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ABSTRACT

This report presents data from one elementary school's (Hartford, CT region) second year (1996-97) implementation of a mathematics reform action research project by the professional development team. Teachers from grades 2-5 systematically implemented an ancillary problem solving curriculum in their classrooms after receiving training by a university facilitator and attending a summer institute. The team met biweekly to support full implementation of the research plan and data collection. Implementation of the ancillary mathematics program began in fall 1996 and continued through June 1997. A matched pairs strategy was employed to allow for year-to-year control group comparisons. Intervention group students in grades 2-5 learned and practiced 10 problem solving strategies throughout the year. Teachers, in consultation with university faculty, increased the use of problem solving activities over 2 years using multiple strategies. Holistic and standardized assessment determined the overall effects of using action research to improve student mathematics learning. Treatment classes completed a pretest and posttest, a whole-class selected problem test, and student interviews. Students in control and treatment groups completed two sets of standardized measures in 1996 and 1 year later. Results indicated that during the second implementation year, most students successfully learned the selected strategies. However, when comparing them with matched controls on standardized measures, there was no difference between groups. (Contains 30 references and 4 tables.) (SM)

Action Research in Professional Development Schools: Effects on Student Learning

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Professional development schools have become part of the national effort to reform schools and improve the education of teachers (Darling-Hammond, 1994; Holmes Group, 1990; Vail, Cooper, & Frankels, 1997). Initially, universities embarked on school-university collaboration with their own needs in mind--a systematic strategy for handling placements for field experiences and faculty-designed research (Berg & Murphy, 1992; Brown, 1992; Zimpher, 1990). Subsequently, restructured relationships emerged in school-university collaboration which were governed more by teacher and school interests (Lytle & Cochran-Smith, 1992; Zuelke & Nichols, 1996).

Today, hundreds of professional development schools operate to reform schools and improve the education of teachers through school-university partnering intended to be mutually beneficial. Experienced teachers need to continue to grow and interact with peers and other educators and to discover ways to enhance educational experiences for students. For universities, prospective teachers need excellent models in their preservice training to become good teachers and university faculty need teachers' perspective on school-based research.

However, recent authors are calling for professional development schools to focus more on demonstrating that their activities are directly associated with improved student learning (Abdal-Haqq, 1998; Valli, Cooper, & Frankes, 1997). Simultaneously, draft standards for professional development schools (Levine, 1997) call for "continuous improvement supported by on-going practice based research" and "university and school-based teachers decid[ing] together what research focus they will...plan and implement...together."

If there is a viable future for professional development schools, one means for generating commitment from policymakers and the public is to demonstrate that this school reform strategy yields significant improvement in student learning. The future of professional development schools is probably not found in a past that was perhaps satisfied with only new structures for student learning (e.g., whole language, interdisciplinary teaching). Educational policymakers and the public wants results that are associated with improved student achievement. If teacher educators claim that action research in professional development schools improves student learning then evidence of this effect needs to be generated and widely disseminated. The need to focus professional development schools on student learning is an imperative of the present and the immediate future. Without the resolve to provide convincing evidence that action research in professional development schools improves student learning, it is unlikely that this school improvement effort will be long lived.

Current literature on professional development schools has centered primarily on case descriptions of these developing models. Few studies have assessed the effects on K-12 students in professional development schools (Abdal-Haqq, 1998; Teitel, 1996; Vail, Cooper, & Frankels, 1997). Although the expectations are high that children in professional development schools achieve at higher levels of learning, only a few studies (Stallings, 1991; Wiseman & Cooner, 1996) have shown that improved student learning is an outcome of professional development school operation. Furthermore, there is scant evidence that this improved student learning would not have also occurred in matched control group classrooms and schools not associated with a professional development school. Clearly an urgent need exists to conduct more research to determine if students learn better in these schools. Without data which supports the belief that students achieve higher learning, it will be difficult for educational policy makers to advocate that professional development schools be widely replicated.

At the same time that professional development schools are being created which include action-research on teacher practice, new national and state academic content and student performance standards are being developed and implemented. One set of these national content standards, the focus of this study, are those developed by the National Council of Teachers of Mathematics (NCTM, 1989; 1991). These standards recommend that the study of mathematics emphasize problem solving so that students can better understand mathematical content.

