Science: It's Elementary

Year Three Evaluation Report

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INTRODUCTION

This report summarizes the activities and findings of the external evaluation of the *Science: It's Elementary* (SIE) program during the period from July 2008 through June 2009. In the program's third year, the evaluation collected data from a variety of sources using several types of instruments:

Questionnaires

- Administered a questionnaire to collect baseline data on the third cohort of participating teachers and schools;
- Administered a post-professional development questionnaire to gather teachers' opinions of the quality and impact of the professional development;
- Administered an end-of-year questionnaire to examine the impacts of the SIE program on teachers and their teaching;
- Administered a questionnaire for principals of participating schools;

Observations

- Observed a sample of 28 professional development sessions to examine the quality of the training provided to teachers;
- Conducted 12 classroom observations to examine the fidelity and quality with which teachers were implementing the SIE-provided modules;
- Observed the June 2009 Leadership Conference designed to prepare teacher leaders to provide professional development in future years of the program;

Interviews

- Interviewed a sample of 28 teachers participating in the SIE program;
- Interviewed a sample of 27 principals whose schools are participating in the SIE program; [1]
- Interviewed all district science supervisors/curriculum coordinators from the 14 Cohort 3 districts;

Assessments

- Developed four student assessments, one for each grade 3–6 related to the science modules provided by the program for that grade;
- Administered student assessments in the Fall of 2008 in schools participating in the program; and
- Administered four assessments of teacher content knowledge at Module Enrichment workshops.[2]

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[1] For the teacher and principal interviews, HRI drew a random initial sample and made repeated attempts to interview everyone in the sample. HRI randomly selected additional participants as needed to make up for non-response. In an attempt to interview 30 teachers (10 from each cohort), 65 teachers were contacted repeatedly via email and telephone. Thirty-six principals were contacted in an attempt to reach the targeted goal of 30.

[2] HRI received data from only 32 teachers across the four assessments administered at Module Enrichment workshops. This small number of responses prohibits any meaningful analyses of these data; thus, these data are not included in this report.

After a brief description of the SIE program and the evaluation plan, this report describes the teachers, schools, and districts participating in SIE; the nature and quality of the services provided by the program; and evidence of the program's impact on teachers, their teaching, and their students. The report concludes with a summary of major achievements and HRI's recommendations for the program.

OVERVIEW OF *SCIENCE: IT'S ELEMENTARY*

The SIE program is managed by ASSET Inc. and overseen by the Pennsylvania Department of Education. SIE is an initiative aimed at improving elementary science instruction across the commonwealth of Pennsylvania. The program is focused on helping schools and districts implement an inquiry-based, hands-on science education program, with the ultimate goal of improving student learning. To accomplish its goals, SIE provides participating schools with module-based science instructional materials; teacher professional development around specific modules and inquiry-based science teaching more generally; and opportunities for strategic planning to help create supportive systems for science education reform. The program has six main components:

1. Strategic Planning Institute: Based on the National Science Resource Center's LASER model, these institutes are intended to help schools and districts understand, plan for, and successfully implement inquiry-based elementary science programs. Each school joining SIE sends a team comprised of administrators, teachers, and community partners to the Strategic Planning Institute (SPI) to learn about science education reform and to develop a three-year strategic plan for their school.

2. Vision Conference: This one-day event for school, district, and community leaders is intended to help foster a common, long-term vision for science education among a larger and more diverse group of stakeholders than the SPI. Attendees include superintendents, district administrators, school board members, principals, and community representatives for both newly joining and prospective districts.

3. Teacher Professional Development: SIE offers three types of professional development. Teachers new to SIE attend a one-day Foundations course to learn about the program's vision for science teaching. In addition, each teacher responsible for teaching an SIE-supported science module is expected to attend a one- or two-day Initial Module Training[3] focused on that module. This training provides teachers with an opportunity to familiarize themselves with the instructional materials; receive practical tips for using them in their classrooms; and learn teaching strategies, such as integrating science and literacy through the use of science notebooks. After teachers have implemented a module twice, they are offered a two-day Module Enrichment Training on that module to learn more about the targeted science content and how to implement the module more effectively. Teachers repeat this professional development cycle of Initial Module Training and Module Enrichment for each SIE-supported module they implement.

