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ABSTRACT

Project Special Elementary Education for the Disadvantaged (SEED) is a nationwide program in which professional mathematicians and scientists from universities and research corporations teach conceptually oriented mathematics to full-sized classes of disadvantaged elementary school students as a supplement to their regular mathematics instruction. Instruction is through a Socratic group discovery format. In the Dallas (Texas) schools, Project SEED was used with all grade levels in schools with a high percentage of low-income students. Evaluation considered program impact after one, two, and three semesters of instruction for four groups of students in grades 4, 5, and 6, 1,666 in all, which were more than 95 percent Black, and more than 80 percent eligible for free or reduced-price lunches. Achievement was determined with the Iowa Test of Basic Skills and some other measures. Impact was apparent with even one semester of SEED instruction, as well as cumulative with two and three semesters. Achievement continued higher for SEED students in comparison with non-SEED students even two years after SEED instruction. Student attitudes toward SEED instruction were positive. Three tables present study findings. (SLD)

FINAL REPORT

THE LONGITUDINAL EFFECTS OF SEED INSTRUCTION ON MATHEMATICS ACHIEVEMENT AND ATTITUDES

REIS89-033-2

DEPARTMENT OF RESEARCH, EVALUATION, AND INFORMATION SYSTEMS

DISD

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FINAL REPORT

The Longitudinal Effects of SEED Instruction On Mathematics Achievement And Attitudes

REIS89-033-2

William J. Webster and Russell A. Chadbourn

Approved report of the
Department of Research, Evaluation, and Information Systems

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Dallas, Texas
November 1989

EXECUTIVE SUMMARY

The Longitudinal Effects of SEED Instruction On Mathematics Achievement And Attitudes

Evaluators: William J. Webster and Russell A. Chadbourn

PROGRAM DESCRIPTION

Project SEED is a nationwide program in which professional mathematicians and scientists from major universities and research corporations teach abstract, conceptually-oriented mathematics to full-sized classes of elementary school children on a daily basis as an extra-period supplement to their regular arithmetic program. The mathematics is presented through the use of a Socratic group discovery format in which children discover mathematical concepts by answering a sequence of questions posed by the SEED instructor. Project SEED believes that only persons who understand mathematics in depth possess the versatility to capitalize on the unconventional and often original insights that children are capable of making in an open-ended mathematical dialogue. The initial mathematical topics are chosen from high school and college algebra to reinforce and improve the students' computational skills and to help equip them for success in college-preparatory mathematics courses at the secondary level. Subsequent material establishes the mathematical foundation for a number of advanced areas of study and progresses into advanced topics in abstract algebra and other areas. Project SEED teaches entire regular elementary school classes rather than specially selected groups of students. Although SEED was originally begun as a program for the educationally disadvantaged (the acronym SEED stands for Special Elementary Education for the Disadvantaged), the project now is implemented with all levels of children across the nation. In its DISD implementation, SEED was used with all levels of students and was not intended as a program for a specific group of students. The DISD implementation of SEED also continued SEED's nation-wide practice of using intact classes in the schools in which it is implemented.

EVALUATION QUESTIONS

1. What is the impact of one, two, and three semesters of SEED instruction on mathematics achievement and attitudes?

2. Is there a cumulative impact of two and three semesters of SEED instruction?

3. Is there a differential grade retention rate between SEED participants and nonparticipant comparison groups?

4. Do former SEED students enroll in more higher level math classes than their nonparticipant comparison groups?

5. Is there a differential withdrawal rate between former SEED students and their nonparticipant comparison groups?

6. Is there a long-term impact of three semesters of SEED instruction on mathematics achievement?

METHOD

Four different samples of SEED and comparison students were analyzed. Students who had SEED in the Learning Centers in 1984-85 to 1986-87, 1985-86 to 1987-88, and 1986-87 to 1988-89 were the treatment group in investigating questions 1, 2, and 6. Comparison students were matched to SEED students on six pre-treatment variables (sex, ethnicity, grade, free lunch status, bus status, and mathematics achievement level). The sample used to investigate questions 3, 4, and 5 consisted of students who had three semesters of SEED in 1984-85 to 1986-87 and their matched comparison group (same matching variables as above), as well as samples of students who had one semester of SEED in 1982-83 or 1983-84.

Criterion variables for the achievement questions were the Concepts, Problem Solving, Computation, and Total Scores on the mathematics subtest of the Iowa Tests of Basic Skills (ITBS) as well as the elementary Survey Tests of Essential Elements/Learner Standards (STEELS) (when available). Grade equivalent scores, the scale scores for the ITBS, were used for all comparisons. Tests for statistical significance were computed on all comparisons using tests for differences between means for correlated data. In all cases non-directional tests were used.

Criterion variables for the follow-up studies where student grade retention rates, student withdrawal rates, and student enrollment patterns in mathematics courses.

Samples were over 95% Black, about 80% on free or reduced lunch, and included students who scored in every decile of the pre-treatment achievement distributions.

RESULTS

Tables 1, 2, and 3 present the achievement results for each of the three SEED samples and comparison groups. Perusal of these data suggest:

1. Immediate impact of one semester of SEED instruction on mathematics achievement.

2. A cumulative impact of two and three semesters of SEED instruction on mathematics achievement.

3. Continued high mathematics achievement two years after SEED. (We only have samples that have progressed through the eighth grades).

Table 1
Longitudinal Achievement Trends Of SEED
And Comparison Students, Grades 4-6, Spring, 1985 to Spring, 1987, and Follow-Up, Spring, 1989
(Study A)

SEED, 1985-87, 1989	Spring, 1985				Spring, 1986				Spring, 1987				Spring, 1989			
	$\overline{X}$	S	G		$\overline{X}$	S	G	D	$\overline{X}$	S	G	D	$\overline{X}$	S	G	D
Concepts	4.89	1.08	4	.13*	6.08	1.31	5	.61**	7.31	1.52	6	.86**	8.44	1.64	8	.36**
Problem Solving	4.36	1.08		.10*	5.26	1.19		.29**	6.24	1.50		.44**	7.70	1.52		.22
Computation	5.04	0.89		.19**	6.30	1.10		.45**	7.45	1.41		.69**	8.55	1.24		.30**
Total	4.76	0.89		.14**	5.88	1.07		.45**	7.00	1.36		.61**	8.24	1.29		.30**
Reading	4.29			.20**	5.50			.24**	6.01			.28**	7.17			.12
	N = 479				N = 475				N = 475				N = 375			
Comparison, 1985-87, 1989																
Concepts	4.76	1.11	4	-	5.47	1.26	5	-	6.45	1.49	6	-	8.08	1.65	8	-
Problem Solving	4.26	1.07		-	4.97	1.29		-	5.80	1.48		-	7.48	1.55		-
Computation	4.85	0.86		-	5.85	1.15		-	6.76	1.25		-	8.25	1.23		-
Total	4.62	0.89		-	5.43	1.11		-	6.34	1.27		-	7.94	1.32		-
Reading	4.09				5.26				5.73				7.05			
	N = 479				N = 446				N = 410				N = 331			

