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ABSTRACT

The goal of Minicourse 5 is to increase the skill of inservice teachers (grades 4-6) in tutoring students whose understanding of mathematical concepts and procedures is weak. Emphasis is on actively involving the student in the tutoring process and developing his understanding, rather than rote learning, of mathematical concepts. The course consists of five lessons on different sets of tutoring skills: (1) prompting questions and verbal praise, (2) diagnostic questions, (3) demonstration techniques (estimation, the number line, expanded notation, manipulative materials, diagrams and pictures, and number sentences), (4) evaluation and practice examples, and (5) organizing the classroom for increased tutoring time. In the main field test of the course 49 teachers (volunteers) were videotaped during two tutoring sessions (one for a student having difficulty with number operations, one with verbal reasoning problems) before and after the course. Each tape was scored by two trained raters on six variables. A replication study was also conducted using 17 inservice teachers. Results demonstrate that the course accomplishes its objective. Major gains were in use of demonstration techniques, diagnostic questioning, and verbal praise. An operational field test with 290 teachers is under way to determine whether course materials contain all the information needed by school districts to use the course independent of supervision. (JS)

MINICOURSE FIVE: TUTORING IN MATHEMATICS

Meredith Gall, Barbara Dunning, and John Galassi

Far West Laboratory for
Educational Research and Development

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Goal and Scope of the Course

The goal of Minicourse Five is to increase the skill of teachers in tutoring students whose understanding of mathematical concepts and procedures is weak. Although the course is focused on remediation, the tutoring skills are also useful in regular mathematics instruction. The teacher who uses the skills presented in this minicourse should be able to actively involve the student in the tutoring process. She should also be able to develop the student's understanding, rather than rote learning, of mathematical concepts. Thus, the content of Minicourse Five is supportive of the objectives found in the "new" mathematics curriculum. The course was developed originally for teachers of grades four through six, but teachers in the primary grades have also found it helpful. It is possible, too, that teachers of remedial mathematics in junior high school or high school will find the course skills appropriate to the tutoring of older students.

Although we were not able to locate research concerned with the tutoring proficiency of teachers, small-scale observational studies which we performed indicated that the typical tutoring interaction is deficient in two major respects: the interaction is too short (about fifteen seconds on the average) and consists primarily of telling the student his error.

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[1]Material for this paper was drawn from Borg, W. R., Kelley, M. L., Langer, P., Gall, M. D. The Minicourse--A Microteaching Approach to Teacher Education. Los Angeles: Macmillan Educational Services, (in press).

[2]Paper presented at the annual meeting of the American Educational Research Association, Minneapolis, March 1970.

Many of the illustrations in John Holt's classic How Children Fail (1964) are concerned with the failure of teachers to explain mathematical concepts to students in a meaningful way. We have also been given similar reports by the developers of new mathematics curricula based on individualized instruction. A major objective of curricula such as IPI[3] and Project PLAN[4] is to free the teacher's time for more individual tutoring of students. Yet the curriculum developers have found that participating teachers need skill training in order to use their tutoring time effectively. Minicourse Five was designed to meet this need.

Minicourse Five consists of five lessons, each of which covers a different set of tutoring skills. Although tutoring interactions at the elementary school level may be concerned with a variety of mathematics content, they can usually be divided into two types: number operations (addition, subtraction, multiplication, division) and verbal or "story" problems. The specific skills presented in Minicourse Five were selected after our research team had completed numerous discussions with consultants, classroom observation, and an intensive review of the literature. The skills that were finally included in the course were those which appeared to be particularly appropriate for increasing tutoring effectiveness in the areas of number operations and verbal reasoning problems. They are shown in Table 1.

In Lesson One, teachers practice using prompting questions and verbal

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[3] IPI (Indivdually Prescribed Instruction) was developed by Research for Better Schools, Inc.