Thus far, some evidence exists that classrooms which have responded to these mathematics' reforms have produced positive student achievement results based on single or partial year instructional intervention (Carpenter, Fennema, Peterson, Chiang, & Loef, 1989; Cobb, et al., 1991; Hiebert & Wearne, 1993). However, Wood and Sellers (1996) found that students needed to learn mathematics in reform-based classrooms for two years before significant differences in student achievement in mathematics could be observed. Moreover, in these studies, teachers transformed the entire mathematics program. It is not known what the results will be when teachers incrementally introduce these reforms--maintaining a textbook approach to teaching mathematics while simultaneously introducing problem solving strategies through a structured set of ancillary curriculum materials. Since this latter approach is likely to be an important step for the incremental introduction to new mathematics standards, it is important to understand if this approach provides significant changes in student learning.

The creation of professional development schools which focus on national content standards offer teachers and university faculty a useful opportunity to conduct collaborative action research to determine if these standards are truly producing the intended changes in student learning. Cochran-Smith & Lytle (1993) note that a strength of action research is that teachers often develop or select the materials and assess the effects of their teaching on student progress, using multiple sources of data for analysis. Teachers who partner with university faculty in collaborative research have opportunities to field test new practices and reflect on the results of their work (Clark & Moss, 1996; Oja & Smuylan, 1989). Such data, including information on student achievement, can assist educators in determining the worth of adopted projects (Bickel & Hattrup, 1995).

Furthermore, Slavin (1996; 1997) and Pogrow (1996) argue strongly that educators must assess the outcomes of school-based interventions in terms of student learning before recommending adoption by others. Similarly, Kimball, Swap, LaRosa, & Howick (1995), cited in Teitel (1995), caution professional development school representatives that

the goal of improving students' learning experiences

> must take precedence over other aspects of partnership function, . . . [t]he means to effective partnership can easily become ends in themselves. For example, the energy for change in schools may become focused only on improving working condition for teachers, establishing more collaborative decision making structures, or creating more flexible schedules, all of which can be a means to an end of learning but cannot be ends in themselves. Administrative practice can change without passing advantage to the classroom. (p. 24).

In Abdal-Haqq's (1998, p.31) view, "if children are not significantly benefiting from the investment of time, effort, and resources devoted to PDSs, then both children and investors are being betrayed...human and fiscal resources...are squandered if PDS implementers do not at least attempt to devise, test, refine and document effective curriculum and practices."

What are effects on student learning when a professional development school team introduces reforms in mathematics instruction? In this study, a professional development school team identified the content area of mathematics as an area of student need. Using the content standards of the NCTM as the guide for its work, the professional development school team selected instructional materials designed to support their students in problem solving while at the same time a textbook approach to instruction continued. Teachers, in consultation with university faculty, increased the use of problem solving activities with students over two years and measured the effects on student performance. The study, using a collaborative action-research model, reports the results of the second year of this effort. For one of these teachers, the results of students who were engaged in new mathematics instruction for two years is shared. The first year of this intervention is presented in an earlier paper (Devlin-Scherer, et al., 1997).

Method

The Professional Development School Network

In October of 1994, the School of Education and Professional Studies at Central Connecticut State University was funded by the Office of Educational Research and Improvement of the United States Department of Education to improve student achievement through school-based reform and to enhance the preparation of teachers who work in urban schools. The vehicle for enacting these primary goals was the creation of a set of professional development schools in the area adjacent to the university. Performance standards in the fields of mathematics and English/language arts provided the focus for school improvement projects. Professional teaching standards, developed by the National Board for Professional Teaching Standards and the National Council for the Accreditation for Teacher Education guided the effort to improve the preparation of teachers to teach in urban settings.

Ten elementary, middle, and high schools from the Hartford, Connecticut region formed a network of professional development schools to launch student standards-based action research school improvement projects and simultaneously guided the improvement of the university's teacher education program. The results of one elementary school's second year (1996-1997) implementation of its mathematics reform action research project is the focus of this study. Two second grade teachers, three third grade teachers, one fourth grade teacher, and one fifth grade teacher systematically implemented an ancillary problem solving curriculum in their classrooms and completed data collection activities.

