EXTERNAL EVALUATION OF THE PROGRESSIVE SCIENCE INITIATIVE

NEW JERSEY CENTER FOR TEACHING AND LEARNING

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Introduction

Just over one year ago, 42 teachers from 21 middle and high schools in three New Jersey districts – Jersey City, Newark and Patterson, as well as the Paramus campus of the Bergen County Technical Schools – arrived at Bergen County Technical High School in Teterboro for an orientation meeting that would mark the beginning of a new and rather arduous journey for them. They were about to participate in a unique and challenging program – the Progressive Science Initiative (PSI) – that would initially lead to a state physics teaching endorsement and, for some, eventual graduate degrees. The intent of the program then and currently was and is to dramatically increase the number and quality of physics, chemistry and biology teachers in the state, where there is a dearth of all three. Several aspects made this program unique, and they are highlighted below.

Program characteristics

1. The program is administered by the New Jersey Center for Teaching and Learning, with courses being taught by K-12 teachers identified by CTL and hired by Kean University as adjuncts. These courses are for graduate credit from that institution.

2. The program consisted of five weeks of intensive summer training, followed by additional coursework throughout the academic year – one evening per week and every third Saturday.

3. The initial two courses were an algebra-based physics sequence preparing the participants to teach introductory and Honors physics.[1]

4. Participating teachers' classrooms were equipped with SMART Board™ technologies, including an interactive whiteboard to demonstrate concepts and more fully engage students in the learning process, and student responders (more commonly referred to as "clickers") to facilitate formative assessment of learning on both topic-by-topic and general concept levels.[2]

5. The classrooms were also outfitted with round tables to facilitate social constructivism by having students working cooperatively in small groups. None of the teachers had ever used round tables previously, although they were taught physics using round tables in the classrooms that the Kean University professors used to teach them the program.

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1 The full PSI program is focused on preparing current teachers in other fields to teach physics, chemistry and/or biology, with the intention that these courses be taught in that sequence in the schools, rather than in the inverse order that is the standard in most districts in the country.

2 For those unfamiliar with student responders, they and the SMART Boards help teachers gauge when to move on, which concepts need more work and which students need help. Students enter responses to a question on the SMART Board in hand-held computer devices (SMART Responders), and a pie chart appears on the SMART Board showing the distribution of responses.

6. Nearly $10,000 worth of laboratory and other teaching supplies were provided for each teacher.

7. One of the professors made several visits to participants' schools and classrooms during the school year to:

   a) Observe the teachers,

   b) Determine their knowledge and comfort levels with the material,

   c) Offer suggestions for pedagogical and content improvement,

   d) Recommend ways through which to improve the integration of the SMART Board interactive technology into the teaching and learning process,

   e) Help embed the program's approaches in the classroom to make it more closely related to the teachers' work experiences.

   f) Make certain teachers were conscientiously using the responders to formatively assess student learning and facilitate feedback,

   g) Trouble-shoot equipment problems or issues, and

   h) Discuss the program with district and school science and math supervisors, department chairs and principals to obtain their opinions of the program's impact – and occasionally with some non-program participants to answer questions of those who wished to join the program in the future.

8. Participating districts contributed approximately $18,000 per teacher toward tuition, with those costs largely being paid with Title I and II funds.

Participant Characteristics

1. Although all 42 of the teachers were licensed and certified, only eight of them had significant backgrounds in physics (i.e., physical science teaching certifications), although a majority of the others held certifications in other STEM areas such as mathematics, chemistry, biology, or elementary and/or middle school science. Still others had special education credentials.

2. There was a wide range of teaching experience among this initial cohort, ranging from six with one year or less at the time of application to the program to two participants with more than 25 years of experience – including one with 39 years. As shown in Table 1, 78 percent had 10 years or less of experience. The remaining 7 (18%) with 11 or more years of teaching experience include those with physics certifications who wished to add to their instructional repertoire.

Table 1. *Years of teaching experience among PSI participants.*

Teaching Experience	Number	Percent
One year or less	6	14
2-5 years	15	36
6-10 years	12	28
11-15 years	2	5
15-20 years	1	2
20 or more years	4	10
No Data (early withdrawals)	2	5
Total	42	100

3. While all of the participating teachers had baccalaureate degrees in their respective disciplines or areas of study, one had two such degrees, one had a specialist degree, and 17 had master's degrees.

