

A sign of the times - more is better: Exploring the additive effect of professional development on student science exam outcomes

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The purpose of this paper is to examine longitudinal quantitative and qualitative data to uncover how an additive effect of professional development influences student outcomes. The program evaluation of a large science grant initiative outlined the delivery of a series of professional development opportunities to a select number of educators throughout a large urban city school district in upstate New York. Student scores on a state science exam were analyzed not only by whether or not the student's instructor received professional development from the grant, but also by whether students received instruction from a series of educators with grant training over the three years of the grant initiative. Qualitative data, in the form of interviews and classroom observations, provided insight for future program evaluation. The authors argue that the pattern of results affirm that professional development positively influences student performance, and informs discussion for implications of professional development duration and intensity.

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Evaluation has many roles in an educational context (Worthen & Sanders, 1987), but its primary purpose is to ascertain the merit of whatever construct is being examined (Scriven, 1973). Although few would question the merits of delivering research based professional development to educators, a need to understand the manner through which such training can impact student outcomes remains. A three year Math Science Partnership (MSP) Science Initiative Program, funded by the US Department of Education, sought to establish the link between teacher content and professional development on student outcomes. In addition to examining the yearly impact of professional development on content tests, students were tracked over the grants duration so that a possible additive effect of professional development could be explored.

Purpose

The purpose of this project was to examine longitudinal quantitative and qualitative data to uncover how an additive effect of professional development influences student outcomes. The program evaluation of a large science grant initiative outlined the delivery of a series of professional development opportunities to a select number of educators throughout a large urban city school district in upstate New York. Student outcome were measured through the grant designed curriculum unit assessments as well as the 4th grade State Science Tests.

Theoretical background of the study

As educational reform initiatives are adopted by American school systems, professional development has become of great concern for evaluators, policy makers, and educators (Penuel, Fishman, Yamaguchi, Gallagher, 2007). Large scale studies have found that professional development can positively influence teacher knowledge, but a need to understand how it influences student performance remains (Garet, Porter, Desimone, Birman, & Yoon, 2001; Supovitz & Turner, 2000). Although student achievement is positively related to instructional quality (Darling-Hammond, 2000), research examining how professional development impacts student outcomes over time is limited (Fishman, Marx, Best, & Ta, 2003).

To address these questions, a mixed method evaluation of a three year, Math Science Partnership (MSP) Initiative Program, a national grant project offering professional development to selected elementary educators throughout a large urban city in upstate New York, was employed. Although training primarily occurred over the summers, a wide variety of services, such as embedded lesson development, and unit planning, were offered year round.

Throughout the project's duration, quantitative data, in the form of a state wide standardized Science assessment (grade four elementary-level science exams), were collected, allowing comparisons between students instructed by MSP educators and those who received instruction from non-MSP educators. Additionally, the additive effect of PD was investigated focusing on MSP participation for multiple years by comparing 4th grade scores of students who worked with a series of MSP teachers (from grade 2 through 4), based on whether they had a MSP teacher one, two, or three years over the duration of the grant. Collectively, these results allowed for evaluation of whether the professional development offered by MSP effectively facilitates student performance, and whether an additive effect exists.

To guide quantitative findings, a qualitative analysis, in the form of case studies, supplemented our understanding by delineating what was happening in the classroom. Using in-depth interviews with MSP faculty and classroom observations, trained evaluators noted differences in lesson design (e.g. level of assistance, regulation, and inquiry) based upon pedagogical transitions aligned with the professional development. Analyses of these data elucidate the underlying mechanisms of what was effective and allows for considerations of development and implementation of future programs.

Methodology

The Mathematics-Science Partnership. The project summarized in this paper was funded under the New York State Title IIB Mathematics-Science Partnership. Fifty elementary teachers, grades 2-4 and their students in a large urban school district in New York State participated in this project. The focus for the grant was science

education with an emphasis on the living environment. The main goal of the initiative was to improve the skills of teachers in science by offering professional development in content and pedagogy. The long term goals of the project were to improve students' learning and achievement in science by providing teachers in grades 2-4 with sustained professional development on pedagogy and living environment science. At the initiation of the project, direct stipend based instruction was provided for teachers to review or enhance key science content. Subsequently, a Science Instructional Support Teacher (IST) directed the participants through afterschool professional development, Lesson Studies and assistance through coaching and mentoring as part of that process, when requested.

