}{2}$ on the chalkboard. Have a student explain the steps needed to find the difference. Then write the problem $6\frac{3}{5} - 2\frac{1}{2}$ on the chalkboard. Ask students how they would solve this problem (in the same manner as the first, with the additional step of subtracting the whole numbers). Then write the problem $6\frac{1}{2} - 2\frac{3}{5}$ on the chalkboard. Ask how the problem differs from the previous one. (Possible answers: The fractions in the mixed numbers have been switched; the bottom fraction is greater than the top one; in order to subtract the fractions, renaming will be necessary.) Have a volunteer solve the problem using numbers and symbols, diagrams, or fraction pieces.

Activities such as these may function well for higher performing students, but for lower performers they may not function as intended. These students need carefully controlled explanations and active involvement. The danger of the exercises is that the teacher will be communicating only with the higher performers.

Reteaching. The need for consistency of teacher language and demonstrations is particularly important for lower performing students. Both the higher-approval basal and the stronger-pedagogy basal make provisions for reteaching to students who encounter difficulty. Interestingly, both programs have two provisions for reteaching. A reteaching workbook contains extra worksheets designed to reteach the skill and provide extra practice. In many cases, the re-teaching is clearer and more explicit than the initial example in the student text. For example, in the '91 version of the student text, the page that introduces reducing fractions to their lowest terms models both by repeated division,

$$\frac{18}{24} \div \frac{2}{2} = \frac{9}{12} \div \frac{3}{3} = \frac{3}{4}$$

and by dividing both terms by their greatest common factor:

$$\frac{18}{24} \div \frac{6}{6} = \frac{3}{4}$$

The reteaching page only models dividing by the greatest common factor and provides several more structured examples.

The other provision for reteaching is a suggestion in the Teacher's Guide under a special section entitled "at risk" or "reteaching tips." Quite often, the suggestions in these sections are not consistent with the original teaching in the student text. For example, the Teacher's Guide in the '89 version of the stronger-pedagogy basal recommended a reteaching activity for students having difficulty finding the lowest common multiple in which the students use models of pictures to illustrate addition and subtraction problems:

$$\frac{1}{2} + \frac{1}{4}$$

This in itself is a good activity, but does not deal with the strategy for finding the lowest common multiple.

At other times, the reteaching tips are unwieldy. For example, the '91 version of the stronger-pedagogy basal suggests the following: "For the first error, have students make a list of several numbers less than 20. For each, have them list and label first all its factors and then all its multiples."

Manipulative activities. A fundamental objective of any math program is to instill in students a clear understanding of the events signified by a mathematical operation. The manipulative activities should provide a framework for understanding but not interfere with the teaching of the algorithm itself. In addition, since tasks with manipulatives can be very time consuming, the activities should be planned very carefully.

The 1989 higher-approval basal program integrated the use of manipulatives in a manner that would take a great amount of time and quite likely result in students having difficulty. For example, the lesson that introduced adding fractions with different denominators began with 13 problems in which the students used punchout fraction models to work problems. Halfway through the lesson, the algorithm was modeled as a way to record the student's work. No specific direction in using the algorithm was given until the next lesson in conjunction with problems with mixed numbers.

Several manipulative exercises that were excessive, time consuming, and/or vague in the '89 higher-approval basal version were replaced with more appropriate activities in the '91 version. For example, when the concept of equal fractions was introduced in the '89 version, a rather difficult and unwieldy exercise in which the students were supposed to cut out number lines and compare them was suggested. In the '91 version, this exercise was replaced by a less time-consuming exercise in which the teacher presents a diagram showing windows divided into different numbers of parts and leads a discussion of how various fractions are equal because they have the same amount.

On the other hand, a major change between the '91 version and the '89 version of the stronger-pedagogy basal program was the inclusion of many more hands-on exercises in the '91 version. The 1989 stronger-pedagogy basal program presented few hands-on activities with manipulatives. The conceptual understanding was developed through pictorial representations, with the teacher either directing the students' attention to drawings in the student text and asking questions or writing a diagram on the board and referring to it.

In the '91 version three new lessons, each involving the use of manipulatives, were added. One dealt with equivalent fractions, one with improper fractions, and one with problems in which fractions with unlike denominators are added or subtracted. The lesson on equivalent fractions had students use fraction pieces and counters to work 20 equivalent fraction problems. The lesson on improper fractions has the students use fraction pieces or draw pictures to change mixed numbers to improper fractions and vice versa. The unit on adding fractions with different denominators had the students solve 10 problems using fraction pieces.

An illustration of a problem that may occur when manipulatives are not used carefully occurs in the '91 version of the stronger-pedagogy basal in a lesson on comparing fractions with different denominators. The lesson, the eighth in the chapter, presents fraction pairs such as 1/2 and 3/7. The students are to write the correct sign > < = between the fractions. The student text page begins with an illustration of using fraction pieces, circles formed by fractional parts, and using a number line to determine the relation of 5/8 to 1/2. The text then says, "You can compare fractions using fraction pieces or the number line. You can also compare fractions by finding equivalent fractions with a common denominator. The text then models these steps:

- Look at the demoninators.
- Write equivalent fractions with a different demoninator.
- Compare the numerators.
- The fractions compare the same way the numerators compare.

