Improving elementary science instruction and student achievement: The impact of a professional development program

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Abstract

Background/Context: The mission of Teaching SMART, a science inquiry professional development program for elementary school teachers, is to encourage the performance and persistence of all students, particularly female and minority youth, in elementary science. Teaching SMART provides instruction, hands-on training, and long-term technical assistance and support for third through fifth grade teachers in a given school to increase their awareness and comfort level in using equitable, hands-on inquiry, and exploration-based approaches to teaching science, ultimately enhancing student achievement. The Teaching SMART intervention has been fully developed and implemented in school districts around the country.

Purpose/Objective/Research Question/Focus of Study: The study was designed to establish the efficacy of Teaching SMART (Teaching Science, Mathematics and Relevant Technologies); a science professional development program for teachers with students in grades 3 through 5. Teaching SMART promotes scientific inquiry and emphasizes the importance of equity, empowerment, exploration, and fun in the classroom. The paper focuses on two primary outcomes for the teachers and students who participated in the three year implementation of Teaching SMART: (1) the impact on science teaching practices of teachers and (2) effects on student achievement in science.

Setting: There are 35 elementary schools ranging in size from 400 to 1100 students in a large Florida school district, characterized by low-SES, diverse minority groups, and linguistic minority groups with three schools having a majority student population that is non-white. There are 18 Title I schools in the district with a free/reduced lunch eligibility rate greater than 50%. The mobility rate among students is 44%. In the fall 2005, there were approximately 62,768 students attending pre-kindergarten through 12th grades, including 28,831 students at the elementary level in grades k-5. The racial composition of the elementary students is 78% White, non-Hispanic, 4% African American, 12% Hispanic, 6% other (including American Indian, Asian, and Multi-racial).

The school district has three guiding principles, continuous progress, continuity of caring, and ensuring equity and excellence. The intent of continuous progress is to enhance students' academic, social/emotional, and physical performance with a curriculum that allows students to progress at their own rate. The "blurring" of ages across grades results in multiage or non-graded classrooms. About 60 percent of the teachers in the study taught classes with multiple combinations of grade levels, including three and four, four and five, and three through five. The goal of continuity of caring allowed students to have individual teachers or teams of teachers across multiple years. Most of our schools' buildings (14 of 20 schools) were designed with four classrooms having a common core area that included common restrooms, open area, and storage or support staff rooms called pods. The four teachers in a pod work together to varying degrees as a team. Some schools follow the continuous progress plan while others allowed teams to move students among the four teachers. In some teams we find teachers teaching by grade levels for science, while in others teachers taught multigrade science.

When we implemented the program in the fall of 2005 the state testing of fifth grade science was included in each school's accountability measure. The district also began a district-wide

professional development program based on Learning Focused Strategies (LFS), developed by Max Thompson and Julia Thompson. This program was implemented in groups of elementary schools each year for three years. The program focused on generic teaching strategies such as, essential questions, activating, teaching, and summarizing strategies.

There was growing pressure placed upon teachers to focus on reading. Some principals would not allow teachers to use any science reading activities as part of their required uninterrupted 90 minute reading/language arts block. The district uses an integrated thematic program. The themes for elementary intermediate science were clustered across three years by semester among science, social studies, and health, typically a science, social studies, and health related theme. The district curriculum map for the science included 60 days of science themes for year one, 80 days for year two, and 55 days for year three. The district encouraged integration of content so teachers could include applicable science lessons as part of their social studies or health themes.

Population/Participants/Subjects: This is an analysis of the first cohort of third grade students participating in three years of implementation with 129 initial teachers. In all, there are 964 third grade students from ten treatment and ten control schools.

Intervention/Program/Practice: Teaching SMART is a comprehensive, three-year teacher professional development program designed to produce systemic changes in the classroom and the school through improving science education at the elementary school level. The professional development program is intended to change teaching practice in accord with the National Research Council's National Science Education Standards. The program is designed to support the development of teachers' confidence in teaching science through the development of their science content knowledge and pedagogical skills. In turn, students' attitudes toward and confidence in science are expected to improve. Teacher professional development consists of three annual trainings with classroom follow-up visits by the resource teachers and half-day networking sessions. The program is delivered by district resource teachers who have been trained and monitored by Teaching SMART program staff. The Teaching SMART program provided teachers with 103 lessons that were adapted to follow the Teaching SMART format. The lessons were reorganized by the Teaching SMART resource teachers to align with the district's three year thematic cluster program. There were an average of 45 Teaching SMART lessons recommend a year and 85 unduplicated recommended lessons across the three year cluster. At the conclusion of each level of teacher training, teachers signed a "contract" stipulating participation in Teaching SMART activities that included completing minimum of two lessons per month. The resource teachers prepared kits for each teacher and school. These kits contained the majority of the materials needed to conduct the recommended activities. The resource teachers also would assist teachers by providing perishable supplies. These kits were "refurbished" each year by the resource teachers.

