A Professional Development Model for Math and Science Educators in Catholic Elementary Schools: Challenges and Successes

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Catholic elementary schools must continue to invest in the professional development of math and science teachers in order to prepare students for the challenging work that lies ahead of them. The purpose of the study was to examine the degree to which the Initiative for Catholic Schools (ICS), a 2-year professional development program for science and math teachers, demonstrated positive outcomes within the context of Catholic elementary education across the five levels of impact for a professional development program: participants' reactions, participants' learning, organization support and change, participants' use of new knowledge and skills, and student learning outcomes. The results provide evidence of positive outcomes in the participants' reactions, participants' learning, organization support and change, and participants' use of new knowledge and skills. The impact on student learning outcomes was less consistent and varied by grade level.

The United States places a high priority on science and mathematics education to advance its position in a global society. Disappointingly, the progress made in reforming science and mathematics education has been mixed. According to the most recent Trends in International Mathematics and Science Study (TIMSS) comparing fourth and eighth graders' achievement to their peers in other countries, fourth grade students' achievement improved considerably, but eighth grade achievement remained flat (Mullis, Martin, Gonzalez, & Chrostowski, 2004). Given that our nation's youth compete in an increasingly global economy emphasizing math, science, and technology advancement, science and mathematics educators must respond to

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the renewed demands for quality science and mathematics instruction or risk leaving their students ill prepared to succeed.

The Essential Role of Professional Development

With the passage of the No Child Left Behind Act in 2001, public school districts are accountable for providing "highly qualified" teachers for every student. Public school districts are provided federal funding through Title II for the purposes of preparing, training, and recruiting high-quality teachers. In order for Catholic elementary schools to continue to attract, train, and recruit high-quality science and math teachers, considerations must be made for the professional development of these educators. An intentional, ongoing, and systemic model for professional development is critical for meeting the demands in today's Catholic school classrooms.

The purpose of this article is to describe the results of a comprehensive evaluation of the Initiative for Catholic Schools (ICS), a 2-year professional development program designed to increase the knowledge and skills of science and math teachers, strengthen leadership, and increase student achievement in science and math in Catholic elementary schools. The evaluation examined the degree to which the ICS program demonstrated positive outcomes across the five critical levels of impact for a professional development program: participants' reactions, participants' learning, organization support and change, participants' use of new knowledge and skills, and student learning outcomes. In this article, a review of the literature on professional development is provided, followed by a detailed description of the ICS program, the methods used to evaluate the program, the results obtained, and a discussion of these results within the larger context of professional development and educational accountability.

Five Levels of Impact for a Professional Development Program for Educators

The current emphasis on professional development comes from the growing recognition that education is a dynamic, challenging professional field where the stakes are high (Guskey, 2000). Guskey proposed a model for evaluating the impact of professional development that is comprised of five levels: (a) participants' reactions, (b) participants' learning, (c) organization support and change, (d) participants' use of new knowledge and skills, and (e) student learning outcomes. Although designed as a model for evaluation, understanding which outcomes will be measured and how is an essential early step in program development (Worthen, Sanders, & Fitzpatrick, 2004). Recognition of the potential impact of professional development on multiple levels challenges those designing professional development programs to consider the linkages between the levels (e.g., how participants' use of new knowledge and skills will realistically lead to improved student learning outcomes) in order to maximize comprehensive reform.

Level 1: Participants' Reactions

Measuring participants' initial satisfaction with a professional development program can provide immediate information to help improve design and delivery (Guskey, 2000). Such information can also give insight into the degree to which the participants are grasping the content of the professional development program and its perceived value. Equally important, measuring participants' reactions can also reveal procedures and activities that promote participants' learning as well and those that inhibit learning (Guskey, 2000).

Level 2: Participants' Learning

The degree to which participants learn what was intended is critical to establishing the merit and worth of a professional development program. Specific criteria and indicators of learning must be defined early in the program development process (Guskey, 2000). In a review of studies investigating the effects of professional development on student learning, the greatest effects were observed when teachers were engaged with knowledge directly relevant to what students were learning (Kennedy, 1998 as cited in Guskey, 2000).

In addition to the content knowledge presented in a professional development program, teachers can also be expected to gain in their own estimation of their ability to teach effectively. Self-efficacy is defined as a belief in one's own abilities to perform an action or activity necessary to achieve a goal or task (Bandura, 1997). Beliefs about one's own abilities to accomplish specific tasks are powerful predictors of behavior. Self-efficacy beliefs influence choices, effort, and persistence in the face of adversity (Pajares, 1997).

As it relates to teachers, teacher self-efficacy is the belief that one can bring about desired outcomes of student engagement and learning, even among those students who may be difficult or unmotivated (Tschannen-Moran & Hoy, 2001). Teacher self-efficacy has been linked to teachers' taking responsibility for student achievement (Guskey, 1982, 1988) and greater persistence in working with struggling students (Gibson & Dembo, 1984). Teacher self-efficacy is predictive of a willingness to implement innovative teaching strategies and improve methods of instruction (Allinder, 1994; Guskey, 1984, 1988; Smylie, 1988; Stein & Wang, 1988).