Where:

$\overline{X}$ = mean grade equivalent

S = standard deviation

G = grade

D = difference between experimental (SEED) and comparison groups with the difference being tabled with the statistic that is the highest

* = $p \leq .05$

** = $p \leq .01$

Note: Groups were matched on Spring, 1984 data. In Spring, 1984, there were no differences between the groups on the aforementioned matching variables. Students in the experimental group had three semesters of SEED, one in the fourth grade, one in the fifth grade, and one in the sixth grade.

Table 2
Longitudinal Achievement of SEED And Comparison Students,
Grades 4-6, Spring, 1986, To Spring, 1988, and Follow-Up, Spring, 1989
(Study B)

SEED, 1986-88, 1989	Spring, 1986				Spring, 1987				Spring, 1988				Spring, 1989			
	$\bar{X}$	S	G	D	$\bar{X}$	S	G	D	$\bar{X}$	S	G	D	$\bar{X}$	S	G	D
Concepts	4.91	1.01	4	.34**	6.82	1.34	5	.89**	7.47	1.63	6	-	7.89	1.67	7	.52**
Problem Solving	4.22	1.11		.15*	5.48	1.30		.41**	6.45	1.64		-	7.44	1.53		.51**
Computation	5.34	0.94		.41**	6.58	1.09		.60**	7.74	1.19		-	8.19	1.38		.52**
Total	4.82	0.90		.30**	6.29	1.12		.63**	7.22	1.35		-	7.85	1.36		.52**
Reading	4.71	0.97		.19**	5.11	1.19		.09					6.64	1.41		.32**
	N = 329				N = 329				N = 329				N = 274			
Comparison, 1986-88, 1989																
Concepts	4.57	1.00	4	-	5.93	1.30	5	-	Data not available				7.37	1.56	7	-
Problem Solving	4.07	1.16		-	5.07	1.26		-					6.95	1.44		-
Computation	4.93	0.86		-	5.98	1.01		-					7.67	1.27		-
Total	4.52	0.90		-	5.66	1.04		-					7.33	1.26		-
Reading	4.52	1.10		-	5.02	1.25		-					6.32	1.49		-
	N = 329				N = 329								N = 274			

Where:

$\bar{X}$ = mean grade equivalent

S = standard deviation

G = grade

D = difference between experimental (SEED) and comparison groups with the difference being tabled with the statistic that is the highest

* = $p \leq .05$

** = $p \leq .01$

Note: Groups were matched on Spring, 1985 data. In Spring, 1985, there were no differences between the groups on the aforementioned matching variables. Students in the experimental group had three semesters of SEED, one in the fourth grade, one in the fifth grade, and one in the sixth grade. Data are not available for the comparison group in Spring, 1988, because the systemwide testing program was temporarily interrupted.

Table 3
Longitudinal Achievement of SEED And Comparison Students, Grades 4-6, Spring, 1987 To Spring, 1989 (Study C)

SEED, 1987-89	Spring, 1987				Spring, 1988				Spring, 1989			
	$\bar{X}$	S	G	D	$\bar{X}$	S	G	D	$\bar{X}$	S	G	D
Concepts	5.22	1.22	4	.52**	6.68	1.42	5	-	7.69	1.43	6	1.04**
Problem Solving	4.29	1.22		.29**	5.70	1.21		-	6.73	1.43		.65**
Computation	5.29	0.97		.52**	6.55	0.99		-	7.61	1.27		.82**
Total	4.94	1.00		.45**	6.31	1.07		-	7.34	1.26		.83**
Reading	4.07	1.07		-	5.46	1.19		-	6.23	1.61		.23**
	N = 545				N = 545				N = 545			
Comparison, 1987-89												
Concepts	4.70	1.17	4	-	Data not available				6.65	1.48	6	-
Problem Solving	4.00	1.22		-					6.08	1,54	-	-
Computation	4.77	0.99		-					6.79	1.29		-
Total	4.49	1.00		-					6.51	1.30		-
Reading	4.16	1.08		.09					6.00	1.45		-
	N=545								N=545			

Where:

$\bar{X}$ = mean grade equivalent

S = standard deviation

G = grade

D = difference between experimental (SEED) and comparison groups with the difference being tabled with the statistic that is the highest

* = $p \leq .05$

** = $p \leq .01$

Note: Groups were matched on Spring, 1986 data. In Spring, 1986, there were no differences between the groups on the aforementioned matching variables. Students in the experimental group had three semesters of SEED, one in the fourth grade, one in the fifth grade, and one in the sixth grade. Data are not available for the comparison group in Spring, 1988, because the systemwide testing program was temporarily interrupted.

In terms of the follow-up of students who had three semesters of SEED instruction in the fourth, fifth, and sixth grade in the Centers in 1984-85 through 1986-87, the following results were obtained:

1. 36.1% of former SEED students have been retained at least one year as compared to 42.3% of their matched comparison group.

2. 34% of former SEED students are enrolled in higher level math courses in 1989-90 as compared to 28.8% of their matched comparison group.

3. 80.9% of former SEED students are still enrolled in Dallas schools in 1989-90 compared to 76.6% of their matched comparison group.

Some portion of the success of the follow-up SEED students may be attributed to the Centers (retention, higher level math courses, withdrawal rate), however, these results are consistent with the results obtained from two previous follow-up studies of non-Center students who had one semester of SEED in either the fourth, fifth, or sixth grades in 1982-83 or 1983-84 and who had not been exposed to Center programs.