Sample and Design

The elementary school in this study is part of a school district with a 64% minority population. District elementary school enrollment includes 5000 children. At the district level 65% of the students live in homes with non-English as its primary language and 56% receive free or reduced-priced meals. The sample K-5 elementary school includes 480 students of which 54% represent minority populations. Of that number 43% are Hispanic and 11% African-American. In the sample school 54% of the students reside in homes with non-English being spoken and 42% receive free or reduced-priced meals. In this setting, teachers volunteered to participate in professional development and classroom implementation activities.

One dimension of the evaluation of the mathematics program intervention compared students at the sample school to matched students at similar schools in the district. The schools were nearly identical in the percentage of students receiving free or reduced-priced meals and closely aligned on the mathematics achievement on the most recently administered Connecticut Mastery Test. Individual students were matched on the basis of standardized test scores routinely administered by the school district. Prior to the full year implementation, students in sample classrooms who had taken the Spring 1996 Stanford Achievement Test in mathematics were matched with students in control schools.

Implementation of the ancillary mathematics program began in the Fall of 1996 and continued through June 1997. A matched pairs strategy was employed in order to allow for year-to-year control group comparisons and to provide a vehicle for longitudinal follow-up of as many students as possible who were identical in mathematics academic achievement before the program was introduced.

Mathematics Program Intervention

The problem solver activities for learning problem-solving strategies (Hoogeboom & Goodnow, 1987) was selected for the ancillary mathematics program intervention. Ten problem-solving strategies were taught and practiced by second-fifth grade students throughout the school year. The origin of providing systematic instruction and practice in problem solving in mathematics comes from the work of Polya (1973) and more recently has been promoted by the NCTM. The selection of these specific problem solving curriculum materials were based on positive comments from representatives in a nearby district which had used the program for several years.

The program has students follow a basic process for solving problems including understanding the problem, devising a plan, carrying out the plan, and looking back. Additionally, ten categories of problems which students encounter in the study mathematics are directly taught and practiced. Examples of these categories are make an organized list, table, pattern, or picture; guess and check; and logical reasoning. A total of 120 problems comprise these curriculum materials and permit teachers to develop various instructional implementation strategies during its full year of use.

Teacher Development: Years 1 & 2

Spring 1995 Mathematics Workshops. Before beginning classroom implementation activities in Year 1, one university project facilitator provided three workshops at the sample school. The contents of these workshops included the NCTM standards, using hands-on mathematical manipulatives for teaching of fractions and measurement, and strategies for teaching problem solving.

Summer Institutes. Three of the sample teachers and a university faculty project facilitator, who had delivered the Spring 1995 mathematics workshops at the sample school, completed a five day summer institute in 1995. At this institute the NCTM standards were shared and procedures for creating and carrying out an action research project were explained. At the conclusion of the summer institute the teachers and the university facilitator had developed a written plan for implementing and evaluating the use of new mathematics standards in classrooms focused on improving problem solving.

Five additional site-based days during this summer were used by the institute team to further develop their implementation and evaluation plan. The ten problem solving strategies were discussed, the use of math manipulatives and cooperative learning was explored, a holistic scoring rubric was developed, and the concepts of using student interviews and mathematics journals were developed. The overall goal of these site-based days were to provide time for the teachers to make final preparations for the full-year of implementation and evaluation activities.

During the 1996 summer institute most of the seven Year 2 teachers and two university facilitators worked within the summer institute setting and during site-based days to interact as a team with other network professional development schools and to plan the 1996-1997 mathematics program implementation.

Study Group Meetings and Related Professional Development. During the 1996-1997 school year the nine-person team met bi-weekly (the team met weekly during the 1995-1996 school year) to support full implementation of the action research plan and the data collection procedures. The team's meetings included sharing classroom successes and concerns, providing additional training, coordinating the logistics of assuring that teachers had appropriate copies of curriculum materials, implementing the testing and scoring procedures, and discussing the results of the Year 1 intervention.

