Abstract Title: Teacher Change and Student Learning: What Works?

MSP Project Name: University of Pennsylvania Science Teacher Institutes (PennSTI)

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120 word summary:

The University of Pennsylvania's MSP project involved intensive, content-based professional development designed to change both teacher content knowledge and teaching practices as well as to ensure broadly defined student success. Over three summers and two academic years, four cohorts of diverse teachers were enrolled in science and science education courses, leading to an MS degree. Qualitative and quantitative data, collected from teachers and their students before, during, and after teacher participation showed more frequent use of inquiry by teachers and students and provided strong evidence of enhanced teacher and student content knowledge. Findings were used to guide changes in the implementation and curricula of the project's courses and in the instruments and tests that provided evidence of success.

Section 1: Questions for dialogue at the MSP LNC.

What type and what amount of teacher professional development (PD) leads to sustained changes in teaching practices and student learning? How do we ensure that positive changes for students and/or teachers are sustained after the period of funding?

Section 2: Conceptual framework

Context of the work within the STEM education literature and within your MSP project:

Recent policy documents focused on science and mathematics education reform have proposed that content-based professional development for teachers improves student success (National Academy of Science, 2005; National Science Foundation, 2007). The PennSTI (Science Teachers Institute) project broadly defined student success in terms of academic, personal, and social changes. That is, students of participating teachers as well as the teachers themselves would increase their understanding of science so that they could make decisions based upon evidence, could collaborate with others in educational, social, or family settings, and could act supportively and compassionately toward others and the environment. Extensive data, collected by both project and evaluation personnel, attest to the success of the project.

The professional development for teachers involved successful completion of an MS degree in either general science or chemistry. Teachers completed eight science courses and two science education courses over three, consecutive summer sessions and during two academic years. Summer courses were taught during the regular 8-week summer sessions and involved four days/week. During the mornings, teachers attended graduate courses, taught by scientists, while afternoons were open for group work and library work. There were all-day field experiences as well. The pedagogy courses were offered during the school year specifically so that research projects, aimed at changing teaching practices, could be carried out in the teachers' classrooms. The project's science courses focused on developing teachers' middle school science (MISEP) or high school chemistry (MCEP) content knowledge, while the education courses were designed to encourage teachers to integrate new instructional and assessment strategies into their science teaching. The teacher cohorts were recruited from diverse sources including urban, suburban, and rural schools. To date, eighty teachers, enrolled as four cohorts (A, B, C, and D), have completed the STI project.

Because the PennSTI project did not interact directly with students, student success was measured by data collected through student and teacher responses to valid and reliable questionnaires, through classroom observations, and through student achievement tests. Both participating teachers and one class of their students annually responded to questionnaires that assessed changes in teaching and learning practices as well as principal and parental/adult support for science, understanding of the nature of science, and friends' attitudes about science (students only). In addition, before participating and after completion teachers completed a content test, while one class of their students completed a content test before their teacher participated and annually thereafter.

The teacher questionnaire included subscales focused on inquiry teaching practices, student inquiry activities, principal and parent/adult support for science education, and understanding of the nature of science. The first subscale, "What I do in class," consisted of 13 items that asked teachers to report how often they used reform or standards based teaching practices, such as *asking students to supply evidence to support their claims, allowing students to ask questions,* or *arranging for students to work in groups*. The next subscale, "What my students do in class," consisted of 14 items that asked teachers to report what their students did in class, such as *using data to justify responses to questions, arguing or debating with one another about the interpretation of data, using educational technology in the classroom,* or *learning about real world applications of science*. The next two subscales ("What principals do" and "What adults/parents do") focused on principal and adult support for standards based teaching. The subscales consisted of 18 and 13 items, respectively. The final subscale, "Views about science," consisted of eight items that assessed teachers' attitudes and opinions toward science. The student questionnaire contained subscales on inquiry teaching practices, student inquiry activities, parent/adult support of science studies, friends' interest in science, and student views of science. Teaching and learning subscales in the student questionnaire ("What I do in class" and "What my teacher does in class") contained items parallel to ones on the teacher questionnaire so that teacher self-report data could be confirmed by student responses. All items were answered using Likert-type scales that indicated frequency of use—*almost never* to *very often*-- (teaching, learning, principal, parent, and friends' interest in science) or level of *agreement/disagreement* (nature of science and student views of science). All student responses to the questionnaires and the content tests were analyzed using Item Response Theory (Rasch Model). Teacher responses to the content tests also were analyzed using IRT. Due to relatively low numbers, teacher responses to the questionnaire were analyzed using raw scores.

Claims examined in the work:

Intensive, content-based professional development changes teaching strategies (Table 1), enhances teacher content knowledge (Table 2), and improves student achievement (Table 3).

Increased teacher content knowledge and better student understanding of the nature of science enhance student achievement; however, demographic characteristics (gender and/or race/ethnicity) continue to affect student success in science (Table 4).