12

The Longitudinal Effects Of SEED Instruction On Mathematics Achievement and Attitudes, 1988-89

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PROGRAM DESCRIPTION

Project SEED is a nationwide program in which professional mathematicians and scientists from major universities and research corporations teach abstract, conceptually-oriented mathematics to full-sized classes of elementary school children on a daily basis as an extra-period supplement to their regular arithmetic program. The mathematics is presented through the use of a Socratic group discovery format in which children discover mathematical concepts by answering a sequence of questions posed by the SEED instructor. Project SEED believes that only persons who understand mathematics in depth possess the versatility to capitalize on the unconventional and often original insights that children are capable of making in an open-ended mathematical dialogue. The initial mathematical topics are chosen from high school and college algebra to reinforce and improve the students' critical thinking and computational skills and to help equip them for success in college-preparatory mathematics courses at the secondary level. Subsequent material establishes the mathematical foundation for a number of advanced areas of study and progresses into advanced topics in abstract algebra and other areas. Project SEED teaches entire regular elementary school classes rather than specially selected groups of students. Although SEED was originally begun as a program for the educationally disadvantaged (the acronym SEED stands for Special Elementary Education for the Disadvantaged), the project now is implemented with all levels of children across the nation. In its DISD implementation, SEED was used with all levels of students and was not intended as a program for a specific group of students. The DISD implementation of SEED also continued SEED's nation-wide practice of using intact classes in the schools in which it is implemented.

A Typical SEED Class

Project SEED is a supplementary program which is taught entirely by the SEED specialist assigned to a given class. The students in the class receive regular baseline instruction in mathematics from their DISD teacher. (This will either be a mathematics teacher in a departmentalized setting or the classroom teacher in a self-contained setting.) The students then receive a period of SEED instruction four days a week from the SEED specialist. The fifth period is an in-service period for the SEED specialist which will be discussed in more detail later. In this fifth period, the students work at the direction of the classroom teacher. This work may or may not be related to the material taught in Project SEED at the discretion of the teacher, but it usually is not. The teacher is always present while SEED is being taught but has no direct instructional role in the project.

Instruction in the SEED program will be considered in two parts, the instructional methodology of SEED and the mathematics content of the program. SEED uses a group instruction methodology. The class is taught using a series of directed questions. The instructor asks questions of individuals in the class or of the class as a whole. New material is introduced at a slow pace and the majority of classroom time is usually spent in working on applications related to material previously encountered or in reviewing new and previous work. This stress upon application and review is intended to insure that the students have a solid foundation in previously learned material before new material is introduced.

The SEED specialist uses a number of devices to manage the instruction in the classroom. The students are required to respond to most of the questions and discussions in the class. The responses are given using hand signals unless the students are asked directly to verbally respond. Signals are used to indicate agreement and disagreement with the topics of discussion and to respond to questions. The purpose of the signals is to give the instructor continual feedback about student perceptions of the material, to ensure group response which involves most (if not all) of the students in the dialog on the material, and to maintain a degree of order in the classroom which could not be achieved using verbal responses. On the basis of the observations of SEED classes during the process evaluation, the signals seem to succeed in accomplishing these purposes.

To help ensure student involvement, each student is to be called on several times each period to provide answers or comment. In the event a student is not participating in the discussions, the SEED instructor will use such devices as having the student call on another student to provide an answer or calling on the student to provide a number for a problem. Other devices used to keep student involvement at a high rate include having all students participate in group verbal responses to questions, having students write answers to questions on their papers and checking all or part of the papers immediately, or having all students show the answer to a question on their fingers. These methods and a number of others are all designed to keep student interest and involvement high, as well as accomplishing other instructional objectives.

To mitigate problems associated with locus of control in the classroom, the SEED instructor moves frequently in the classroom and avoids teaching and questioning from the same spot. This also helps keep students attentive since, at any moment, the instructor may be asking the next question from any part of the room. SEED classes have a higher proportion of visitors than usual and the visitors and the teacher are utilized by the instructor. For example, the instructor might ask a visitor to call on a student with his or her hand up to answer a question. In this fashion, the students become accustomed to visitors and they are not usually a source of interruption in the classroom.

The primary feature of the instructional system, however, is the set of questions asked by the SEED specialist. Almost all the instruction is done through the use of questions. Rarely does the instructor directly tell the students anything. This is done, again, to help keep the student actively involved in the progress of the class and to avoid having the student as a passive recipient of the subject material. The instructor, in preparing for the class, thinks through the subject matter to be presented and assembles a list of sequenced questions which will be used as the basis of the questions asked of the students in class. These questions develop the content to be covered in a logical and detailed sequence which is then transferred to the classroom. They form the heart of the SEED instructional process. In general, the SEED classes observed in the process evaluation visits exhibited thorough preparation on the part of the instructors as evidenced by the careful sequence of questions used in the instructional process.

SEED Mathematics Content

The mathematics content observed in the SEED classes consisted primarily of a thorough preparation in pre-algebra mathematics and beginning concepts of abstract algebra, with examples taken from the real number system. Some of the topics observed included properties of positive and negative numbers, properties of exponents, the additive law of exponents, definition and properties of logarithms, use of the distributive law of real numbers to prove properties of positive and negative numbers, the definition and properties of additive and multiplicative identities, the definition of additive inverses, the definition and properties of negative exponents, the definition and application of summation and product symbols, and an introduction to mathematical series.

As indicated by the former General Superintendent, the Dallas Independent School District (DISD) has an underlying goal in instituting the SEED program. This goal is to encourage more students to participate in the high school algebra sequence and the mathematics sequences following algebra. The hope is that participation in the SEED program will give more students the motivation to take the course sequences and will equip them with the necessary mathematical skills to succeed in these sequences. The sample of mathematical skills observed in the SEED classes was relevant to this goal. One of the objectives of this study is, within the limitations discussed in the Methods section, to determine if this phenomenon can be documented.

SEED as a Classroom Methodology

During the 1982-83 school year, a number of SEED classroom observations were conducted by the District's Research and Evaluation Department. The procedure was informal with no quantifiable criteria, but rather it was based on impressions of the SEED program contrasted with other instructional systems. These impressions are relevant because they further describe the treatment as implemented in the District.

According to an earlier evaluation report (Mendro, REIS83-019, 1983), the first impression produced by SEED was that it contained a highly effective instructional system which could be implemented successfully by a wide variety of instructors. The organization of the classroom management techniques was such that the program generally showed good control of instruction in all the classes observed.