Neither the teaching of the use of the manipulatives nor the teaching of the component skills of finding the lowest common denominator and rewriting fractions with a different denominator have been thorough enough to enable the students to successfully employ the use of manipulatives or the use of these component concepts to work the problems. The last time the students worked with fraction circles was six lessons earlier, and they worked with a much smaller range of problems. In that earlier unit, they worked equations in which the denominator of one fraction was the common denominator, e.g., $\frac{3}{4} + \frac{2}{8}$ In the current lesson, problems such as $\frac{3}{4} + \frac{7}{10}$ are presented. Finding the common denominator for these fractions is much more difficult than for $\frac{3}{4} + \frac{2}{8}$ The skill of finding the lowest common denominator is not taught until later in the program.

Guided Practice

Many students need a transition between the explanation given in the introduction and the problems to be worked independently. Good, Grouws, and Ebmeier (1983) found that guided practice is an effective way for teachers and students to interact. In guided practice, which occurs after a concept is introduced, the teacher asks questions that prompt appropriate student application of the new concept.

Guided practice is the primary means by which the teacher ensures that the students can apply the concepts that they learn. During guided practice, teachers prompt the students, but as the students approach mastery, teachers should decrease the level of prompting until the students are functioning independently (Paine, Carnine, White, & Walters, 1982).

As a general rule, structure should be provided to facilitate students working at an acceptable success rate of at least 70-80 percent. (A success rate is calculated by making a fraction.)

$$\frac{\text{number of problems worked correctly}}{\text{number of problems attempted}}$$

As noted earlier, basals offer rather vague explanations for introducing new concepts. After these initial explanations and activities, students are expected to work several problems on their own without explicit guidance from the teacher. Neither the higher-approval basal nor the stronger-pedagogy basal provide suggestions for conducting guided practice. No specific wording suggested that the students utilize the steps that are modeled in the student text. In both versions of the stronger-pedagogy basal program and the higher-approval basal program, the major part of the guided practice section of the Teacher's Guide alerted the teacher to common errors the students might make.

Practice Opportunities

Practice enables a student to become fluent in working problems. Providing adequate practice to enable students to be able to work a problem with little effort is particularly important when the concept is a component of more complex problems. An example of where the lack of adequate practice on a component involves the teaching of lowest common denominator in the the higher-approval basal program. In the '89 version of the higher-approval basal, Lesson 90 teaches students to find the lowest common denominator of two fractions. This skill is used in Lesson 91 when students compare fractions with different denominators. A chapter review test after Lesson 97 tests the skill. No practice is provided again until an optional daily maintenance exercise on Lesson 107 in which students compare mixed numbers with different denominators just prior to Lesson 108, which introduces adding fractions with unlike denominators.

In the '91 version, the same problem with practice remains. Finding the least common denominator is taught in Lesson 101, utilized in Lesson 102 where students compare fractions with unlike denominators, and tested after Lesson 103. No practice, however, is provided until Lesson 113, when adding fractions with different denominators is presented.

After students are able to work a new type problem with relative ease, they should be provided with discriminated practice in which problems of the recently introduced type are integrated with problems of previously taught types. For example, after students learn to convert improper fractions to mixed or whole numbers, they must learn when a fraction is an improper fraction, e.g., 11/4 is an improper fraction, but 4/11 is not an improper fraction. Neither program provides a mixed practice set which requires students to discriminate which fractions are to be rewritten. The first time students receive practice in this discrimination is in the units that introduce adding and subtracting fractions with like denominators. Some problems have answers in which the answer is an improper fraction. The lack of prior discrimination practice that focuses solely on *when* to convert a fraction to a mixed number puts the students at risk. The lesson that introduces adding and subtracting fractions will be more difficult because the students not only have to focus on adding and subtracting, but also have to deal for the first time with when to convert fractions to mixed numbers.

Review

Review is the means by which a student receives the practice needed to retain what he has learned. Review can take the form of the actual problems or the skill can be integrated as a component within a more complex setting. The review in both the higher-approval basal and the stronger-pedagogy basal was sparse in the '80 versions and remained sparse in the '91 versions.

In the '91 version of the higher-approval basal, the chapter on addition and subtraction of fractions was followed by chapters on multiplying fractions, statistics, geometry, and ratios proportion and percent. The chapter on multiplying fractions started with Lesson 118. Here are the problems involving multiplication of fractions in the remainder of the 150-lesson book:

120 – 3-story problem applications
132 – 3 problems (add 3 fractions)
139 – 8 problems

In the 1991 stronger-pedagogy basal program, six chapters followed the addition and subtraction of fractions chapter which ended on page 296. Here is the review provided in the remainder of the 456-page text:

p. 306 – 1 story problem
p. 321 – 3 problems
p. 326 – 2 problems
p. 339 – 1 problem
p. 414 – 3 problems

Summary

In our judgment, these representative math basals published in the '80s are not effective professional tools. Unfortunately, the 1991 versions of these programs did not make changes that would significantly ameliorate the major problems we found in the 1980's editions. Neither program's revision reflected improvements in problems caused by rapid introduction of skills, lack of adequate review, lack of a guided practice, and lack of clear teacher explanations of more complex topics.