Section 3: **Explanatory framework**.

Evaluation and/or research design, data collection and analysis:

Initial findings, using data from Cohort A teachers and their students, indicated that the PennSTI's PD was effective in increasing teacher content knowledge and in changing teaching practices as well as affecting student success. During 2009-2010, Cohort B and C teachers completed their course work and evaluations. The analyses reported here assess whether or not the initial findings are replicated, thereby, strengthening support for content-based, sustained PD.

With each successive cohort, findings from the previous cohort(s) were used to revise both the content and pedagogy courses as well as the instruments used to assess changes in teaching and learning practices and in student and teacher achievement. The Rasch Model was used in analyzing the data, particularly the student achievement data, in order to provide set of anchor items with which to measure success across the cohorts. Annually, project and evaluation personnel met to discuss the findings, what they meant, and what type of revisions might lead to increased success.

The evaluation examined if participants changed their teaching strategies and if student science achievement improved. Table 1 shows the paired-samples *t*-test comparisons of Cohorts B and C middle school science (MISEP) and high school chemistry (MCEP) teachers' responses to the subscales that assess frequency of use of inquiry instruction before (pre) and after (final) participation in the STI. With the exception of Cohort B and C middle school teachers, all teachers reported that they used standards-based learning strategies significantly more often after they completed the PennSTI project. And all teachers in both groups responded that their students were more frequently involved in inquiry and active learning after, compared to before, the project. The difference in the responses of the two teacher groups suggest that middle school science, compared to chemistry, teachers more often used inquiry instruction prior to participating in the project—a finding that is widely supported in the literature.

Table 2 provides paired-samples *t*-test comparisons of teachers' content test scores before and after completion of the PennSTI project for both cohorts. In all cases, there are highly significant differences in teachers' scores before and after completion of the project. This outcome for sustained, content-based PD is supported by the findings of Cohen and Hill, 2001.

Comparisons also were made of the achievement tests scores of students of MISEP and MCEP Cohort B teachers and for Cohort C MCEP teachers in 2006 (Pre), 2007 (Post Year 1), 2008 (Post Year 2), and 2009 (Final) and of Cohort C teachers in 2007 (Pre), 2008 (Post Year 1), 2009 (Post Year 2), and 2010 (Final).[1] Cohort B MCEP student achievement test scores increased over time with Post Year 2 and Final mean scores significantly higher than the mean score prior to teacher participation (Pre). Cohort B MISEP student scores did not indicate enhanced student achievement. Project personnel used these findings to adjust course curricula

[1] In 2010, only 11 Final Student Questionnaires were returned; therefore, Cohort C MISEP analysis includes Pre, Post 1, and Post 2.

and increased observations were used to confirm changes in teaching practices for Cohort C MISEP teachers.[2] Cohort C MISEP and MCEP student achievement test mean scores increased over time with Post Year 2 mean scores significantly higher than the mean scores of the previous two years, as shown in Table 3.

TABLE 1
Comparison of Cohorts B and C MISEP and MCEP Teachers' Responses on the Teacher Questionnaire: Pre and Final

Cohort & Course	**Subscale**	**Time**	***M***	***SD***	***t***	***df***	***p***	**Cohen's *d***
Cohort B MISEP	What I (teacher) do in class	Pre	3.32	0.51	-0.96	8	.363	-0.33
		Final	3.48	0.47				
	What my students do	Pre	3.07	0.50	-2.48	8	**.038**	-0.85
		Final	3.41	0.27				
Cohort B MCEP	What I (teacher) do in class	Pre	3.09	0.46	-2.30	10	**.044**	-0.92
		Final	3.48	0.38				
	What my students do	Pre	3.08	0.50	-2.93	10	**.015**	-0.68
		Final	3.41	0.46				
Cohort C MISEP	What I (teacher) do in class	Pre	3.22	0.54	-1.64	9	.134	-0.49
		Final	3.48	0.52				
	What my students do	Pre	3.19	0.40	-2.30	9	**.047**	-0.73
		Final	3.46	0.35				
Cohort C MCEP	What I (teacher) do in class	Pre	3.11	0.42	-4.52	9	**.001**	-0.87
		Final	3.47	0.41				
	What my students do	Pre	2.98	0.44	-5.25	9	**.001**	-1.28
		Final	3.50	0.38				

TABLE 2
Comparisons of Cohorts B and C MISEP and MCEP Teachers' Content Test Scores: Pre and Final

Cohort & Course	**Time**	***n***	***M***	***SD***	***t***	***df***	***p***	**Cohen's *d***
Cohort B MISEP	Pre	11	50.41	3.90	-8.69	10	**< .001**	-1.89
	Final	11	59.07	5.18				
Cohort B MCEP	Pre	14	41.30	6.54	-4.06	13	**.001**	-1.47
	Final	14	50.44	5.84				
Cohort C MISEP	Pre	13	49.13	5.69	-11.00	12	**< .001**	-1.80
	Final	13	58.84	5.05				
Cohort C MCEP	Pre	9	44.26	6.90	-12.31	8	**< .001**	-1.73
	Final	9	55.99	6.65				

[2] Both groups of MISEP teachers were drawn from the three state area surrounding Philadelphia. There was no discernable difference in the demographic data gathered for Cohorts B and C middle school teachers.