The second positive feature of the SEED program was the in-service system. Recall that the SEED instructor teaches four periods and has one in-service period per class each week. The purpose of this in-service period is to conduct discussions with the classroom teachers about the students and the progress of the SEED class, and to observe other SEED instructors and provide them with feedback on their implementation of the program. This system has two obvious advantages. First, during an in-service period, the instructor has a chance to reflect on the instructional components of the program and his or her implementation of them; the instructor has a chance to see and critique other instructors, which helps keep these skills sharp and allows for transmission of effective techniques through direct observation; and, finally, the instructor has a chance to participate in discussions with other instructors, all of whom share common problems and interests. This first advantage of the in-service period generally provides the instructor with a chance to keep the instructional techniques fresh and alive and gives the project a formal mechanism for transmitting effective teaching techniques. The second advantage is that during the non-in-service days, the instructor is liable at any time to have other SEED instructors and trainees sit in on a class and provide a required critique of his or her teaching that day. This process of continual peer-evaluation is perceived as an extremely powerful method of insuring high quality teaching throughout the program.

Thus, the conclusion drawn regarding the instructional quality of SEED was that the program had a very good classroom management system. The quality of instruction was consistently good across the program and it seemed to have an excellent internal procedure for building and maintaining that quality.

PREVIOUS EVALUATION STUDIES

Two series of studies on the impact of SEED were completed during the 1987-88 school year. Both studies focused on the immediate and longitudinal impact of SEED instruction on achievement in and attitudes toward mathematics.

Study 1. The first series of studies examined the impact of one semester of SEED instruction on mathematics achievement and attitude. Six different treatment groups with their respective comparison groups were compared relative to post-SEED achievement trends and mathematics course enrollment. The design was set up so that each study was replicated within the design. Analyses were performed on two separate and distinct groups of fourth, fifth, and sixth graders, each being followed for a period of five years. Further replication studies were accomplished by examining the immediate impact of SEED instruction on student achievement in the year that SEED was offered, thus examining the impact of SEED on a group of students that did not exhibit the mortality of the five-year longitudinal groups.

In the case of this series of studies, SEED students were exposed to regular math plus SEED instruction while comparison students were exposed only to regular math. Thus, part of the treatment was additional exposure to mathematics (45 minutes). Longitudinal group sizes ranged from 32 to 87. Short-term group sizes ranged from 245 to 295. Initial groups were chosen in 1982-83 and 1983-84.

The results of this first series of studies suggested strong and consistent immediate impact of SEED instruction on mathematics as measured by the Concepts, Problem Solving, Computation, and Total sections of the Iowa Tests of Basic Skills. These improved scores were generally present at least one year after students had been exposed to SEED. The results also suggested greater impact of SEED on the achievement of lower socioeconomic students. In addition, former SEED students clearly took higher percentages of advanced courses than did their matched comparisons (Webster and Chadbourn, 1988).

Study 2. The second series of studies examined the achievement trends of students who were enrolled in SEED three semesters, one in the fourth grade in 1984-85, one in the fifth grade in 1985-86, and one in the sixth grade in 1986-87.

Project SEED has been implemented in three special schools since the 1984-85 school year. Although the schools have many special programs and arrangements, they were primarily designed to raise student achievement levels in reading. Classes were self-contained and the homeroom teacher generally taught all subject areas except music and art. We must recognize from the outset that the instructional treatment in mathematics represents an extra 45-minutes of SEED instruction per day for four days a week. Comparison students had mathematics instruction by either self-contained teachers or mathematics specialists for 60-minutes per day. SEED students had instruction by self-contained teachers (non-mathematics specialists) plus the instruction by SE'D instructors. These are the best comparisons that are available since all students in the special schools have SEED.

As in the series of studies outlined as Study 1 of this investigation, Comparison Groups were randomly selected from groups of students similar to those who received SEED instruction. The same selection criteria were used as were used in Study 1 of the investigation except, of course, the Comparison Groups matched the characteristics of the Study 2 SEED students.

Two major questions were examined. First, were the post-SEED instruction achievement trends of SEED students different from those of Comparison students who were not exposed to SEED? This question was examined separately using the Math Concepts, Math Problem Solving, Math Computation, and Math Total scores on the ITBS.

Second, given that the schools studied had many special arrangements over other schools, the same type of longitudinal analysis was done on reading. The case for a treatment effect of Project SEED would be greatly enhanced if math trends among Center students were more positive than reading trends. The Reading subtest of the ITBS was used for this analysis. In addition, SEED data bases were established such that SEED student achievement as well as mathematics course selection versus that of Comparison Students can be analyzed over succeeding years.

The cohort samples for this part of the study required four years of test data. There were 517 SEED and 517 Comparison students. The samples were one hundred percent Black and Hispanic and seventy-nine percent on free and reduced lunch. Their pre-1984 achievement levels ranged from the first to the tenth decile.

The results of this series of studies suggested an immediate impact of SEED at the fourth grade level on mathematics achievement. This impact increased at grade 5 and further accelerated at grade 6. Thus, students who entered the fourth grade about even with their peers left the sixth grade about one-half year ahead of their peers in Problem Solving and almost one year ahead in Concepts. In addition, they were at or above grade level in Concepts, Computation, and Total Math scores.

Both the Seed and Comparison samples had Spring, 1984 mean scores of 3.33 in Reading. During the succeeding three years of instruction, the SEED sample advanced to a mean score of 5.98 while the Comparison sample advanced to a mean score of 5.55. Thus, the SEED sample gained 2.65 grade equivalent units in reading while the Comparison sample gained 2.22 grade equivalents in reading. Compare this to a mean gain of 3.18 grade equivalent units in mathematics for the SEED students versus 2.36 grade equivalents for the Comparison group.

STUDY DESCRIPTION

The Theoretical Comparison Group

In the field of practical evaluation it is often impossible to implement true experimental designs. The concept of randomly assigning students to treatments is repugnant to most educators, particularly in situations

22

where it is perceived that one group of randomly assigned students will be deliberately withheld from what is often believed to be an effective educational treatment. Thus the problem of identifying appropriate comparison groups is crucial to the interpretability of results. The literature is replete with warnings of the threats to the validity of experiments involved in comparing non-randomly assigned intact groups.