During this second year of implementation the team, as they had during Year 1, visited another school in the region implementing problem solving instruction in mathematics and presented the Year 1 intervention results at two national conferences. Team members attended professional development network forums which focused on sharing project strategies across school sites engaged in various action research interventions. Additionally, as they had during Year 1, the team participated with schoolwide faculty in several professional development workshops related to implementing both ther textbook and problem solving components of the mathematics curriculum. Finally, the team sponsored a second annual family math night for project classrooms and produced a monthly newsletter on problem solving which was distributed to parents.

Teacher Intervention Strategies

Multiple and flexible strategies were employed to infuse problem solving in mathematics in the curriculum using the selected intervention materials. All seven teachers had the opportunity to adapt the problem solving curriculum materials to their own classroom setting. Teachers used a direct instructional strategy, with the use of an overhead projector, moving from directly teaching the strategy in a full group to students solving each problem independently. Some teachers used cooperative learning and assigned some problems for homework. One third grade teacher describes her Year 2 intervention strategy as follows:

> I try to do the Problem Solver as a daily Math Journal exercise. Most weeks I will do from three to five examples. We do the first 48 examples as a whole class activity. These first 48 examples list the strategy it is teaching and I feel it is important to model the correct way to solve the problem and to explain how you got your answer. The examples from #49 to #120 do not tell the students what strategy to use and sometimes more than one strategy is implemented to solve the problem.
>
> I read the problem with the class while I work with a transparency. We circle the question and underline the data in each problem. I give the class time to solve the problems on their own from #49 to #120. I check the class answer by walking around while they are working out their answers and sometimes students with the correct answer will model it on the overhead transparency for the class.
>
> I have completed all 120 problems in the third grade Problem Solver in the last two years of doing the program. I am now [Year 3, February 1998] half way through the book and it is half way through the school year. The Problem Solver takes anywhere from 15 minutes to 45 minutes daily. Starting as soon in September as possible is working out well.

Assessment Instruments

Holistic and standardized assessment instruments were used to determine the overall effects of using action research via a professional development school to improve student learning in mathematics. A pre- and post-test was administered to treatment classrooms in Fall 1996 and Spring 1997. This test consisted of problems matched to the problem solving strategies embedded in the ancillary curriculum materials. Two additional routine problem closely aligned to the type of problems found in the textbook-based curriculum was also included. A holistic scoring rubric, comprising a scale of one to four, was used to score each pre-post and selected problem test.

After teaching a problem solving strategy, students were administered a whole class selected problem test to determine their level of learning (see Devlin-Scherer, et al., 1997 for Year 1 results). Finally, randomly selected high, medium, and low achievement students were interviewed at the beginning and end of the year and asked to mark a four-point Likert-scale instrument indicating their perceived competence in a problem solving approach to mathematics. The scale ranged from "I do not understand how to solve problems. I do not know where to begin. I am usually stuck," to "I understand how to solve problems. I can clearly explain my answer. I always have acceptable answers" (see Devlin-Scherer, et al., 1997 for Year 1 results).

Two sets of standardized measures were utilized. The first was the Stanford Achievement Test (SAT)--sub-test Mathematical Applications. Both treatment and control students in grades three, four and five (test data was not available for grade two) were administered this test in May 1996 and again in May 1997. The second was the Connecticut Mastery Test (CMT)--Mathematics Section--administered to students in Connecticut beginning in grade three (no data was available for grade two students) in the September of each year. Students in the treatment and control grade classrooms completed this test in September 1996 and again in September 1997.

Analyses

The second year problem solving holistically scored data were analyzed using t-tests to compare pre-post changes for students in the classrooms of the seven sample teachers.

For the SAT instrument, 1996 to 1997 raw score ANOVAs determined if treatment and control students had made significant gains in grades three, four, and five. The raw score results of the 1997 CMT compared treatment and control students using ANOVA procedures. Finally, a third grade classroom's treatment and associated control students, who had begun the intervention in 1995, were compared using 1995-1997 SAT data and the results of the 1997 CMT.

Results

Holistic Measures

Tables 1.1-1.8 report comparisons of Fall to Spring holistic test scores for students. These yielded significant positive results for all six strategies as well as the two routine problem examples. Of the 55 comparisons 42 produced significant results. Grade four and five students did not produce significant results on the routine problems and grade five students did not yield significant results for several of the non-routine problems. Overall, however, teachers taught these strategies well, and as measured by pre-post tests highly related to the actual problem solving strategies, students learned these at significant levels in a majority of classrooms.