4. Delivery of Classroom Science Materials: In addition to the professional development, the SIE program delivers science modules directly to schools for teachers to use in their classrooms. After instruction with the modules is completed, they are returned to ASSET where they are refurbished for use again the following year.

[3] Most Initial Module Trainings are two days long; because some of the primary grades modules contain fewer lessons than the other modules, the Initial Module Trainings for these modules are one-day long.

5. Leadership Conference: This three-day conference is intended to help develop the capacity of teachers selected by schools participating in SIE to become teacher leaders who can mentor and coach other teachers in their schools and districts. The program also expects that some of these teacher leaders will later be able to serve as facilitators of Initial Module Trainings.

6. Showcase of Student Learning: To help build community support for science education improvement, SIE encourages each participating school to host a Showcase of Student Learning. During this event, parents, and other community stakeholders are engaged in science activities that highlight the hands-on, inquiry approach. These activities are typically led by students who have experienced this approach in their science instruction. SIE provides materials and support to schools for hosting these events.

Figure 1 shows the program's theory of action, i.e., how program activities are intended to fit together to produce the desired short- and long-term outcomes.

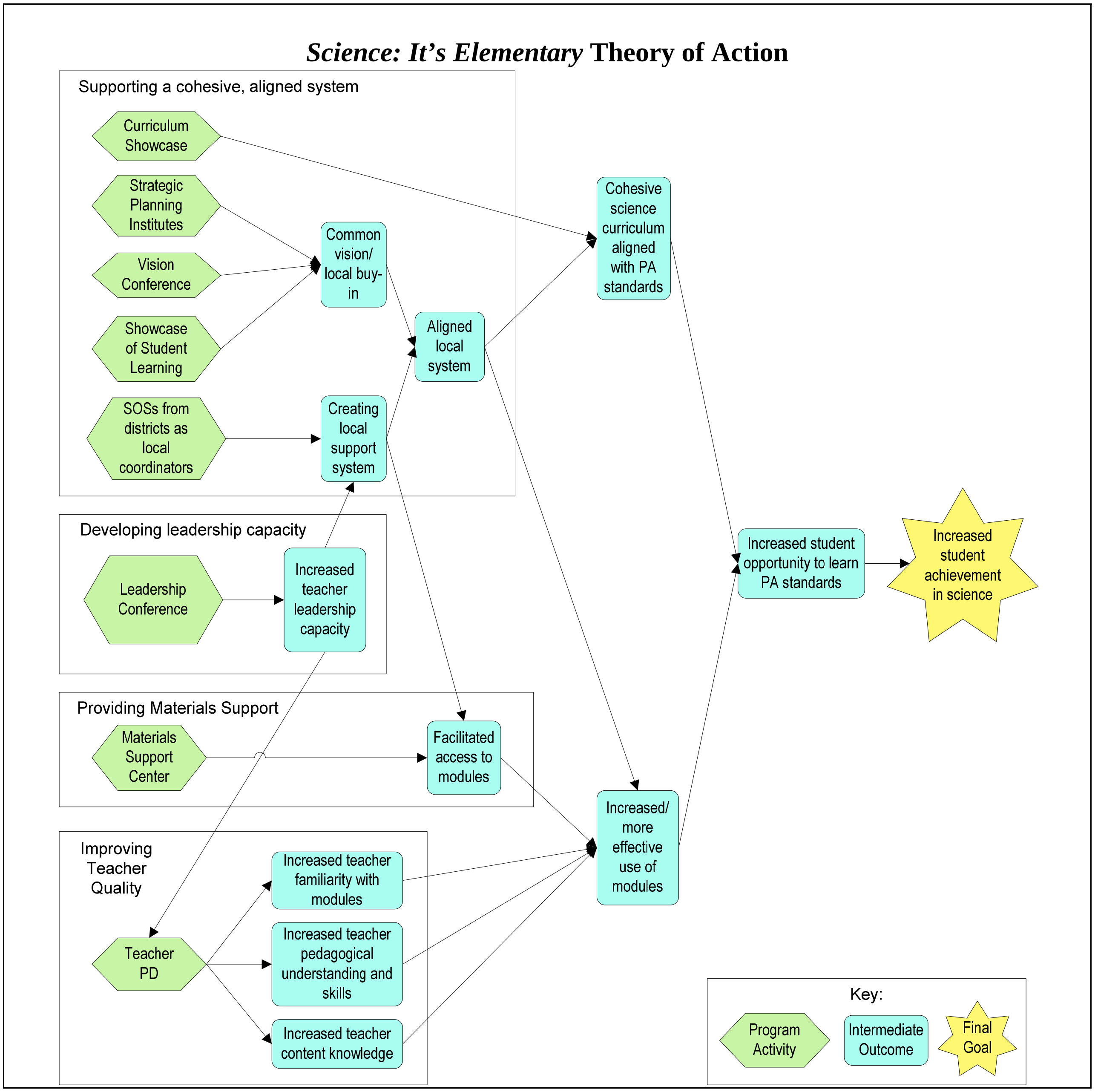

Figure 1

In addition, the SIE program requires each school to designate a Support On Site person (SOS). The SOS serves as the main conduit between the SIE program and the school, both for passing along important information from the program to the teachers and for helping teachers resolve any problems with the modules or professional development that may arise. The SOS is also responsible for registering teachers for SIE professional development and coordinating evaluation activities for the school.