The higher-approval basal program of 1991 did make some improvements compared to its 1989 edition. Activities from the '89 edition that seemed to be potentially confusing or too time consuming have been eliminated or revised. On the other hand, the 1991 stronger-pedagogy basal program reflects changes from the 1989 program which could make it a less effective tool, especially for the less-experienced teacher. As noted in the introduction, our interest was in fundamental aspects of pedagogy, not the new NCTM standards in and of themselves. The '91 edition of the stronger-pedagogy basal added many activities to reflect the new NCTM standards. The higher-approval basal also has many activities that are consistent with the standards. The central point, however, is that if students are not able to compute fractions, the failure they experience will not lead them to value mathematics, reason mathematically, communicate mathematics, or solve problems. ◆

References

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Good, T. L., Grouws, D. A., & Ebmeier, H. (1983). *Active Mathematics Teaching.* New York: Longman.

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then, allowed for a more precise examination of the specific effects of the two discourse styles on retention and problem solving.

Method

Subjects

Subjects were eighth graders at one school in a primarily medium-sized, middle class school district. Forty-six students from two Earth Science classes participated. After four weeks of preliminary instruction in physical science concepts and principles, students within each class were matched on the Reading Comprehension subtest of the Metropolitan Achievement Test (Psychological Corporation, 1978) and the Science subtest of Comprehensive Test of Basic Skills (McGraw-Hill, 1983) and then randomly assigned to either an experimental or comparison group *within each* of the two classes. This resulted in four groups: two conditions for each class.

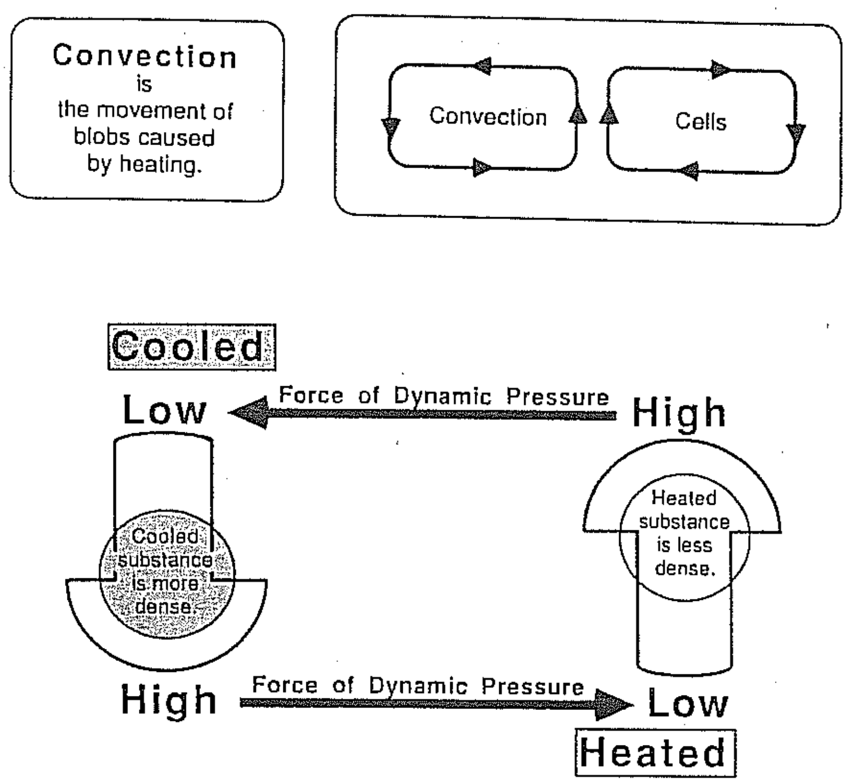
Students were generally at or above grade level in reading and science. Mean performance on the Metropolitan Achievement subtest in reading corresponded to the 75th percentile and on the Comprehensive Test of Basic Skills subtest in science, the mean was the 70th percentile. A one-way ANOVA was performed on the raw scores from each measure, and non-significant differences were found among the four groups.

Materials

Contents of the pre-intervention phase. For the first four weeks, all students learned a set of basic physical science principles. Students learned the direct relationship between changes in temperature and the velocity of molecules. With the aid of computer graphics, students saw how two objects of different temperatures, when in contact, gradually move toward the same temperature (i.e., the principle of conduction). Concepts such as density and convection were also taught along with the principles of static and dynamic pressure. These principles were presented as "informal quantitative functions" (Mayer, 1985); that is, descriptions that showed the quantitative relationship between variables, but lacked the mathematical formulas expressing these relations.

Convection is a central, but difficult concept in earth science, requiring a synthesis of many of the specific concepts and principles just mentioned. Figure 1 is a diagram of the model used to show students how these concepts and principles work in concert to form a convection cell.