[4] Project PLAN (Program for Learning in Accordance with Needs) was developed by the American Institutes for Reserach.

praise in a tutoring situation.[5] Lessons Two, Three, and Four present a sequential set of skills which make up a tutoring strategy. We have named this strategy the Basic Tutoring Sequence. The first step of the sequence, covered in Lesson Two, is the skill of asking diagnostic questions to determine the nature of the student's difficulty. Based on his diagnosis, the teacher will use one or more demonstration techniques to develop the student's understanding of a mathematical concept or computational procedure. The demonstration techniques covered in Lesson Three are estimation, the number line, expanded notation, manipulative materials, diagrams and pictures, and number sentences. In Lesson Four teachers receive training in the final two steps of the Basic Tutoring Sequence: evaluation of the student's progress by assigning him an example to solve on his own, and assignment of practice examples so that the student can consolidate and maintain his learning. A fifth lesson, presented in the teacher's handbook, suggests techniques by which the teacher can increase the amount of time available for individual tutoring.

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[5] As used here, "prompting questions" refer to requests by teachers for a student to do or say something, e.g., draw a number line, state a number fact. Such requests increase the active involvement of students in the tutoring process.

Table 1
MINICOURSE FIVE
LESSON OBJECTIVES

Lesson 1 - Practice Lesson and Introduction to the Basic Tutoring Sequence

Behaviors:
1. Verbal praise.
2. Prompting questions.

Lesson 2 - Diagnosis

Behaviors:
1. General Diagnostic Questions (e.g., "How did you get your answer?")
2. Number Operations: ask questions to test students' understanding of place value, regrouping, and renaming.
3. Verbal Reasoning Problems: ask student to read the problem and decide what number operation to use.

Lesson 3 - Demonstration

Behaviors:
1. Estimation.
2. Number operations: depending on the situation, use expanded notation, the number line, or manipulative materials.
3. Verbal Reasoning Problems: have the student draw a picture of the problem and write a number sentence to express the problem's requirements.

Lesson 4 - Evaluation and Practice, and Review of the Basic Tutoring Sequence

Behaviors:
1. Assign an evaluation example.
2. Assign practice examples.

Lesson 5 - Organizing the Classroom for Increased Tutoring Time

Behaviors:
1. Students correct their own work.
2. Students tutor each other (peer tutoring).

Main Field Test

The main field test in our R & D cycle is an experiment to determine whether each minicourse brings about significant changes in teachers' classroom behavior that are significant in both a statistical and a practical sense. The experimental design used for the main field test of Minicourse Five was the single group, pre-post design. A control group was not established because of the expense involved and because we believed that teachers' tutoring behavior was fairly stable and not likely to be affected by such confounding factors as time of year or student maturation. The main purpose of the experiment was to evaluate the effectiveness of Minicourse Five by comparing teachers' use of specific tutoring skills immediately before and after the course.

Sample. A total of 49 teachers (grades 3-6) volunteered to participate in the main field test. Each teacher was videotaped before and after the course. One of the teachers eventually dropped out of the study because of illness. Further, several teachers were eliminated from the sample either because their videotapes were of poor quality or because they failed to follow directions for pre- and post-taping. For most of the data analyses reported here, complete pre-post data were available for 43 number operations essions and 46 verbal problem sessions.

The participating teachers were employed in three predominantly middle-class school districts. The teachers' mean age was 34.6 (S.D. = 10.0), while their mean number of years of teaching experience was 9.1 (S.D. = 6.2). The male-female ratio of the sample was 11:36. The number of teachers at the third, fourth, fifth, and sixth grade levels was 15, 11, 10, and 11 respectively. All but four of the members of the

sample had previously been involved in at least one inservice workshop on teaching the "new" mathematics.

Measures of Tutoring Behavior. Each teacher was asked to conduct two tutoring sessions which were videotaped for evaluation purposes. In the first session teachers were asked to tutor a student from their class who was having difficulty with number operations. The second session was conducted with a student having difficulty with verbal reasoning problems. Teachers were told to carry out whatever tutoring was necessary to take care of the student's difficulty. Ten minutes were allotted for each tutoring session. However, the teacher could take less time if desired. The same procedure was used to collect videotapes before and after the minicourse.

Each tape was assigned a code number and scored in random order by two raters. About a day was spent training the raters to score each set of tutoring behaviors.[6] The median inter-rater reliability coefficient for the tutoring measures was .82. Only two coefficients were below .70. After all the tapes had been scored by both raters, their scores were averaged for use in the data analysis.