All of the comparisons in this series of studies utilize theoretical comparison groups. Each student in each of the experimental groups (SEED) was systematically matched to a comparison student. These comparison students were drawn from many District schools and thus represent many different math treatments. The one thing that they all have in common is that they have not been exposed to SEED. All matching was done in the year prior to exposure to SEED. Variables used in the matching process were:

1. sex
2. ethnicity
3. grade (previous and current year)
4. socioeconomic status as indicated by free lunch
5. bus status (ride or not)
6. achievement levels (math total)

Design

The purpose of this latest series of studies is to determine if:

1. the impact of one, two, and three semesters of SEED instruction at the 4-6 level on mathematics achievement can be replicated on a new sample using the ITBS and can be extended to a series of more specific curriculum-referenced tests, the Survey Tests of Essential Elements/Learner Standards (STEELS), and

2. the cumulative impact of three semesters of SEED instruction can be replicated, and

3. there is a differential grade retention rate between SEED participants and the nonparticipant comparison groups. This question will be examined in the short-term, that is during the years of SEED participation as well as longitudinally, and

4. former SEED students enroll in more higher math classes than their non-SEED comparison groups, and

5. former SEED students withdraw from school less than their non-SEED comparison groups, and

6. there is a long-term impact of three semesters of SEED instruction on mathematics achievement.

Four different samples were used. All SEED and comparison groups were matched on the basis of the aforementioned variables. The four samples were:

1. Students who had SEED instruction in the Centers as 4th graders in 1984-85, 5th graders in 1985-86, and 6th graders in 1986-87 compared to their matched comparison group (Study A).

2. Students who had SEED instruction in the Centers as 4th graders in 1985-86, 5th graders in 1986-87, and 6th graders in 1987-88 compared to their matched comparison group (Study B).

3. Students who had SEED instruction in the Centers as 4th graders in 1986-87, 5th graders in 1987-88, and 6th graders in 1988-89 compared to their matched comparison group (Study C).

4. Follow-up of the students who had one semester of SEED instruction in the fourth, fifth, or sixth grades in 1982-83 or 1983--84 and their matched comparison groups (Study D). This follow-up, reported last year, was augmented by a follow-up of students who had three semesters of SEED in 1984-85, 1985-86, and 1986-87, as well as sixth graders who only had one semester of SEED in 1984-85.

<u>Study A.</u> Study and follow-up of SEED students who had SEED instruction in the Centers in the fourth grade in 1984-85, the fifth grade in 1985-86, and the sixth grade in 1986-87. SEED students were compared to comparison students on the <u>ITBS</u> Concepts, Problem Solving, and Computation subtests, <u>ITBS</u> Total Math, student retention rate, and student dropout rate. Most of these students were in the eighth grade in 1988-89. In addition, the mathematics course selection of these SEED students was compared to that of similar comparison students.

Study B. Study and follow-up of SEED students who had SEED instruction in the Centers in the fourth grade in 1985-86, the fifth grade in 1986-87, and the sixth grade in 1987-88. SEED students were compared to comparison students on the ITBS Concepts, Problem Solving, and Computation subtests and the ITBS Total Math score. Most of these students were in the seventh grade in 1988-89.

Study C. Study of SEED students who had SEED instruction in the Centers in the 4th grades in 1986-87, the fifth grade in 1987-88, and the sixth grade in 1988-89. Comparisons were the same as those outlined in Study B.

Study D. Reports the follow-up of students who had one semester of SEED instruction in the fourth, fifth, or sixth grades in 1982-83 or 1983-84. This is a follow-up of those students studied in Study 1. SEED students were compared to comparison students on course selection, retention rate, and withdrawal rate. Students were either in the 9th, 10th, or 11th grade. Also followed up in this study were students who had one semester of SEED in each of the fourth, fifth, and sixth grades in 1984-85, 1985-86, and 1986-87, as well as those students who had one semester of SEED in the sixth grade of 1984-85.

Limitations

Project SEED is currently implemented in the Learning Centers. The Learning Centers are special grades 4-6 schools that have a number of enhancements over regular 4-6 schools. It is practically impossible to completely eliminate the effects of the Learning Centers from the effects of SEED instruction. However, a number of observations seem appropriate.

The Learning Centers were established in 1984-85. For the first two years of operation, the Learning Centers had staff incentive pay goals based on student reading achievement. Mathematics achievement was not part of the goal, but was added for the 1986-87 school year. The reader will note that all comparisons in this study include longitudinal reading comparisons. It was reasoned that if there were major differences between reading achievement trends and mathematics achievement trends, and reading achievement was and still is the primary goal of the Learning Centers, that much of these mathematics achievement differences could be attributed to Project SEED.

In 1986-87 the Learning Centers implemented a Computer Math Program that was to supplement Project SEED. That is, Project SEED was to be taught one semester and Computer Math was to be taught one semester. According to the Program Manager, 1986-87 was beset with implementation problems for the Computer Math Program. Insufficient hardware, no software, and not enough computer specialists were among the problems that plagued the program during most of the 1986-87 school year. Thus, any impact that the Computer Math program had would have to be reserved for 1987-89 and later.

A final confounding variable relates to teacher training. During the summer of 1986, all Center math teachers were trained in SEED strategies by Project SEED staff. This training had, of course, varying influence on different teachers.

Method

Grade equivalent scores, the scale scores for the ITBS were used for all achievement comparisons. Tests for statistical significance were computed on all comparisons using tests for the differences between means for correlated data. In all cases non-directional tests were used.

Characteristics of the samples used in the various studies included a high percentage of Black students (over 95%), about 80% students that were on free or reduced lunch, and students who scored in every decile of the pre-treatment achievement distributions.

RESULTS

Tables 1,2, and 3 display the results of three different longitudinal studies (Studies A, B, and C). Table 1 follows the group that had SEED in the Centers in 1985 through 1987, and then examines their achievement scores when most of them are in the eighth grade in 1988-89. In order to be included in either the SEED or Comparison Groups, a student had to be enrolled in the third grade in 1983-84 and return to attend fourth grade in 1984-85. Note the differential study retention rates between the two samples (SEED, grades 4-8, 78.2%; Comparisons, grades 4-8, 69.1%). This, of course, is probably due in part to the Learning Center environment, although Study 1 found similar patterns when no Learning Centers were involved.