4. While 34 of the teacher participants (83%) came to the program without physics backgrounds, additional learning challenges to them and others were augmented by the fact that only seven percent had ever used student response systems, and three-quarters of them (76%) had never used an interactive "white board" – two integral instructional and formative assessment tools that are tenets of the PSI approach.

Findings

Evaluation Approach

An external evaluation of a program is tasked not only to document the activities, outputs, outcomes and impacts of a program, but to find the answers – and the reasons for those answers – to the following basic questions:

- *Is the program doing the right things?*
- *Is the program doing those things right?*

Evaluation activities included:

1. Pretests and posttests of the PSI participants prior to and at the conclusion of the five-week summer course, respectively, including:
    a. An Attitudes and Beliefs survey regarding the teaching and learning of science and the use of new technologies (e.g., SMART Boards, student responders, etc.) in instruction and formative assessment.
    b. The College Board's standardized Accuplacer tests in Arithmetic, Elementary Algebra, and College-Level Math;[3] and
    c. A program-developed physics content test.
2. Individual and group interviews with participating teachers and their PSI professors.
3. Classroom site visits during the school year to observe the teachers, followed by informal feedback to the teachers and semi-formal, post-visit discussions of each teacher with the professor who made the program's site visits.
4. Interviews with principals, assistant principals, district administrators, and district and school science and mathematics supervisors, and curriculum coordinators during various school site visits.

Program and Teacher Participant Outcomes

1. Participant retention through "graduation" – the completion of the intensive two-course physics program – was excellent. Of the 42 who began the program, 39 (93%) successfully completed, and were recognized in a special ceremony in June 2010.[4]

[3] Mathematics tests were used for this purpose because the PSI physics is algebra-based.
[4] Two of the non-completers removed themselves early during the summer program, and one left the program near its conclusion, when one district retroactively instituted a policy stating that teachers who did not pass the PRAXIS examination would have to refund the amount the district paid to enroll them in the program.

2. All 39 of those teachers taught PSI physics during the 2009-2010 school year. Thirty one (73%) of them had never taught physics before.

3. These teachers were impacting some 1,200 students in their physics classes.

4. Many of the teachers are providing early-morning and after-school tutoring to those students needing more individual assistance.

5. According to the director of the PSI at Kean University, between one-third and one-half of the completers have expressed interest in continuing their studies in pursuit of a master's degree in physics or science education – which is particularly striking given the fact that 40 percent of them already had master's degrees in other areas.

6. A total of 65 teachers are currently participating in either the second physics-sequence cohort or the more recently instituted chemistry component as part of PSI's continuing effort to supply qualified science teachers in a variety of subjects.

7. It is anticipated that as many as 10,000 students could be impacted by PSI-trained teachers during 2010-2011 school year.

Once the teachers return to their schools to teach these courses themselves, they are armed with the same "notebook"/lesson guide that was used during their own training, which has the entire course detailed on almost a daily basis, including when and how one might chose to use the SMART Board, indications of opportunities to demonstrate concepts through use of laboratory sessions, suggestions regarding when they might wish to conduct formative assessments of learning through use of the student responders before moving on to a new lesson or topic, and built-in unit examinations that students must take at the end of each.

8. However, all of the above instructional materials, teaching aides and other accoutrements, as well as the instructional patterning of their professors, have not lead to 'lock-step' instruction or "cookbook" approaches on the part of these teachers. To the contrary, the curriculum is not heavily prescriptive in terms of actually delivery. Personal teaching styles were very much in evidence during site visit observations, and their dissimilar approaches did not seem to differentially affect student engagement, participation or learning.

This person exhibited the potential to be a good teacher, but the lack of any science or mathematics background was seen by this teacher as an impediment to her passing the PRAXIS, and she did not want to risk having to repay the money for the program.

All were teaching using their own techniques, styles and examples, and allowing student questions to integrate unanticipated but related topics into the overall approach. The conceptual examples used by the teachers, the manner in which the SMART Board is integrated into the instruction, the extent and manner in which the responders are used, and the amount of whole group work versus small group (table) or laboratory work, and other more subtle factors all provided opportunities for some very unique approaches.

a. Some teachers exercised more control over the SMART Board, using it more as a communication advice – going through problems with students interacting, but with themselves writing on the board most of the time. Others had students interact directly with the board a good deal of the time.

b. Some made use of the student responders more frequently than others.

c. Some were more likely than others to assign individual and/or group problems and "roam the room" to provide assistance when they observed the need for it.