A teacher's self-efficacy has been found to play a critical role in his or her ability to impact student achievement (Ashton, 1985; Ashton & Webb, 1986). With particular respect to science and math education, several studies have shown a positive association between teacher self-efficacy and elementary students' achievement in science (Cannon & Scharmann, 1996), student motivation in mathematics for students transitioning to junior high school (Midgley, Feldlaufer, & Eccles, 1989), and achievement in computer technology (Ross, Hogaboam-Gray, & Hannay, 2001).

Level 3: Organization Support and Change

Organizations have a powerful influence on all aspects of professional development (Guskey, 2000). Successes attained with individual aspects of professional development can be stifled, halted, or essentially canceled by seemingly immutable factors in the organization's culture (Fullan, 1993; Sparks, 1996; Sparks & Hirsh, 1997). For professional development programs to maximize their success, careful consideration must be given to organizational elements that include organizational policies (aligned with organization's mission), resources, protection from intrusions, openness to experimentation and alleviation of fears, collegial support, principals' leadership and support, higher-level administrators' leadership and support, recognition of success, and provision of time (Guskey, 2000).

Level 4: Participants' Use of New Knowledge and Skills

The degree to which teachers are able and willing to apply new knowledge and implement new instructional strategies competently is the most critical measure of the effectiveness of a professional development program. Producing deep, meaningful, and sustainable changes in teachers' instructional practices is difficult, according to Coburn (2003), as teachers are: (a) likely to gravitate toward approaches that are congruent with their prior practices and avoid approaches that conflict with prior practices (Spillane, 2000), (b) focus on surface manifestation (such as discrete activities, materials, or classroom organization) rather than deeper pedagogical principles (Coburn, 2002; Spillane, 2000; Spillane & Callahan, 2000; Spillane & Zeuli, 1999), and (c) graft new approaches on top of existing practices without altering classroom norms and routines (Coburn, 2002; Cuban, 1993). Incorporating new practices and techniques to unique, on-the-job conditions is an uneven process that requires time and effort (Joyce & Showers, 1995). The obstacles to increasing teachers' use of new knowledge and skills highlight the challenges of planning, implementing, and evaluating high-quality professional development for teachers.

Level 5: Student Learning Outcomes

The ultimate goal of any professional development program for teachers is an increase in student achievement. The results of a recent study provide additional evidence that student achievement is largely attributable to the contribution of the teacher. Using data from a 4-year experiment in which teachers and students were randomly assigned to classes to estimate teacher effects on student achievement, Nye, Konstantopoulos, and Hedges (2004) found that the variance due to the differences among teachers was substantial in comparison to the variance attributable to naturally occurring school effects. Thus, "which teacher a student happens to get within a school matters more than which school the student happens to attend" (p. 247). Empirical evidence of the impact of teacher effects on student achievement supports previous research concluding that the teacher is the primary school-based determinant who affects the variance in student achievement (Goldhaber & Brewer, 1997; Sanders & Rivers, 1996).

The Initiative for Catholic Schools (ICS) Program

The ICS program was a 2-year professional development program designed to improve teaching strategies and content knowledge in science and mathematics and school leadership. The goals of the ICS program are: (a) to develop and strengthen leadership in Catholic elementary schools, (b) to improve the curriculum in science and mathematics, (c) to improve student learning and retention in basic science and mathematics content, and (d) to implement a student-oriented pedagogy. Seventy-seven Catholic elementary schools located in a Midwestern city were invited to submit a proposal for participation in the program. Twenty-one school teams were selected based on their responses to questions pertaining to their goals and intentions as they related to science and mathematics. Each school team consisted of at least one science teacher, at least one mathematics teacher, and the school principal. The participating schools were diverse in socioeconomic status, ethnic backgrounds, and location (see Appendix A).

The participants in the 2-year program met for monthly workshops during the academic year and for 2 weeks in each summer session. Science and math educators met as separate groups. The monthly sessions and the two 5-day summer sessions were taught by university faculty members whose areas of expertise were science and mathematics education. The monthly workshops examined topics that included constructivist learning theory; the learning cycle; national, state, and district standards; and pedagogical practices such as assessment, inquiry-based instructional techniques, curriculum planning and the use of technology to enhance instruction. The focus of the summer sessions was content, although effective teaching strategies were modeled and discussed. In the summer of the first year, science educators focused on life science and math educators examined content in geometry and probability. In the summer of the second year science educators examined physical science content and math educators explored algebraic logic and measurement.

Guskey's (2000) model provided a framework for the design of the ICS program. At Level 1, participants' reactions were sought, as science and math teachers were asked to submit written input on the daily summer sessions at the completion of each day and asked to provide a written reflection at the completion of the 5-day workshop. Standard course evaluations developed by the host university were also used to assess participants' reactions.