Insert Table 1.1-1.8 about here

Standardized Measures

Stanford Achievement Test. For treatment and control group students completing the Stanford Achievement Test (Table 2) neither group produced significant results.

Insert Table 2 about here

Connecticut Mastery Test. The CMT analyses (Table 3) indicates a significant result favoring the grade four control students in measurement/geometry. There were no other significant differences between treatment and control students on the total test nor the four sub-tests analyzed.

Insert Table 3 about here

Long Term Effects for 1995 Third Grade Classroom. When comparing the 1995-1997 SAT results for these Year 1 students, neither the treatment or control groups yielded significant changes. In the same fashion when analyzing the 1997 CMT data for these groups there appeared to be no significant difference between them on the total test and the sub-tests.

Insert Table 4 about here

Discussion

During the second year of the implementation of this problem solving mathematics project evidence shows that a majority of students successfully learned the six selected strategies. However, when comparing the students with their matched controls on a nationally standardized measure and a state administered assessment test, there appeared to be no differences between the two groups. Testing the concept that it may take two years for differences to emerge between treatment and control classrooms was not confirmed with the students from a Year 1 third grade classroom.

How can these results be explained? That students learned these six strategies of problem solving is a testament to the good teaching they received throughout the school year. Most of the teachers developed an appropriate methodology for implementing this ancillary problem solving curriculum.

The disappointing results on the standardized measures perhaps can be explained in a variety of ways. The amount of time devoted to teaching and practicing the problem solving strategies, while at the same time maintaining high levels of implementation of the textbook-based curriculum may not have been adequate at least to attain positive results on the SAT and CMT measures. Perhaps the somewhat high SAT pretest scores created a ceiling effect that thwarted anticipated differences between treatment and control students. Or perhaps the matched control students made gains in their mathematics achievement because some of their teachers were participating in mathematics instructional improvement activities with an area consultant.

It is also important to note the difficulty in maintaining intact student samples in this urban district. Treatment students were matched with controls the Spring of the year before implementation began on the SAT test, proceeded through the implementation year and tested in the Spring again on the SAT, and then were administered the CMT the following Fall. The grade five teacher, for example, worked with 25 students, although only 19 took both SATs and only 10 were left in the district to compare their CMT results. Loss of sample was also a factor in the results of the comparisons made for the grade 3 students over a two-year period. Some teachers noted that the students lost from the samples were those who made the greatest gains. With sample sizes so low, differences between treatment and control groups needed to be much greater for these comparisons to be significant.

There also appears to be little theoretical evidence that students who learn these strategies well will translate the results on more traditional standardized measures of mathematical achievement. Although the teachers in this study maintained their use of the textbook curriculum in a variety of ways, they did not emphasize the more routine problems encountered on standardized tests and this may have been associated with less impressive results on the standardized measures. If the NCTM Standards, particularly in problem solving, are to become widely accepted and translated into curriculum and instructional materials, it will be important for high stakes standardized measures of achievement to be in close congruence with these problem solving strategies.

Finally, it may be essential for action research projects associated with professional development schools to select interventions which have demonstrated prior success in student learning on standardized measures before the intervention is selected for adoption. Much time and effort is devoted to planning, implementing, and evaluating an intervention described in this study. It would be prudent to not adopt curriculum materials only based on the positive comments of others. Instead, a careful review of the results of the program for significant positive effects for treatment compared to control classrooms would give teachers and university faculty more research-based reasons to assume the intended intervention will likely cause the expected positive results for student learning.

This study begins to address the need for professional development schools to demonstrate that the collaborative activity of schools and universities does produce significant positive changes in student learning. If action research on new instructional strategies is a vehicle for improvement of the quality of education in our nation, perhaps professional development schools can play a role in introducing these collaborative methods of inquiry within their network schools. Coupling implementation of new instructional strategies with a carefully designed action research model may be a powerful approach to ensure that students maximize their learning. More research will be needed to determine if this approach to school improvement merits further development and additional resources.