In Year Three, SIE added another cohort of schools to the program. In total, over 2,500 teachers in 138 schools participated in the SIE program this year. Table 1 shows the distribution of schools across the education regions in Pennsylvania.

Table 1
Distribution of Schools Participating in SIE

		Number of Schools			
	Region	**Total**	**Cohort 1**	**Cohort 2**	**Cohort 3**
East	1	18	10	8	0
	2	12	4	3	5
	3	7	4	3	0
Central	4	14	4	4	6
	5	18	9	8	1
	6	23	11	10	2
West	7	22	9	12	1
	8	24	15	8	1
	Total	**138**	**66**	**56**	**16**

OVERVIEW OF THE SIE EVALUATION

The evaluation plan for SIE was developed by HRI in conjunction with key stakeholders with the goal of examining the major elements of the program's theory of action. The questions driving the evaluation focus on four main areas: (1) the development of an aligned system to support effective science education; (2) professional development for teachers; (3) the impacts of the program on teachers and their teaching; (4) and the impacts of the program on students. The key evaluation questions, by area, are:

System Alignment

1. How are school systems changing to support effective science instruction as a result of SIE?

Professional Development

2. What is the quality of the professional development provided to teachers?

3. What is the quality of the SIE leadership training?

Impacts on Teachers and Their Teaching

4. What is the impact of SIE on teachers' preparedness to implement the modules?

5. What is the impact of SIE on teachers' implementation of the modules?

Impacts on Students

6. What is the impact of SIE on student achievement in science?

This report provides data to help answer these questions based upon the program's activities in Year Three.

The Context for Improving Science Instruction in SIE Schools

Although helping schools and districts create fully-aligned systems is beyond the scope of SIE's mandate, the school and district contexts in which the program is being implemented will likely factor into the success of the program. Data from teacher and principal questionnaires, as well as interviews with samples of teachers, principals and Cohort 3 district supervisors shed light on how these contexts are impacting SIE's efforts to improve elementary science education.