TABLE 3

Comparisons of Cohort B and C MISEP and MCEP Students' Achievement Test Scores: Pre, Post Year 1, Post Year 2, and Final

Cohort & Course	**Time**	***n***	***M***	***SD***	***F***	***df***	***p***	η^2
Cohort B MISEP	Pre (2006)	292	58.57	11.87	1.40	3, 826	.242	0.01
	Post1 (2007)	219	60.64	12.50				
	Post2 (2008)	146	59.12	10.51				
	Final (2009)	173	59.04	10.72				
Cohort B MCEP	Pre (2006)*	110	34.44	7.14	4.88	3, 412	**.002**	0.03
	Post1 (2007)	121	35.48	7.08				
	Post2 (2008)*	121	37.49	9.17				
	Final (2009)*	64	38.43	8.31				
Cohort C MISEP	Pre (2007)	230	55.50	11.78	26.10	2, 566	**< .001**	0.08
	Post1 (2008)	174	54.09	11.25				
	Post2 (2009)**	165	62.23	10.13				
Cohort C MCEP	Pre (2007)[a]	188	41.08	6.16	9.18	3, 604	**< .001**	0.04
	Post1 (2008)[b]	91	40.17	8.48				
	Post2 (2009)[ab]	208	44.32	8.35				
	Final (2010)[b]	121	43.32	8.18				

* Tukey post hoc test indicated that mean scores for Post 2 and Final were significantly higher than Pre score.
** Tukey post hoc test indicated that mean score for Post 2 was significantly higher than Pre and Post1 scores.
[a] Tukey post hoc test indicated that mean score for Post 2 was significantly higher than Pre score.
[b] Tukey post hoc test indicated that mean scores for Post 2 and Final were significantly higher than Post1 score.

Multiple regression analyses examined what factors predicted student achievement scores.[3] As shown in Table 4, the combination of variables explained approximately 32% of the variance for Cohort B MISEP students, 13% of the variance for Cohort C MISEP students, and 18% of the variance for Cohort C MCEP students. For middle school students, student group (favoring White), teacher content knowledge, and student understanding of the nature of science were significant predictors of achievement. For chemistry students—a selective group, neither gender nor student group was a significant predictor. However, parental support and an understanding of science were significant predictors of achievement. The combination of student data describing changes in teaching and learning, understanding of science, friends and family interest in/support for science as well as changes in student achievement provided a multi-faceted approach to assessing the PennSTI's comprehensive definition of student success. In addition, the variety of data allowed the project to make targeted mid-course changes.

[3] Data for Cohort B MCEP students were not used, because only 61 students, taught by 3 teachers, completed both the test and questionnaire.

TABLE 4

Multiple Regression Analyses for Cohorts B and C MISEP and MCEP Students' Achievement Test Scores: Final Data

	Standardized Coefficients (β)		
Predictors	**Cohort B MISEP (*n* = 148)**	**Cohort C MISEP (*n* = 169)**	**Cohort C MCEP (*n* = 116)**
Gender	0.01	0.09	-0.11
Student Group	0.17 *	0.16 *	0.16
Teacher Content Knowledge	0.29 ***	0.18 *	0.11
What I (student) do in class	-0.06	-0.09	0.10
What my teacher does in class	-0.07	0.10	0.05
What my friends do	0.22 *	0.02	0.10
What parents/adults do	-0.18 *	-0.10	-0.24 **
My views of science	0.29 **	0.27 **	0.33 **
Adj R^2	0.32	0.13	0.18

For Gender: 0=Female, 1=Male.
For Student Group: 0=Non-White, 1=White.
For Teacher Content Knowledge: 0=All questions answered incorrectly, 100=All questions answered correctly.
For What I (student) do in class, What my teacher does in class, What my friends do, and What parents/adults do: 0=The student selected *almost never* for all items in this subscale, 100=The student selected *very often* for all item in this subscale.
For My views of science: 0=The student selected *strongly disagree* for all items in this subscale, 100=The student selected *strongly agree* for all item in this subscale.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Key insights that have value for the Learning Network:

Using sustained PD, the PennSTI focused on increasing teacher content knowledge and the use of inquiry in teaching science, leading to enhanced student success. The project was successful in meeting its goals with three cohorts of teachers. However, evidence from these analyses as well as those involving another project at the University of Pennsylvania suggests that there is a lag between the initial PD and the implementation of change in the classroom and enhanced student learning (Kahle & Scantlebury, 2009). The challenge is to implement long-term PD for teachers and to support them until they are comfortable making the desired changes so that their students benefit from their new knowledge, attitudes, and skills.

References

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