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TABLE 1.1

Comparison of Fall 1996 and Spring 1997 Problem Solving Holistic Test Scores for Grades 2-5 Treatment Classrooms

Problem Solving Strategy by Grade	n	Mean Fall '96 (SD)	Mean Spring '97 (SD)	*t*	*p*
Organized List					
Grade 2 (A)	24	1.04 (.20)	2.84 (.94)	-9.33	.000***
Grade 2 (B)	23	1.04 (.20)	2.29 (.69)	-8.51	.000***
Grade 3 (A)	18	1.28 (.46)	2.89 (.90)	-6.76	.000***
Grade 3 (B)	24	1.96 (1.20)	3.88 (.45)	-7.35	.000***
Grade 3 (C)	25	2.67 (1.31)	3.52 (.82)	-2.72	.010**
Grade 4	20	2.15 (.88)	3.00 (.86)	-3.10	.004**
Grade 5	25 [1]				

[1] The Grade 5 teacher did not pre-post test for Organized List.

TABLE 1.2

Comparison of Fall 1996 and Spring 1997 Problem Solving Holistic Test Scores for Grades 2-5 Treatment Classrooms

Problem Solving Strategy by Grade	n	Mean Fall '96 (SD)	Mean Spring '97 (SD)	*t*	*p*
Make a Table					
Grade 2 (A)	24	1.04 (.20)	3.17 (.96)	-10.57	.000***
Grade 2 (B)	23	1.82 (1.01)	3.52 (.81)	-6.12	.000***
Grade 3 (A)	18	1.33 (.69)	2.89 (.76)	-6.45	.000***
Grade 3 (B)	24	1.08 (.28)	2.71 (.96)	-8.00	.000***
Grade 3 (C)	25	1.13 (.34)	2.52 (1.42)	-4.78	.000***
Grade 4	20	2.15 (.99)	3.25 (.85)	-3.77	.001***
Grade 5	25	2.76 (1.23)	2.76 (1.20)	.00	1.00

TABLE 1.3

Comparison of Fall 1996 and Spring 1997 Problem Solving Holistic Test Score for Grades 2-5 Treatment Classrooms

Problem Solving Strategy by Grade	n	Mean Fall '96 (SD)	Mean Spring '97 (SD)	*t*	*p*
Make a Pattern					
Grade 2 (A)	24	1.08 (.28)	2.83 (.76)	-10.56	.000***
Grade 2 (B)	23	1.22 (.74)	3.39 (.84)	-9.34	.000***
Grade 3 (A)	18	1.83 (1.04)	3.56 (.71)	-5.80	.000***
Grade 3 (B)	24	1.33 (.64)	3.46 (.62)	-4.17	.000***
Grade 3 (C)	25	1.50 (.51)	2.92 (1.00)	-6.31	.000***
Grade 4	20	2.25 (1.07)	3.00 (.92)	-2.38	.023*
Grade 5	25	2.28 (1.10)	2.88 (1.09)	-1.94	.059

TABLE 1.4

Comparison of Fall 1996 and Spring 1997 Problem Solving Holistic Test Scores for Grades 2-5 Treatment Classrooms

Problem Solving Strategy by Grade	n	Mean Fall '96 (SD)	Mean Spring '97 (SD)	*t*	*p*
Guess & Check					
Grade 2 (A)	24	1.87 (1.03)	2.75 (.99)	-2.99	.005***
Grade 2 (B)	23	1.04 (.20)	2.79 (.93)	-8.99	.000***
Grade 3 (A)	18	1.67 (.91)	3.06 (1.00)	-4.37	.000***
Grade 3 (B)	24	2.25 (1.22)	3.46 (.72)	-4.17	.000***
Grade 3 (C)	25	2.64 (1.19)	3.24 (1.20)	-1.78	.082
Grade 4	20	1.35 (.81)	3.55 (.76)	-8.85	.000***
Grade 5	25	2.24 (1.23)	2.84 (1.34)	-1.64	.110

TABLE 1.5

Comparison of Fall 1996 and Spring 1997 Problem Solving Holistic Test Score for Grades 2-5 Treatment Classrooms