9. During every site visit, all of the PSI teachers had objectives and homework posted in the room, as well as the formulas, scientific notations, equations and so forth that had both been previously covered and those with which they were currently working.

10. Classroom management and student engagement were both observed to be excellent in virtually every instance.[5]

11. The few participants with physics backgrounds not only learned new instructional approaches, laboratory experiments and SMART technology skills, but they also contributed valuable experience and information to this cohort to supplement that of the professors.

12. The school-year classroom visitations by the PSI professor who conducted these were invaluable to the teachers in several respects, providing feedback, reinforcement and additional information throughout the year, and supplying the type of insights that only can be gained by watching teachers actually providing instruction and interacting with students in their classrooms.

13. The formal class sessions held during the school year were equally valuable, and were enhanced by the fact that the professor who made the site visits was one of those who also taught those courses and was able to share the information gained on site with his colleagues.

[5] Although classroom management is not part of the PSI program, this finding probably reflects the fact that, for the most part, "seasoned" teachers were selected for the program.

14. Some of these teachers have other instructional assignments besides physics, and they have integrated the SMART Boards, student responders, and other techniques into other classes. One said: "This is going to make me a better teacher when I teach biology next year.

15. There are many reports of the PSI teachers having influenced other teachers in their schools in a variety of subject areas to integrate SMART techniques and equipment into their instruction.

16. The program was developed *by* and *for* teachers, and those using it are continually involved in its evolution. These teachers are part of a learning community that exchanges new ideas, approaches and techniques on an ongoing basis – in person and through cyber connections. As a result, a community of learners evolved, with PSI teachers working with other PSI teachers in their school and districts, and even beyond their own district when they were the only participating teacher in the school – creating a virtual professional learning community.

    These exchanges were done via telephone calls, texting and in-person before or after school, as well as through the interactive site created by the program on which they could ask for advice from others regarding approaches to certain lessons. They also interacted one evening a week and every third Saturday in classes for several hours, which facilitated further conversations with their peers and professors.

17. All of the teachers except those with strong physics backgrounds commented that the second (academic-year) course was more difficult than the summer course. Therefore, if they missed a class, which was sometimes inevitable, given the nights-and-weekends schedule, they experienced difficulty catching up with the class.

18. No PSI teachers experienced difficulty in working with and enabling the learning of students with learning or physical challenges. For example:

    a) Two classes in which all students were classified as having learning disabilities were observed, and both the PSI teacher with a credential in special education and the PSI teacher without any background in this area delivered spot-on lessons that resulted in complete attention and participation from the students, as well as an obvious grasp of the material as revealed through their responders.

    b) In another class that was completely comprised of students with learning challenges, the PSI teacher focused a good deal of time on "the four students who really want to learn and are trying hard." The others were pretty much disengaged, but were not obtrusive.

    c) An additional class included four hearing-impaired students, one of whom also had a learning disability, and two other students with learning disabilities only. Here the teacher paid close attention to those with learning disabilities, and used a headset with an amplification device that served all 17of the students well.

Only one district science supervisor expressed disappointment that many of the non-math and science administrators in her district seemed to be unaware of the program. She therefore asked PSI staff to give a presentation for district administrators at one of their meetings, including demonstrating the SMART Board and responders, as well as conveying the PSI instructional philosophy and approach.

Pretests and Posttests

Attitudes and Beliefs

Among the pretest and posttest surveys, participants were asked to rate the extent to which they agreed with certain statements about teaching and learning science and physics and their confidence levels regarding their abilities and their anticipation of success on a 5-point scale, with "1" indicating the highest level of agreement. Their comparative responses are included in Table 2, which shows that while maintaining through the 5-week summer course that *learning* science is *not* more difficult than learning other subjects, the participants became less likely to agree that *teaching* science is more difficult than teaching other subjects. As an example of this change, in early-program interviews, several of the teachers expressed the following concern: "If I don't know it, how can I teach it?"