The following variables were scored for each tutoring session:

a. Length of session. The length of each tutoring session was recorded up to a period of ten minutes. Since some tutoring sessions were longer than the allotted ten minutes, raters were instructed to only score the tutoring behaviors that occurred in the first ten minutes of each session.

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[6]Diagnostic questions were scored on the first viewing of the tapes, demonstration techniques on the second viewing, and verbal praise, evaluation, and practice on the third viewing.

b. Diagnostic questions. A frequency count was made for each of the five diagnostic question categories. The categories of general questions and number concepts were scored for the number operations sessions. The categories of general questions, reading difficulties, word definitions, and selection of appropriate number operation were scored for the verbal problem sessions.

c. Demonstration techniques. The raters scored the frequency and amount of time that a teacher used each of the six demonstration techniques presented in the minicourse: estimation, expanded notation, number line, manipulative materials, diagram or picture of a problem, and number sentences. Raters were instructed to record only the amount of time that each technique was actually used in the tutoring sessions since teachers often alternate between various techniques within a session.

d. Evaluation. Raters recorded whether an evaluation example was assigned to the student. Two criteria were used to make this determination. If the teacher made a statement indicating that the student was to solve an example on his own, the evaluation phase was scored as present. A score was also given if the teacher assigned an example (without stating that the student was to solve it on his own) and did not intervene for at least half a minute.

e. Practice. The practice phase was scored as present if the teacher made a statement such as, "Now do these at your desk" or "Here are some to do for practice."

f. Verbal praise. Raters counted each occurrence of verbal praise in the tutoring session. The number of different types of praise used by each teacher was also scored. Since funds for scoring were running low, we felt that an accurate estimate of change in this behavior could be obtained by scoring only one pre-tape and one post-tape session for each teacher. Pre- and post-sessions involving number operations were scored for half the teachers; the verbal problem sessions were scored for the other half.

The use of prompting questions was not measured because of the difficulty in deriving a meaningful index of this variable. One teacher would ask a single prompting question such as, "Draw a number line" while another might make several requests to accomplish the same purpose, e.g., "We're going to draw a number line. First, will you draw a line . . . now

will you mark off the units . . . now make a point of origin." Therefore, a frequency count does not provide a meaningful index of teachers' use of these questions to involve students in the tutoring process.

Research Results

Table 2 shows the comparative length of each tutoring session before and after the minicourse. It will be recalled that teachers were allotted up to ten minutes with each student. Teachers spent more time on both sessions after the course, although the increase is statistically significant only for the number operations session. The increased length of the post-course sessions probably can be explained by the increased amount of time that teachers spent using tutoring skills, particularly demonstration techniques.

In Lesson One teachers were given training in using verbal praise and asking prompting questions. As shown in Table 3, significant increases occurred in teachers' frequency of verbal praise (approximately a fifty per cent gain) and use of different types of praise. The Wilcoxon matched pairs test rather than the t-test was used to test the statistical significance of the difference between matched pairs of scores since some of the tutoring behaviors yielded markedly skewed score distributions. In addition to presenting pre-course and post-course means, we have also shown sign changes in Table 3 and subsequent tables so that the reader can determine how many teachers made a positive change, a negative change, or no change.

The statistical analysis for the tutoring behaviors covered in Lesson Two are presented in Table 4. A highly significant shift occurred in the

Table 2
Length of Tutoring Sessions Before and After Minicourse Five

Session	Pre Mean	Pre S.D.	Post Mean	Post S.D.	t
Number operations	8.53 min.	1.72 min.	9.30 min.	1.10 min.	2.64*
Verbal problem	8.50 min.	1.61 min.	8.87 min.	1.36 min.	1.19

* $p < .01$

Table 3
Frequency of Verbal Praise Before and After Minicourse 5

Measure	Mean		Sign changes			Wilcoxon	z
	Pre	Post	+	0	-	T	
Frequency of praise	6.86	10.59	32	2	12	190	3.56**
Types of praise	2.60	3.03	27	6	13	219	2.57*

Note. Above analyses are based on one tutoring session for each teacher.
* $p < .005$
** $p < .001$