Problem Solving Strategy by Grade	n	Mean Fall '96 (SD)	Mean Spring '97 (SD)	*t*	*p*
Make a Picture					
Grade 2 (A)	24	1.42 (.58)	2.71 (.75)	-6.66	.000***
Grade 2 (B)	23	1.04 (.20)	2.75 (.74)	-10.94	.000***
Grade 3 (A)	18	1.39 (.70)	2.44 (.78)	-4.27	.000***
Grade 3 (B)	24	2.00 (.72)	3.46 (.88)	-6.26	.000***
Grade 3 (C)	25	2.48 (.59)	3.36 (.91)	-4.07	.000***
Grade 4	20	2.00 (1.03)	2.65 (.88)	-2.16	.038*
Grade 5	25	2.92 (.86)	2.80 (1.04)	.44	.660

TABLE 1.6

Comparison of Fall 1996 and Spring 1997 Problem Solving Holistic Test Scores for Grades 2-5 Treatment Classrooms

Problem Solving Strategy by Grade	n	Mean Fall '96 (SD)	Mean Spring '97 (SD)	*t*	*p*
Logical Reasoning					
Grade 2 (A)	24	1.50 (.66)	3.13 (.90)	-7.14	.000***
Grade 2 (B)	23	1.04 (.20)	3.25 (.99)	-10.71	.000***
Grade 3 (A)	18	1.94 (1.30)	3.56 (.62)	-4.74	.000***
Grade 3 (B)	24	1.88 (.99)	3.58 (.72)	-6.84	.000***
Grade 3 (C)	25	2.44 (1.12)	3.72 (.74)	-4.77	.000***
Grade 4	20	2.80 (.70)	3.30 (.98)	-1.86	.071
Grade 5	25	2.68 (1.11)	3.28 (.84)	-2.16	.037*

TABLE 1.7

Comparison of Fall 1996 and Spring 1997 Problem Solving Holistic Test Scores for Grades 2-5 Treatment Classrooms

Problem Solving Strategy by Grade	n	Mean Fall '96 (SD)	Mean Spring '97 (SD)	*t*	*p*
Routine 1					
Grade 2 (A)	24	2.83 (1.46)	3.71 (.69)	-2.65	.012*
Grade 2 (B)	23	1.04 (.20)	3.25 (1.07)	-9.90	.000***
Grade 3 (A)	18	1.39 (.96)	2.44 (.83)	-4.27	.000***
Grade 3 (B)	24	3.64 (.57)	3.92 (.40)	-2.01	.050*
Grade 3 (C)	25	3.92 (.28)	3.88 (.33)	.46	.650
Grade 4	20	3.70 (.57)	3.60 (.68)	.50	.620
Grade 5	25	3.52 (.87)	3.80 (.50)	-1.39	.170

TABLE 1.8

Comparison of Fall 1996 and Spring 1997 Problem Solving Holistic Test Scores for Grades 2-5 Treatment Classrooms

Problem Solving Strategy by Grade	n	Mean Fall '96 (SD)	Mean Spring '97 (SD)	*t*	*p*
Routine 2					
Grade 2 (A)	24	3.00 (1.35)	3.71 (.86)	-2.17	.037*
Grade 2 (B)	23	1.26 (.86)	3.65 (.71)	-10.23	.000***
Grade 3 (A)	18	1.89 (.76)	3.44 (.78)	-6.05	.000***
Grade 3 (B)	24	3.42 (.83)	3.96 (.20)	-3.11	.005**
Grade 3 (C)	25	2.96 (1.23)	3.44 (1.12)	-1.43	.160
Grade 4	20	2.70 (1.34)	2.90 (.91)	-.55	.590
Grade 5	25	2.84 (.99)	2.56 (1.11)	.87	.390

TABLE 2

Comparison of 1996 and 1997 Stanford Achievement Test Raw Scores (Mathematics Applications) for Treatment (T) and Matched Pairs Control (C) Grade Three-Five Classrooms*