Study of the achievement data in Table 1 suggest some impact of SEED instruction on mathematics achievement after one year of instruction (ranging from 1.0 to 1.9 months). Computation is the area most affected while Problem Solving is the area least affected. The difference between SEED and Comparison students widens during the second year of SEED instruction on all subtests and is still wider by the end of the third year to the

Table 1
Longitudinal Achievement Trends Of SEED
And Comparison Students, Grades 4-6, Spring, 1985 to Spring, 1987,
and Follow-Up, Spring, 1989
(Study A)

SEED, 1985-87, 1989	Spring, 1985				Spring, 1986				Spring, 1987				Spring, 1989			
	$\bar{X}$	S	G	D	$\bar{X}$	S	G	D	$\bar{X}$	S	G	D	$\bar{X}$	S	G	D
Concepts	4.89	1.08	4	.13*	6.08	1.31	5	.61**	7.31	1.52	6	.86**	8.44	1.64	8	.36**
Problem Solving	4.36	1.08		.10*	5.26	1.19		.29**	6.24	1.50		.44**	7.70	1.52		.22
Computation	5.04	0.89		.19**	6.30	1.10		.45**	7.45	1.41		.69**	8.55	1.24		.30**
Total	4.76	0.89		.14**	5.88	1.07		.45**	7.00	1.36		.61**	8.24	1.29		.30**
Reading	4.29			.20**	5.50			.24**	6.01			.28**	7.17			.12
	N = 479				N = 475				N = 475				N = 375			
Comparison, 1985-87, 1989																
Concepts	4.76	1.11	4	-	5.47	1.26	5	-	6.45	1.49	6	-	8.08	1.65	8	-
Problem Solving	4.26	1.07		-	4.97	1.29		-	5.80	1.48		-	7.48	1.55		-
Computation	4.85	0.86		-	5.85	1.15		-	6.76	1.25		-	8.25	1.23		-
Total	4.62	0.89		-	5.43	1.11		-	6.34	1.27		-	7.94	1.32		-
Reading	4.09				5.26				5.73				7.05			
	N = 479				N = 446				N = 410				N = 331			

Where:

$\bar{X}$ = mean grade equivalent

S = standard deviation

G = grade

D = difference between experimental (SEED) and comparison groups with the difference being tabled with the statistic that is the highest

* = $p \leq .05$

** = $p \leq .01$

Note: Groups were matched on Spring, 1984 data. In Spring, 1984, there were no differences between the groups on the aforementioned matching variables. Students in the experimental group had three semesters of SEED, one in the fourth grade, one in the fifth grade, and one in the sixth grade.

extent that SEED students lead comparison students by 8.6 months in Math Concepts, 4.4 months in Math Problem Solving, 6.9 months in Math Computation, and 6.1 months for the Total Math section of the ITBS. Compare these differences to the 2.8 month difference in Reading. These results are before the implementation of the Computer Math program. Two years later in 1989, when SEED and Comparison students are in the eighth grade, SEED students are still about three months ahead of comparison students in Math Computation and Math Total scores and 3.6 months ahead in Mathematical Concepts.

Table 2 examines a different group of SEED students. These students had SEED as fourth graders in 1985-86, fifth graders in 1986-87 and sixth graders in 1987-88. This study (Study B) is different from Study A in that all students had to have their matched counterpart intact in order to remain in the study. It was reasoned that Study A included a bias against SEED and the Centers since poorer students tended to leave the Comparison Group in greater numbers than they left SEED.

Study of Table 2 suggests strong impact of one semester of SEED instruction (ranging from 1.5 to 4.1 months) in the fourth grade with the same widening achievement gap as the group progresses upward through fifth grade as was found in Study A and the previously reviewed Study 2. By the end of the fifth grade (2 semesters of SEED), the SEED group is ahead of the Comparison Group by 8.9 months in Math Concepts, 4.1 months in Math Problem Solving, 6.0 months in Computation, and 6.3 months i Total Math Score. Note the Reading scores that, after two years in the Centers, were about the same for the SEED and Comparison Groups. The Computer Math

Table 2
Longitudinal Achievement of SEED And Comparison Students,
Grades 4-6, Spring, 1986, To Spring, 1988, and Follow-Up, Spring, 1989
(Study B)

SEED, 1986-88, 1989	Spring, 1986				Spring, 1987				Spring, 1988				Spring, 1989			
	$\bar{X}$	S	G	D	$\bar{X}$	S	G	D	$\bar{X}$	S	G	D	$\bar{X}$	S	G	D
Concepts	4.91	1.01	4	.34**	6.82	1.34	5	.89**	7.47	1.63	6	-	7.89	1.67	7	.52**
Problem Solving	4.22	1.11		.15*	5.48	1.30		.41**	6.45	1.64		-	7.44	1.53		.51**
Computation	5.34	0.94		.41**	6.58	1.09		.60**	7.74	1.19		-	8.19	1.38		.52**
Total	4.82	0.90		.30**	6.29	1.12		.63**	7.22	1.35		-	7.85	1.36		.52**
Reading	4.71	0.97		.19**	5.11	1.19		.09					6.64	1.41		.32**
	N = 329				N = 329				N = 329				N = 274			
Comparison, 1986-88, 1989																
Concepts	4.57	1.00	4	-	5.93	1.30	5	-	Data not available				7.37	1.56	7	-
Problem Solving	4.07	1.16		-	5.07	1.26		-					6.95	1.44		-
Computation	4.93	0.86		-	5.98	1.01		-					7.67	1.27		-
Total	4.52	0.90		-	5.66	1.04		-					7.33	1.26		-
Reading	4.52	1.10		-	5.02	1.25		-					6.32	1.49		-
	N = 329				N = 329								N = 274			

Where:

$\bar{X}$ = mean grade equivalent

S = standard deviation

G = grade

D = difference between experimental (SEED) and comparison groups with the difference being tabled with the statistic that is the highest

* = $p \leq .05$

** = $p \leq .01$

Note: Groups were matched on Spring, 1985 data. In Spring, 1985, there were no differences between the groups on the aforementioned matching variables. Students in the experimental group had three semesters of SEED, one in the fourth grade, one in the fifth grade, and one in the sixth grade. Data are not available for the comparison group in Spring, 1988, because the systemwide testing program was temporarily interrupted.

program had no impact on these results since it had not as yet been implemented. The Spring, 1989, ITBS results suggested strong differences (over 5.0 months) in favor of SEED students in all measured areas of mathematics. By this time the Reading Scores of Center students had also become significantly better than the Comparison Group. However, since there is a major District Reading Improvement Program in the seventh grade it is unclear whether this improvement in reading can be attributed to the Centers or the Reading Improvement Program. SEED students were at or above grade level in all measured mathematics areas on the ITBS except for Problem Solving where they were about 3.6 months below grade level. SEED students were 1.16 years below grade level in Reading.