Figure 1. Convection Diagrams



Causal discourse style. Students in the experimental group continued in materials that were organized around a causal discourse style. This program, which is largely contained in the *Earth Science* (Systems Impact, 1987) videodisc course, evolved from a comprehensive review of the material typically covered in eighth grade physical and earth science courses. The design of this course — sequencing of concepts, nature of explanations, use of examples — followed principles articulated in Engelmann and Carnine's (1982) *Theory of Instruction*. The videodisc materials contained brief graphic demonstrations of concepts and the occasional use of archival footage to present ideas.

The physical science principles learned during the first four weeks of instruction were linked causally to a variety of large scale terrestrial phenomena, such as major circulation patterns in the atmosphere, oceans, and mantle. For example, using their understanding of convection cells, students learned that the movement of material in the mantle occurs in a convection-like pattern over millions of years. The earth's core was identified as the heat source responsible for this constant circulation. Students were shown how movement in the upper layers of the mantle near the lithosphere was causally related to mid-ocean trenches, plate tectonics, subduction zones, earthquakes, volcanic activity along fault lines, and mountain building near coastal regions. Convection cells formed a basis for explaining this large scale pattern of movement and its subsequent effect on other geological phenomena. Figures 2 and 3 depict for the reader the relationship between the physical science principle of convection and a range of earth science phenomena.

Other physical science principles such as static pressure were applied to common earth science topics such as the rock cycle and the weathering process. This explanation linked the three basic types of rocks, and it relied heavily upon the initial explanations of how heat, temperature, and the principle of static pressure are related. Deteriorating surface rocks, many of which are igneous in origin, were shown as sediments accumulating in low areas and piling up. Over time, the increasing weight of the materials transformed basic sediments such as lime, mud, and sand into sedimentary rocks. Further increases in pressure and temperature changed these rocks into metamorphic materials.

Figure 2. Convection in the Earth's Mantle and Crust

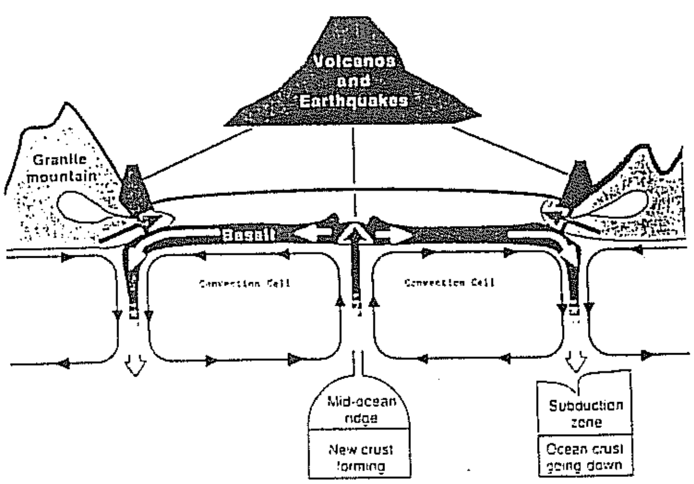
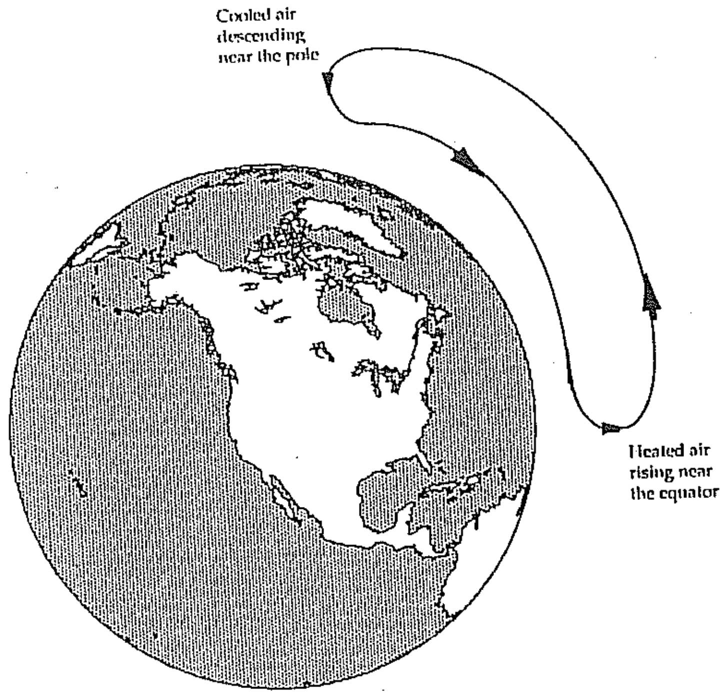


Figure 3. Atmosphereic Convection in the Northern Hemisphere



This kind of causal presentation was in contrast to more typical treatments of the topic in junior high school earth science textbooks, where, for example, the basic unit of rock forming minerals was mentioned (i.e., silicate tetrahedron) along with brief definitions of intrusive and extrusive rocks, the formation of crystals, and an array of examples of the three basic rock types (e.g., feldspar, diorite, gabbro, gneiss, alabaster).