Research design: A randomized controlled trial is used in which schools were randomly assigned to either a treatment or control condition. Teachers in treatment schools participate in the Teaching SMART professional development program while teachers in control schools participated in a business-as-usual condition.

Data collection and analysis: Baseline data were collected from teachers and their students in the fall of 2005 and then annually each spring. The items used in the teacher and student survey were adapted from the work of the Council of Chief State School Officers (Blank, Porter & Smithson, 2001). Scores from the instructional practice items were explored through factor analysis where five categories were created: empowering, hands-on, exploring, inquiry, and conventional practices. In this analysis, we focus on the reported impact of professional development on science inquiry and hands-on activities. Three measures of science achievement are used to evaluate the impact of the Teaching SMART professional development program on student outcomes. Two measures were developed by the Partnership for the Assessment of Standards-based Science (PASS) and consist of a performance task and a multiple choice assessment. Students' responses to multiple-choice PASS items are computer scored while performance items are scored using analytical rubrics with high interrater reliability (Klein, Stecher, Shavelson, McCaffery, Ormseth, Bell, Comfort & Othman, 1998). The third measure is the state of Florida standardized test, the Florida Comprehension Assessment Test (FCAT). A repeated measures analysis of the Florida Comprehensive Achievement Test (FCAT) scores for treatment and control schools for 2005, 2006, and 2007 using HLM 6.06.

Findings:
Teachers' instructional practice scores for Inquiry and Hands-On activities on the teacher survey that was administered at four time points (baseline fall 2005, spring 2006, spring 2007, and spring 2008) were analyzed (see Table 1). Overall, treatment teachers scored higher on inquiry [$F = (3, 887) = 26.93$, $p<.005$, Partial Eta Squared=.08] and hands-on activities [$F = (3, 887) = 18.41$, $p<.005$, Partial Eta Squared=.06] (see Figure 1 and 2) instructional practices than control teachers. The effect size of these measures is small explaining less than 10 percent of the variance.

A repeated measures analysis of the Florida Comprehensive Achievement Test (FCAT) fifth grade science scores for treatment (n=10) and control (n=9) schools for 2005, 2006, and 2007 using HLM 6.06 indicated that the average initial score for schools was 290.2 ($p < 0.001$) and the average change for schools was 0.28 ($p < 0.003$) per unit time (year). The predicted difference in FCAT scores (Figure 3) between treatment and control schools per unit time was 0.47 (greater if a treatment school), but this difference was not significant ($p < 0.89$).

Conclusions:
We are encouraged by the teachers reported change in practice and the concurrent student reports. The lack of significant effects on measures of student achievement may be due to a variety of factors including contextual pressures emphasizing reading and mathematics achievement. Repeated measures analyses of the recent FCAT scores at the student level may provide greater power.

During the implementation of the Teaching SMART program there are a number of issues that may have influenced teacher practices and student achievement. Issues include the district context, and the Teaching SMART program structure and implementation. The school district's support was initially very strong, but waned as the program progressed. The supervisor for elementary science was routinely present for the opening of each of the multiple beginning training sessions and on half of those trainings her supervisor spoke of the district's support for

the program. These two initial people were promoted at the end of the first year. Their replacements, although very supportive, underwent a period of learning the details of the program. The district simultaneously implemented their district-wide Learning Focused Strategies (LFS) teacher professional development program. The Learning Focused Strategies is described as a research based school improvement framework of best practices that emphasizes planning, prioritized curriculum, instructional strategies, assessment and school organization to maximize student achievement. During the three years of Teaching SMART, successive schools were also participating in the district's LFS program. From our interviews, observations of the Teaching SMART training, and feedback from the resource teachers we discern that teachers and principals sometimes viewed the Teaching SMART program as an additional burden. Other staff changes may have influenced teacher perceptions of the program. During the second year of the program 35 percent of the principals of participating schools were changed and during the third year of the program another 25 percent changed. Another major change during the second year was the loss of one of the three resource teachers due to a promotion to an assistant principal. Although these changes were handled smoothly, they tended to undermine the continuity of delivery and support.

The district's thematic curriculum structure for science and the increasing focus on reading and reading test scores are also an area of concern. The district's thematic approach combined with Teaching SMART's minimum requirement of two lessons per month may have provided an insufficient dosage of student participation in science. A recurrent theme of teacher comments was insufficient time for teaching science.