Table 3 studies yet another group of SEED students. These students had SEED as fourth graders in 1986-87, fifth graders in 1987-88, and sixth graders in 1988-89. This study utilized the same methodology as was used in Study B.

Study of Table 3 suggests a much stronger impact of SEED instruction after one semester than was suggested by Study A or Study B (2.9 to 5.2 months). Once again, however, the widening impact of SEED instruction is evidenced by the end of the sixth grade (Math Concepts = 1.04 years; Math Problem Solving = 6.5 months; Math Computation = 8.2 months; Math Total = 8.3 months). SEED students are ahead of the Comparison Group by 2.3 months in Reading. The SEED group is above grade level (6.8) in all measured areas in mathematics except Problem Solving where the students are 1.09 months below grade level. In Reading, they are 5.7 months below grade level.

Table 3
Longitudinal Achievement of SEED And Comparison Students,
Grades 4-6, Spring, 1987 To Spring, 1989 (Study C)

SEED, 1987-89	Spring, 1987				Spring, 1988				Spring, 1989			
	$\bar{X}$	S	G	D	$\bar{X}$	S	G	D	$\bar{X}$	S	G	D
Concepts	5.22	1.22	4	.52**	6.68	1.42	5	-	7.69	1.43	6	1.04**
Problem Solving	4.29	1.22		.29**	5.70	1.21		-	6.73	1.43		.65**
Computation	5.29	0.97		.52**	6.55	0.99		-	7.61	1.27		.82**
Total	4.94	1.00		.45**	6.31	1.07		-	7.34	1.26		.83**
Reading	4.07	1.07		-	5.46	1.19		-	6.23	1.61		.23**
	N = 545				N = 545				N = 545			
Comparison, 1987-89												
Concepts	4.70	1.17	4	-	Data not available				6.65	1.48	6	-
Problem Solving	4.00	1.22		-					6.08	1,54		-
Computation	4.77	0.99		-					6.79	1.29		-
Total	4.49	1.00		-					6.51	1.30		-
Reading	4.16	1.08		.09					6.00	1.45		-
	N=545								N=545			

Where:

$\bar{X}$ = mean grade equivalent

S = standard deviation

G = grade

D = difference between experimental (SEED) and comparison groups with the difference being tabled with the statistic that is the highest

* = $p \leq .05$

** = $P \leq .01$

Note: Groups were matched on Spring, 1986 data. In Spring, 1986, there were no differences between the groups on the aforementioned matching variables. Students in the experimental group had three semesters of SEED, one in the fourth grade, one in the fifth grade, and one in the sixth grade. Data are not available for the comparison group in Spring, 1988, because the systemwide testing program was temporarily interrupted.

The results of Studies A, B, and C are very consistent. They suggest an immediate impact of one semester of SEED instruction in the fourth grade as measured by the ITBS. The first year impact is primarily in the areas of Mathematical Concepts and Computation. Mathematical Concepts appear to be the area most affected by exposure to two or three semesters of SEED instruction. Evidence of longitudinal impact of three semesters of SEED instruction is present two years after students have left SEED (the furthest former SEED students who last had SEED in 1986-87 had progressed).

Study D followed-up students who had one semester of SEED in the fourth, fifth, or sixth grades in 1982-83 or 1983-84 and their matched comparison groups. These students were in high school or middle school in 1987-88, depending on the group. For purposes of comparison, Math 7 and Math 8 were considered as normal matriculation at the middle school level while Algebra I and Algebra II were considered advanced. At the high school level, Algebra I, Algebra II, Computer Math, and Geometry were considered advanced while Fundamentals of Mathematics and Consumer Mathematics were not. Pre-Algebra was not included in the analysis because whether or not it is an advanced course depends on the grade level at which it was taken. All students who were originally enrolled in SEED or the Comparison group and were still enrolled in the District, regardless of whether or not they had test data, were included in this portion of the study. For both the 1982-83 and 1983-84 groups, the former SEED students took significantly higher percentages ($p \leq .01$) of advanced courses than Comparison students. For the 1982-83 sample, now in high school, 70.5% of the courses selected by former SEED students were higher level math courses while 54.7% of those selected by former Comparison students were the same (N = 2168). For the 1983-84 sample, 67.6% of the courses selected by former SEED students were higher level math courses as compared to 46.8% of those selected by former Comparison students (N = 1450). One unexpected result of this series of studies suggested that Comparison students were retained in grade twice as often as the SEED students.

Study D also followed-up students who had three semesters of SEED in the fourth, fifth, and sixth grades in 1983-84, 1984-85, and 1985-86. For the SEED group, 1131 of 1398 students are still in the Dallas schools in 1989-90 (80.9%). Of the 1131 students remaining, 408 have been retained at least one year (36.1%). For the Matched Comparison group, 1070 of 1398 students are still in the Dallas schools in 1989-90 (76.5%). Of the 1070 students remaining, 453 have been retained at least one year (42.3%). Both the withdrawal rate differences and the retention differences are statistically significant ($p \leq .01$) in favor of former SEED and Center students.

When most of these students reached the tenth grade in 1988-89, former SEED students also enrolled in more higher level math classes. Criteria had to change since the District changed the way in which students were assigned to Fundamentals of Mathematics. Higher level math classes at the tenth grade level were considered to be Algebra II, Algebra II Pre-Honors, Geometry, Geometry Pre-Honors, Trigonometry, and Pre-Calculus. The two groups had about the same number of students in Algebra II (SEED = 202, Comparison = 203). However, in every higher level mathematics course beyond Algebra II, with the exception of Pre-Calculus (SEED-7, Comparison-8), SEED students out enrolled Comparison students (Algebra II PH, SEED-39, Comparison-20; Geometry, SEED-81, Comparison-54; Geometry PH, SEED-40, Comparison-16; Trigonometry, SEED-16, Comparison-7). Thus approximately 34% of former SEED students (385) remaining in the District (1131) are enrolled in higher level math courses in 1989-90 while 28.8% of Comparison students (308) remaining in the District (1070) are similarly enrolled ($p \leq .01$).

