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ABSTRACT

Researchers have become concerned with the need to make research relevant to the interests and concerns of practitioners, and to facilitate the application of new knowledge about teaching and learning to the ongoing teaching-learning process of the classroom. This paper presents examples of the ways in which research findings from two ETEP (Effective Teacher Education Program) studies and two data collection procedures taken from these studies may be applied to teaching and to the training of teachers. The two ETEP studies concern the effects of teacher use of probing and redirection and teacher use of higher cognitive questions on student achievement and attitudes. The four approaches to application of the research are: (1) application through development of teacher training programs and materials; (2) application through use of new knowledge by teachers to modify how they structure the teaching/learning situation and how they interact with students; (3) application through use of data collection procedures as instructional vehicles and as self-development tools; and (4) application through teachers serving as researchers who validate and evaluate findings as they are applied in the classroom. A consideration of a new approach to research and development in teaching, which will increase the likelihood that research on teaching will be applied in the classroom in order to improve educational opportunities, is presented. (JMF)

TEACHER EDUCATION DIVISION PUBLICATION SERIES

APPLICATION OF RESEARCH TO TEACHING

Beatrice A. Ward and William J. Tikunoff

REPORT A75-2

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APPLICATION OF RESEARCH TO TEACHING*

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From its inception nine years ago, the Far West Laboratory for Educational Research and Development has been engaged in research and development activities related to teaching. This work began with heavy emphasis upon application of research to teaching through the development of teacher training products. More recently, our work has emphasized basic research seeking answers to the question, "What is effective teaching in specific instructional situations for what types of learners?"

As we have become more involved with conducting rather than applying research, we also have become concerned with the need to make the research relevant to the interests and concerns of practitioners, i.e., teachers and teacher trainers, and to facilitate the application of new knowledge about teaching and learning to the ongoing teaching-learning process of the classroom.

The purpose of this paper is to explore several ways in which research can be applied to teaching. For purposes of illustration,

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research findings from three studies conducted by the Effective Teacher Education Program (ETEP)* will be presented.

Application of Research to Teaching: What Do We Mean?

The research process may be categorized into five major steps:

1. Establishing the questions to be answered/hypotheses to be tested.

2. Preparing a research design that attends to these questions including identifying the variables of interest; identifying/developing procedures for studying (measuring) these variables; and determining what, if any, treatment conditions are to be imposed.

3. Conducting the study. More specifically, this involves setting up the conditions necessary to collect the desired information (data) and collecting the information itself.

4. Analyzing the data so as to obtain answers to the questions/hypotheses on which the research is focused.

5. Reporting and interpreting the results.

Given the effects of each of these steps upon the educational knowledge base, it can be argued that all five steps are relevant to teaching. We agree: teachers and teacher trainers should be involved in the entire process. However, in terms of direct applicability to the ongoing teaching process, the two aspects of research that are most important are the findings that result from the research (the new knowledge that is gained) and the methods and procedures used to acquire the new informati bout teaching and learning.

* A research program carried out at the Far West Laboratory under the auspices of NIE Contract No. NE-C-3-0108. The research studies include: Gall, et al., The Effects of Teacher Use of Questioning Techniques On Student Achievement and Attitudes; Snow, et al., Extended Analysis of Two Experiments on Teaching; Williams, Math Tutoring Study: Teachers as Tutors; Paraprofessionals as Tutors; Cross-age Tutoring.

It is not necessary here to elaborate the need to apply new knowledge to teaching. This topic has long been a matter of concern to the field of education.

On the other hand, application of the research methods and procedures used to acquire information about teaching and learning is a relatively

he most part, practitioners have not capitalized

ting that goes into developing these pro-

lection are seldom applied to the

ess frequently utilized directly in

the teaching/learning.

A more definitive purpose of this paper, therefore, is to present examples of:

- the ways in which research findings from two ETEP studies may be applied to teaching and teacher training; and
- the ways in which two data collection procedures taken from these studies may be applied to teaching and to the training of teachers.

The findings and procedures to be discussed are exemplary only. They in no way exhaust the array of new knowledge resulting from the research and/or the complete set of data collection procedures used in the various ETEP studies.

In addition to discussing the findings and data collection procedures from the ETEP research on teaching, the paper concludes by considering a new approach to research and development in teaching--an approach that we propose will increase the likelihood that research on teaching will be applied in the classroom in order to improve educational opportunities.

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*-Microteaching and Flanders' Interaction Analysis systems are two examples when this has been done.

Four Approaches to Application of Research

The application of research to teaching may be accomplished in a variety of ways. Four strategies that appear to be workable are discussed below.

1. Application through development of teacher training programs and materials. Training programs and materials have been the primary approach to applying research to teaching for the past ten years. A common theme for educational reform in the late 1960's and early 1970's was the need for products that would promote the use of new knowledge and skills by teachers. Inasmuch as the majority of the individuals in education today are familiar with one or more of these products, this paper will not elaborate on the characteristics of this application strategy.

2. Application through use of new knowledge by teachers to modify how they structure the teaching/learning situation and how they interact with students. The ultimate goal of any educational research is application of new knowledge in the ongoing learning experiences of each student. With or without special training, a teacher applies knowledge about teaching and learning whenever (s)he makes an instructional decision. The challenge, therefore, is to make research findings available to teachers in a form and via a process that relates directly to classroom decision-making. This paper will give special consideration to this strategy.

3. Application through use of data collection procedures as instructional vehicles and as self-development tools. In order to gain control of the content and, at times, the process of instruction, researchers frequently develop curriculum units, tests and/or other

techniques for measuring student performance, systems for observing and recording teacher-student interactions, etc. A teacher can utilize such materials to improve instruction within the classroom.

For example, a fifth grade teacher might incorporate into a regular mathematics program those curriculum materials that were originally developed for a research study of effective mathematics teaching at that grade level. (S)he also might adopt for classroom use a diagnostic instrument used to measure student reading comprehension in a research study of the teaching of reading.

This paper will present three examples of research procedures that may be applied in the classroom.

A teacher also can apply data collection procedures as self-analytic tools. The interaction analysis system and microteaching are two examples of data collection procedures that have later been used by teachers as a means for analyzing and improving their teaching. Two others will be discussed in this paper.

4. Application through teachers serving as researchers who validate (and evaluate) findings as they are applied in the classroom. Replication of a particular research study is the generally accepted procedure for establishing that a given set of findings is valid and stable. Another approach that may be less rigorous, but that nonetheless is empirically sound, would be to have teachers apply and test the findings in their instructional programs. Immediately following each application, the teacher would report the outcomes from both a teacher and student perspective. Compilation of such reports would provide valuable evidence of the accuracy and worth of the research findings. It also would suggest

new areas of inquiry that should be pursued by the researchers. This paper also will provide an example of this approach to application of research in teaching.

The Effective Teacher Education Program

The Effective Teacher Education Program (ETEP) is a program of research and development in teaching that, to date, has had three major purposes:

- To develop teacher training materials that incorporate the micro-teaching approach to training and that develop teachers' use of specified teaching skills (the Minicourses);
- To study the effects upon student outcomes of specific teaching skills (for the most part these have been skills that were contained in one or more of the Minicourses);
- To test various approaches to the study of teaching.

The current programmatic effort is devoted entirely to the latter two objectives. Some two and a half years of research are now completed and in the final stages of report preparation.

The research topics selected for study by ETEP were a direct outgrowth of the competency-based teacher education movement. Teaching skills considered important by theorists, researchers, and trainers (e.g., Dodl, 1972; Turner, et al., 1973) were included in the Minicourses. These skills, in turn, became the focus of the ETEP research. The three aspects of teaching that have been investigated include:

- Use of questioning skills. Two questioning studies were conducted. The purpose of Study I was to study the effects on student achievement and attitudes of teacher use of probing and redirection during a discussion. The purpose of Study II was to investigate the effects of teacher use during discussions of differing proportions of higher cognitive questions (25%, 50%, 75%) in relation to fact-recall questions on student achievement and attitude. The teaching skills of interest were taken from Minicourse 1, Effective Questioning - Elementary Level, and Minicourse 9, Higher Cognitive Questioning.

- Use of mathematics tutoring skills. Three studies were conducted, each employing a different individual in the tutorial role (regular classroom teacher, paraprofessional, junior high school student).

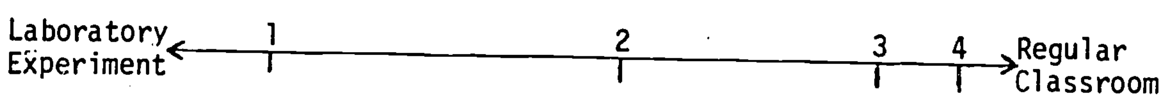
  Data from the teacher as tutor study will be presented here. The purpose of this study was to answer questions about the effects of tutoring in mathematics on students' mathematics achievement, self-concept as it relates to mathematics, attitude toward mathematics, and external locus of control as it relates to mathematics. The tutoring skills to be studied were taken from Minicourse 5, Individualizing Instruction in Mathematics.

- Use of an independent learning system. The purpose of this study was to investigate the effect upon students of an instructional system. Training in the implementation and use of the independent learning system was provided by Minicourse 15: Organizing Independent Learning--Intermediate Level. Data from this study are presently being compiled and analyzed. They, therefore, will not be reported here.

In addition to studying the effects on students of teacher use of various skills, the ETEP research has explored four approaches to the study of teaching. The approaches fall along a continuum of research techniques that range from a tightly controlled laboratory experiment to work in the regular classroom where instructional and other variables are allowed to vary naturally (see Figure 1).

FIGURE 1

Continuum of Approaches to the Study of Teaching



1--Semi-programmed approach
2--Experimental Teaching Unit
3--Train teacher; study specific skills in specified instructional setting
4--Train teacher; establish instructional system; study overall effect.

The semi-programmed approach was used in the questioning studies. In this approach, the teacher is provided a set of curricular materials to use with the students. The sequence in which the materials are to be used is specified and the teacher is directed to conduct discussion and/or some other activity as part of each day's lesson. When a discussion is specified, the teacher is provided a script which tells her/him the questions to ask and in what sequence. The script is only "semi" programmed because some teacher behaviors during a discussion are contingent upon student responses. For example, in the questioning studies, the script could dictate the question to be asked and approximately how many times probing was to occur but it could not prescribe which student responses would be probed.

The Experimental Teaching Unit (ETU) approach was incorporated as a sub-study in the mathematics tutoring study with teachers as tutors. This unit consisted of a statement of teaching and learning objectives, curricular materials for students, and criterion-referenced pre and post tests. Teachers were allowed to organize and teach the unit as they wished. This approach, therefore, controls the content but not the process of instruction.

The third approach, training teachers to use a particular set of skills, then studying the effects in a given content area and/or instructional setting, is a familiar form of research on teaching. It has been used in a large number of the existing studies of teachers. It was employed in the ETEP math tutoring studies.

The fourth approach parallels the research procedures applied to ma. previous studies of innovative educational programs. Teachers are trained in a new educational program; the program is put into operation; the effects on students are studied. As noted earlier, this approach was used in the ETEP independent learning study.