Baseline Status of Cohort 3 Schools

Overall, the science programs of Cohort 3 schools (i.e., those joining SIE in Year Three) prior to participating in SIE were very similar to Cohort 1 and 2 schools when they joined the program. Interviews with random samples of Cohort 3 principals and teachers indicated that prior to SIE the majority of Cohort 3 schools' science instruction was very traditional and uninspiring, relying heavily on lecture, textbooks, and worksheets. Typical responses included:

> *Prior to joining SIE, I think we had the mindset, not intentionally, but I think our mindset was, "Let's get our information out of a book."* [Principal]
>
> *We were very textbook-based, very worksheet dependent...Pretty much lecture and taking notes and here is an activity on paper that you need to do.* [Principal]
>
> *We were using a very old science textbook, 20 years old…We would read with the book and perhaps provide a video to supplement it or bring in an experiment I could find online to do. Tests were paper and pencil.* [Teacher]

In addition, Cohort 3 teachers' prior experience with kit-based science instruction was minimal. On a baseline questionnaire administered to teachers attending a Foundations course (i.e., those teachers new to the SIE program), only about one-quarter of respondents indicated they had previously taught science using a module like those provided by SIE.[4] Of these teachers, fewer than half had received professional development on those modules.

When asked to identify the strengths of their school's science programs, approximately one fifth of baseline questionnaire respondents indicated the use of hands-on or inquiry-based instruction as the greatest strength. Teachers also cited aspects of their schools' curriculum and the high quality of the staff as particular strengths, although each was mentioned by fewer than one-quarter of respondents. Other responses, given by only a handful of respondents apiece, included having a program that is interesting to students, and having high quality science textbooks. Sample responses included:

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[4] The baseline questionnaire was administered at the beginning of each Foundations course by program staff. HRI received 448 baseline questionnaires.

The main strengths of my school's science program are that it is hands-on with very little reading and memorizing involved. Through the hands-on activities, the students get excited about their role in experimentation, and it works for special education students whose reading level is not at grade level.

Currently, we are teaching [science] through our reading program. The main strength is that we are incorporating science with reading.

We have experienced teachers who plan and teach a strong standards-based curriculum.

When asked how their school's science programs could be improved, Cohort 3 teachers identified a number of areas. Approximately, one-quarter of baseline questionnaire respondents noted that their schools need more resources and/or instructional materials for science. The need to incorporate more hands-on/inquiry-based approaches to teaching was also mentioned by close to a quarter of respondents. In addition, over fifteen percent of respondents indicated that more instructional time was needed for science. Other areas for improvement mentioned, none by more than a few teachers, were elevating the emphasis on science to equal that of reading and mathematics, increasing alignment with state standards, and increasing the number of topics covered. The following comments illustrate teachers' responses:

My school's science program has not been updated in many years. It could be improved with more up-to-date information, materials, and instructional methods.

Our school's science program can be improved by purchasing more materials and supplies relating to science.

We need more hands-on experiences and inquiry-based instruction.

Cohort 3 Schools' Visions for their Science Programs

In addition to characterizing the initial profile of their schools' science programs prior to joining SIE, Cohort 3 teachers, principals, and district science supervisors were asked in interviews to describe their vision for their science programs. The overwhelming sentiment, among both teachers and administrators, was that they would like to see their science programs move toward a more hands-on, inquiry-based approach. This result is not surprising given that these schools chose to participate in the SIE program. Typical responses included:

I would love to have students doing science-related things every day, hands-on kinds of things. [Teacher]

Our vision is to move from a textbook-driven, memorize the facts, teacher tells you what is going to happen and why, to an inquiry-based, hands-on doing science [program]. [District Supervisor]

We are really looking at having an inquiry-based approach to teaching science...One of the reasons that we were so interested in being part of SIE is because that is the approach that the modules take. [Principal]

Many interviewees also indicated that they believed students would gain a better understanding of science and be able to apply that knowledge to real-world situations as a result of a more hands-on, inquiry-based program. About half of the interviewed district supervisors also indicated that they hoped having the SIE program in their school buildings would result in an increase in excitement about, and interest in, science, among both students and teachers. As two said:

> *What I hope will happen will be that our faculty and our kids will get excited about learning and that our kids will learn those critical skills that they need to be successful in anything that they do.*