Data Sources. In an effort to meet the challenge of documenting knowledge gained, the evaluation in this project began in the preparatory phases of development (Year One) and formative evaluation occurred in a planned cycle of yearly documentation of progress (Jacobson, 2003). General data sources included District records documenting the number of teachers who received professional development, the frequency of teacher involvement, and depth and frequency of involvement with in the varied modalities of presentation. Evaluators observed a purposive sample of these to validate participation, relevance, and integrity of transfer. Data was collected through direct observation of use in the classroom, as well as through written and oral teacher reflections, and group/individual interviews. Student achievement outcomes were assessed using pre/post unit tests representing the grant developed curriculum units. Data for these units were collected from two samples of students: 1) students served by MSP teachers, accounting for number of years in an MSP class, and 2) students not taught by an MSP teacher.

Instruments: The Syracuse City School District, with guidance of the evaluators, developed a science content survey based on the New York State Science assessments for grades 4 and 8. The pre- and post-test surveys contained questions used to assess student knowledge in the living environment domain reflecting the New York State curriculum guidelines and content strands. Reliability coefficients for the teacher content test items were generated for the overall test performance, as well as the performance on the subgroups of sustainability and growth, for test integrity data. Validity of the developed instruments was established during the assessment development process, and re-established through alignment processes of teacher content test questions to NYS Science Curriculum.

Results and Conclusions

Teacher outcomes: After participation in the grant provided professional development, changes in teachers' Year Three content knowledge were documented as was sustainability of significant growth obtained during Year One and Year Two. Syracuse City School District MSP teachers made significant gains in living science content knowledge from Year One to Year Three. Continued documentation of reliability and validity of the instruments verified the generalizability of these findings. Outcomes indicated that teachers significantly improved their content knowledge after participating in the professional development, lesson study and learning communities. MSP participant performance on District developed content tests significantly improved from pre to post-test (See Table 1). This trend in a gain on the yearly post-test, relative to the yearly pre, suggests that MSP participants continued to learn new information relevant to life and environmental science content each year.

When asked about their professional development experience, teachers stated that they were better prepared to teach science highlighting their ability to encourage student interest in science, manage a class engaged in project work, and listening/asking questions as students work. Teachers also reported confidence in multiple pedagogical techniques including having students work in cooperative learning groups as well as in leading a class using investigative strategies, all methods supported through participating in the professional development sessions. Participants developed, piloted, and refined Science units reflecting changes in content and the pedagogy. Observations of science unit implementation, interviews with teachers and administrators, teacher self-reports, and student data confirmed the transfer of knowledge in content and pedagogy into the classroom. Teachers utilized multiple methods of assessment, increased their confidence in and use of the new pedagogy and science content, and continued to support student-centered approaches to learning. Evaluators' observations of classrooms confirmed constructivist activities, both directly related to the new science curriculum units and professional

development content.

Table 1
MSP Participants, Pre and Post Professional Development Test Comparison

<u>Living Environment/ Life Sciences</u>	n*	Pre		Post		Dependent t-test
		Mean	St. Dev.	Mean	St. Dev.	
Year One	36	8.69	1.26	9.47	0.91	4.47**
Year Two	26	6.69	1.62	7.73	0.67	2.78**
Year Three	33	18.18	2.70	18.88	1.58	2.09**

*Participant matched assessments, ** $p < .05$ (two-tailed)

Student Outcomes: Outcome variables included New York State science scores for students in Grade 4 and were used to form two groups: a sample of students served by MSP teachers and all other students in Grade 4. New York State science scores for students in Grade 4 indicated that students with MSP teachers. Additionally, grant developed assessment tests were administered to MSP and non-MSP classrooms throughout the duration of the grant. These tests were based on the New York State Science Standards and reflected standards based on material developed within grant related curriculum. Findings indicated that students taught by an MSP participant had higher post-test scores than pre-test, for all units for each grade level, over all three years. This trend suggests that the MSP grant initiative had a positive impact on student outcomes across the grant's duration. Over the course of the three year grant, results for students in Grades 2, 3 and 4 on local pre- and post-unit content tests indicated that MSP students showed improvement and scores in Grades 2 and 3 were notably better than those in non-MSP classrooms. (See Table 2 and 3).