The discussion which follows is concerned with reporting and applying the findings of the ETEP Questioning and Teacher as Math Tutor Studies; and with considering the usefulness and applicability of the semi-programmed and ETU approaches to research on teaching. The Independent Learning Study will not be discussed inasmuch as data analyses are not yet completed.

The Questioning Studies

Two studies of teacher use of questioning skills have been conducted as part of the ETEP effort. They are Study I: The Effects of Teacher Use of Probing and Redirection on Student Achievement and Attitudes and Study II: The Effects of Teacher Use of Higher Cognitive Questions on Student Achievement and Attitudes.* Both studies were directed by Dr. Meredith D. Gall, who has recently joined the School of Education faculty at the University of Oregon.

Both Study I and Study II were designed to reduce and/or eliminate several previously identified research problems. These included the need for random assignment of students to treatment, matching of student

* For complete report of the studies see: Gall, et al., The Effects of Teacher Use of Questioning Techniques on Student Achievement and Attitudes. San Francisco: Far West Laboratory for Educational Research and Development, 1975.

outcome measures with the intended instructional purpose(s) of the treatment conditions, controlling for opportunity to learn, control and monitoring of treatment conditions to be sure they were maintained, and investigation of the critical assumptions underlying the statistical procedures used in analyses of data.

Study I was designed to determine what student learning outcomes were affected by presence or absence of probing and redirection in discussions and presence or absence of discussions themselves. It also investigated the relative effect on student learning of teachers' questions delivered in discussions compared with the same questions presented and answered in written format.

While the outcomes of Study I are of interest, we have elected to devote this presentation to a discussion of Study II. Complete information regarding Study I is available in the research report.

Study II, The Effects of Teacher Use of Higher Cognitive Questions on Student Achievement Attitudes, included four treatment conditions--three discussion treatments and an art activity treatment. All treatments were administered to students randomly formed into treatment groups from sixth grade classrooms in the cooperating school district. All groups used a specially prepared curriculum on ecology. The treatments were administered by specially trained teachers, not the students' regular teachers. Each teacher taught four different treatment groups each day using the specially prepared curricular materials and the semi-programmed discussion script to guide the presentation of the treatments. Table 1 outlines these treatments and indicates the percent of higher cognitive questions and the other teaching skills used in the discussions based on the semi-programmed scripts. The treatments covered ten lessons in ecology.

TABLE 1

STUDY II Treatments

Treatment	Content
25% Higher Cognitive Questions	Curriculum materials followed by discussion including 8F + 4MF + 4HCQ + probing and redirection.
50% Higher Cognitive Questions	Curriculum materials followed by discussion including 4F + 4MF + 8HCQ + probing and redirection.
75% Higher Cognitive Questions	Curriculum materials followed by discussion including 4MF + 12HCQ + probing and redirection.
Art Activity	Ecology - related art activity

F = Fact question
MF = Multi-fact question
HCQ = Higher cognitive question

Fidelity of treatment was investigated along two dimensions. First, a check was made on how closely the teachers adhered to the semi-programmed scripts. Second, the time required to conduct the lessons in each treatment was checked. Both these factors were checked by audiotaping three of the discussions conducted by each teacher on each of two days (Lesson 2 and Lesson 7). This sample of six discussions per teacher was rated to establish treatment fidelity.

According to the ratings of the audiotapes, the teachers appear to have followed the question format. In only six instances out of the 144 lessons rated for Studies I and II combined did teachers change the order of the questions. Other deviations either did not occur or occurred very infrequently.

The treatments were similar in length. The average length per treatment was 16.24 minutes for the 25% HCQ treatment plus 12 minutes of filler activity; 21.87 minutes for the 50% HCQ treatment plus 6 minutes of filler; and 27.65 minutes of discussion for the 75% HCQ treatment. The art activity treatment stopped after 29 minutes each day.

The effects of the Study II treatments were investigated through a "Latin square" design. The term "Latin square" comes from an ancient puzzle that deals with the number of different ways Latin letters can be presented in a square (matrix) such that each letter appears once, and only once, in each column and each row. Thus, in Study II a Latin square assignment as presented in Table 2 was used. Each teacher taught each treatment condition and all treatments were assigned to each classroom, but a given student was randomly assigned to only one treatment.

Study II Results. The statistical analyses for Study II were planned in response to two research objectives:

- To determine what student learning outcomes were affected by variations in the percentage of higher cognitive questions in discussions;
- To determine what student learning outcomes are affected by presence or absence of discussions.

The student outcome measures used in the study are listed in Table 3. They include measures of students' factual knowledge related to the ecology curriculum and students' ability to work with and extend this knowledge at higher cognitive levels. Student performance was measured in both written and oral form inasmuch as the treatment conditions emphasized oral discussion. Each student was administered a test battery before, immediately after, and/or two weeks after the treatments to determine the effects of the treatments on achievement and attitudes

TABLE 2

Study II
Composition of Squares

SQUARE 1

ECOLOGY TEACHER	SCHOOL 7		SCHOOL 8	
	9AM* Class 13	10:00AM Class 14	12:30PM Class 15	2:00PM Class 16
8	Treatment 1 B=3 G=3	Treatment 3 B=3 G=3	Treatment 4 B=5 G=6	Treatment 2 B=3 G=3
7	Treatment 3 B=3 G=3	Treatment 2 B=3 G=3	Treatment 1 B=3 G=3	Treatment 4 B=5 G=4
10	Treatment 4 B=2 G=11	Treatment 1 B=3 G=3	Treatment 2 B=3 G=3	Treatment 3 B=3 G=3
12	Treatment 2 B=3 G=3	Treatment 4 B=6 G=9	Treatment 3 B=3 G=3	Treatment 1 B=3 G=3

SQUARE 2

ECOLOGY TEACHER	SCHOOL 9		SCHOOL 10	
	9AM Class 17	10:00AM Class 18	12:30PM Class 19	2:00PM Class 20
4	Treatment 1 B=3 G=3	Treatment 3 B=3 G=3	Treatment 2 B=3 G=3	Treatment 4 B=8 G=7
11	Treatment 3 B=3 G=3	Treatment 2 B=3 G=3	Treatment 4 B=8 G=7	Treatment 1 B=3 G=3
1	Treatment 4 B=6 G=6	Treatment 1 B=3 G=3	Treatment 3 B=3 G=3	Treatment 2 B=3 G=3
5	Treatment 2 B=3 G=3	Treatment 4 B=3 G=7	Treatment 1 B=3 G=3	Treatment 3 B=3 G=3

SQUARE 3

ECOLOGY TEACHER	SCHOOL 11		SCHOOL 12	
	9AM Class 21	10:00AM Class 22	12:30PM Class 23	2:00PM Class 24
6	Treatment 1 B=3 G=3	Treatment 3 B=3 G=3	Treatment 4 B=7 G=7	Treatment 2 B=3 G=3
2	Treatment 3 B=3 G=3	Treatment 2 B=3 G=3	Treatment 1 B=3 G=3	Treatment 4 B=6 G=8
3	Treatment 2 B=3 G=3	Treatment 4 B=6 G=7	Treatment 3 B=3 G=3	Treatment 1 B=3 G=3
9	Treatment 4 B=7 G=7	Treatment 1 B=3 G=3	Treatment 2 B=3 G=3	Treatment 3 B=3 G=3

* Times are approximate.

Treatment 1 = 25% Higher Cognitive Questions
Treatment 2 = 50% Higher Cognitive Questions
Treatment 3 = 75% Higher Cognitive Questions
Treatment 4 = Art Activity
B = Boys
G = Girls

TABLE 3

Study II

Achievement Measures

INSTRUMENT	VARIABLES MEASURED	POINT OF ADMINIS-TRATION	APPROXIMATE TESTING TIME**
Comprehensive Tests of Basic Skills-Reading	Vocabulary; Comprehension	Pre*	52 minutes
Ecology Information Test	Amount of information about ecology	Pre, post, delayed	15 minutes
Oral Test	Ability to state orally opinions, predictions, solutions, inferences, etc.	Pre, post	10 minutes
Essay Test	Ability to state in writing opinions, predictions, solutions, inferences, etc. Ability to state in writing reasons and if-then relationships.	Pre, post	25 minutes
Population Test	Ability to state in writing opinions, predictions, solutions, inferences, etc. Ability to state in writing reasons and if-then relationships.	Delayed	25 minutes
Question-Generating Test: Paper-and-Pencil Measure	Ability to generate questions. Quality of questions generated.	Pre, post	20 minutes
Question-Generating Test: Oral Measure	Ability to generate questions. Quality of questions generated.	Pre, post	2 minutes

* Data collected by the participating school district, not by the researchers.

** These are average times for test administration. All tests except the Question Generating Test (Paper-and-Pencil Measure) were primarily power tests.

related to the specific curriculum which they have studied. The oral measures were administered to each student on a one-to-one basis and the students' responses were audiorecorded. These audiotapes were scored to obtain the student's rating for the specified variables. For purposes of this discussion, only the achievement outcomes will be considered since few differences occurred in the affective areas. Students appears to have liked all the treatments inasmuch as each provided a diversion from regular classroom instruction. Complete information on all the variables may be obtained from the final report of the study.

Table 4 presents the results of the analysis of variance for the ability, achievement, and attendance variables. The table contains the following information:

- The name of each dependent variable.
- The name of the variable used to adjust the student's scores on the dependent variable, if any.
- The error mean square and its degrees of freedom.
- The F-statistics for each dependent variable for treatment effects, class effects, teacher effects, square effects, and treatment by square interaction.
- The omega squared (strength of association) statistics. This statistic is interpreted as the percentage of variance in the dependent variable attributable to the treatment effect for that column.