Table 4
Frequency of Diagnostic Questions Before and After Minicourse Five

Question type	Session[a]	Mean		Sign changes			Wilcoxon	
		Pre	Post	+	0	-	T	z
General questions	N O	2.87	3.93	26	4	13	251.5	1.94*
Number concepts	N O	1.36	2.34	16	16	11	111.5	1.87*
General questions	V P	2.55	2.60	24	6	16	363.0	.63
Reading difficulty	V P	2.05	2.44	26	4	16	338.0	.97
Word definitions	V P	0.43	1.57	35	7	4	72.0	4.44**
Number operation	V P	1.01	1.74	24	12	10	61.0	4.04**
Total questions	N O & V P	10.25	15.23	33	0	9	141.5	3.88**

O = number operations; V P = verbal problem.
* $p < .05$
** $p < .001$

mean number of diagnostic questions asked by the teachers. On the average, teachers asked about 50 percent more diagnostic questions after the course than before the course. Of the 42 teachers for whom complete data were available for this analysis, approximately 80 percent (33 out of 42) showed a positive sign change. Changes in teachers' use of each category of diagnostic question were also analyzed. Statistically significant changes occurred in four of the six categories. Both the most and least change occurred in the verbal problem session. Teachers appeared already to have the skill of asking general diagnostic questions and asking the student to read the problem; however, as a result of the minicourse, they acquired the skills of testing students' understanding of words in verbal problems and testing ability to select the correct number operation to solve the problem.

Several analyses were carried out on the demonstration techniques which teachers practiced in Lesson Three. As shown in Table 5, highly significant gains occurred in the total amount of time which teachers spent using demonstration techniques in each of the two tutoring sessions. Teachers used these techniques to tutor students on number operations twice as long after the course than before. For tutoring on verbal problems the increase was also approximately double.[7]

Not only did teachers spend more time using these techniques after the course, but they also used significantly more techniques in each tutoring session. As can be computed from Table 6, only 5 percent of the teachers

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[7]Since the total time measures were quite skewed, it is informative to study the pre- and post-tape medians. For the number operations session, the medians of the pre- and post-tapes are 18" and 168", respectively. This is an eightfold increase. For the verbal problem session, the pre- and post-tape medians are 48" and 167", respectively. This is a threefold increase.

Table 5
Time Spent Using Demonstration Techniques
Before and After Minicourse Five

Demonstration Technique	Session[a]	Mean		Sign changes			Wilcoxon	
		Pre	Post	+	0	-	T	Z
Estimation	N O & V P	6"	28"	19	21	3	42.0	2.74***
Expanded notation	N O & V P	33"	51"	15	23	5	65.5	1.49
Number line	N O & V P	14"	23"	10	31	2	13.0	2.04*
Manipulative materials	N O & V P	43"	104"	16	22	5	49.0	2.31**
Diagram	N O & V P	50"	95"	26	8	9	142.5	2.83***
Number sentence	N O & V P	24"	35"	17	19	7	72.0	2.23**
Total time	N O	76"	155"	28	4	11	170.5	3.07***
Total time	V P	85"	167"	35	0	9	172.0	3.77***

[a]N O = number operations; V P = verbal problem
*p < .05
**p < .01
***p < .005
****p < .001

used more than one technique in the number operations session before the course. After the course, this figure increased to 39 percent of the teachers. Further, the percentage of teachers using more than one technique in the verbal problem session before the course was 22 percent; after the course this figure rose to 78 percent.

The data analyses carried out on the tutoring behaviors of Lesson Four, evaluation and practice, are shown in Table 7. Almost no change from pre-course to post-course occurred in teachers' assignment of at least one evaluation example. A statistically significant change did occur in teachers' practice examples, however. Whereas only 2 percent of the teachers assigned practice examples before the course, 24 percent of the teachers made such an assignment after the course. The ten minute limit for each tutoring session should be considered in interpreting these results. Since evaluation and practice occur logically at the end of a tutoring session, it is possible that some teachers did not have an opportunity to exhibit these behaviors in the time allotted them. Evidence for this possibility is the fact that of the 16 teachers who did not use evaluation in either postcourse session, 50 percent of them were unable to complete either session. In contrast, only 23 percent of the 30 teachers who used evaluation did not complete their session. A similar situation is found for assignment of practice examples. Forty percent of the 35 teachers who did not use practice did not complete either session. But only one of the 11 teachers who did use practice was unable to complete either session.