The structure of the Teaching SMART resource teacher's classroom visits may have contributed to some teachers' apparent decrease in participation in classroom lessons. As part of the Teaching SMART program, the resource teachers decreased the number of classroom visits as well as the type of support they provided each year to encourage teachers to take on the responsibility of improving their science instruction so they could be relatively independent of outside support by the end of the program. Many teachers progressed along with the program's expectations, but a number of teachers appeared to need additional support to continue their growth in science instruction.

Delivery of the professional development by the resource teachers was always well planned and structured based upon the experience of the Teaching SMART program director. We found the implementation among repeated trainings was uniform, but that problems the resource teachers had were not always adequately addressed. Initially the resource teachers tended to deliver the training in didactic manner undermining the inquiry base of the program.
Overall these context and programmatic issues may have slowed the growth of teachers participating in the program. This slowed growth for teachers combined with a lag in increases in student achievement scores offers some optimism for the success of the Teaching SMART program.

Tables and Figures

Table 1. Comparison of treatment and control teachers' hands-on activities and inquiry scores

		Treatment			Control				
Factor	Wave	M	N	SD	M	N	SD	ES	Description
Hands-On	Fall 2005	2.88	173	0.68	2.8	78	0.56	0.12	negligible
	Spring 2006	3.18	168	0.54	2.92	101	0.54	0.48	medium
	Spring 2007	3.26	109	0.43	3.08	73	0.51	0.39	small
	Spring 2008	3.29	58	0.42	3.07	47	0.46	0.50	medium
Treatment	T F05 to S06	2.88	173	0.68	3.18	168	0.54	0.49	medium
	T F05 to S07	2.88	173	0.68	3.26	109	0.43	0.64	medium
	T F05 t S08	2.88	173	0.68	3.29	58	0.42	0.65	medium
Control	C F05 to S06	2.8	78	0.56	2.92	101	0.54	0.22	small
	C F05 to S07	2.8	78	0.56	3.08	73	0.51	0.52	medium
	C F05 t S08	2.8	78	0.56	3.07	47	0.46	0.51	medium
Inquiry	Fall 2005	2.68	173	0.62	2.71	78	0.53	0.05	negligible
	Spring 2006	2.87	168	0.58	2.73	101	0.5	0.25	small
	Spring 2007	3.04	109	0.48	2.84	73	0.53	0.40	small
	Spring 2008	3.17	58	0.58	2.82	47	0.48	0.65	medium
Treatment	T F05 to S06	2.68	173	0.62	2.87	168	0.58	0.32	small
	T F05 to S07	2.68	173	0.62	3.04	109	0.48	0.63	medium
	T F05 t S08	2.68	173	0.62	3.17	58	0.58	0.80	large
Control	C F05 to S06	2.71	78	0.53	2.73	101	0.5	0.04	negligible
	C F05 to S07	2.71	78	0.53	2.84	73	0.53	0.24	small
	C F05 t S08	2.71	78	0.53	2.82	47	0.48	0.21	small