At Level 2, participants' learning was evaluated using multiple methods throughout the professional development program. First, graduate-level credit was awarded to the ICS teacher participants and grades were assigned in accordance with the university guidelines. In addition, pre- and post-tests were administered to the teachers during the summer sessions to measure the extent of science and mathematics knowledge acquisition. Lesson plans were also collected and the teachers were directly observed teaching their students in their school buildings. Math teachers designed their curriculum based on the course of study through the development of a curriculum map as further evidence of development in their pedagogical knowledge and skills. A pre- and post-test measure of science teaching self-efficacy and math teaching self-efficacy was also administered to science and math educators, respectively.

Organization support and change (Level 3) was addressed in the design of the ICS program, with each participating school committing a team of educators and administrators to the 2-year professional development process. Furthermore, one of the objectives of the ICS program was to develop teacher leaders at each school. Teacher leaders were expected to share their knowledge and skills with other science and mathematics teachers in their buildings. The principal was critical in establishing a venue where sharing could occur and in supporting the implementation of new teaching strategies. In addition, each school team was required to develop a site-based school improvement project in science or mathematics in their schools. These projects ranged from executing a science enrichment program to revising and implementing a mathematics curriculum.

As evidence of participants' use of new knowledge and skills (Level 4), science and math teachers were required to submit their most recent lesson plan on two occasions during the ICS program year. The lesson descriptions were analyzed by university faculty based on the presence of critical elements of constructivist learning theory. A list of these critical elements appears in the Method section.

Student learning outcomes (Level 5) were assessed using standards-based tests of life science, probability, and geometry. These tests were administered at the beginning and end of the school year to measure achievement gain. These same tests were administered to students attending one of three comparison schools in order to determine the degree to which the gains achieved by the ICS students met or exceeded the gains demonstrated by students whose teachers did not participate in the ICS program.

Method

Purpose of the Current Study

The purpose of the study was to examine the degree to which the ICS program demonstrated positive outcomes across the five levels of impact for a professional development program: participants' reactions, participants' learning, organization support and change, participants' use of new knowledge and skills, and student learning outcomes. This investigation extends the previous research by rigorously examining the impact of a comprehensive professional development program within the context of Catholic elementary education in general, and math and science education, specifically. A recent review of the research literature on professional development programs for teachers indicated that very few empirical studies of the impact of these programs existed (Mohler, Morrison, Hunley, & Grogan, 2007). Of these studies, only a minority included a clearly stated goal, a clear description of the methodology, and specific outcome measures.

Setting

Seventy-seven Catholic elementary schools located in a Midwestern city were invited to submit a proposal for participation in the ICS program. Of these potential participants, 21 Catholic elementary schools submitted a proposal and were then selected for participation. A team from each school consisted of at least one science teacher, at least one mathematics teacher, and the school principal. The participating schools were diverse in socioeconomic status, ethnic backgrounds, and location (see Appendix A). All funding for ICS was granted by a private foundation, the Buenger Foundation, in collaboration with a Catholic university in the area.

Participants

Science educators. Twenty-four science teachers participated in the ICS program. Among these teachers there were 23 females and 1 male. The prior teaching experience of the science teachers ranged from 0-39 years, with an average of 14 years of teaching experience (an average of 9 years teaching science). Due to attrition, there were 18 science teachers participating in the ICS program as of the second year.

Math educators. The math educators in this study were comprised of 24 math teachers from the 21 schools participating in the ICS program. All of the math teachers were female. The prior teaching experience of the math teachers ranged from 0-34 years, with an average of 13 years of teaching experience (an average of 12 years teaching math). Through attrition, there were 22 math teachers participating in the ICS program at the end of the second year.

Design and Procedures

The study used descriptive research methods to describe quantitative outcomes of the ICS program. Pre-experimental within-subjects designs were used to examine changes in mean ratings of teacher self-efficacy and mean gains in student achievement over the course of the ICS program. Changes in teacher self-efficacy ratings were measured across a 10-month period from the beginning of the ICS program to midway through the program. The teacher participants were provided a paper version of the teacher self-efficacy rating scale and a self-addressed, stamped envelope.

A pre-test post-test comparison group quasi-experimental design was used to examine the gains in science and math achievement relative to those of a comparison group. Tests of student achievement in science and math were administered in October (pre-test) and again in April (post-test) of the same academic year to students in the ICS schools at the grade levels taught by ICS teacher participants. These same tests were administered in the same time frame to students in three Catholic elementary schools from the same school system. The comparison schools were selected on the basis that they featured a range of socioeconomic diversity among the student population that was comparable to that of the ICS schools (see Appendix A).