Content

Participants' pretest and posttest content scores on three tests administered prior to and at the conclusion of the five-week summer course, respectively, were also compared using the following four tests:

- **Physics** (created by the professors to reflect the skill sets being taught in the course);
- The College Board's Accuplacer **Arithmetic** examination;
- The College Board's Accuplacer **Elementary Algebra** examination; and
- **The** College Board's Accuplacer **College Mathematics** examination**.**

Table 2. *Teachers indicating the extent to which they agree or disagree with each of the below statements on a pretest and a posttest:* (1=Strongly Agree; 2=Tend to Agree; 3=Tend to Disagree; 4=Strongly Disagree; 5=Unsure/Don't Know) *

Statement	Rating	
	Pre-test	**Post-test**
Learning science is more difficult than learning other subjects.	3.0	3.0
Teaching science is more difficult than teaching other subjects.	**2.3**	**2.9**
I am confident about my understanding of science in general.	1.3	1.4
I am confident about my understanding of physics.	**2.1**	**1.5**
I am confident about my understanding of mathematics.	**2.6**	**1.8**
I am confident about my ability to use technology.	1.5	1.4
I am confident that I will be/was successful in this course.	1.3	1.3
I am confident that I will be successful teaching physics this fall.	**2.0**	**1.2**
I am confident that I will be successful in facilitating PSI in my school.	1.4	1.5

- Responses highlighted in bold and red highlight substantial changes found in teachers' responses between survey administrations.

Statistical tests were employed to determine if any differences found in mean scores between the pretests and posttests were larger than one might expect by accident – i.e., if the tests were simply administered again, with no expectation that results would differ except for natural variations in scores from one testing to another. The t-test statistic provides a measure of whether differences in scores of a given size could have arisen by chance. The choice of using a one-tailed versus a two-tailed t-test depends on what hypothesis is being tested concerning why one might expect the scores to change. If one is expecting scores to improve because of some intervention, one is then expecting the second score to be higher than the first and a one-tail test would be used to see if that is the case. Otherwise one would just use a two-tailed t-test, which is a test of whether the two scores are simply different from each other – either higher or lower. Therefore, in this instance the focus is on the one-tailed test.

Physics. The physics content pre/posttest was developed according to the constructs shown in Table 3. On this test, the average score improved by 4 points, from 13 to 18, between administrations. Using a Stat Trek formula,[6] we obtained a t-score of 7.695 for the difference between 5 and zero, which is significant regardless of whether one uses a one-tailed or two-tailed test. This makes general as well as statistical sense, as 34 of the 38 teachers taking both tests showed gains ranging up to 11 points.

Table 3. *Physics pretest and posttest assessment topics and the number of items pertaining to each topic.*

Physics Assessment Topic	Number of Questions	Physics Assessment Topic	Number of Questions
Kinematics	2	Thermodynamics	2
Dynamics	4	Electricity	3
Circular Motion	2	Magnetism & Induction	2
Gravitation	2	Oscillations and Waves	2
Energy	3	Waves and Optics	2
Rotational Motion	1	Atomic & Nuclear Physics	1
Momentum	2	Vectors	2
Energy	3	Graphing	2

Accuplacer Arithmetic. The Accuplacer Arithmetic test results told a very different story regarding its pre/posttest analysis than did the physics test, as shown in Table 4. Results for this test did not show any improvement. The average post score of 102.74 is a little lower than the pre score of 103.33 but that difference is not statistically different. However, a lot of variation was found among these tests. That is, 22 teachers improved their scores by up to 26 points, with six improving by 10 points or more. However, 18 lowered their scores by up to 22 points, with seven lowering their scores by 10 points or more.

6 http://stattrek.com/AP-Statistics-4/Paired-Means.aspx#example1.

It is highly doubtful that the PSI course these teachers took caused any of them to deteriorate by 10 points or more, so it could be that this is just a problem of having a lot of variability in the test results on the Accuplacer Arithmetic test. If one's score can drop by 10 points on the re-administration of the test following five weeks of instruction – presumably without the course having done any damage to certain teachers' knowledge or abilities which they brought to the course – perhaps one can increase his or her score by 10 points just as easily without having learned much.

Table 4. *Results of pretest and posttest analyses for Accuplacer Arithmetic test*

Statistic	Pretest	Posttest
Mean	103.3333	102.7436
Variance	331.807	430.9325
Observations	39	39
Pearson Correlation	0.871613	
Hypothesized Mean Difference	2	
Df	38	
t Stat	-0.86542	
P(T<=t) one-tail	0.19612	

Accuplacer Elementary Algebra and Accuplacer College Mathematics.