Figure 1. Teacher means for hands-on activity scores

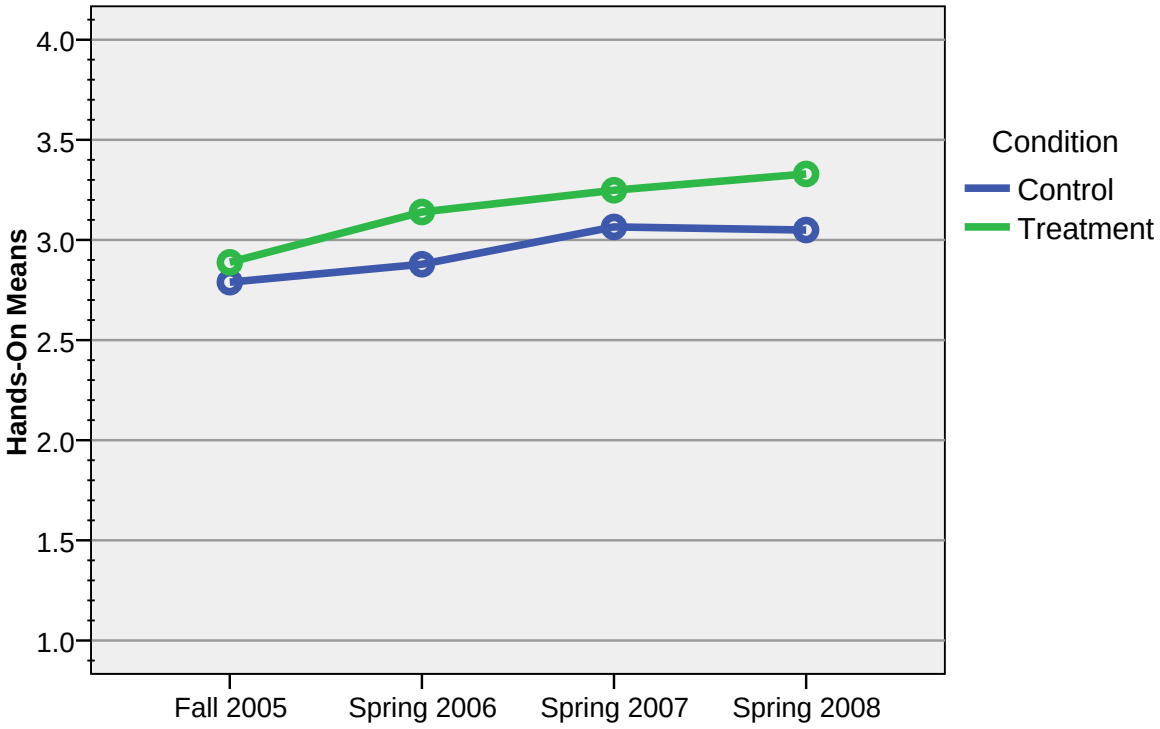

Figure 2. Teacher means for inquiry activity scores

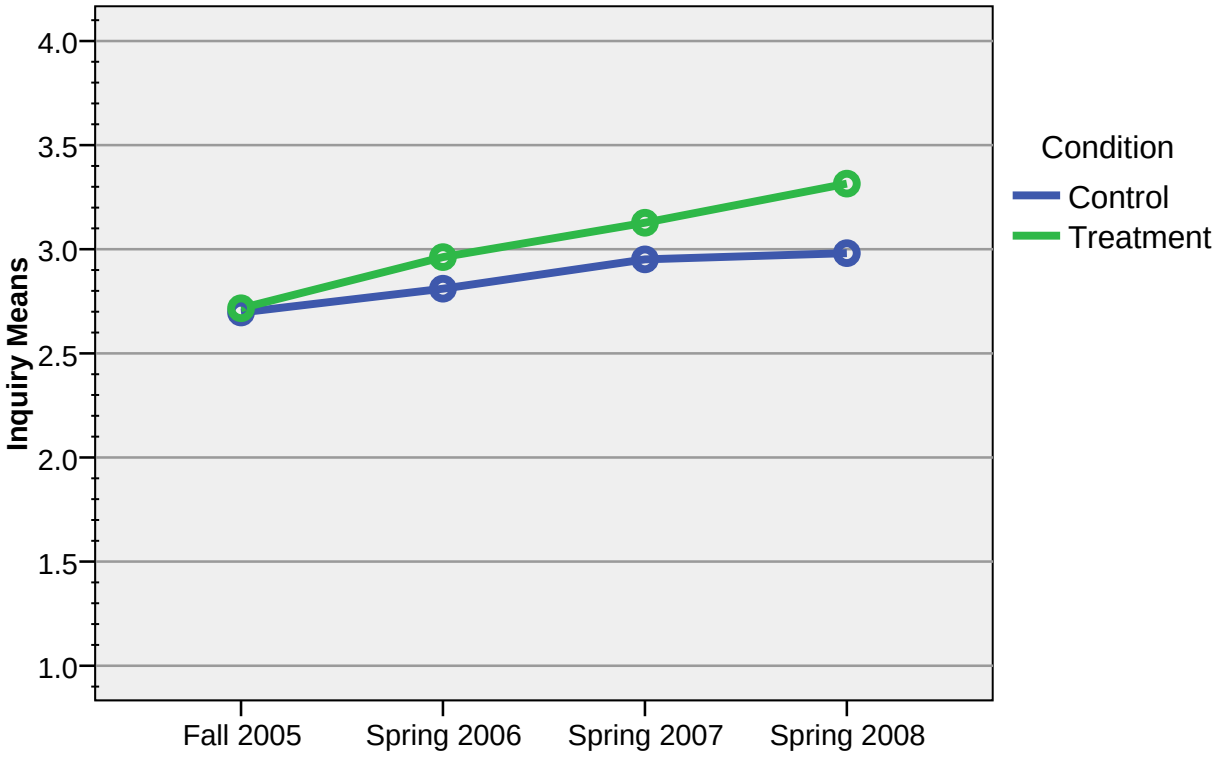

Figure 3. Comparison of treatment and control student FCAT school scores