Measures and Analyses

Science Teaching Efficacy Beliefs Instrument (STEBI). The STEBI, developed by Riggs and Enochs (1990), was used to measure the teachers' judgment of their self-efficacy in teaching science. This instrument measures two aspects of science teacher efficacy. The personal science teaching efficacy (PSTE) assesses teachers' degrees of confidence that they can perform a given action successfully. The science teaching outcome expectancy (STOE) assesses teachers' perceptions that a given action will have a favorable result. The PSTE subscale consisted of 13 items and the STOE subscale was comprised of 10 items. The STEBI was structured using a 5-point Likert rating scale, where 5 = "Strongly Agree," 4 = "Agree," 3 = "Uncertain," 2 = "Disagree," and 1 = "Strongly Disagree." An analysis of the internal consistency of the STEBI provides support for the basic integrity of the two subscales and the overall reliability of the instrument (Bleicher, 2004).

Changes in teachers' self-efficacy were analyzed by comparing the teachers' self-ratings at the beginning of the ICS program with the teachers' self-ratings midway through the ICS program (10 months later), a critical point in the formative evaluation of the program as determined by the program's key stakeholders and sponsors. Paired-sample *t*-tests were conducted to determine the degree to which the changes in the mean self-ratings were statistically significant. Effect sizes were calculated to determine the strength of the mean change, where an effect size of .20-.49 represented a small effect, .50-.79 indicated a medium effect, and .80 or greater represented a large effect.

Mathematics Teaching Efficacy Beliefs Instrument (MTEBI). The STEBI was adapted to create the Mathematics Teaching Efficacy Belief Instrument by university faculty members in science education and math education directly involved in the ICS program for the purpose of this evaluation. Changes in teachers' self-efficacy were analyzed by comparing the teachers' self-ratings at the beginning of the ICS program with the teachers' self-ratings midway through the ICS program (10 months later). Paired-sample *t*-tests were conducted to determine the degree to which the changes in the mean self-ratings were statistically significant. Effect sizes were calculated to determine the strength of the mean change, where an effect size of .20-.49 represented a small effect, .50-.79 indicated a medium effect, and .80 or greater represented a large effect.

Assessment of lesson plans. ICS teachers were required to submit their most recent lesson plan at the beginning of the program and again at the end of the program. Lesson plans were assessed by university faculty in science and math education using a rubric comprised of the critical elements of constructivist learning theory: student directed, conceptual development, performance-based objectives, use of science equipment/math manipulatives, group work, and accurate science/math content. The rubric for assessing science lesson plans also included inquiry approach and the rubric for assessing math lesson plans included use of technology, multiple solutions, and proper terminology.

Site-based improvement project evaluation. As previously described, each school team participating in the ICS was required to develop a site-based school improvement project related to improving the math and/or science program in their school. The plans were evaluated by the ICS project director and two university faculty members directly involved with the ICS program. Judgments of the quality of the plans were based on three factors: comprehensiveness, feasibility, and likelihood of attaining the desired objective. The quality of the plans were rated using a 5-point categorical rating scale, where 5 = "Very high quality," 4 = "High quality," 3 = "Average," 2 = "Below average," and 1 = "Poor." The degree to which the plans aligned with the goals of the ICS program was assessed using a 5-point categorical rating scale, where 5 = "Perfectly aligned," 4 = "Mostly aligned," 3 = "Moderately aligned," 2 = "Minimally aligned," and 1 = "Not aligned" (see Appendix B).

Standards-based tests of achievement in math and science. University faculty members with expertise in science and math education developed the Standards-Based Tests of Achievement in Math and Science. Test items were sampled from items on the Proficiency Test at Grades 4 and 6, from the Ohio Achievement Test for Grade 8, and from the Ohio Diagnostic Test for Grades 1, 2, and 3. This test content was available in the form of sample test questions from the state Department of Education website (Ohio Department of Education, 2008). Questions were selected based on their teach-test content overlap with the ICS program (see Table 1). The teachers learned the same concepts albeit at the collegiate level during the summer sessions. In this way, there were links connecting teachers' content knowledge, the curriculum established by the Archdiocese, and the students' experiences in the classroom. The teachers who participated in the ICS program administered the Standards-Based Test of Achievement in Science (Grades 4-6) and Math (Grades 1-3) to their students in October and again in April of the same academic year. This academic year represented the ICS teachers' second year of participation in the ICS program.

Results

Level 1: Participants' Reactions

According to the data gathered from the course evaluations, all but one of the teacher participants responded that the ICS course met or exceeded their expectations. Their qualitative comments indicated that they valued being able to visualize science and math concepts in a conceptual manner. All but one of the teachers judged the content and pedagogy emphasized in the ICS course as being beneficial (the exception was a first grade teacher who commented that the math content geared to Grades 1-3 was too advanced for her students). The qualitative comments centered on deepening the conceptual knowledge of concepts, connecting the concepts to appropriate hands-on materials, and acquiring many activities they could use in the classroom. Likewise, when asked which components of the ICS course were the most beneficial, teachers responded that they valued the materials, handouts, and activities they could use in the classroom. According to these participants, math activities addressing more advanced concepts (i.e., beyond the third grade) were the least beneficial aspects of the ICS course.