Thus, terrestrial phenomena, at least as it is commonly covered in eighth grade earth science texts, was linked causally to underlying physical principles such as pressure, temperature, and velocity as much as possible. Naturally, there were some earth science concepts where the initial physical science principles did not apply directly (e.g., the direction of major air masses affecting North America, the formation of fossils). In these instances, presentations and discussions focused on the distinct features of the concept and its explicit relation to other concepts taught in the course.

Topical discourse style. The reader is reminded that all of the students in this study learned exactly the same physical science principles (i.e., the Pre-Intervention Phase) during the first four weeks of instruction under identical teaching conditions. However, once students were assigned to separate treatments, those in the Topical group were taught the same earth science subjects as the Causal group, but in a discourse form similar to the way they are presented in traditional materials. In this study, *Focus on Earth Science* (Charles Merrill, 1981) was the basis for organizing the topical materials.

Rather than causally linking all major terrestrial patterns to convection as described above, the same earth science topics were presented sequentially as a collection of descriptions. Broad themes commonly found in textbooks (e.g., the rock cycle; the earth's surface processes; seasons, climate, and weather; the earth's internal processes) were used to organize these topics.

Tornadoes, for example, were explained in the larger context of climate and weather. Students learned about high pressure (anticyclones) and low pressure (cyclones). This information was followed by discussions of fronts, changes in weather, and weather forecasting. Each topic was described in appropriate detail, but the causal links between topics and underlying physical science principles were missing. Students were shown cut away models of the earth similar to Figure 2, but no causal relationship between mantle convection and the different earth science phenomena was drawn.

To control for the effects of a medium (i.e., graphic presentations), students in the Topical group were shown an approximately equal amount of visual material. Videodisc segments from the *Windows on Science* program (Optical Data, 1988), slides, and movies accompanied the presentation of earth science topics. Dramatic archival footage of tornadoes from the videodisc program, for example, was used to show their destructive power. Complementing this presentation were class discussions and lectures that emphasized the time of year, general locations (e.g., "Tornado Alley" in the Midwest), and average wind speeds of tornadoes.

Procedures

Students were taught 40 minutes per day for ten weeks. During the first four weeks — the Pre-Intervention Phase — all participants in both groups learned the same physical science principles (e.g., conduction, dynamic pressure, convection). This was done to insure that all students had common background knowledge. What varied during the subsequent six weeks of the study was the discourse style used to link these principles to terrestrial phenomena (i.e., causally for those in the experimental group and topically for those in the comparison group).

Criterion measures administered at the end of the Pre-Intervention Phase indicated that all students had mastered the basic physical science principles at an 85 percent level or higher, and that there were no significant differences between groups when they were randomly assigned to each condition. The subsequent intervention, described below, lasted six weeks.

Causal instruction. Students in this group continued instruction with the aid of many visual materials (i.e., videodisc segments and occasional films). The basic physical science principles were linked causally to a range of earth science phenomena. This instruction did not entail further instruction on the physical science principles, as all students had mastered these principles by the end of the Pre-Intervention Phase.

Direct instruction was used throughout each lesson in order to control the number of concepts and the amount of vocabulary taught during the intervention. The teacher elaborated on the concepts and conducted brief discussions during most class periods. Students also completed written exercises covering the day's lesson.

Examples from local surroundings or those that students would readily understand formed the basis for many of the discussions. For example, the instructor used inclement weather that occurred during the study to discuss weather fronts, high and low pressure systems, and their linkage to convection and dynamic pressure. These discussions often focused on the implications of concepts and any student misconceptions that may have arisen.

Topical instruction. Lessons for this group also followed the direct instruction method. The teacher began each lesson by reviewing several key concepts from the previous lesson and providing an overview the day's material. The teacher asked questions to check for understanding and then conducted a discussion of the new material. As in the Causal group, examples from local conditions or those that students would be likely to know about were used most often. In the discussion of inclement weather mentioned above, each concept (e.g., high pressure, cold fronts) was discussed clearly and with adequate depth. However, there were no causal links to the underlying principles of convection and dynamic pressure.

Slides, short movies, and videodisc segments (i.e., *Windows on Science*, Optical Data, 1988) also were shown to further explain the concepts and to control for the amount of visual material presented in the study. Finally, as was the case in the Causal group, students completed brief written exercises covering the day's lesson. The overall content of instruction, while it followed a different discourse style, was the same as that of the Causal group.

Two researchers with considerable public school experience were responsible for all of the teaching. Assignment of teachers to treatment was counterbalanced, with the two researchers changing groups half of the way through the six week intervention. The total time for instruction was controlled in this study; both groups received the same amount of teaching and independent work over the six weeks.