Table 2
Comparison of MSP Pre and Post Tests
on Curriculum Unit Assessments Over Three Years

Unit Assessment	n	Pre-Test		n	Post-Test		df	t-test
		Mean	St. Dev		Mean	St. Dev.		
Year One								
Grade 2: Unit 1	110	4.79	2.01	182	6.41	2.80	NA	NA
Grade 3: Unit 1	254	8.57	2.94	194	10.18	3.07	NA	NA
Grade 4: Unit 1	147	9.93	3.22	153	11.94	2.79	NA	NA
Year Two								
Grade 2: Unit 1	252	5.73	1.99	247	7.00	2.27	485	6.6*
Grade 3: Unit 1	200	8.23	3.25	160	10.53	3.28	358	6.6*
Grade 4: Unit 1	132	10.33	3.45	145	12.13	3.00	274	4.6*
Year Three**								
Grade 2: Unit 1	41	4.68	2.20	41	6.61	2.27	485	4.9*
Grade 2: Unit 2	85	4.93	1.68	85	6.74	1.95	358	8.4*
Grade 3: Unit 1	64	6.64	2.67	64	9.55	2.93	274	8.3*
Grade 3: Unit 2	52	10.35	5.58	52	15.04	5.47	485	8.4*
Grade 4: Unit 1	95	10.61	3.1	95	11.67	2.7	358	4.4*
Grade 4: Unit 2	86	6.88	2.34	86	9.24	2.37	274	8.4*

** $p < .05$ (two-tailed)**Due to IRB regulations Year One and Two were unmatched; however, access to match pre- and post-test was granted for Year Three

Table 3
Comparison of MSP and Non-MSP Students
on Curriculum Unit Assessments Over Three Years

Unit Post-Assessment	n	MSP		n	Non-MSP		df	Independent t-test
		Mean	St. Dev		Mean	St. Dev.		
Year One								
Grade 2: Unit 1	182	7.00	2.79	69	5.00	1.88	182	3.9*
Grade 3: Unit 1	194	10.18	3.07	75	8.15	2.74	149	5.0*
Grade 4: Unit 1	153	11.94	2.79	80	10.35	2.80	170	4.2*
Year Two								
Grade 2: Unit 1	247	7.00	2.27	93	6.00	2.08	338	3.8*
Grade 3: Unit 1	200	10.53	3.28	28	7.50	2.45	226	4.7*
Grade 4: Unit 1	132	12.13	3.00	57	11.44	2.89	187	1.4
Year Three								
Grade 2: Unit 2	95	8.82	2.09	60	9.68	2.33	153	2.3*
Grade 3: Unit 2	57	14.49	5.6	19	11.32	4.5	74	2.2*
Grade 4: Unit 1	108	11.73	2.7	21	10.90	2.41	127	1.4

* $p < .05$ (two-tailed)

MSP grant developed unit post-tests compared students served by MSP teachers to those in non-MSP classrooms to show change after involvement in the grant created curriculum. Analyses indicated that students of MSP teachers also performed better on curriculum unit post-test, relative to those taught by non-MSP faculty. MSP students tended to perform significantly better than did students of Non-MSP educators on unit post-test assessments across all three years of the grants duration. Unit 1 assessments for Grade 4 in Year Two and Year Three were the only assessments which did not yield significant differences. Although the mean differences between these groups are not significantly different, the pattern of means is similar to all other assessments across all other years (e.g. that MSP students performed higher than did non-MSP students). These results, coupled with observational data, suggest students taught by MSP faculty are more engaged, and use higher level thinking skills.