Level 2: Participants' Learning

Grades earned in graduate-level courses. In science, 17 of the participants received an A and 1 participant received a B for both the life science and physical science courses. In the probability and geometry course, 20 participants received an A, 2 participants received a B and 2 participants received a C. For the algebraic thinking and measurement course, 21 participants received an A, 1 participant audited the class and received an S. One math teacher withdrew from the course due to illness.

Included in the course grades were the teachers' scores on the pre- and post-test on content knowledge. The mean change in performance, as given by the difference in the percentage correct from the pre- to the post-test of the Teachers' Content Knowledge, was as follows: Probability (+48.6 percentage points), Geometry (+29.2 percentage points), Algebra (+45.3 percentage points), Measurement (+46.1 percentage points), Life Sciences I (+39.6 percentage points), Life Sciences II (+14.2 percentage points), Physical Sciences I (+25.0 percentage points), and Physical Sciences II (+23.8 percentage points). The change in percentage correct from pre-test to post-test was statistically significant at the .05 level for all of the gain scores listed above.

Table 1

Standards-Based Tests of Achievement in Math and Science Test Construction

Grade Level	Content Assessed	Number of Items and Item Format
Grade 1	Geometry	7 Fill-in/Open-Ended 2 Multiple Choice 1 Extended Response
	Probability	9 Fill-in/Open-Ended 4 Multiple Choice
Grade 2	Geometry	7 Fill-in/Open-Ended 2 Multiple Choice 1 Extended Response
	Probability	8 Fill-in/Open-Ended 2 Multiple Choice
Grade 3	Geometry	16 Fill-in/Open-Ended
	Probability	14 Fill-in/Open-Ended
Grade 4	Life Science	8 Multiple Choice 2 Extended Response
Grade 5	Life Science	8 Multiple Choice 2 Extended Response
Grade 6	Life Science	9 Multiple Choice 1 Extended Response

Teachers' self-efficacy outcomes. The results of this investigation indicate that science and mathematics teachers participating in the ICS program demonstrated increases in their teaching self-efficacy during the course of their participation in the ICS program. Science teachers' ratings increased overall from a mean of 88.53 ($SD = 9.52$) to 98.53 ($SD = 7.21$). This increase in science teachers' self-reported self-efficacy was statistically significant ($t = -4.79$, 14, $p = 0.00$) and represented a strong effect ($ES = 1.05$).

Similar results were obtained for the mathematics teachers participating in the ICS program. Mathematics teachers' ratings increased overall from a mean of 88.33 ($SD = 8.38$) to 95.07 ($SD = 7.97$). This increase in math teachers' self-reported self-efficacy was statistically significant ($t = -5.43$, 14, $p = 0.00$) and represented a strong effect ($ES = .80$).

Level 3: Organization Support and Change

All of the schools participating in the ICS program committed a team of educators and administrators to the initiative. One hundred percent of the schools completed a site-based school improvement project in science or mathematics in their schools. A list of the projects along with a rating of their quality and alignment with the goals of the ICS program appears in Appendix B.

Level 4: Participants' Use of New Knowledge and Skills

Fifteen math teachers submitted a brief description of their most recent math lesson at the beginning of the ICS program (January) and at the end of the calendar year (December) for analyses by a university faculty member. The lesson descriptions were coded based on the presence of critical elements of constructivist learning theory. Analyses of these lesson plans indicate that math teachers demonstrated marked increases in the application of effective math pedagogy as evidenced by their descriptions of their most recent lessons (see Figure 1).

Nineteen science teachers submitted a brief description of their most recent science lesson at the beginning of the ICS program (January) and again at the end of the ICS program (August of the following year) for analyses by a university faculty member. The lesson descriptions were coded based on the presence of critical elements of constructivist learning theory. Science teachers participating in the ICS program demonstrated marked increases in the application of effective science pedagogy as evidenced by their descriptions of their most recent lessons (see Figure 2).

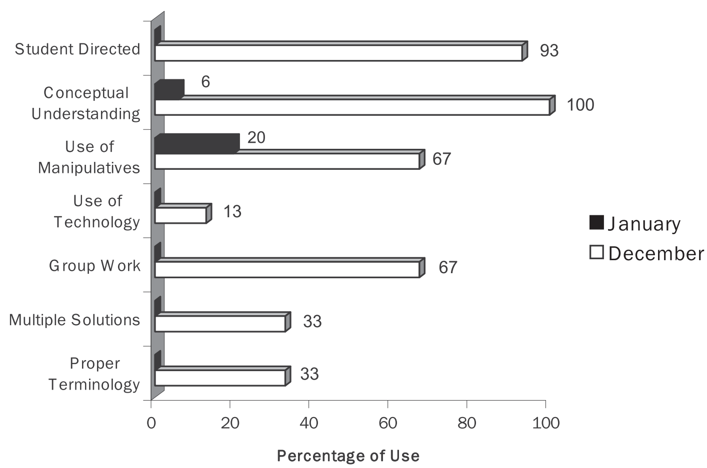

Figure 1. Analyses of math teachers' lesson plans, January to December.