The analyses for these two tests at first suggest significant improvement. Their t-stat of 1.72 for Algebra is significant at the 5 percent level of confidence (0.04682) in a one-tailed test and the t-stat of 2.305 for College Mathematics insignificant at close to 1 percent (0.01341) in a one-tailed test. (See Tables 5 and 6, respectively.) Some doubts surface, though, upon closer scrutiny of individual scores.

For example, in Elementary Algebra, 19 teacher scores got better by up to 35 points with 8 teachers improving by 10 points or more. On the other hand, fourteen teachers got worse by up to 39 points, with 4 teachers deteriorating by 10 points or more. Average scores were around 100, so the average improvement of 1.2 points is quite small and depends heavily on the mix of the outliers. If the largest observed improvement were dropped, the average improvement would become to 0.3 points.

Results are similarly variable – both up and down – for the College Mathematics exam. The average pre-test score on this exam was 55 points. Twenty-four teachers improved by up to 28 points, but the scores of 14 declined by up to 31 points. There were 11 teachers who improved by 10 points or more, six who deteriorated by 10 points or more, and an average improvement of 2.8 points. Again, the scores of the outliers heavily influenced the size of the average improvement.

Table 5. *Results of pretest and posttest analyses for Accuplacer Elementary Algebra test*

Statistic	Pretest	Posttest
Mean	100.8947	102.7368
Variance	595.0156	600.6856
Observations	38	38
Pearson Correlation	0.84158	
Hypothesized Mean Difference	2	
Df	37	
t Stat	-1.72081	
P(T<=t) one-tail	0.04682	

Table 6. *Results of pretest and posttest analyses for Accuplacer College Mathematics test*

Statistic	Pretest	Posttest
Mean	55.10526	57.81579
Variance	642.3129	717.5057
Observations	38	38
Pearson Correlation	0.884728	
Hypothesized Mean Difference	2	
Df	37	
t Stat	-2.30581	
P(T<=t) one-tail	0.013414	

Comments on Content Pretests and Posttests

As shown, the teachers' scores showed generally good improvement on the posttest over the pretest for the physics content test, with 90 percent demonstrating improvement. However, the three Accuplacer pretest and posttest analyses did not show convincing gains, regardless of certain aberrant statistical constructs – seemingly a result of the wide variance in score increases and decreases between two groups of teachers, especially on the Elementary Algebra and College Mathematics tests. There may be several possible reasons for these findings:

- The Accuplacer tests may simply not be appropriate proxy measures for the mathematics skills that are being taught to convey the physics content of the course the teachers had taken.
- The Accuplacer posttests were given immediately at the conclusion of the five-week summer session, which may have been too soon to measure learning. Perhaps if more time had elapsed – e.g., after they had been teaching physics using the algebra approach for a while – and possibly even after having taken the second physics course during the school year – such timings of the Accuplacer posttests may have been more appropriate.
- All three of the Accuplacer posttests, as well as the Attitudes and Beliefs and physics content posttests, were given as the very last activity on the last day of the summer session, and the teachers were well aware that they were not to be used to for grading purposes, which may have lead them to not take them seriously.
- The teachers were exhausted, with those without physics backgrounds reportedly having spent two to four hours a night on homework after a full day of class for the five weeks preceding the Accuplacer posttests.

Student Outcomes

Because the ultimate beneficiaries of the program are the students who are being taught by – and/or will be taught by –teachers using the PSI approach, more time must transpire before any definitive student impact results can be obtained – e.g., enrollment and success in other, more advanced science and mathematics courses in high school, earning credit-engendering Advanced Placement Physics scores, and high achievement on the SAT regular math score, the SAT subject tests in physics and math, and so forth. Eventually, postsecondary outcomes in math and science for those who pursue higher education will reflect long-term achievement.