Measures

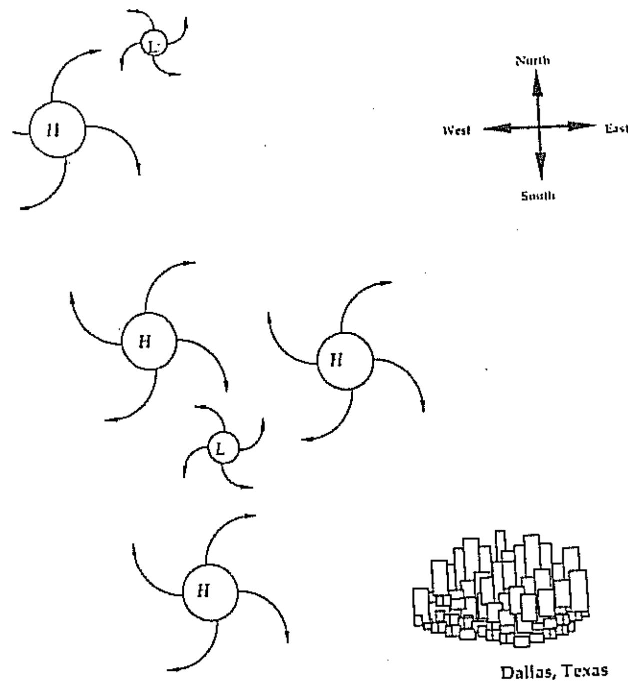
All students were administered four measures. Two of the measures — the Physical Science Test and the Earth Science Test — were designed to assess students' retention of the key conceptual information covered over the entire ten weeks of the study (i.e., material from the four week Pre-Intervention Phase and the six week intervention). The Physical Science Test (16 items) covered information from the first four week Pre-Intervention Phase; conceptual material that was the same for all of the students.

The Earth Science Test (50 items) involved concepts (e.g., subduction, the Coriolis force, condensation, relative humidity) that were presented to both groups during the six week intervention. Internal consistency reliability (coefficient alpha) for the Physical Science Test was .71, and for the Earth Science Test, the key criterion measure, it was .86.

Each of the above measures was based on a sample of 75 eighth grade students who were taking earth science at the time, but did not participate in the study. Both tests were administered as posttests; the Earth Science Test was given again, two weeks later, as a maintenance test.

A third measure, the *Application Problems Test*, was administered during the posttest phase. This 27-item test assessed the students' ability to apply the physical and earth science concepts learned over the entire ten weeks of instruction to novel, challenging problems. Items on this measure included problems such as a set of high and low pressure areas moving in an easterly direction toward Dallas, Texas, as shown in Figure 4 below. Changing conditions resulted in an extreme low pressure system amid several highs. The students were asked to predict what was most likely to happen as well as the physical science principle that best explained this phenomena (dynamic pressure in this instance). Other problems asked about the subduction process of oceanic and continental crust plates, the large scale movement of air masses over the United States, and the transformation of sediments into sedimentary and metamorphic rocks. These problems were unlike any of the exercises presented to either group during the six week intervention. Internal consistency reliability of this measure was .79, based on the same sample of 75 eighth graders who did not participate in the study.

Figure 4. Applications Test Item



A 33-item *Key Facts Test* was the fourth measure administered to all students. It was constructed as a measure of automaticity (i.e., how quickly students could recall facts presented during the first four weeks of instruction). This test was group administered, and students were given three seconds to write answers to each question (e.g., How many feet of sea water equals one atmosphere?, What part of the earth receives the most solar energy?). The three second time constraint, which is a common limit for math facts, helped gauge the student's retrieval rate. The *Key Facts Test* was administered three times: at the end of the Pre-Intervention Phase, as a posttest at the end of the six week intervention, and two weeks later as a maintenance test.

Results

Physical Science Test

A one-tailed t-test was performed on the Physical Science Test after the 10 weeks of instruction. This test covered the material that was taught to all students during the first four weeks of the study. Mean performance for Causal group was 12.87 (SD = 2.39). For those in the Topical group, it was 11.04 (SD =

3.53). Results of the *t*-test show a significant difference between the groups favoring the Causal group $t_{(1,44)} = 1.95$; $p = .03$.

Earth Science Test

A 2 x 2 (treatment by time of test) analysis of variance with repeated measures on one factor was performed on the Earth Science Test. Items on this test covered the same key concepts presented to both groups during the six week intervention. Table 1 provides the descriptive statistics for the correct number of responses for each group on the post and maintenance tests. Means have been converted to a percent correct.

The analysis shows a significant main effect for instructional method ($p < .001$). There was no significant drop in scores from post to maintenance test for either treatment group, nor was any significant interaction was found.

The Application Problems Test

A one-tailed t-test was performed on the Application Problems Test, administered immediately after the intervention. Table 2 presents the posttest descriptive statistics for the Causal and Topical groups. Results of the t-test show significant differences between the groups favoring the Causal group ($p < .001$).

The Key Facts Test

This measure was administered three times: at the end of the Pre-Intervention Phase, as a posttest six weeks later, and as a maintenance test (i.e., two weeks after the posttest). The purpose of this measure was to assess automaticity in earth science facts. A 2 x 3 (treatment by time of test) analysis of variance with repeated measures on one factor was performed on this measure. Table 3 presents descriptive statistics for each administration of the test. The analysis showed a significant interaction between treatment and time $F_{(2,88)} = 4.72$; $p < .01$. A test for simple main effects was conducted, indicating significant differences between instructional groups favoring the causal condition on both the posttest ($F_{(1,44)} = 9.39$; $p < .01$) and maintenance test ($F_{(1,44)} = 9.38$; $p < .01$).