Inspection of Table 4 indicates that there were six dependent variables on which the treatment group means differed significantly: Ecology Information Test Intentional Scale II, Ecology Information test 25% Intentional Scale, Ecology Informatin Test Incidental Scale II, Oral Test Content Scale, Oral Test Logical Extension Scale, Essay Test

Study II

Analysis of Variance Summary for
Measures of Ability, Achievement, and Attendance

DEPENDENT VARIABLE	ADJUSTING VARIABLE	MSerror df=18	F VALUES AND ω² FOR ANALYSIS OF VARIANCE EFFECTS									
			Treatment		Class		Teacher		Square		Treatment by Square	
			F 3,18	ω²	F 9,18	ω²	F 9,18	ω²	F 2,18	ω²	F 6,18	ω²
STATUS VARIABLES												
Number of Sessions Attended		0.51	0.18	0.00[a]	0.46	0.00	0.96	0.00	1.49	0.02	1.11	0.01
CTBS[b] - Total Reading		48.25	0.53	0.00	1.38	0.02	0.82	0.00	0.93	0.00	1.01	0.00
KNOWLEDGE VARIABLES												
Ecology Information Test:												
Intentional Scale II, post		0.33	8.55*	0.31	1.42	0.05	1.08	0.01	0.72	0.00	0.69	0.00
Intentional Scale II, delay	total rdng.	0.40	12.51*	0.42	0.77	0.00	0.92	0.00	3.85*	0.07	0.54	0.00
25% Intentional Scale II, post	total rdng.	0.35	9.40*	0.40	1.00	0.00	0.54	0.00	0.48	0.00	0.28	0.00
25% Intentional Scale II, delay	total rdng.	0.49	5.20*	0.25	0.75	0.04	0.42	0.00	0.54	0.00	0.73	0.00
Incidental Scale II, post	total rdng.	0.48	7.49*	0.27	1.60	0.07	0.88	0.00	2.37	0.04	1.57	0.05
Incidental Scale II, delay	total rdng.	0.68	7.30*	0.28	1.37	0.05	0.49	0.00	1.86	0.03	0.90	0.00
HIGHER COGNITIVE VARIABLES												
Oral Test:												
Content, post	pre	1.10	5.53*	0.19	0.42	0.00	0.73	0.00	9.88*	0.25	2.12	0.15
Logical Extension, post	pre	0.68	4.91*	0.13	3.49*	0.25	1.19	0.02	3.22	0.05	1.42	0.03
Essay Test:												
Content, post	pre	1.19	8.15*	0.14	9.77*	0.52	1.35	0.02	1.57	0.01	0.97	0.00
Logical Extension, post		0.71	1.18	0.01	2.49*	0.27	0.35	0.00	0.15	0.00	0.34	0.00
Transfer Test:												
Content, delay	Ess.Cont.pre	2.29	0.32	0.00	1.75	0.15	0.34	0.00	1.78	0.04	0.58	0.00
Logical Extension, delay		0.39	0.54	0.00	3.33*	0.32	1.24	0.03	1.03	0.00	0.38	0.00
QUESTION GENERATING VARIABLES												
Written Question Generating Test:												
Non-pertinent Questions		0.16	1.08	0.00	1.41	0.07	0.77	0.00	2.29	0.05	0.74	0.00
Pertinent Questions	pre	3.52	2.81	0.04	7.63*	0.43	1.33	0.02	15.10*	0.20	0.33	0.00
Specific Questions		1.53	2.66	0.07	3.95*	0.36	0.40	0.00	0.50	0.00	1.02	0.00
Request for Rationale		0.18	0.37	0.00	0.61	0.13	0.65	0.00	0.27	0.00	0.21	0.00
Quality Rating		0.06	0.51	0.00	1.75	0.14	0.90	0.00	0.83	0.00	0.36	0.00
Oral Question Generating Test:												
Non-pertinent Questions		0.03	1.23	0.00	1.61	0.05	0.98	0.00	3.86*	0.08	1.41	0.22
Pertinent Questions		0.45	0.61	1.00	0.66	0.00	0.98	0.00	0.49	0.00	1.22	0.13
Quality Rating.		0.07	0.12	0.00	1.24	0.05	0.47	0.00	3.35	0.11	0.32	0.00

*Significance at the .05 level. The .05 levels for F values with the following degrees of freedom are:
$F_{2,18}=3.55$ $F_{3,18}=3.16$ $F_{6,18}=2.66$ $F_{9,18}=2.45$

[a] ω^2 = proportion of total variance explained (omega squared).

[b] CTBS= Comprehensive Tests of Basic Skills.

Content Scale. For these variables, the differences among treatments were greater than would be expected to occur by chance in 95 out of 100 comparisons of the treatments.

Since all the information test subscales emphasize factual knowledge and the content scales of the oral and essay tests, while requiring higher cognitive responses, build these responses from the actual content of the questions asked during the discussions, the treatments seem to have had more influence upon recall of information than upon the various higher level outcomes. Of the six variables where statistically significant differences occurred, only the logical extension measure on the oral test represents a higher cognitive outcome that requires the student to formulate responses that go beyond the concept of the treatments.

To determine which treatment means differed significantly from each other on the achievement variables, planned comparisons were made of the treatment means. Table 5 presents these comparisons.

The F-statistics for the planned comparisons (see the last 4 columns of the table) show that percentage of higher cognitive questions was a statistically significant influence on the amount of information acquired by students as measured by subscales on the Ecology Information Test. There also were some differences on the oral test measures, particularly when the art activity was compared with the combination of all the discussion treatments.

The pattern of treatment mean scores for the subscales of the Ecology Information Test is depicted in Figure 2. It appears that a U curve describes the relationship between percentage of higher cognitive questions and achievement. In all cases the 50% Higher Cognitive Question

TABLE 5

STUDY II

Treatment Means and Planned Comparisons of Measures of Ability, Achievement, and Attendance

DEPENDENT VARIABLE	ADJUSTING VARIABLE	TREATMENT MEANS: 25% HCQ Treatment (1)	50% HCQ Treatment (2)	75% HCQ Treatment (3)	Art Activ. II (4)	PLANNED COMPARISONS: Treatments 1 vs 2 $F_{1,18}$	Treatments 2 vs 3 $F_{1,18}$	Treatments 1 vs 3 $F_{1,18}$	Treatments 1,2,3 vs 4 $F_{1,18}$	Treatments 1,2,3 vs 4 Prop.[a]
STATUS VARIABLES										
Number of Sessions Attended		9.23	9.04	9.17	9.21	0.45	0.19	0.06	0.07	0.13
CTBS[b] - Total Reading		61.69	64.71	61.85	63.63	1.13	1.10	0.00	0.14	0.09
KNOWLEDGE VARIABLES										
Ecology Information Test:										
Intentional Scale II, post		6.27	5.94	6.29	5.26	2.01	2.21	0.00	22.83*	0.89
Intentional Scale II, delay	total rdng.	6.19	5.26	5.85	4.74	13.12*	5.31*	1.73	24.10*	0.48
25% Intentional Scale II, post	total rdng.	4.68	3.53	4.01	3.62	22.96*	3.97	7.83*	5.21*	0.18
25% Intentional Scale II, delay	total rdng.	4.52	3.56	3.76	3.56	11.59*	0.50	7.30*	2.67	0.47
Incidental Scale II, post	total rdng.	5.97	4.92	5.83	5.00	13.66*	10.29*	0.24	6.34*	0.28
Incidental Scale II, delay	total rdng.	5.91	4.52	5.34	4.67	17.22*	5.97*	2.91	4.49*	0.21
HIGHER COGNITIVE VARIABLES										
Oral Test:										
Content, post	pre	8.88	8.83	8.42	7.35	0.01	0.96	1.17	15.15*	0.91
Logical Extension, post	pre	4.03	3.80	3.10	2.95	0.50	4.30	7.73*	6.39*	0.43
Essay Test:										
Content, post	pre	11.58	12.55	11.64	10.36	4.73*	4.11	0.02	18.54*	0.76
Logical Extension, post		2.11	2.30	2.03	1.68	1.34	0.62	0.04	2.89	0.81
Transfer Test:										
Content, delay	Ess.Cont.pre	8.79	8.99	8.62	8.40	0.10	0.07	0.61	0.61	0.64
Logical Extension, delay		1.67	1.73	1.85	1.51	0.07	0.22	0.53	1.37	0.72
QUESTION-GENERARING VARIABLE										
Written Question Generating Test:										
Non-pertinent Questions		0.37	0.43	0.61	0.34	0.11	1.28	2.15	0.86	0.27
Pertinent Questions	pre	12.48	13.51	12.52	11.29	1.80	1.69	0.00	6.12*	0.73
Specific Questions		3.24	4.16	3.12	2.81	3.36	4.25	0.05	2.87	0.36
Request for Rationale		0.56	0.51	0.42	0.39	0.08	0.29	0.65	0.42	0.38
Quality Rating		2.94	2.98	2.85	2.94	0.21	1.48	0.57	0.02	0.01
Oral Question Generating Test:										
Non-pertinent Questions		0.18	0.11	0.14	0.14	3.49	1.17	0.62	0.17	0.05
Pertinent Questions		1.85	1.87	1.56	1.64	0.00	1.25	1.11	0.27	0.15
Quality Rating		1.06	1.10	1.05	1.02	0.07	0.19	0.03	0.17	0.46

*Significance at the .05 level. The .05 level for F values with 18 degrees of freedom is: $F_{1,18} = 4.41$

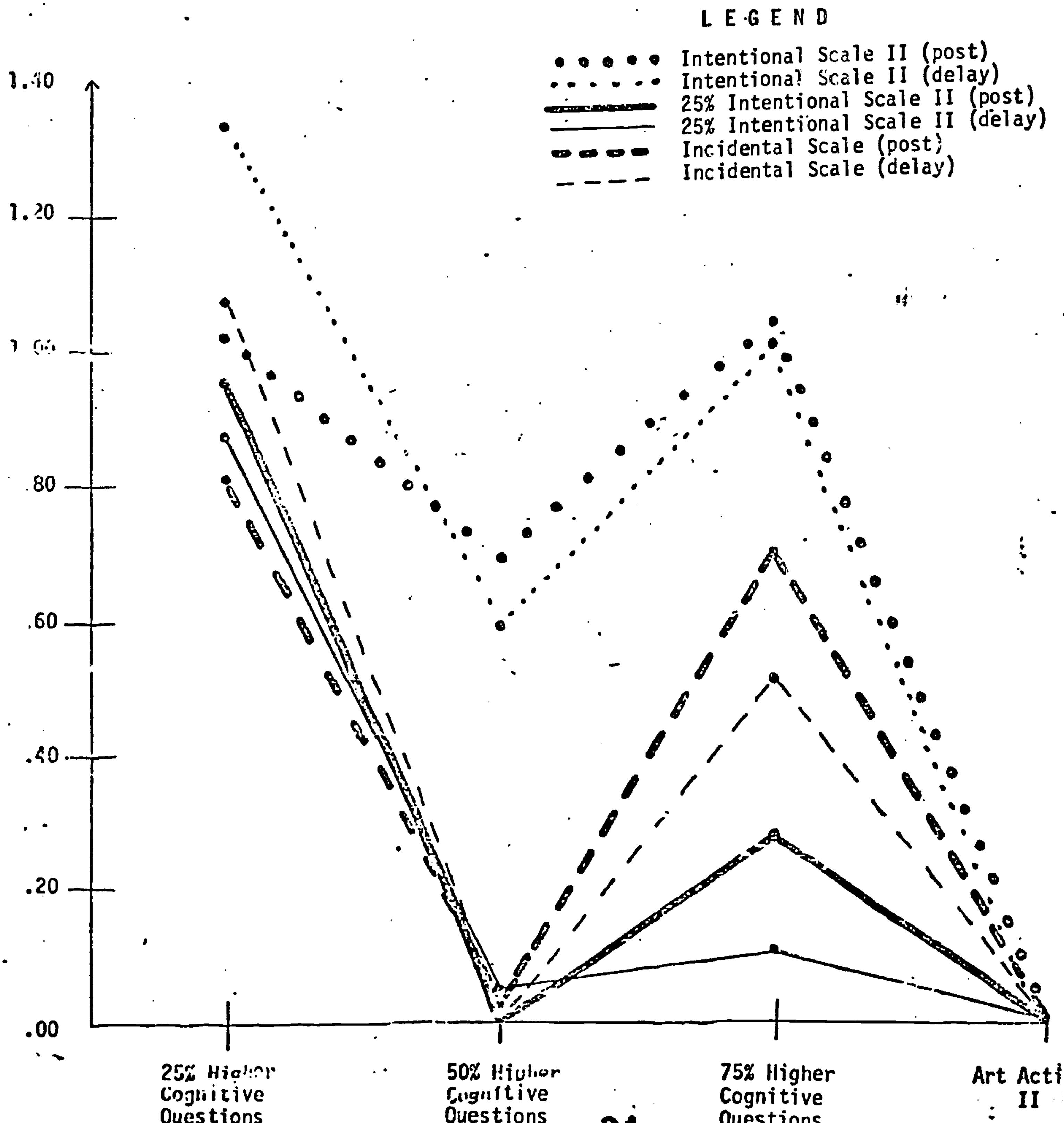
[a]Prop. = Sum of squares for Treatments 1, 2, 3 vs 4 as a proportion of total treatment sum of squares.