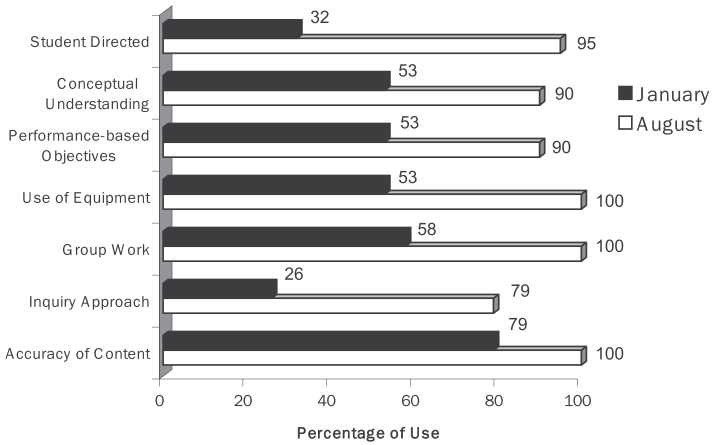

Figure 2. Analyses of science teachers' lesson plans, January to August.

Level 5: Student Learning Outcomes

During the second year of program participation, students taught by an ICS teacher demonstrated gains in math achievement in probability that were statistically significantly greater than those of the students in the comparison schools at Grade 3 (t = 5.805, 263, p = 0.00). There were no statistically significant differences between the ICS students and the comparison school students at Grades 1 and 2 (see Table 2). In geometry, students taught by an ICS teacher demonstrated gains in math achievement that were statistically significantly greater than those of the students in the comparison schools at Grade 3 (t = 7.281, 263, p = 0.00). There were no statistically significant differences between the ICS students and the comparison school students at Grades 1 and 2 (see Table 3).

During the second year of program participation, students taught by an ICS teacher demonstrated gains in science achievement that were statistically significantly greater than those of the students in the comparison schools in life science at Grade 5 (t = 5.570, 325, p = 0.00) and Grade 6 (t = 2.57, 306, p = 0.01). Students in the comparison schools outperformed ICS students at Grade 4 (see Table 4).

Table 2

Results of the Standards-Based Math Test in Probability

	Number of Students	October 2005 Mean (*SD*)	May 2006 Mean (*SD*)	Achievement Gain
Grade 1				
ICS Students	22	69.9% *(17.21)*	89.5% *(12.46)*	+19.6
Comparison	96	65.4% *(17.33)*	81.0% *(19.68)*	+15.5
Grade 2				
ICS Students	44	49.1% *(14.91)*	69.6% *(23.12)*	+20.5
Comparison	55	58.7% *(14.41)*	73.6% *(14.58)*	+14.9
Grade 3				
ICS Students	164	47.0% *(17.27)*	70.8% *(17.55)*	+23.8**
Comparison	101	51.9% *(19.20)*	61.2% *(18.14)*	+9.3

** Statistically significant at .01 level

Table 3

Results of the Standards-Based Math Test in Geometry

	Number of Students	October 2005 Mean (*SD*)	May 2006 Mean (*SD*)	Achievement Gain
Grade 1				
ICS Students	22	70.0% *(21.11)*	88.0% *(14.41)*	+18.0
Comparison	96	56.2% *(17.97)*	80.9% *(15.35)*	+24.7
Grade 2				
ICS Students	44	45.9% *(15.90)*	57.5% *(15.27)*	+15.8
Comparison	55	55.8% *(14.87)*	62.7% *(14.71)*	+21.2
Grade 3				
ICS Students	164	14.5% *(7.87)*	44.2% *(19.58)*	+29.7**
Comparison	101	16.5% *(9.95)*	29.5% *(15.23)*	+13.0

** Statistically significant at .01 level

Table 4

Results of the Standards-Based Science Test in Life Science

	Number of Students	October 2005 Mean (*SD*)	May 2006 Mean (*SD*)	Achievement Gain
Grade 4				
ICS Students	64	56.9% *(20.15)*	66.3% *(15.38)*	+9.4
Comparison	107	46.5% *(16.44)*	64.7% *(16.50)*	+18.2*
Grade 5				
ICS Students	229	49.2% *(16.46)*	60.3% *(16.82)*	+11.1*
Comparison	98	63.3% *(16.67)*	61.8% *(15.36)*	-1.4
Grade 6				
ICS Students	197	48.6% *(18.04)*	61.5% *(19.71)*	+12.9*
Comparison	111	56.2% *(22.36)*	63.0% *(22.51)*	+6.8

* Statistically significant at .05 level

Discussion

The current climate in education, with its emphasis on accountability and highly qualified teachers, is supported by the notion that the professional development of teachers is critical to improving student learning. More than 20 years of research suggests that notable improvements in education almost never take place in the absence of professional development (Guskey, 2000). Given that professional development efforts vary widely based on differences in program context, the structure and format of the experience (process), and the context in which implementation occurs, the most relevant question when evaluating the impact of a professional development program is, "under what conditions (that is, what content, types of formats, contextual characteristics, and so forth) is professional development likely to yield positive effects?" (p. 33).