Discussion

The main results of this study corroborate, and in many respects extend, past research on discourse styles. Students taught with the causal structure significantly outperformed those in the comparison group on the kinds of measures commonly used in discourse studies. That is, retention of material as measured by the Physical Science, Earth Science, and Key Facts tests significantly favored those in the causal condition, and effects were maintained over time. These findings were consistent with past research (Meyer, 1977; Meyer & Freedle, 1984), which has shown

Table 1. Means and Standard Deviations for Correct Answers on the Earth Science Test

		Post Test			Maintenance		
Instructional Group	N	M	SD	Mean % Correct	M	SD	Mean % Correct
Causal Structure	23	39.1	5.98	78.2	39.3	5.86	78.8
Topical Structure	23	23.8	7.26	47.6	24.4	8.09	48.8

Table 2. Summary of *t*-Test for the Applications Test

Instructional Group	M	SD	Mean % Correct	*t*	df	p
Causal Structure	21.35	3.66	79	5.2	44	.0001
Topical Structure	14.31	5.36	53			

Table 3. Means and Standard Deviations for Correct Answers on the Key Facts Test

		Pre-Intervention			Posttest			Maintenance		
Instructional Group	N	M	SD	Mean % Correct	M	SD	Mean % Correct	M	SD	Mean % Correct
Causal Structure	23	27.7	4.05	84	29.3	3.68	89	29.4	3.3	89
Topical Structure	23	27.5	4.03	83	24.8	5.88	77	5.3	5.41	78

weaker effects on measures of retention for a collection of descriptions or topical approach.

Yet a more detailed examination of these measures reveals the potential impact of longer texts on retention. Prior research suggests that ideas located highest in the hierarchy are retained better than those at lower levels (Eylon & Reif, 1984; Meyer et al., 1980; Walker & Meyer, 1980). This pattern can be found in the Topical treatment during the posttest phase, where mean performance on the Physical Science test (concepts highest in the hierarchy) was 69 percent as compared to the mean retention of 48 percent on the Earth Science test (concepts at the next level below).

However, this difference was only marginally present for the Causal group, whose mean performance scores were 80.4 percent and 78.2 percent respectively, on the Physical and Earth Science measures. Furthermore, the highest mean levels of retention for the Causal group were on the Key Facts Test, items lowest in the hierarchy.

Students in both groups were equivalent on this latter measure *before* the intervention. Yet significant differences favoring the Causal group developed by the post and maintenance test phases. This finding is noteworthy insofar as neither group of students continued to systematically practice these facts during the intervention. Instead, students were exposed to them on an incidental and context-dependent basis. For example, in the unit on the the oceans, students were reminded that 33 feet equalled one atmosphere of sea water.

While these results are at odds with prior research into hierarchical organizations and discourse styles, they are understandable in this instructional context. Unlike so much of the research into discourse styles and revised science texts, the intervention in this study lasted six weeks rather than one or two sittings involving short passages. Practice and review were consistent instructional practices for both conditions. This was especially the case in the Pre-Intervention Phase, where all students were learning the background knowledge (i.e., high level physical science principles and related facts) necessary for the earth science instruction. Furthermore, the length of the intervention allowed students to reflect on the material gradually.

With the length of intervention as a important factor in this study, the effects of the different discourse styles rather than levels of information in a hierarchy become critical. Topical discourse, by definition, entails a collection of topics — each of which may be adequately described — but there are few logical relations *between* topics. For the naive learner, the cumulative effect of such a collection is diminished retention, and, as Meyer (1984) points out, "few expectations other than generally knowing that more is to come" (p. 12).

A decline in the retention of facts over the intervention indicated the effects of the topical style. The weak links to other concepts and principles resulted in information that was more isolated in memory, and with fewer retrieval cues available for the naive learner.

By contrast, the cumulative effects of the causal discourse heightened student understanding. The reasons for this have to do with fostering conceptual understanding as a part of knowledge acquisition. Naive students, such as the ones in this study, have a much more difficult time than sophisticated learners or experts in detecting important concepts and the relationships between concepts in complicated material such as science (Dee-Lucas & Larkin, 1986, 1988; Mayer, 1985).

The explicit causal links between the physical science principles of the Pre-Intervention Phase and the subsequent earth science concepts rendered a more comprehensible and conceptually sophisticated picture of earth science than what occurred as a function of the weaker, topical linkages. Put another way, the acquisition of new knowledge (new earth science concepts) is best served when prior knowledge (underlying physical science principles) is utilized. Conceptual understanding is enhanced when the fit between new information and prior knowledge is explicit and well-structured (Glaser, 1990; Prawat, 1989; Voss, 1987).

The effect of an integrated, conceptual understanding can then be seen in its transfer to problem solving. In science, explanatory frameworks — ones that capitalize on the rules of science — provide a superior base for solving problems than descriptive ones (Bromage & Mayer, 1981; Engelmann & Carnine, 1982; Mayer, 1985). Comparative performance on the Application Problems Test corroborates this view of knowledge utilization. On this measure, students were asked to solve problems involving the relationships between a common phenomena and underlying physical science principles. Success on these exercises required students to detect the most salient features of the problem and then functionally relate these features to underlying principles.