For the time being, however, the following qualitative findings from this evaluation, which provide some early impressions and indicators that bode well for positive future academic performance will need to suffice:

1. Some the students at a few schools were not able to begin the course lessons at the level considered appropriate for the PSI program's or their districts' grade level expectations – eighth grade in middle schools; ninth grade in the high schools.[7] Some very basic mathematics concepts needed to be reviewed for certain classes. In addition, the concept of having all examples and problems presented using the metric system of measurement was especially confusing for many. Still, after a few weeks of generally unplanned-for remediation, all teachers were moving beyond the basics and at close to the same pace.[8]

2. District and school science and math supervisors interviewed were all very impressed with the PSI program, and many are sending other teachers to the program. Teachers and some STEM administrators reported being "amazed" at how students were reluctant to leave the classroom when the bell rang until they solved a problem on which they were working, and others reported overhearing students talking about physics concepts outside of class. Many comments concerned how well the PSI students were doing in algebra because of PSI's algebra-based approach.[9] Three exact and exemplifying quotes from these individuals are given below:

   - *Students are cross-talking about solving, reasoning and processes rather than just answers.*
   - *Everyone is pretty much in shock about how well it is going and how much the students are learning.*
   - *I would have to call it a miracle.*

3. A substantial number of students (nearly one-half of those enrolled in PSI physics during 2009-2010) have signed up to continue in the subsequent physics course.

4. Given general statistics and the evaluation team's past experience with STEM programs, there appear to be a relatively large proportion of young women in the program – frequently equal to or more than the number of young men in any given classroom. Although not all students were present on the days of the evaluation site visits, head counts revealed that 55 percent of the students overall were girls. Even considering that in the PSI approach a physics course marks the beginning of a typical science sequence rather than its concluding (or sometimes penultimate) course, this proportion still seems higher than one might expect. Following the course-taking pattern by gender could provide interesting data as the full PSI curriculum continues to unfold.

[7] The Jersey City district was the only one of the three to include middle school teachers.

[8] By the time of the March 2010 evaluation site visits, all but one of the teachers were within one or two lessons of one another.

[9] As asserted by the Director of the New Jersey Center for Teaching and Learning, who spearheaded the development of the PSI approach several years ago, only 10 percent of the concepts taught in high school physics required trigonometry. The rest, including the principles of mechanics, electricity and magnetism, can be taught using algebra. Teaching science with algebra also provides context for students who don't easily see how math relates to their daily lives.

Discussion

The external examination of the PSI program found it to be a high-quality effort to address the shortage of qualified science teachers in New Jersey. PSI was created by and for teachers, and this, its preliminary expansion, was administratively and instructionally responsive to and delivered a rigorous and effective training program for the teachers involved. More specifically, this introductory offering of the program experienced excellent retention (93%), in spite of the fact that 35 of the 42 teachers involved did not have backgrounds in physics. In spite of all the accoutrements available to the PSI teachers – the SMART boards, student responders, round tables, and the same detailed lesson-plan notebook that was used during their own training – individual teaching methods were much in evidence in their own classrooms.

In addition to the intensive, five-week summer course for the teachers, there were three important components that provided continuity of content and contact during the school year. First, a subsequent course met six times each month during the school year, including certain evenings and on Saturdays. Second, the visits to the PSI teachers' classroom by one of the teaching professors provided onsite advice and helped to entrench the PSI approach into their daily instructional activities. Third, a professional learning community was encouraged and evolved among the teachers through a combination of in-person, telephone and online communications regarding techniques, examples, laboratory exercises and 'hooks' to engage students and illuminate content.

The following discussion highlights various aspects and issues surrounding the Progressive Science Initiative within the context of both other research and current program operations.

Program Components

The evaluation considered whether the basic PSI course components (i.e., SMART Boards, course notebooks, responders, round tables) are separable, or if results are more positive when they are used together. There was not really an opportunity to ascertain an answer to this question objectively, since all the teachers are making use of them all. However, according to the PSI teachers, the PSI method seems to require a unified approach, as all elements are tied together instructionally to support student learning.

The inclusion of one of the professors as a site visitor to the schools to observe the PSI teachers and help to embed the PSI philosophy and approach into their classrooms and – in those instances where several teachers are involved in the program -- the school culture itself, is critical to the success of the program. Additionally, conversations that professor and the director of the NJ Center for Teaching and Learning have with district and school science and mathematics supervisors, principals, vice-principals, and others is another important element of the program, in that they answer questions about the program, allay any misperceptions, obtain feedback, and lay the groundwork for the continuance of the program through district support and subsequent teacher enrollments.