[b]CTBS = Comprehensive Tests of Basic Skills.

FIGURE 2

Patterns of Treatment Differences for

Ecology Information Subtests in Study II



*Data points on the graph are based on unadjusted treatment means. The three recitation treatment means are expressed on the ordinate as absolute

(HCQ) treatment has considerably lower outcomes than the other two discussion treatments. The 75% HCQ and 25% HCQ treatment outcomes fall at similar points for the various subtests. Outcomes for the art activity treatment approximate those for the 50% HCQ treatment.

Since this finding was somewhat unexpected--a gradual increase in outcomes was expected moving from the art activity to 25% HCQ, to 50% HCQ, with 75% HCQ being highest--a secondary analysis of the data was requested. Dr. Richard Snow of Stanford University conducted this analysis.*

The purpose for reanalysis of the data from Study II was to extend the understanding of the data from the Gall analysis rather than to double check the earlier analysis.

A first step in the reanalysis was a factor analysis of the pre-measures for both Studies I and II. This showed five factors: (1) general scholastic ability and prior achievement (verbal, comprehension, and essay tests); (2) oral measures and discussion-attitude measures; (3) word association; (4) question generating, specific; and (5) quality ratings (question generating and oral).

Simple and multiple regression analyses using the pre-factors as aptitudes predicted outcome variables with substantial multiple correlations. Some outcome measures were highly predictable such as the ecology information test and the essay test. Others, such as the question-generating test, were less predictable.

These analyses also uncovered various higher order interactions. Some examples of aptitude-treatment interactions from Study II include:

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* For complete information on the secondary analyses see Snow, et al., Extended Analysis of Two Experiments on Teaching. Palo Alto: Stanford University, 1975.

- Based upon examination of the regression of the ecology information test measures on general ability (factor 1), it appears that the V-shaped average curves (see Figure 2) apply mainly to students of low ability. The 50% higher cognitive questioning (HCQ) condition is particularly bad for low ability students, while the 25% and 75% conditions are much better. Among higher ability students the three questioning conditions do not differ.
- On the oral outcome measures, students low in general ability did best in the 25% HCQ condition while high ability students did poorest here. For them the 50% HCQ condition was the best.
- Based upon a higher order interaction combining pre-factor 1 (general ability) and pre-factor 5 (quality rating) in predicting population-total measures, the 25% HCQ treatment was best for highs on these combined factors while the 75% HCQ treatment was best for lows.

In general, the reanalyses showed that the effects of treatment in Study II were far more complex than might have been expected. Outcome is often a function of entering aptitudes and their interactions with treatment conditions. While the complex aptitude-treatment interactions can be interpreted only with caution, they suggest that no one treatment is routinely best for all students.

Implications of the Study II Findings. The general conclusions to be drawn from the Study II that were reported here are obvious.* Foremost is the findings that a teacher's use of higher cognitive questions may not, in and of itself, lead to improved performance for all students. The context of the situation in which the questions are used warrants as much, if not more, consideration than the skill of asking higher cognitive questions. In particular, attention should be given to:

- The structure of the discussion in which the questions are used. In Study II both the 25% HCQ and the 75% HCQ discussions had an obvious purpose and structure. In the 25% discussions, students were asked to devote most of the time to review of facts contained in the ecology unit curricular materials and a smaller amount of

* The findings in this paper do not include all the results obtained from Study II. See the final report for a complete statement of results.

time at the end of the discussion relating and extending these facts. The 75% discussions followed an opposite structure--a little time for review, much of the time relating and extending the ideas. The 50% HCQ discussions, on the other hand, tended to mix up the two processes, and may, therefore, have confused some students.

- The entering abilities of the students. The aptitude-treatment interactions discussed earlier in this paper underline, once again, the need to adapt instructional strategies to the needs of students. Appropriate use of a teaching skill--in this instance asking higher cognitive questions, with students with one level of entering aptitude--is not necessarily appropriate for other students. This conclusion was also supported in Study I where, using the ecology information test as criteria, students high in general ability did best when teachers used probing and redirection to follow-up student responses during a discussion. Low ability students were better off without probing and redirection.

Effective teaching, therefore, probably centers around when a skill is used, with whom, for what purpose, within what form of total instructional situation rather than presence or absence of the skill.

The implications of such complex research findings--and they have been reported in several recent research reports--are considerable for both the trainer of preservice teachers and the inservice teachers who are already in "daily" contact with students.

In a competency-based preservice program that was responsive to the findings of Study II, a training program on the use of higher cognitive questions would include experience in generating and asking different types of higher cognitive questions, as most programs currently do. But it also would build knowledge about the types of student entry abilities and the degree of prior knowledge that should be considered when a discussion was planned and provide experience in recognizing and/or measuring various levels of these abilities. It would provide practice in planning and conducting discussions with different overall structures and sequences of questions with different students and require the trainees to analyze which discussion context seemed to work best for them with which students.

A critical question is how many of the latter four training activities are included in the existing preservice training programs? Does work with the competency of asking higher cognitive questions include training in all the elements that interact when the skill is used effectively in teaching?

For the inservice teacher, response to such findings may emphasize self-analysis and on-the-job practice. The inservice teacher might inquire into the structure of the discussions held in the classroom. Are the types of questions asked and the sequence in which they are asked modified according to the entry ability and prior knowledge of the students who are participating?

On the other hand, inservice teachers also may need additional training in order to apply findings that are as complex as those from Study II inasmuch as their previous training and experience may not have focused upon such elements as those student entry-abilities related to performance in various forms of discussion treatments.

Incorporating research findings into teaching and teacher training may require more than reading the research report. A redesign of the training program may be necessary to incorporate findings into its structure and thereby affect existing competencies.

A Study of The Teacher as Math Tutor

The Teacher as Math Tutor Study* also was conducted as part of the ETEP effort. This study was conducted with fourth and fifth grade students to answer questions concerning the effect of tutoring in mathematics upon students' mathematics achievement, self-concept in mathematics, attitude toward mathematics, and external locus of control as it relates to mathematics. The study was conducted by Dr. Barbara Ivory Williams of the Far West Laboratory staff.

The study included four treatment conditions: two tutoring treatments, one in which teachers received special training in tutoring and one in which teachers received no special training; a supplementary treatment in which teachers conducted no regular tutoring but gave one-half hour of additional group mathematics instruction to the lower one-half of their classes each week for ten weeks; and a special control treatment in which teachers conducted their regular mathematics instruction.

The Math Tutoring Study represents the third approach to the study of teaching outlined earlier in this paper. It is a familiar form of research on teaching which trains teachers to use a particular set of skills, then studies the effects in a given content area.

Students in the study were designated as target students--four students from each classroom who were below the school median on their Comprehensive Tests of Basic Skills (CTBS) score and their Iowa Tests of Basic Skills (ITBS) Modern Mathematics Supplement score and who received tutoring in the two tutoring treatments or received the extra half-hour per week of group; and non-target students--four additional students, matched on

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* For complete report of the study see: Williams, et al., Math Tutoring Study: Teachers as Tutors; Paraprofessionals as Tutors; Cross-age Tutoring. San Francisco: Far West Laboratory for Educational Research and Development, 1975.

Teachers as Math Tutors Study

Teachers and Students by Treatment Grade

TABLE 6

Grade 4

...ourse 5 ...ed Tutors	Regular Tutor		Supplemental Treatment		Special Control
...er n = 8	teacher n = 10*		teacher n = 9		teacher n = 4
NonTarget Pupils	Target Pupils	NonTarget Pupils	Target Pupils	NonTarget Pupils	Control Pupils
8	2	3	4	4	--
2	3	3	--	--	--
4	4	2	3	4	--
4	4	3	4	4	--
--	4	2	4	3	--
--	4	4	3	3	--
--	2	2	4	3	--
4	4	4	4	4	--
3	4	2	4	2	--
3	4	3	3	3	--
--	--	--	--	--	32
--	--	--	--	--	11
28	35	28	33	30	43 = 227

...this treatment conditin taught a fourth/fifth grade class and ...ed 2 fourth graders and 2 fifth graders.

TABLE 7

Grade 5

School	Minicourse 5 Trained Tutors		Regular Tutor		Supplemental Treatment		Special Control
	teacher n=8		teacher n=8*		teacher n=7		teacher n=5
	Target	NonTarget	Target	NonTarget	Target	NonTarget	Control Pupils
1	4	3	4	2	4	4	--
2	--	--	4	4	3	4	--
3	4	3	4	4	3	4	--
4	3	3	4	4	4	4	--
6	4	4	--	--	--	--	--
7	4	4	2	0	--	--	--
9	4	4	4	3	4	4	--
10	4	4	4	2	4	4	--
11	4	4	4	3	4	4	--
12	--	--	--	--	--	--	25
13	--	--	--	--	--	--	12
14	--	--	--	--	--	--	24
TOTALS	30	29	30	22	26	28	61 = 226

*One teacher in this treatment condition taught a fourth/fifth grade class and therefore tutored 2 fourth graders and 2 fifth graders.

CTBS pre scores, from each of the classrooms. Nontarget pupils were not identified to their teachers. Target/nontarget designations were not made for pupils in the special control treatment. Tables 6 and 7 indicate the number of teachers and students in each treatment by school for fourth and fifth grade.

Based on this design, it was possible to consider the effects upon students that could be related to the tutoring process itself as contrasted with those that were related to extra time spent in mathematics regardless of the teaching-learning process employed.

In order to study the effects of tutoring, it was important that the treatment conditions be in operation over a reasonable period of time. For purposes of this study, two and one-half months--extending from early January to mid-March--were selected. During this time, all teachers who participated kept a daily log indicating the student who was tutored (if appropriate to the treatment), the mathematics area in which the tutoring or extra group instruction occurred, the activity in which the remaining students in the classroom were engaged, the mathematics area on which the class was working for the present week, an estimation of the progress that the tutored pupil made (if appropriate), the total number of minutes the tutoring session or the extra group session lasted.