The reader should recall that the first group of students studied through Study D are not former Center students. These are students who had one semester of SEED in various schools throughout the District in 1983-84. Thus the apparent impact of SEED on grade retention and enrollment in higher level mathematics courses cannot be completely attributed to the Centers.

To further test the hypothesis of SEED impact as opposed to Center impact, students who had SEED for only one semester in 1984-85 were followed-up. Of these students (N = 452), 19.5% of former SEED students were retained at least one year in the ensuing four years while 22.6% of Comparison students received similar treatment. In terms of withdrawal rate, 26.3% of former SEED students had withdrawn from District schools as compared to 28.1% of former Comparison students. Although neither of these differences are statistically significant, they are both in the expected direction.

After examining the data relative to SEED students five years later, the enrollment patterns of former 1985-88 SEED students were examined to determine if trends were developing as early as the seventh grade. In this analysis, Math 7 PH, Pre-Algebra and Pre-Algebra PH were considered higher level math courses. All former SEED and Comparison students were included in this analysis, whether or not they had all the necessary test scores to have been included in the original Study B. Out of 616 course enrollments for former SEED and Center students, 105 (17.0%) were in higher math courses. For comparison, out of 654 course enrollments for former Comparison students, 66 (9.9%) were in higher mathematics courses. Thus the previous trend appears to hold ($p \leq .01$).

The final issue that this phase of the SEED studies examined is whether or not the results obtained from the ITBS are mirrored on a series of curriculum-referenced tests known as the Survey Tests of Essential Elements/Learner Standards (STEELS). The STEELS were first used systemwide in the Dallas Independent School District (DISD) in 1987. The Study A STEELS group outperformed the Study A Comparison Group on the 1987 6th grade Mathematics STEELS, although not at a level that reached statistical significance ($p \leq .06$).

The Study B SEED group outperformed the Study B Comparison group on both the 5th and 6th grade STEELS ($p \leq .01$). The Study C SEED group outperformed the Study C Comparison Group on 4th, 5th, and 6th grade STEELS ($p \leq .01$). Thus, it appears that the more curriculum-referenced STEELS tests reflect the same patterns as evidenced on the ITBS, that is, SEED students tend to achieve better.

COST OF SEED

For 1988-89 the SEED budget was $1,242,000. Although this money was all budgeted in the Learning Centers' budget, the program was also implemented in thirteen schools outside the Learning Centers. According to program records, SEED staff served 2,736 Learning Center students plus an additional 1,695 students outside the Learning Centers. In addition, 280 students were served by District teachers in their final year of SEED training.

For the purpose of calculating the cost of the program, the 2,736 Learning Center students plus the 1,695 other students served were used as the basis for the calculation. SEED is a one semester treatment. It is designed that way. It doesn't make a great deal of sense to multiply the cost of the program by two because the regular District teacher is already included in the District per pupil expenditure. The SEED cost is over and above the average per pupil expenditure for the District.

If we divide $1,242,000 by 4,431 students, we get a per pupil expenditure of $280. However, this is somewhat misleading since the Centers have smaller pupil-teacher ratios and more teacher training than the regular schools. According to program records, $933,000 is spent on the Centers. This comes to an expenditure of $341 per pupil. Using the other $309,000 for the other schools, their per pupil expenditure comes to $183 per pupil.

In order for us to compare the costs of SEED with other compensatory programs, it would be informative to determine the costs of some other compensatory programs during the 1988-89 school year. According to the Planning Guide for 1988-89, the Chapter 1 direct instruction budget was $12,592,003. According to the Chapter 1 Evaluation Report (REIS89-001), 15,467 students had been served by the end of the fifth sixth-weeks. This is an expenditure of $814 per pupil.

The Reading Improvement Program budgeted $3,288,821 at grades 7-8 (Planning Guide) and served 7825 students at a cost of $420 per pupil. At grade 9 the budget was $1,660,774 at a cost of $437 per pupil (3,799 pupils served).

As a final comparison, desegregation funds at the 4-6 level were budgeted at a level of $553 per pupil. SEED has demonstrated greater academic impact than any of the aforementioned programs.

DISCUSSION

This study, the second in a series of studies on SEED, has taken an in-depth look at the impact of SEED instruction on mathematics achievement as measured by the ITBS and STEELS and on student attitudes toward mathematics as measured by the enrollment of students in advanced math courses. Most of the students in the SEED group are also Center students, thus introducing an intervening variable into the process of interpreting the results. Analyses of Center Reading achievement were conducted to provide some measure of the impact of the Centers independent of SEED. Early non-Center SEED groups were also studied for this purpose.

One factor that must be considered when attempting to interpret SEED results is that the program, by its very nature, is extremely well implemented. SEED classroom instruction varies very little from one classroom to the next. This gives an effective program a tremendous advantage over many other programs that are only semi-implemented in a real environment. It is a very rare program that is well implemented in its first year and continues to have little variance in implementation between classrooms. Most educational program managers could learn a great deal about staff training, observation, and implementation from Project SEED.

Although the primary focus of this series of investigations was to examine the impact of Project SEED in the Learning Center environment, part of the study focused on non-Learning Center students who had only one semester of SEED in the fourth, fifth, or sixth grade. Although the achievement impact of this strategy appeared to wash out after two years, former SEED students still appeared to enroll in more higher level math classes, withdraw from the District less, and be retained fewer times than did their matched Comparison groups. Next year, we plan to resume the study of non-Learning Center SEED students to determine if the previously noted impact of one semester of SEED instruction can be replicated.

Meanwhile, we feel quite confident in stating that three semesters of SEED instruction in the Centers contributes substantially to:

1. increased mathematics achievement as measured by the ITBS and STEELS, and

2. increased enrollment in higher mathematics courses in subsequent years, and

3. lowered grade retention and District withdrawal rates in subsequent years, and

4. a cumulative impact on mathematics achievement, that is, longer exposure to SEED (up to three semesters) appears to accelerate measured mathematics achievement growth, and

5. retention of mathematics gains for at least two years after exposure to SEED (this trend will continue to be followed since the 1984-85 SEED group (the first in the Centers) was only two years out of the sixth grade in 1988-89.