Classroom Site Visits

Some education researchers have posited that teachers are defensive when being observed by administrators, other teachers, their professors or evaluators (Good and Brophy, 2000; Waxman, 2003; Sasson, 2008). This was clearly not found to be the case in this instance. As far as the teachers in the PSI program are concerned, they always welcomed both the visiting professor and evaluator graciously and treated us as though it was an honor to have us visit their classrooms. I suggest that this was because PSI is not like most professional development activities, which tend to be of much shorter duration, less intense, and do not include substantial graduate-level credits. The PSI learning activities are concentrated and rigorous, and require extensive hours of classroom instruction and homework. As a result, real feelings of "community" and "family" were expressed during conversations with the participating teachers.

Long-Term Change

Regardless of how successful a PD program for teachers is judged during and shortly after delivery, the long term effectiveness of the intervention is paramount – i.e., did it bring about lasting change? Thairtwo years. Although those sessions were well-attended and received high marks in participant evaluations at their conclusion, the researchers found that, "while successful in establishing an extensive network of teacher trainers and a standardized approach to teacher professional development, observations indicated that the teaching practices of many teachers remained unaffected" (p. 204).

In addition, a recent Westat evaluation of Florida's $22 million summer workshops for math and science teachers, which provided professional development services for math and science teachers throughout the state, revealed that "most of the program's signature curriculum modules did little or nothing to improve the content understanding of participating teachers" (Lauman, et.al, 2009). Less-than-positive outcomes such as these are unlikely to result from the PSI effort, for the following reasons:

1. The PSI teachers have fully embraced the concept and tools of the PSI approach to teaching and learning.
2. The PSI teachers have expressed the teaching and learning benefits they have found in the new equipment and technologies have been installed in their classrooms, including a giant SMART Board at the front of the room, responders in students' hands, and round tables throughout.[10] These add certain learning and practice conditions beyond pedagogy and content.
3. The PSI approach has been embedded in the classroom through numerous onsite visits by one of the professors, which helped to tie the content and pedagogy more closely to the teachers' day-to-day work experiences.

Teacher Collaboration

Online communication among the PSI teachers is an important and successful component of the PSI program, although that has not been found to be a sustained activity in other PD projects in which it has been emphasized. Stephens and Hartmann (2004) found in their study of a multi-year PD program emphasizing online teacher collaboration that in spite of structural adjustments that were continually made to support that element of the process, no "traction" was ever established in this regard. Dede (2006), Lock (2006), and Green and Cifuentes (2008) report similar results. However, Flanagan (2009) maintains that when collaborative online learning is engaged in effectively, "the most valuable and significant benefit is that teachers can share their personal teaching expertise and innovative ideas with colleagues (p.8)."

Flanagan's scenario is closer to what was found in the PSI program, in which the professors and teachers create a "virtual learning community" through which the PSI teachers exchange information and ideas regarding both content and pedagogy – what the NJ Center for Teaching and Learning staff have termed *SMART Lesson Study*. This is a model based on the principles of *Japanese Lesson Study*, and is designed to assist educators deliver effective instruction in United States classrooms. *Japanese Lesson Study* is a

[10] Many teachers commented on how well the tables supported peer interactions and facilitated peer teaching, and stated that they would never return to having students sit in rows, as long as round tables were available to them.

process in which teachers jointly plan, observe, analyze, and refine actual classroom lessons, often called "research lessons". Lesson study is widely credited for the steady improvement of Japanese instruction, and since 1999 has emerged in many sites across the United States (Chokshi and Fernandez, 2004; Lewis and Hurd, 2004; Penuel, et al, 2007; Tsubota, 2007; Darling-Hammond, et al., 2009).

While the principles of the two approaches are in alignment, *SMART Lesson Study* is more relevant for many U.S. educators because it is designed to address the challenges educators face when using *Japanese Lesson Study* in the U.S., particularly the lack of a uniform curriculum and time for educators to collaborate. *SMART Lesson Study* uses the technology of SMART Notebook and SMART Response software to foster collaboration among educators.

In both *Japanese Lesson Study* and *SMART Lesson Study*, teachers think about the long-term goals of education and carefully consider the goals of a particular subject area, unit or lesson. However, the time to collaborate on these lessons is essential to *Japanese Lesson Study*, and collaboration time is not usually available for US educators. In Japan, teachers are provided time for both individual and collaborative planning purposes, while comparatively little time is built into the work day for educators in the U.S. So, while implementations of this approach are being attempted in the United States, there are differences that make its direct transfer impractical.