Tables 8 and 9 present data regarding the average number of minutes each target pupil was tutored per week. Since teachers in the supplemental treatment gave no students regular, systematic one-to-one assistance and the tutoring sessions, for the most part, came close to the prescribed 30 minutes of tutoring per week for each target student, the treatments appear to have been sufficiently well maintained to permit investigation

Average Number of Minutes Tutored Per Week

by Teacher and Pupil

TABLE 8

Grade 4

	Minicourse 5 Trained Tutors				Regular Tutors			
School	Pupil 1	Pupil 2	Pupil 3	Pupil 4	Pupil 1	Pupil 2	Pupil 3	Pupil 4
1	22.8	27.8	25.2	25.6	29.5	29.5		
3	19.5	18.0	16.8	21.8	25.8	26.7	25.0	26.7
4	19.5	24.4	20.6	18.4	22.8	23.0	21.2	24.3
9	18.0	17.0	21.0	21.0	28.5	28.0	29.5	29.5
10	31.8	29.0	26.8	25.7	27.5	25.0	27.5	30.8
11	16.7	18.3	28.7	19.7	24.0	24.0	27.0	30.0

TABLE 9

Grade 5

	Minicourse 5 Trained Tutors				Regular Tutors			
School	Pupil 1	Pupil 2	Pupil 3	Pupil 4	Pupil 1	Pupil 2	Pupil 3	Pupil 4
1	18.3	16.3	21.1	22.2	21.0	27.0	24.0	24.0
3	22.9	25.7	23.7	21.9	31.3	22.7	25.0	23.9
4	21.0	16.5	15.0		27.5	24.4	24.4	21.9
9	24.6	21.4	19.1	17.1	27.7	25.0	26.0	21.0
10	21.7	20.0	16.7	23.3	15.0	22.5	25.5	18.0
11	29.0	28.5	22.5	27.5	28.1	28.8	30.0	30.0

Teacher as Math Tutor Results. Before presenting the results of this study, it should be noted that within each school that participated in the study, the fourth and fifth grade students were randomly assigned to teachers for the school year in which the study was conducted. Such sampling procedures are rarely found in studies of teaching. They greatly increase the degree of generalizability of the study results.

The statistical analyses for the Math Study were planned in response to five research questions:

- Do pupils who receive systematic mathematics tutoring perform better on a set of dependent variables than pupils of comparable ability in the same classes who do not receive systematic mathematics tutoring?

- Do pupils who receive systematic mathematics tutoring from tutors trained in tutorial skills perform better on a set of dependent variables than pupils of comparable ability who receive systematic mathematics tutoring from tutors who have not had mathematics tutoring training?

- Do pupils who receive thirty minutes of systematic mathematics tutoring per week perform better on a set of dependent variables than pupils of comparable ability who receive an additional thirty minutes of group mathematics instruction per week?

- Do pupils who do not receive systematic mathematics tutoring but are in classes where systematic mathematics tutoring takes place perform better on a set of dependent variables than pupils of comparable ability who do not receive tutoring and are in classes where no systematic mathematics tutoring takes place?

- Are there particular combinations of tutoring skills or interpersonal behaviors which are positively related to specific pupil outcomes?

For purposes of this portion of the paper, we will consider only the first four questions. The fifth question will be discussed later when the Experimental Teaching Unit is presented.

The student outcome measures used in the study are listed in Table 10. They include measures of students' mathematics achievement, attitude toward mathematics, and external locus of control. All instruments were administered from October 29 to November 9 in 1973 and again from March 18 to March 29, 1974.

TABLE 10

Math Tutoring Study
Student Measures

Instrument	Variable Measured	Point of Administration
Comprehensive Tests of Basic Skills, Form Q, Level 2	Computational Skills	Pre, Post
Modern Mathematics Supplement, Iowa Tests of Basic Skills	Understanding of mathematical concepts	Pre, Post
Modified Sears Self-Concept Inventory	Academic self concept, mathematics self-concept	Pre, Post
Dutton-Likert Attitude Towards Mathematics Scale	Attitude toward mathematics	Pre, Post
Feelings About Mathematics Scale	External locus of control as related to mathematics	Pre, Post

For purposes of this discussion, only the achievement outcomes will be presented. Complete information on all the variables may be obtained from the final report of the study.

Table 11 presents the results of the analyses of covariance for CTBS for grades 4 and 5 for all treatment groups. The Table also contains the pre, post and adjusted mean CTBS scores for students in the various treat-

TABLE 11

Math Tutoring Study
Computational Skills - CTBS

ANALYSIS OF COVARIANCE

COMPREHENSIVE TESTS OF BASIC SKILLS

ANALYSIS OF COVARIANCE

Grade 4

	D.F.	Sum of Sq.	Mean Sq.	F Ratio	F Prob
...usted	6	466.1	77.7	1.82	0.10
	1	5158.0	5158.0	120.99	0.00
	214	9122.9	42.6		
...pes	6	172.2	28.7	0.67	0.68
	208	8950.7	43.0		

	N	Pre Mean	Post Mean	Adjusted Mean	Standard Error
	30	13.5	22.4	21.7	1.19
	28	12.8	17.8	17.7	1.23
	35	11.6	20.0	21.0	1.12
	27	12.4	21.9	22.2	1.26
...arget	31	12.5	20.8	21.0	1.17
	30	11.6	20.6	21.6	1.20
	41	14.2	20.6	19.1	1.03

COMPREHENSIVE TESTS OF BASIC SKILLS

ANALYSIS OF COVARIANCE

Grade 5

Source	D.F.	Sum of Sq.	Mean Sq.	F Ratio	F Prob
Equality of Adjusted Cell Means	6	548.9	91.5	1.87	0.09
Zero Slope	1	2706.2	2706.2	55.34	0.00
Error	218	10660.9	48.9		
Equality of Slopes	6	314.2	52.4	1.07	0.38
Error	212	10346.7	48.8		

Group	N	Pre Mean	Post Mean	Adjusted Mean	Standard Error
Mini 5 Target	31	22.0	28.7	28.6	1.26
Mini 5 NonTarget	28	22.2	30.7	30.5	1.32
Regular Target	30	22.4	30.0	29.7	1.28
Regular NonTarget	22	21.8	28.4	28.4	1.49
Supplementary T Target	26	22.3	29.3	29.0	1.37
Supplementary T NonTarget	28	22.6	28.2	27.8	1.32
Special Control	61	20.8	25.3	25.9	0.90

TABLE 12

Math Tutoring Study
Mathematics Concepts (ITBS)

ANALYSIS OF COVARIANCE

IOWA TESTS OF BASIC SKILLS

ANALYSIS OF COVARIANCE

Grade 4

	D.F.	Sum of Sq.	Mean Sq.	F Ratio	F Prob
djusted	6	407.1	67.9	2.30	0.04
	1	2439.3	2439.3	82.72	0.00
	214	6310.5	29.5		
lopes	6	255.2	42.5	1.46	0.19
	208	6055.3	29.1		

	N	Pre Mean	Post Mean	Adjusted Mean	Standard Error
	30	12.2	16.8	16.4	1.00
t	28	10.3	13.4	14.3	1.03
	34	10.9	14.3	14.8	0.93
et	28	11.1	17.5	17.8	1.03
Target	33	10.6	15.6	16.3	0.95
	29	12.0	16.1	15.8	1.01
	40	13.6	14.8	13.5	0.87

IOWA TESTS OF BASIC SKILLS

ANALYSIS OF COVARIANCE

Grade 5

Source	D.F.	Sum of Sq.	Mean Sq.	F Ratio	F Prob
Equality of Adjusted Cell Means	6	142.4	23.7	.69	0.66
Zero Slope	1	1036.6	1036.6	30.22	0.00
Error	205	7031.6	34.3		
Equality of Slopes	6	152.0	25.3	.73	0.63
Error	199	6879.7	34.6		

Group	N	Pre Mean	Post Mean	Adjusted Mean	Standard Error
Mini 5 Target	29	13.8	17.2	17.0	1.09
Mini 5 NonTarget	28	13.4	17.6	17.6	1.11
Regular Target	30	13.3	17.7	17.8	1.07
Regular NonTarget	22	12.0	16.0	16.6	1.26
Supplementary T Target	23	14.2	18.2	17.8	1.22
Supplementary T NonTarget	25	13.5	16.7	16.7	1.17
Special Control	56	13.5	15.7	15.7	0.78

Inspection of Table 11 shows that differences among the seven treatment means approach traditional levels of statistical significance--that is an F-probability of .05 or less. Looking at the adjusted post score means for each treatment for fourth grade, the nontarget students in the classes of the teachers who received special training in tutoring had the lowest mean score while the nontarget students in the classes of teachers who tutored but received no special training had the highest scores. At the fifth grade level, the special control students had the lowest adjusted mean post scores while the nontarget students in the trained teachers' classes had the highest scores.

The ITBS findings showed significant differences at fourth but not fifth grade. In the fourth grade, the special control students showed the lowest adjusted post scores; the nontarget students in classes where teachers tutored but received no special training received the highest scores. The pattern for fifth grade, while not significant, was similar to that for the CTBS; the special control students were lowest, the nontarget students from regular teacher tutor classes and the supplementary treatment target students were highest.

Based on these results, it appears that some extra mathematics instruction may be helpful but it does not matter whether it is in the form of small group instruction or one-to-one tutorial assistance. Further, to have teachers who were providing extra instruction to some students who were below the school median on mathematics achievement may have had some serendipitous effects on other below-median students.

Table 13 presents a three-factor analysis of covariance that permits more indepth answers to the research questions because important interactions

TABLE 13

Math Tutoring Study
Mathematics Concepts (ITBS)

SPECIAL ANALYSIS OF COVARIANCE

IOWA TESTS OF BASIC SKILLS

SPECIAL ANALYSIS OF COVARIANCE

Grade 4

	Sum of Sq.	D.F.	Mean Sq.	F Ratio	F Prob.
	451.2	1	451.2	17.82	0.00
	115.4	2	57.7	2.28	0.11
(Method)	150.7	3	50.2	1.98	0.12
	261.6	5	52.3	2.07	0.08
School	389.7	10	39.0	1.54	0.14
Method) ol	134.5	15	9.0	0.35	0.99
e	658.7	1	658.7	26.01	0.00
	2228.1	88	25.3		

ADJUSTED MEANS

METHOD I: Mini 5		METHOD II: Regular Tutor		METHOD III: Supplemental Treatment		School
Target	NonTarget	Target	NonTarget	Target	NonTarget	Mean
16.1	12.1	10.9	20.1	12.4	10.7	13.6
14.4	12.4	19.6	20.0	17.7	18.0	16.9
14.3	14.4	15.2	13.1	22.5	19.1	16.6
17.7	16.5	15.2	19.0	18.6	16.2	17.2
15.4	13.1	13.9	18.0	14.5	15.7	14.9
13.6	11.9	15.3	17.0	13.5	12.8	14.0
15.2	13.5	15.4	18.2	16.6	15.4	
14.4		16.7		16.0		

IOWA TESTS OF BASIC SKILLS

SPECIAL ANALYSIS OF COVARIANCE

Grade 5

Source	Sum of Sq.	D.F.	Mean Sq.	F Ratio	F Prob.
Mean	1126.4	1	1126.4	30.62	0.00
Method	9.1	2	4.6	0.12	0.88
Target (Method)	41.1	3	13.7	0.37	0.78
School	179.5	5	35.9	0.98	0.56
Method X School	452.1	10	45.2	1.23	0.28
Target (Method) X School	497.4	15	33.2	0.90	0.57
Covariate	211.3	1	211.3	5.74	0.02
Error	3458.1	94	36.8		

ADJUSTED MEANS

School	METHOD I: Mini 5		METHOD II: Regular Tutor		METHOD III: Supplemental Treatment		School
	Target	NonTarget	Target	NonTarget	Target	NonTarget	Mean
1	14.3	21.3	18.2	13.9	17.5	18.3	17.4
2	17.1	13.9	13.2	17.1	18.8	18.6	16.5
3	15.4	17.4	20.4	23.7	19.5	18.9	19.5
4	21.0	13.9	24.0	17.7	19.0	13.2	18.2
5	23.2	18.4	17.3	10.7	18.8	17.2	18.0
6	17.5	18.5	13.4	14.2	14.0	15.6	15.6
Target Mean	18.0	17.1	17.8	17.1	17.9	17.0	
Method Mean	17.6		17.5		17.4		

among variables could be accounted for. Factor one, method, contains the three primary treatments; the special control group was not used for this analysis. Factor two represents target nested within method and contains the target and nontarget designation of students. Factor three consists of the six schools in which the three primary treatment conditions were represented at both grade levels.