For example, one the problem presented a natural setting where heavy rainfall was causing increasing runoffs and mud deposits from the side of a mountain. Students were asked to project into the distant future the effects of these deposits, the type of rock formation that would evolve, and what would explain this kind of formation. As stated earlier, these problems were unlike problems or exercises presented over the six week intervention, where the relationships between the type of sediments and their sedimentary rock form as well as the role of static pressure was much more explicit. Students in the Causal group successfully performed these problems at a much higher level than those in the Topical group.

Implications for Commercial Science Materials

Generally, the results of this study raise serious questions regarding the design of most commercial science textbooks at the secondary level. These texts tend to follow a topical discourse style with the additional complication of a demanding level of vocabulary. The extent to which this fleeting coverage of terms and concepts occurs has been documented in both science (Linn, 1987; Tyson & Woodward, 1989; Armbruster & Valencia, 1989) and social studies (Beck, McKeown, & Gromoll, 1989; Gagnon, 1987; Sewall, 1988). A clear example of this can be seen in the earth science text used to prepare explanations and discussions for the Topical condition. Newton's three laws of motion, a complex and extremely important set of principles, were described in the passage below — and *only* this passage.

Galileo found that an outside force was necessary to stop the motion of a body once it was moving. Later Isaac Newton summed up his understanding of motion in three laws. The first law states that a *body continues at rest, or in motion, until acted upon by an outside force.* The second states that *the amount of motion in a moving body is equal to the mass multiplied by the acceleration of a body.* The third law states that *for every actions there is an equal and opposite reaction.* Newton's three laws are the bases for our understanding of the movement of all observable bodies. These laws do not fit the behavior of particles of subatomic size nor movement at the speed of light (Charles Merrill, 1981, p. 463).

The very next paragraph summarized Einstein's theory of relativity. In texts where there are many complex ideas or where scores of concepts are explained in a cursory manner, as in the passage above, naive students have a difficult time comprehending the material (Kintsch & Keenan, 1973; Kintsch, Kozminsky, Streby, McKoon, & Keenan, 1975; Voss, 1978). This fleeting coverage of terms and concepts comes at the expense of instruction that fosters a deeper conceptual understanding of scientific methods and theories (Linn, 1987; Tyson & Woodward, 1989).

Improving science texts for naive students through a causal approach, or what Mayer (1985) calls an "explanative structure," is one logical solution to this problem. Science is a natural content area for the causal discourse style, and when knowledge is organized as such, it takes on the character of a strong schema (Anderson, 1984). It also has an impact on science learning at a deeper level.

A well-developed understanding of a content area ideally teaches students, particularly naive students, a keener sense of the discipline — a sense of its "logic" (Resnick, 1987). Science educators (Linn, 1987; Mullis & Jenkins, 1988) argue that students should learn more than facts and concepts. Hypothesis formation and testing, the ability to work from data, and deductive and inductive logic should play a central role in learning. By using a causal structure which relates physical science principles to terrestrial phenomena, students were introduced to a common logic of the sciences: the hypothetical deductive method of explanation.

Combining the logic of the discipline with domain specific knowledge is a new, and markedly different way of constructing expository material for young secondary students. A good deal of thoughtful analysis is required to identify and carefully organize key concepts in science. Principles of instruction (e.g., Engelmann & Carnine, 1982) and content expertise are critical features for successfully reorganizing science materials. Yet in science instruction for naive learners, a shift from the topical to more effective forms of discourse can foster a better conceptual understanding, one that enhances retention and problem solving. It underscores the contemporary view that knowledge of a domain and the ability to think about or solve problems in that domain are competencies that develop hand in hand and not separately. ◆

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Authors
Siegfried Engelmann and Douglas Carnine

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Skills in include classification, sequence recognition, and important verbal-reasoning categories such as *true/false*, *if/then*, *all/some/none*, and others. All concepts are integrated into the stories. The program leads children toward verbal inventiveness, the capacity for logical deduction, cooperation in group writing and acting projects, an understanding of story patterns, and ability to focus on a story patterns, and ability to focus on a story's central issues.

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Expands reasoning skills and adds new language concepts

Level B expands the strategies taught in Level A. Again, thinking skills introduced through simple activities are developed and used in stories—stories that blend laughter with learning. Students learn to construct and complete deductions and use facts or clues to eliminate possibilities. Besides generalized thinking skills, students also begin to attend to basic precepts of clear writing, such as the need for clear pronoun referents.

Reasoning and Writing, Level C

Puts increased emphasis on written outcomes

Level C introduces more extensive writing activities. All activities are structured to assure students of success. At the same time, students develop important grammatical understandings and learn conventions of correctness. They learn to express themselves in complete sentences, for example, and to recognize subjects, predicates, and pronouns.

Writing is presented as an ongoing process that includes drafting, revising, and editing for clarity—always keeping the reader and the reader's questions in mind. By the end of level C, students are writing relatively long story completions, and are revising their own work.

Authors

Siegfried Engelmann, Karen Lou Seitz Davis, Ann Arbogast, and Jerry Silbert.

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