Table 4
New York State Science Assessment for Grade 4, by Performance Level

Test date	Number Tested	% At performance level			
		Level 4	Level 3	Level 2	Level 1
Year 1					
MSP 4 th grades	259	22	46	22	11
Non-MSP 4 th grades	1381	26	39	20	14
Year 2					
MSP 4 th grades	267	32	40	11	17
Non-MSP 4 th grades	1252	31	36	20	13
Year 3**					
MSP 4 th grades	213	30	41	18	10
Non-MSP 4 th grades	1224	33	34	21	12

In general, Year One students' achievement outcomes, reflected by Grade 4 New York State Science achievement test, indicated that overall 67% of MSP teachers trained students performed at proficient levels, while 66% of students with non-MSP teachers recorded overall proficiency. In Year Two, students of MSP teachers scored higher than their Non-MSP counterparts (72% compared to 67% at Levels 3 and 4). Overall, by the end of Year Two more students were recording scores at Level 3 and 4, meeting proficiency levels for New York State requirements.

In Year Three, students of MSP teachers' scores performed better than their Non-MSP counterparts. Data indicated that MSP students. Overall, by the end of Year Three more MSP students were recording scores at Level 3 and 4, than at the Year One baseline. An increase can also be seen in the non-MSP population, indicating that scores may have been impacted by students having had an MSP trained teacher in one and/or two previous years. Additionally, performance by students on questions defined as Living Environment focused indicated that students of MSP teacher performed better than those students on non-MSP classrooms. Data also outlined a significant increase from Year One baseline on Living Environment questions. Overall at baseline in Year One 51% of students correctly answered Living Environment questions correctly compared to 68% in Year Three (+17%).

In light of the limited contrast in Year Three's state testing comparison of MSP and Non-MSP students, the investigation included a look at how students were impacted by having been in classes of MSP teachers for multiple years.

Table 5
Outcome of MSP State Science Tests
by Number of Years with MSP Teacher

Year with MSP Teacher	4 th grade State Test	
	n	% met proficiency
One Year	375	70
Two Years	97	84

Those students who were assigned to two years of teachers trained through the professional development program increased their scores 14%. Data for those who worked with an MSP teacher for three years was limited to 18 students. Data indicated that 61% of these students achieved proficiency at level 3 and 4 in the 4th grade mathematics assessment. An in-depth look at environment questions was not possible as data for some years was limited.

Case study teachers: Observations of case study teacher classrooms indicated that teachers had developed the ability to use a variety of modes of instruction to meet the needs of students. These methods, in combination with environmental features elicit different levels of student understanding. The most common method reflected a Socratic approach used with a constructivist lesson plan that had as its goal the development of higher level thinking skills.

Nine distinct modes of instruction (lecture, structure/Socratic, teacher demonstration, constructivism, cooperative learning, independent research, contextual application, computer aided instruction, and other) were noted as used by case study teachers. On average, the MSP educators used three different modes of instruction throughout each lesson plan. The most commonly used mode of instruction was structure/Socratic which was present in 86% of the observed lessons, followed by constructivism which was observed in 43% of the lessons, and lecture which was observed in 38% of the lessons. Other modes, such as cooperative learning and teacher demonstrations were observed roughly 30% of the time.

Lessons were coded for student level of understanding, and a full range of Bloom's Revised Taxonomy was evidenced. This included student demonstration of knowledge (identifying, describing, recalling information), comprehension (summarizing, interpreting, and differentiating among facts), application (using information and concepts in new ways), analysis (recognizing patterns, organizing information into components), synthesis (generalizing from facts, making predictions), or evaluation (making decisions, comparing principles,

judging values). Overall 81% of students demonstrated knowledge, 76% demonstrated comprehension, 33% demonstrated application, and 29% demonstrated synthesis showing an attention to higher level thinking.

Student outcomes reflected a scaffolding approach. In examining the quantified observational data, a trend was noted that lessons tended to begin with having students demonstrate lower levels of understanding (i.e. demonstrating knowledge, such as recalling information in a review), and eventually reaching higher levels of understanding (i.e. demonstrating synthesis, such as making predictions).

Implications

Because of the time and the experience of those involved with the MSP grants, a variety of student outcome data was available to evaluators to help determine the influence of the infusion of professional development. The process of “drilling down” through a variety of data collected over time provides credible evidence of practices and outcomes, more depth in investigation of innovative dependent variables possible and usable data that met the needs of all stakeholders. Through this in-depth process, evaluators and decision makers have a richer understanding of the ways that professional development impacts academic achievement and allows for documented change.

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