For this analysis, only the ITBS results are considered. The majority of the variance in students' adjusted mean post scores was accounted for by their performance on the pretest. However, for grade 4 all three main effects--method, target/nontarget designation, and school--approached conventional levels of significance. The method-by-school interaction also approached this level.

With respect to the grade 4 method effect, the adjusted mean was highest for students in the regular (no special training) tutorial treatment and lowest for students in the trained tutorial treatment. The target-within-method effects can be explained by differences between adjusted means for the nontarget students in the trained teachers' classes and the nontarget students in untrained teachers' classes. School effects show that students in school 1 and school 9 differ by a greater amount than students in other schools.

Based upon both the fourth and fifth grade analyses, it appears that target students did not perform markedly better than did non-target students, nor did 30 minutes' additional instruction in a one-to-one tutorial setting result in better student achievement than 30 minutes extra spent in group instruction.

All the analyses presented above, in effect, compare not only the effects of tutoring and no tutoring but also of additional learning time

Implications of the Math Tutor Study Findings. The implications of the Math Tutor Study results for both inservice teachers and teacher trainers, in our opinion, are three-fold.

First, thoughtful reconsideration should be given to the previous research on tutoring. When positive effects were reported, was the additional learning time associated with the tutorial experience controlled for in the study? If not, the research findings, and possibly the use of teacher time for one-to-one tutoring, should be questioned.

Second, based on the findings of the Math Tutoring Study, it appears that teachers have some options when working with students who are below the median in mathematics achievement. Additional mathematics instruction is helpful for these students. But, it is at the discretion of the teacher, whether this is small group or one-to-one instruction (tutoring as defined in the Math Study). Given the organizational and management problems faced by the teacher in a self-contained classroom who attempts to tutor individual students, such options are important. Determining which students will progress through additional small group instruction and which, if any, require one-to-one tutoring, then, becomes an important decision for the teacher. Once again, teaching and teacher training becomes a multi-faceted process that must attend to multiple student variables and multiple teaching strategies.

Third, given that tutoring by specially trained and untrained experienced teachers resulted in similar outcomes for students, questions should be asked about the training needs of experienced teachers. Based upon the tutoring skills contained in the Minicourse used to train the teachers in the Math Tutoring Study, the trained teachers appear to have had considerably more knowledge about when to use the skills than did the untrained teachers. But they used the skills in a tutoring situation in approximately the same way as the untrained teachers.

The measure of teacher knowledge about when to use tutoring skills was obtained through the use of a questionnaire that contained 32 controlled stimulus situations which presented specific mathematics learning problems followed by at least one question about the situation and a blank space for recording the response. The means and standard deviations for the teacher sample are reported in Table 14.

Teacher use of certain tutoring skills and affective behaviors was measured through the use of an observation form. Each teacher, trained or untrained, was observed at least six times. The group means for each skill are reported in Table 15.

The similarity in the average number of times most of the behaviors occurred in a tutoring session regardless of whether the teacher did, or did not, receive special training raises a significant issue for those involved in inservice teacher training. This is the issue of what form of skill training is most productive for experienced teachers. Should the training focus upon presentation of teaching models and practice of these models? Or, would the teacher develop more insight into the use of the skills by being placed in an instructional situation that necessitates and/or implies that certain skills be used, then observing to determine that the skills were used and when, and noting the resulting student responses? Or some combination of both?

It is clear that in this instance, thought needs to be given to differentiating the training of pre-service teachers and practicing

TABLE 14

Math Tutoring Study

Teacher Knowledge About Tutoring Skills

Means and Standard Deviations for the MTQ

by treatment

FOURTH GRADE

	Mini 5 Trained Tutors n = 6		Regular Tutors n = 10		Supplemental Treatment Teachers n = 9	
	Mean	SD	Mean	SD	Mean	SD
	1.8	.60	1.9	.35	2.3	.44
	1.3	.62	.7	.18	.7	.28
ic s	3.7	.70	2.2	.42	2.1	.56
ation es	8.7	1.20	5.4	.64	5.3	1.16
	2.3	.80	1.4	.60	1.4	.38
n	2.0	.68	1.7	.50	.9	.49
	2.3	.62	1.4	.43	.7	.32

Means and Standard Deviations for the MTQ

by treatment

FIFTH GRADE

	Mini 5 Trained Tutors n = 8		Regular Tutors n = 6		Supplemental Treatment Teachers n =	
	Mean	SD	Mean	SD	Mean	SD
Tutoring	3.0	.54	2.3	.80	2.4	.75
Tutoring Sequence	2.2	.38	.6	.20	0.0	0.00
Diagnostic Questions	6.4	.77	2.4	.15	2.7	1.09
Demonstration Techniques	10.9	.95	3.7	.62	3.2	1.02
Practice Problems	2.9	.44	.7	.67	.8	.80
Evaluation Problems	2.3	.59	.7	.42	.4	.40
Verbal Praise	1.3	.53	.7	.42	.8	.49

TABLE 15

Observation Variable Means for Minicourse 5 and Regular Tutors and t-test for Difference in the Means

Variable	Trained Teacher-Tutor	Means Untrained Teacher-Tutor	SE[a]	t[b]
Diag. Q.	13.36	8.86	1.905	2.36*
Prompting	29.42	28.63	3.219	.25
Eval. P.	.64	.56	.088	.91
Prac. P.	.48	.23	.079	3.16**
Demo (t)	47.77	26.95	23.888	.87
Demo (f)	2.51	2.58	.7111	-.10
Praise	13.72	11.59	1.449	1.47
Rapport	5.71	5.73	.194	-.10
Mot. Stmt.	.61	.68	.076	-.92
Decl. Stmt.	14.23	13.84	2.491	.16
Criticism	1.55	2.15	.414	-1.45
Recrim.	.21	.31	.220	-.45

[a] Standard error of the difference between the sample means.

[b] t statistic distributed on 29 degrees of freedom (Observations on Minicourse 5 and 16 Regular Tutors).

* Significant at .05 level.

** Significant at .01 level.

teachers. Based on our findings, it would appear that the experienced teacher might already possess in his/her repertoire those skills that might be proposed as the basis for a training program. If so, attention to establishing criteria for entry level skills is of paramount importance. Often, providing a teacher with precise descriptions of those skills in which training is proposed and a way to observe and analyze his/her teaching in relation to these is all that is necessary to place them in operation. On the other hand, a pre-service teacher will probably need to attend more to the actual development of the skills.

Applying Research Methodology to Teaching

As stated earlier, research findings more frequently have been applied to teaching and to the training of teachers than has the methodology which is used in educational research. However, in the few instances where methodology has been adapted, it has served successfully to train teachers and quite often has become a part of the everyday operations of teaching. Both micro-teaching and interaction nalysis are illustrative of research methodologies that were developed primarily as data collection procedures, and later were adapted to teacher training systems. Today, as regular practice, teachers can occasionally be observed using both to monitor and to analyze their own teaching.

Two examples of such methodology which grows out of ETEP research will be proposed here as potentially significant for the training of teachers. These are (1) the use of Experimental Teaching Units (ETU), and (2) the use of semiprogrammed teaching units.

In this discussion, no attempt is made to distinguish between the pre-service and inservice training of teachers. Instead, however, it is recognized that entry levels into either of the examples described here will differ depending on the experience of the trainee. It is also assumed that the two procedures can be adapted to meet the needs of either a preservice teacher training program or an inservice teacher training program.

Experimental Teaching Units (ETU). The ETUs were developed in order to hold constant the curriculum being taught by a sample of teachers being studied. At the Far West Laboratory, they were used initially in the Math Tutoring Study of ETEP, and the technique was adopted in the Beginning Teacher Evaluation Study (BTES) for the California Commission for Teacher Preparation and Licensing. From this work, five ETUs have been developed:

three for the teaching of mathematics (one at the second grade, one at the fourth grade, and one at the fifth grade), and two for the teaching of reading (one each at the second and fifth grades).

Essentially, an ETU consists of an introduction to the teacher which discusses the rationale for the unit; specific performance objectives, each of which are keyed to items on the pre- and posttests; pretests for the students; a wide variety of instructional materials and activities from which teachers may choose; and a posttest for students. Teachers are instructed to select those objectives on which they will focus and the instructional materials and activities they will use. Pretest information for their students is supplied.

Teachers then may be directed to teach the ETU in any style they prefer to as many students as they desire using any of the instructional materials and activities and/or they may be asked to teach all objectives to all students, differentiating instruction based on the student's performance on the pretest (i.e., according to whether the student has already mastered the objective and therefore is ready to extend the concepts and ideas, or has not mastered the objectives).

The duration of an ETU is approximately three weeks, and teachers utilize the regular instructional time set aside each day for the content area covered by the ETU. Although an ETU focuses on content areas that conform to accepted curriculum objectives for the given grade level, it attempts to cover material not ordinarily stressed by teachers at that grade level. In this way, the teaching experience, as well as the resultant learning experience, is more likely to be unfamiliar. This, in turn, maximizes the conditions under which the effects of teaching can be observed.

The usefulness of ETUs for studying teaching is quickly apparent.

They appear to make it possible for the effects of teaching to show more dramatically than do other approaches to studying teaching, and they therefore appear to have value as tools for studying effective teaching.

In both educational research as well as in the public school practices of evaluating teachers, the effectiveness of teaching typically is determined on the basis of student performance on an achievement tests. It is thus hypothesized that if teachers are teaching effectively, their students will show gains in a pretest-posttest (beginning - end-of-year) comparison. While this practice predominates, there is growing evidence that the items on such achievement tests not only do not focus specifically enough on the instructional objectives a teacher has set for his/her students, but they appear to be biased toward the socio-economic status or the cultural realities of many students. Thus, it would appear that the use of such procedures is questionable as a means for determining teacher effectiveness.

The ETU, on the other hand, by focusing on specific instructional objectives, and by using criterion pretest and posttest items tied to these objectives, makes it possible to study relationships between teacher characteristics, behaviors, instructional decisions and moves, etc. and student outcomes.