Three key features of this professional development program provide insight into the conditions likely to yield positive effects for those seeking to replicate the ICS program. First, science and math teachers were recruited to participate as a team along with their principal. The rationale for using teams of educators is that different members of the team can provide different expertise, support one another when new strategies and information are communicated, serve as models for their colleagues, and demonstrate collaboration (Gideon, 1997; Joyner, 1997; Loucks-Horsley, Love, Stiles, Mundry, & Hewson, 2003). It is likely that the reasonably high retention rate among the participants of the ICS program was due to the team-based structure, as quitting a professional development program is more difficult when it also involves quitting a team of colleagues who share a personal and professional connection. Including the principal as a member of the team was also critical for ensuring ongoing administrative support for the application of content knowledge and skills across settings (training center to classroom) and over time.

A second key feature of the ICS program that created conditions likely to yield positive effects was the use of sufficiently strong incentives. Science and math teachers earned (tuition-free) graduate credit hours as a result of their participation in the ICS program and release time for the monthly workshops during the school day. This second condition was judged to be particularly valued as teachers were not required to sacrifice their personal time in the evenings and on weekends in order to advance their knowledge and skills. In addition, science and math teachers were offered a modest stipend for their attendance at the monthly workshops and summer sessions, however, the stipend was judged by the key stakeholders of the ICS program to be a less valued incentive, and possibly superfluous.

The third and final feature of the ICS program that helped set the conditions for positive outcomes was the fact that the participants were volunteers, rather than mandated attendees. In order to be accepted as a participant in the ICS program, teams of educators had to work together to develop a proposal describing their interest in the program and the potential of the ICS program to enhance their school's effectiveness. Thus, the ICS program capitalized on a selection bias by including only individuals who demonstrated an interest and willingness to join a team of educators committed to the goals of the ICS program.

Limitations

There are several limitations inherent in this study that warrant attention in interpreting the results of this study. First, the teacher participants in the program were self-selected, as previously discussed, and may not be representative of all math and science teachers in Catholic schools (selection bias). The second limitation is the small sample size of teachers participating in this study, which increases the possibility that any one participant could have a considerable impact on the teacher outcomes. A third limitation is the loss of participants during the program year (attrition). Although the attrition rate for the program was judged to be typical for a multiyear program, the degree to which the program produced positive outcomes for all participants, including those who withdrew from the program, is unknown. A fourth limitation is the reliance on outcome measures that are based on self-report to gather data. The final limitation is the absence of a randomized controlled trial to compare outcomes for the program participants with those of a control group. In the absence of a randomized controlled trail, causation (i.e., that the program was the cause of the outcomes observed) cannot be established.

Implications

In the current climate of educational accountability and the demand for "highly qualified teachers" set forth by the No Child Left Behind Act, many states have instituted new regulations requiring ongoing professional development for teachers. Catholic schools and public schools alike seek to encourage teachers to explore new ideas and stay current with developments in the teaching profession. The results of this study indicate that intensive, ongoing professional development can have a positive impact on teachers' self-efficacy and on student achievement in science and mathematics in Catholic elementary schools. Further assessments to determine the effect of the professional development after the ICS program has ended will allow researchers to determine if the positive outcomes for teachers and students maintain, increase, or decrease over time.

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Appendix A

Demographic Characteristics of the ICS Schools and the Schools in the Comparison Group

School	Student Enrollment	Race/Ethnicity: African American	American Indian or Native Alaskan	Asian or Pacific Islander	Hispanic	Multi-racial	White	Economically Disadvantaged	Region
ICS Schools									
CS01	140	0.0%	0.0%	0.0%	0.7%	0.7%	98.6%	11.4%	Urban
CS02	594	7.7%	0.5%	1.2%	0.3%	1.9%	88.4%	4.5%	Suburban
CS03	165	0.0%	0.0%	0.6%	1.2%	0.0%	98.2%	1.8%	Rural
CS04	171	5.8%	0.6%	1.2%	2.9%	7.0%	82.5%	35.7%	Urban
CS05	220	96.8%	0.0%	0.0%	0.0%	3.2%	0.0%	85.9%	Urban
CS06	416	13.9%	0.0%	2.4%	0.2%	5.0%	78.4%	3.1%	Suburban
CS07	1030	0.2%	0.0%	1.1%	0.0%	0.1%	98.6%	7.0%	Suburban
CS08	164	7.3%	0.0%	3.0%	0.0%	5.5%	84.1%	13.4%	Suburban
CS09	249	3.6%	0.0%	4.4%	0.4%	6.0%	85.5%	57.0%	Urban
CS10	192	0.0%	0.0%	0.5%	0.5%	4.7%	94.3%	15.6%	Rural
CS11	505	2.2%	0.0%	0.8%	1.2%	0.6%	95.2%	5.3%	Urban
CS12	373	10.7%	0.0%	0.0%	1.1%	7.2%	81.0%	9.7%	Urban
CS13	155	11.6%	0.0%	5.8%	2.6%	7.1%	72.9%	27.1%	Suburban
CS14	99	91.9%	0.0%	0.0%	1.0%	2.0%	5.1%	56.6%	Urban
CS15	192	0.0%	0.0%	0.0%	0.5%	0.5%	99.0%	24.5%	Suburban
CS16	126	33.3%	0.0%	0.0%	0.0%	7.9%	58.7%	38.9%	Urban
CS17	131	19.1%	.08%	0.0%	0.0%	0.8%	79.4%	90.8%	Urban
CS18	711	0.0%	0.0%	0.1%	0.4%	1.4%	98.0%	6.3%	Suburban
CS19	855	0.0%	0.0%	0.0%	0.0%	0.0%	100%	5.6%	Suburban
CS20	364	3.3%	0.0%	0.3%	0.3%	5.2%	90.9%	6.6%	Suburban
CS21	246	2.0%	0.0%	0.0%	0.4%	1.2%	96.3%	23.6%	Suburban
Comparison Schools									
CS61	637	0.0%	0.0%	0.0%	0.0%	0.0%	99.0%	0.0%	Suburban
CS62	145	91.8%	0.0%	0.0%	0.0%	0.0%	4.5%	92.8%	Urban
CS63	220	2.0%	0.0%	0.5%	1.1%	4.1%	92.3%	5.7%	Suburban