Because of the time and expense involved, it was not feasible to make direct classroom observations of changes in the amount of time which

Table 6
Number of Demonstration Techniques Used Before and After Minicourse Five

Number of techniques	Number of teachers Pre	Post	χ^2
Tutoring sesssion: number operations			
0	18	9	
1	24	19	16.49*
2	2	12	
3	0	6	
Tutoring session: verbal problem			
0	16	1	
1	19	9	
2	8	27	31.60*
3	2	9	

*$p < .001$

Table 7
Evaluation and Practice Before and After
Minicourse Five

Occurrence of the behavior	Number of teachers		
	Pre	Post	x^2
	Evaluation		
Did not occur	17	16	
Occurred in one session	21	22	0.29
Occurred in both sessions	6	8	
	Practice		
Did not occur	43	35	
Occurred in one session	1	11	9.22*
Occurred in both sessions	0	0	

*$p < .005$

teachers spent using the tutoring method during their math periods. However, responses to an item on the post-course questionnaire showed that the amount of reported classroom time spent in tutoring increased "considerably" for six teachers, "somewhat" for 19 teachers, "slightly" for nine teachers, and "not at all" (i.e. stayed the same or decreased) for 10 teachers. Thus, 77 percent of the teachers reported at least some increase in time spent tutoring.

Replication Study. A replication study[8] which employed 17 inservice teachers and "borrowed" students, and which had a shorter time span (two and one-half weeks of daily sessions) than the main field test (four weeks of spaced sessions) was conducted in the summer of 1969. Selected findings from this study are presented in Table 8. Except for frequency of verbal praise and the time measure for demonstration techniques, all gains were as large or larger than those found in the main field test.[9] Thus, the summer study indicated that the findings of the main field test are generally replicable even under varied conditions of administration.

Discussion

The results of the main field test and the summer study demonstrate that Minicourse Five accomplishes its stated objective, namely, to bring

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[8]This study was carried out by Dr. Walter Borg to determine the relative effectiveness of student feedback and peer (fellow teacher feedback) in microteaching.

[9]The frequency of pre-course and post-course verbal praise was based on a scoring of all four sessions for each teacher, whereas in the main field test the frequency count was based on two sessions for each teacher. Concerning demonstraton techniques in the verbal problems session, analysis of the data for each treatment group separately indicated that the gain for one subgroup but not the other was comparable to that obtained in the main field test.

Table 8
Selected Findings of Replication Field Test of Minicourse Five

Tutoring behavior	Session	Mean Pre	Mean Post	Sign changes +	Sign changes 0	Sign changes -	Wilcoxon T	Z
Total verbal praise	NO & VP	19.29	21.59	12	0	5	44	1.54*
Total diagnostic questions	NO & VP	8.88	14.97	12	1	4	15.0	2.74**
Total time, demonstration techniques	NO	68"	176"	15	0	1	4.5	3.31***
Total time, demonstration techniques	VP	67"	98"	10	0	5	34.0	1.48*

*p < .10
**p < .005
***p < .0005

about observable improvement in the mathematics tutoring skills of in-service teachers. The most impressive gains were achieved in the group of tutoring behaviors which we have designated "demonstration techniques." The gains are particularly impressive in view of the fact that the study was done with experience teachers. Almost all of them had taken at least one inservice workshop in the "new" mathematics curriculum, which emphasizes strategies (similar to the demonstration techniques of Minicourse Five) to develop student understanding of concepts and procedures rather than mere rote learning. Substantial gains also occurred in teachers' use of diagnostic questioning and verbal praise. Although teachers did not show an increase in assignment of evaluation examples, they did increase their assignment of practice examples to some extent. It is possible that more positive results would have been obtained had teachers been allotted a longer period of time for each tutoring session.

Minicourse Five is undergoing its operational field test as of this writing. Approximately 290 teachers and coordinators in 13 school districts are participating in it. The purpose of this field test is to determine whether the course materials and the recently developed coordinator handbook which we have recently developed contain all the information needed by school districts to use the course independent of our supervision. In addition, we have developed a package of follow-up lessons, to be completed over a period of six months, so that teachers can continue practicing the skills covered in the course.