Working with an ETU, instructional decisions made by a teacher may be monitored. Attention also may be given to questions such as what objectives were selected? which students received the instruction? was such instruction appropriate? did the students already meet the criteria set by the pretest for those objectives? what instructional materials and/or activities were utilized? did these activities teach to the instructional objectives?

In the Math Tutoring Study of ETEP, the subsection of the study in which the ETU was used showed the advantages of this methodology over the year-long techniques for determining teacher effectiveness.

In the Math Tutoring Study, the relationships between teacher use of specified tutoring skills and other behaviors were studied in terms of students' year-long mathematics achievement in an ETU. For purposes of these analyses, the variables of interest were clustered a priori into five major clusters as outlined in Table 16. Cluster A represents students' prescores on the various measures used in the study.* Clusters B, C, and D represent the teaching behaviors which were observed in the study. Cluster E includes the treatment conditions which we discussed earlier in this paper. The only difference in the year-long and ETU analyses was the addition of the students' ETU prescores to Cluster A.

While the Math Study report includes several analyses** which incorporate the clusters as outlined in Table 16, we have selected the communality analyses for Grade 4 to illustrate our thesis regarding the usefulness of the ETU. The primary focus of the communality analyses is on the uniqueness of estimates of variance of each cluster. Clusters with large uniqueness estimates would be expected to influence student performance.

Table 17 reports the results of the fourth grade analyses. Of particular interest in these results are the lowered uniqueness estimate for Cluster A and the higher uniqueness estimates for Clusters B, C, and D in the ETU analyses as compared with the year-long analyses. Apparently, student entry-level influences posttest performance less in an ETU than in year-long achievement measures. This, in turn, should make it possible for teacher effects to be observed. The increase in uniqueness estimates

* Refer to Table 10 for description of these measures.

**See final report of A Study of The Teacher as Math Tutor for complete information.

TABLE 16

Math Tutoring Study
Clusters of Predictor Variables

Year-Long Study			ETU Study		
Cluster		Variable	Cluster		Variable
A	1	ITBS	A	1	ETU
	2	CTBS		2	CTBS
	3	Academic Self-concept		3	ITBS
	4	Math Self-concept		4	Math Attitude
	5	Math Attitude		5	Academic Self-concept
	6	Locus of Control		6	Math Self-concept
				7	Locus of Control
B	1	Diagnostic Questioning	B	1	Diagnostic Questioning
	2	Prompting		2	Prompting
	3	Evaluation Problems		3	Evaluation Problems
	4	Practice Problems		4	Practice Problems
C	1	Demonstration Techniques (time)	C	1	Demonstration Techniques (time)
	2	Demonstration Techniques (freq.)		2	Demonstration Techniques (freq.)
D	1	Praise	D	1	Praise
	2	Rapport		2	Rapport
	3	Motivating Statements		3	Motivating Statements
	4	Declarative Statements		4	Declarative Statements
	5	Criticism (constructive)		5	Criticism (constructive)
	6	Recrimination		6	Recrimination
E	1	Trained vs. untrained tutor	E	1	Treatment
	2	Target vs. nontarget pupil		2	Target vs. nontarget

TABLE 17

Math Tutoring Study
Square Multiple Correlations and Uniqueness Estimates

Predictor Cluster	Dependent Variable - CTBS		Oependent Variable - ITBS		Dependent Variable - ETU	
	Grade 4 (N = 112)		Grade 4 (N = 112)		Grade 4 (N = 102)	
	Squared Multiple	Uniqueness	Squared Multiple	Uniqueness	Squared Multiple	Uniqueness
A	.423	.218	.432	.251	.2172	.1521
B	.148	.037	.162	.029	.0672	.0531
C	.045	.003	.009	.007	.0207	.0818
D	.177	.054	.112	.037	.2398	.1301
E	.010	.001	.003	.012	.0090	.0081
ABCD	.528		.490		.4522	
ABCE	.475		.465		.3302	
ABDE	.526		.495		.3785	
ACDE	.429		.473		.4072	
BCDE	.311		.251		.3082	
ABCDE	.529		.502		.4603	

for the teacher behavior clusters suggests that this does, in fact, occur.

Further evidence of the extent to which teacher effects appear during the teaching of an ETU as contrasted with year-long studies of teaching is provided by the three-factor analyses for the Math Study. Using Grade 4 analyses to illustrate (see Table 18), the treatment appears to have been more marked during the teaching of the ETU. At least few statistically significant differences were identified relative to long-term student gains on the CTBS compared with gains on the ETU. The method by school results are particularly relevant since, in the three-factor analysis, each cell represents a teacher. This, then, is a measure of teacher effect.

The usefulness to the study of teaching of the methodological approach incorporated in the ETU is clear. This same methodology also can be applied successfully to the practice of teaching. This can be done in two ways. First, teachers can use the ETU format to structure and sequence instruction for their students and to observe and analyze their own instructional styles to identify what teaching strategies are most effective. In using ETUs in this way, the second value to teachers becomes apparent: ETUs can be used by teachers to show the effect they are having on student learning. Both are discussed here.

The idea of instructional units is not new to teaching. However, most instructional units now available focus upon much larger units of instruction than does an ETU. Used for teaching, each ETU would build around a limited number of instructional objectives which are uniquely related to each other in order to construct a specific concept and/or to bring together several small concepts into a larger understanding of a single topic. The sequencing of several ETUs could thus be perceived as teaching a concept or a unit of knowledge.

It is perhaps easiest to discuss the use of an ETU for purposes of

TABLE 18

Math Tutoring Study
THREE-FACTOR ANACOVA Grade 4

CTBS

Source	Sum of Square	d.f.	Mean Square	f	Prob.
Mean	1251.1	1	1251.1	34.72	0.00
Method	1.6	2	0.8	0.02	0.98
Target (Method)	186.9	3	62.3	1.73	0.17
School	68.4	5	13.7	0.38	0.86
Method x School	414.0	10	41.4	1.15	0.34
Target (Method) x School	600.1	15	40.0	1.11	0.36
Covariate	873.1	1	873.1	24.23	0.00
Error	3171.0	88	36.0		

ETU

Source	Sum of Square	d.f.	Mean Square	f	Prob.
Mean	1752.70	1	1752.70	88.18	0.000
Method	143.81	2	71.91	3.62	0.03
Target (Method)	39.53	3	13.18	0.67	0.58
School	229.51	5	45.90	2.31	0.05
Method (School)	592.31	10	59.23	2.98	0.003
Target (School) x Method	110.41	15	7.36	0.37	0.98
Covariate	401.19	1	401.19	20.184	0.00
Error	1729.23	87	19.88		

ADJUSTED MEANS

	METHOD I: Mini 5		METHOD II: Regular Tutor		METHOD III: Supplemental Treatment	
School	Target	Nontarget	Target	Nontarget	Target	Nontarget
1	26.0	15.5	12.4	21.9	23.1	17.6
3	17.4	19.5	23.7	26.7	19.7	19.1
4	19.5	16.7	20.2	18.4	24.2	24.5
9	25.6	20.5	25.0	16.3	20.4	22.9
10	22.9	22.8	17.3	22.9	14.9	18.1
11	22.8	16.2	21.5	22.8	19.4	23.4

ADJUSTED POSTTEST MEANS

	Trained Tutor		Untrained Tutor		Supplemental Treatment	
School	Target $\bar{X}$	Nontarget $\bar{X}$	Target $\bar{X}$	Nontarget $\bar{X}$	Target $\bar{X}$	Nontarget $\bar{X}$
1	20.88	20.41	26.21	31.37	20.17	20.00
3	22.57	22.10	20.67	23.07	22.81	18.31
4	16.48	16.37	19.60	21.88	24.19	27.15
9	25.87	24.98	26.37	25.94	23.25	23.19
10	21.62	23.12	24.62	23.81	16.48	19.36
11	23.99	21.77	19.93	24.24	20.84	19.81

teaching by describing what might be a typical scenario. Teachers at a given school site meet quite often to determine instructional goals for their grade level in all content areas. From these goals, they establish specific instructional objectives for their own students. Focusing on one content area, they could then construct a series of ETUs that, sequenced, would constitute teaching the objectives for that content area. For each ETU, teachers would specify several related instructional objectives and construct items for both a pretest and a posttest that would measure student performance. In addition, instructional materials would be collected and activities organized to teach the objectives. Finally, teachers would determine for themselves what teaching strategies to use while teaching the ETU.

The ETU would be operationalized by pretesting the entire class in order to determine which students could already perform the tasks asked of them by the instructional objectives. For those students who could not, teachers would then follow their plan and teach the ETU, which would normally comprise twenty to forty minutes of instruction per lesson for a period of two to three weeks. At the end of this time, the posttest would be administered to determine the extent to which students who received instruction could now perform the tasks required.

Such an approach to teaching, of course, is exemplary of differentiation of instruction based on differences in both students' needs and abilities. In such a system, teachers would have to differ their instruction to accommodate the needs of both those who "know it" already and those who need instruction. The existence of a repertoire of ETUs which in sequence cover a content area would insure that this is possible.

It is easy to see how teachers could use this approach to analyze their own teaching and to illustrate the effect that their teaching has on their students' learning. As discussed earlier, the use of the ETU seems to be a more viable technique to show teaching effect than merely the use of student achievement test results. With the ETU, teachers are better able to tie test items to instructional objectives on which they plan to focus, to set criteria which constitute successful student achievement of these objectives, and to measure their students' growth. In this way, teachers would also be establishing the ways in which their own teaching is effecting student learning.

Semi-programmed teaching units. The semi-programmed teaching unit originated in educational research as a way to hold a teaching strategy constant in order to study the effects on learning. Such units most frequently are used in experimental research designs. In ETEP, the notion of semi-programmed teaching units was applied in the studies of questioning.

This type of teaching unit features as its central focus a script which is provided to the teacher for use in leading class/group discussion. The discussion is only "semi"-programmed because, although it provides the teacher with sequenced questions to ask, some of the teacher's behavior must remain dependent upon how students respond to the questions. For instance, the intent of such a semi-programmed questioning script might be to build a concept by proceding through a series of questions that first lay the groundwork with fact questions, then apply principles by asking higher cognitive questions. However, should a student answer, "I don't know" to an initial question, the teacher by necessity would have to depart from the script long enough to establish with the class an answer to that question. Thus, a semi-programmed teaching unit can provide a useful guide for a teacher to follow in constructing concepts with his/her class, but a great deal of its success remains with a teacher's ability to augment the script when necessary.

In the ETEP study on the effects of questioning on student achievement and attitude, the semi-programmed discussion script usually consumed twenty to thirty minutes. Each discussion, regardless of treatment condition, consisted of sixteen questions. The decision to use sixteen questions was based upon pilot work, which indicated that teachers in the sixth grade typically could ask fifteen to twenty questions in a twenty to thirty minute period without a time difficulty for either the teacher or the students. In Study II these sixteen questions varied in the number of fact, multi-fact, and higher cognitive questions included in the script based on the percentage of higher cognitive questions in the treatment. The fact and multi-fact questions corresponded to Bloom's knowledge levels. The higher cognitive questions were based on the processes described for the upper levels of Bloom's cognitive taxonomy.