SMART Lesson Study fosters collaboration among teams of educators beyond their immediate work environment through virtual learning communities in revision and exchange of units then occurs between all the teachers of the course. This process can occur at any time, during or outside of school hours, accommodating the schedules of US teachers and especially enhancing the experience for teachers who do not have others in their schools involved with the program. While this process is strongly adapted to the use of electronic implementation, the SMART Lesson Study model encourages face-to-face meetings of teachers as well, which occurs to a great extent in the PSI professional development model.

Student Outcome/Achievement Data

While ample positive anecdotal data regarding the program and student performance is prevalent from all quarters, discussions with the participating districts are underway to identify sources that might be able to provide some preliminary data-based outcome data on students that could answer questions such as: Are there significant differences in algebra achievement levels between those students taking PSI physics and those who are not? Are there significant differences in achievement levels in other courses between those students taking PSI physics and those who are not? Are there significant differences in New Jersey Assessment of Skills and Knowledge (NJ ASK) mathematics test scores between those students taking PSI physics and those who are not? Does one find significant differences in in enrollment patterns in higher-level mathematics and subsequent physics courses between those students taking PSI physics and those who are not? And so forth.

Student Selection

There are instances in which the PSI philosophy may be at odds with the manner in which PSI is being viewed and operated administratively in a small number of schools. As mentioned previously, not all students were able to achieve in the courses without some remediation. While PSI did not suggest or even intend that only the best math and science students be provided an opportunity to take the physics course, there were instances in which very poor-achieving students in science and mathematics ended up in the classes. In these instances, it was unclear what criteria might have been applied.

On the other hand, some schools are screening students so that only those with the highest prior standardized test scores and classroom achievement are enrolled in the PSI courses. Other schools are ‘tracking’ students into particular PSI classrooms based upon their abilities – i.e., those in a ‘fast track’ versus a ‘slow track’ PSI course. In such instances, there seems to be no determination regarding which teacher can most adequately serve which grouping of students. In fact, at one school that had several “tracks,” all of the students in one PSI class were in the home economics and industrial arts track, whereas the instructor had been told that they were in the college track.

Only one principal was not fully supportive of the program. In that instance, it was because he “was under the impression that it was going to support our algebra course.” This school was using (and continues to use) a textbook and approach that is very different from that used in most other schools and is somewhat at odds with the PSI approach. He had been told that PSI would support algebra, but was unaware that the algebra program that had been selected for his school was not in sync with the more traditional algebra approaches with which PSI physics was aligned.

The above examples of misunderstandings regarding both the program and student placements reflects the small window of opportunity PSI staff had to communicate with the districts prior to the beginning of the program during its initial year. This has not happened in the program's subsequent iterations, as NJCTL/PSI staff have been diligent in making their intent for student participation very clear – not 'skimming' the best students, and no inclusion of those who have not exhibited some evidence of an ability and/or an intent to succeed in academic pursuits.

Course Offerings

One principal stated that he had a policy of not offering a course unless it enrolls at least 14 students, stating that he would not make an exception to this rule so that PSI could offer Honors or Advanced Physics because "I do not want to offer these courses just so I can say that my school offers them." The PSI teachers at that school were disappointed because they felt that there were some students who had taken the first PSI physics course who could benefit from subsequent courses, although their numbers did not meet the principal's criterion.

There may well be schools that may have to "work their way up" to preparing a critical mass of students for more advanced physics courses, but it seems unfortunate that students who are able to move ahead are denied that opportunity – especially if they have PSI trained teachers on staff to teach those courses. In such instances, perhaps it might be appropriate for district personnel to examine the situation along with school personnel.

Pretests and Posttests

The Physics test and the Attitudes and Beliefs survey provide useful information concerning mastery of content and viewpoints/opinions regarding teaching and learning science and physics. However, the Accuplacer tests do not appear to be appropriate proxy measures for the mathematics skills that are being taught to convey the physics content of the courses being taught to the teachers. The program has responded favorably to the evaluator's suggestion that their use should be reconsidered – being either discontinued or employed at a later time during the training.

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