Grade	n	Mean 1996 (SD)	Mean 1997 (SD)	*F*	*p*
T Grade 3 (B)	20	26.35 (5.72)	29.90 (7.43)	2.87	.098
C Grade 3 (B)	20	26.35 (5.72)	27.90 (5.65)	.74	.394
T Grade 3 (C)	16	28.13 (3.78)	28.06 (7.12)	.00	.975
C Grade 3 (C)	16	28.13 (3.78)	30.19 (4.74)	1.86	.183
T Grade 4	16	26.94 (6.67)	26.94 (6.67)	.00	1.000
C Grade 4	16	26.94 (6.67)	28.63 (7.78)	.43	.515
T Grade 5	19	27.95 (8.44)	26.32 (9.41)	.32	.577
C Grade 5	19	27.95 (8.44)	27.53 (7.92)	.03	.875

* Grade 2 students' SAT data not available. Grade 3 (A) students were from a bilingual classroom; SAT data not available.

TABLE 3

Comparison of 1997 Connecticut Mastery Test Raw Scores for Treatment and Matched Pairs Control Grade 3-5 Classrooms

CMT Categories/ Grade	n	Mean Treatment (SD)	Mean Control (SD)	*F*	*p*
Concepts					
Grade 3 (B)	17	18.24 (3.56)	18.17 (2.40)	.00	.955
Grade 3 (C)	14	19.36 (1.91)	18.14 (4.50)	.86	.361
Grade 4	14	21.21 (5.96)	22.71 (6.41)	.41	.527
Grade 5	10	24.00 (10.07)	22.70 (7.32)	.11	.745
Number Facts/ Computation					
Grade 3 (B)	17	14.59 (2.09)	14.71 (1.80)	.03	.861
Grade 3 (C)	14	15.21 (1.25)	14.86 (1.66)	.41	.526
Grade 4	14	16.93 (4.75)	19.14 (4.64)	1.56	.223
Grade 5	10	22.20 (6.99)	21.00 (7.06)	.15	.707

TABLE 3 CONTINUED

CMT Categories/ Grade	n	Mean Treatment (SD)	Mean Control (SD)	*F*	*p*
Problem Solving					
Grade 3 (B)	17	53.59 (8.19)	51.71 (8.01)	.46	.503
Grade 3 (B)	14	55.36 (4.75)	53.71 (6.29)	.61	.443
Grade 4	14	41.57 (13.23)	45.93 (9.28)	1.02	.322
Grade 5	10	41.70 (12.74)	40.90 (12.07)	.02	.887
Measurement/ Geometry					
Grade 3 (B)	17	20.41 (3.71)	20.59 (2.21)	.03	.867
Grade 3 (C)	14	20.64 (2.47)	20.64 (3.61)	.00	1.000
Grade 4	14	11.85 (2.51)	13.86 (2.18)	5.08	.033*
Grade 5	10	15.00 (6.00)	15.40 (5.08)	.03	.874
Total					
Grade 3 (B)	17	106.82 (16.17)	105.18 (13.46)	.10	.749
Grade 3 (C)	14	110.57 (8.40)	107.36 (15.02)	.49	.491
Grade 4	14	91.57 (24.11)	101.64 (20.92)	1.39	.248
Grade 5	10	102.90 (34.89)	100.00 (29.31)	.04	.843

TABLE 4

Long Term Effects: Comparison of Stanford Achievement Test (SAT--Mathematics Applications) and Connecticut Mastery Test (CMT) Raw Scores for Treatment and Matched Pairs Control For Year 1 Grade 3 Classroom Over Two Years

Test	n	Mean 1995 (SD)	Mean 1997 (SD)	*F*	*p*
SAT					
Treatment	16	21.56 (5.72)	24.63 (7.43)	2.43	.130
Control	16	21.56 (4.35)	24.75 (8.47)	1.79	.191

Test/ Category	n	Mean Treatment (SD)	Mean Control (SD)	*F*	*p*
CMT 1997					
Concepts	13	19.69 (4.70)	22.31 (3.95)	2.36	.137
Number Facts/ Computation	13	16.31 (4.17)	18.00 (3.85)	1.16	.293
Problem Solving	13	39.62 (10.60)	45.39 (8.80)	2.28	.144
Measurement/ Geometry	13	10.85 (3.44)	12.54 (2.18)	2.25	.147
Total	13	86.46 (18.95)	98.23 (15.96)	2.93	.100

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