Two criteria were used to generate the fact and multi-fact questions. First, each question required the statement of a fact (or facts). Second, the fact required was explicitly stated in the curriculum material for the same day's lesson in which the question was asked. No questions were repeated in different lessons.

The higher cognitive questions also were constructed according to two criteria. First, each higher cognitive question required predictions, solutions, explanations, evidence, generalizations, interpretations, or opinions. Second, these predictions, solutions, etc. were not directly stated in the curriculum material but required the student to expand on or use the information presented in the day's lesson in a new way. The classification system used for the higher cognitive questions was as follows:

- Analysis questions, those which elicit:
    - motives or causes of observed events;
    - inferences, interpretations, or generalizations;
    - evidence to support inferences, interpretations, generalizations.

- Synthesis Questions, those which elicit:

  - predictions;
  - solutions to problems;
  - original communications.

- Evaluation Questions, those which elicit:

  - opinions about issues;
  - judgements about the validity of ideas;
  - judgements about the merit of problem solutions.

The discussions were developed so that the relative proportions of each type of higher cognitive question in a lesson were balanced. Thus, "analysis," "synthesis," and "evaluation" questions were approximately equally represented. To insure that questions were relevant to the curriculum the curriculum objectives were used as a basis for constructing the questions.

The results of the study, discussed earlier in this paper, underscore the importance of the semi-programmed approach to teacher-led discussions in experimental settings. Besides the need to attend to the ratio of higher cognitive questions in relation to fact-recall questions in any discussion, teachers also should be aware that in the Questioning Studies students who were poor readers did as well on higher cognitive questions as did those students who were good readers so long as teachers first established the necessary information base. In the instance of Questioning Study II, semi-programmed discussion scripts for the 25% HCQ and 75% HCQ treatments organized the questions in such a way that fact-recall questions were presented early in the discussion so that necessary information was related to all the students, either by asking these questions of those who could read the material in which the information was contained or by the teacher providing the answers to the questions. It is this sequencing of questions in the semi-programmed script--presenting fact-recall questions first to establish an information base, and then questions that direct students to analyze, synthesize, and evaluate--that establishes the potential of the units for teachers and teacher training re questioning.

It would thus appear that semi-programmed teaching units are promising both as a training device for teaching questioning skills and as a process by which teachers can pre-plan the construction of concepts and/or concept hierarchies to be developed with their students. As a training vehicle, such units organize the content for a given subject area around established instructional objectives, direct the teacher through an established series of activities with his/her students, and provide a semi-programmed discussion script for the teacher to follow in leading students to understanding, to analyzing and synthesizing, and to evaluating what they have learned.

The process of using the semi-programmed discussion script is, in itself, an important process for teachers to consider using. To date much of the training in inquiry approaches to teaching has focused on teacher behavior which probes, elicits, redirects, rewards, etc., a student, rather than on the process of constructing thoughtful, logical questions which properly sequenced can serve as a "map" that leads students to understandings and encourages them to enter into higher cognitive thought processes. Teachers can be taught to construct such scripts to use themselves with their students. Such scripts focus on phrasing, ahead of the discussion, well-constructed, clear questions and sequencing them in order to develop concepts. By additionally assigning students' names ahead of time to questions, teachers can consider the strengths each student may bring to such a discussion without eliminating the poorer readers from involvement in pursuing solutions to the higher cognitive questions.

A New Approach to Research and Development in Teaching

The foregoing discussions of findings and methodology from the ETEP research on teaching underlines the need to apply all that happens in research to teaching and teacher training as it is happening rather than waiting until the research process is completed. When the current research and development model is followed, a great deal of educational research does not find its way into classroom application and a great deal eventually is found to be irrelevant to the improvement of teaching.

Concern for, explanations of, and possible solutions to this problem have been voiced during the past year by several experts in the research and development field (e.g., Guba & Clark, Ovsiew, Krathwohl). Considerable discussion has centered around the inadequacies of the linear research and development model and the limitations of studing the effects of single teaching skills.

There is a clear need to develop strategies that will increase the likelihood that research on teaching will produce results that both can and will be applied in the classroom to improve education. For these reasons, we are proposing a new model for the conduct and dissemination of research on teaching. This model is designed to attack the problems of linearity in the concept of research and development and restrictions of single skill oriented research on teaching. We will deal here with only a brief description of the model. More complete information can be obtained upon request.*

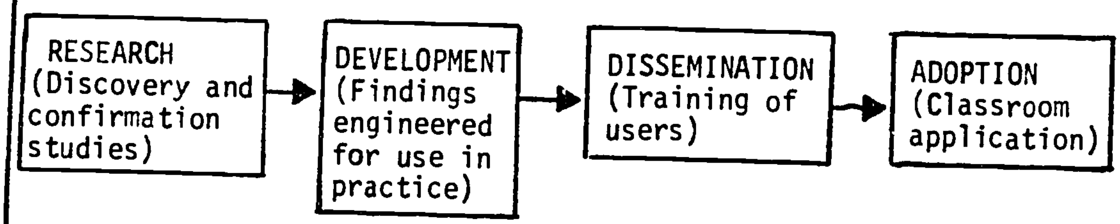
In the traditional research cycle, researchers, trainers, and classroom teachers have largely operated independently; the researchers have conducted their studies with verly little interaction with trainers and

*For complete information see: Ward and Tikunoff: Draft Narrative Outline, Program of Research and Development in Teaching. San Francisco: Far West Laboratory for Educationl Research and Development, 1975.

teachers, only as absolutely necessary to conduct a study. And trainers and teachers have seldom provided feedback to the researchers regarding the relevance and applicability of their methodology and findings. See Figure 3 below.

FIGURE 3

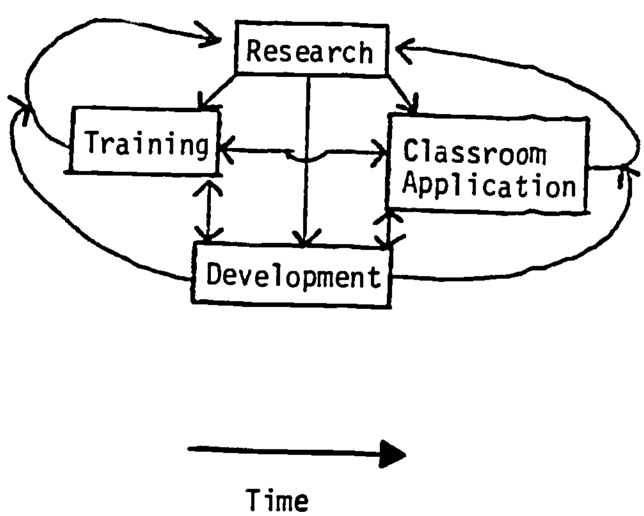
Traditional R & D Cycle in Teaching



Instead, it is proposed that an interactive model be developed, tested, and applied. See Figure 4 below.

FIGURE 4

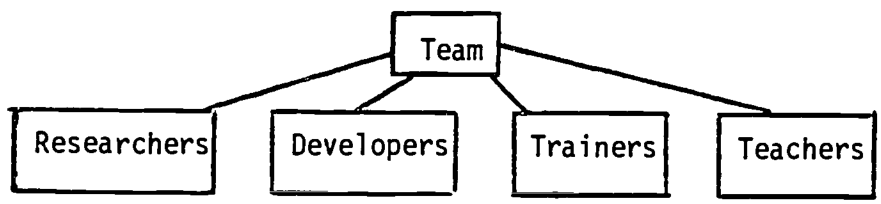
Proposed R & D Cycle in Teaching



In this new approach, the research has built into it a concern for training requirements, stemming from research techniques and research findings, and for classroom reality, as showin by the two-way arros in Figure 4. The research team, depicted in Figure 5, is composed of not only researchers but also trainers and classroom teachers themselves.

FIGURE 5

Research Team



All participate in decisions regarding what should be studied and how it should be studied. Once this decision is reached, the researchers proceed to conduct the study. Concurrently, the trainers and developers examine the data collection procedures used in the research to establish ways for applying them in training, conduct small-scale pilot tests of some of these applications, hypothesize possible outcomes of the research, and implications for training.

The teachers undertake informal and participant observation studies of the extent to which they, and possibly other teachers, are already utilizing those aspects of teaching on which the research is focused. This would include both positive and negative aspects of teaching and learning.

The purpose of this inquiry by teachers, trainers, and developers would be to provide some guidelines regarding how much and what types of training would be needed in order to implement the research findings in classrooms in general.

Several important factors that must be considered in selecting the areas of teaching to be studied include:

- Teaching does not occur as a separate activity. The purpose of teaching is learning on the part of students. Therefore, any study of teaching must take into account learning and thus the actions and characteristics of the learner(s) as well as the teacher(s).

- Teaching and learning are not content free. If one is to be concerned about the multiple dimensions of teaching (and learning) the content of what is to be learned (and taught) must be considered.

- Within the interactive model the applicability of the aspect of teaching to be studied to regular classroom instruction should be considered from the earliest stages of discussion. Realistic and functional teaching events should be the focus of the research.

The research methodology to be utilized in the proposed model should move beyond that traditionally applied in educational-psychology based research. That is not to say that the "traditional" methods of educational research would not be used. What would be done is to consider additional approaches.

Our initial effort in applying anthropological-ethnographic procedures to the study of teaching through the Beginning Teacher Evaluation Study* suggests one new research approach that has high potential for accommodating multi-dimensional, realistic studies of teaching. Others need to be identified.

At the same time, the anthropological-ethnographic process has opened up a need to consider new avenues for collecting information about teaching. In particular, the use of the teacher as a contributor to basic knowledge about teaching--in other words as a researcher--while still maintaining

*The Beginning Teacher Evaluation Study is a program of research on teaching also underway at the Far West Laboratory.

his/her teaching role should be tested.

Such a function for the teacher is essential to the interactive R&D model. Examples of the ways in which the teacher might perform as a researcher include:

- Prepare ethnographic protocols delimiting the teaching/learning events that occurred, the types of students who were involved, the content that was learned, whenever an instructional lesson was particularly successful. These protocols, then, could be compiled, as a source of information about what aspects of teaching warranted further study.

- Conduct self-observation and/or observations of his/her peers to determine whether the dependent and independent variables proposed for a research study are realistic.

One of the advantages of an interactive R&D model is the immediate application of both the data collection procedures and the research hypotheses to training and classroom practice. The design of the delivery system for achieving this goal must consider initial and later applications of the procedures and findings, and should include on the research team the following team members:

- trainers who are actively involved in both preservice and inservice professional development;

- developers who are open to multiple approaches to delivery, i.e., not partial to use of "products" as the only viable training approach; and

- teachers who are working in a setting where they have access to input from other teachers, e.g., be working in a teacher center program (complex).

All should be recognized by their peers as being representative of their needs and interests. This is essential if the "acceptability of proof" issue is to be met.

Within an interactive R&D system such as we have proposed, the four approaches to application of research that were set forth in this paper can be operationalized most expeditiously.