Appendix B

Site-Based School Improvement Projects: Mean Ratings and Standard Deviations

Scale for Quality of the Plan	Scale for Alignment with ICS Goals
5 = Very High	5 = Perfectly Aligned
4 = High	4 = Mostly Aligned
3 = Average	3 = Moderately Aligned
2 = Below Average	2 = Minimally Aligned
1 = Poor	1 = Not Aligned At All

Project Title and Objective	Quality of Plan	Alignment with ICS Goals
Creating an Enrichment Club for Mathematics and Science Objective: To think of science and mathematics as fun.	4.3 (*0.6*)	5.0 (*0.0*)
Keyboarding Competence Objective: Students in K-8 will develop age appropriate keyboarding skills.	3.3 (*0.6*)	2.7 (*1.5*)
Family Night for Mathematics and Science Objective: Develop a program for parental involvement where students teach their parents mathematics and science concepts they are learning.	5.0 (*0.0*)	4.7 (*0.6*)
Creating a site based management system of governance using the power cycle. Objective: Using the power cycle, evaluate current practices to identify areas of concern, make recommendations to decision makers, and facilitate implementation.	4.0 (*0.0*)	4.0 (*0.0*)
Algebra for All Objective: To revise the mathematics curriculum, instruction, and assessment with an emphasis on the algebra strand.	4.7 (*0.6*)	5.0 (*0.0*)
Increasing student achievement and confidence in mathematics Objective: To have students value, enjoy, and become more confident in mathematics.	4.0 (*0.0*)	4.7 (*0.6*)
Taking Community Service to a Higher Level. Objective: To increase student involvement in community service activities.	4.3 (*0.6*)	4.3 (*0.6*)
Increasing Students' Terra Nova scores in Language Arts Objective: To increase Terra Nova scores in Language Arts.	3.7 (*0.6*)	3.0 (*1.0*)
Establish a Resource Center for Science and Mathematics Instruction Objective: Increase the use of manipulatives and technology in classroom instruction.	4.3 (*1.2*)	4.3 (*1.2*)

Build Parish/School Community Objective: To make the school and parish a more unified community.	4.0 (*0.0*)	3.7 (*0.6*)
Improved Instruction using Technology Objective: To expand the use of technology in mathematics and science instruction.	4.0 (*1.0*)	4.7 (*0.6*)
Manipulatives in the Mathematics and Science Classroom Objective: To expose students to strategies for learning mathematics and science through the use of manipulatives.	4.3 (*0.6*)	4.7 (*0.6*)
Excellence in Mathematics and Science Objective: To improve student, teacher, and parent attitudes toward mathematics and science, methods, curriculum, and manipulatives.	4.3 (*0.6*)	4.3 (*0.6*)
Improving student achievement in Geometry Objective: Improving student achievement in geometry.	4.0 (*0.0*)	4.3 (*0.6*)
Reach for the Stars in Mathematics Objective: To increase curricular content and student interest in mathematics.	4.0 (*0.0*)	4.3 (*0.6*)
Advanced Science and Mathematics Project Objective: To increase the opportunities for students to learn science and mathematics through manipulatives, hands-on experiments, and demonstrations.	4.7 (*0.6*)	4.7 (*0.6*)
A Feasibility Study for a Special Education Program Objective: To increase educational opportunities for students in the parish with special needs.	4.0 (*1.0*)	4.0 (*0.0*)
Enhancing Education through Improved Communication with Technology Objective: To improve communication between the school and its community.	4.3 (*0.6*)	4.3 (*0.6*)