> *I am hoping that the students get excited about science and that they engage the parents in science as well, and it gets out to the community that we are participating in a really unique program that is going to help the students have more of an advantage to possibly select careers in science in the future.*

Role of SIE in Achieving Those Visions

According to Cohort 3 district supervisors, the SIE program is an integral part of their plans for improving elementary science instruction. All 14 of the interviewees indicated that the SIE program has already been instrumental by providing professional development and instructional materials. As two supervisors stated:

> *We knew we wanted to go to this more kit approach, hands-on approach…it [SIE] basically serves as the foundation of what we want to accomplish.*

> *Well, SIE has been very helpful in providing the professional development…and also providing the modules…in doing the professional development it will certainly help our teachers have more skill in the classroom to do inquiry-based instruction.*

Another aspect of the SIE program that district supervisors indicated has been particularly helpful in moving Cohort 3 schools towards realizing their vision for the science programs at their schools was the Strategic Planning Institute (SPI). Most indicated that the SPI provided them with an opportunity to develop a plan for integrating SIE into their schools. As one supervisor described:

> *We were able to generate a great, very useful plan for us. When I came back, I actually shared it with the board and got them to approve it with the understanding that it is a working document and it is going to change as we work through the process. It really energized my staff, the ones that were able to go, and they came back and talked to their colleagues and that is great to have happen. There is kind of this excitement in the air…that helped the whole process.*

When asked how the SPI could have been improved, a few district supervisors indicated that they would have liked to bring more district stakeholders, and several said the SPI could have been abbreviated.

Changes in SIE Schools' Science Programs

In Year Three of the program, Cohort 3 schools were just beginning the process of improving their science programs through participation in SIE, while Cohort 1 and 2 schools were in their third and second year, respectively, of the process. In addition to Cohort 3 district supervisors, samples of teachers and administrators, representing all three cohorts, were asked in interviews to comment on the changes that have occurred in their schools since joining SIE. Nearly all Cohort 3 district supervisors, and all interviewed principals across the cohorts, indicated that science has become a higher priority in their schools as a result of participating in SIE. Representative comments included:

> *I would say now [science] is a very high priority…Before I would say that it was very low level…I don't believe we really had science instruction to speak of that was part of our curriculum in K–2…Now we have a comprehensive K–5 program.* [District Supervisor]

> *Before, [science] wasn't a high priority at all because the science curriculum was pretty poor, non-existent…It just got put on the back burner…Science was the least of our worries…What I have come to learn is the role science plays in everything, in reading, in social studies, in math. You could build your curriculum around science…It is such a good catalyst for getting [students] to be psyched about reading and writing and doing math because it is all related to these interesting explorations that they are doing.* [Principal]

Although science instruction has increased in priority in many SIE schools, about one-third of Cohort 3 district supervisors noted that science instruction is still not as high of a priority as reading and mathematics. As two indicated:

> *I don't think any Pennsylvania school can say [science] is number one when we are on the carpet for reading and math every year…certainly it is number two right now.*

> *[Science] would likely come in third; obviously reading and math have to be the priority right now in this state and country…reading comes first, then math, then science.*

One of the most telling indicators of the priority given to science is the amount of instructional time devoted to it. Based on teacher questionnaire data collected at the end of each year of the program,[5] the amount of time devoted to science instruction in Cohorts 1 and 2 schools has increased in their second year of participation. (See Table 2.) The roughly three minute per day increase for Cohort 1 and the one-and-a-half minute per day increase for Cohort 2 are both

[5] In Year Three, the End-of-Year Questionnaire was administered via the Internet with the assistance of each participating school's SOS. SOSs were asked to update a list of teachers at their schools, disseminate the URL for the survey, and follow-up with non-responding teachers. HRI received completed questionnaires from 1,773 of the 2,311 teachers that were registered for the survey, a response rate of 77 percent.

relatively small effects (0.27 and 0.12 standard deviations, respectively).[6] Across an entire year of instruction, this small amount of time adds up to an additional nine hours or so of instructional time in Cohort 1 schools and four-and-a-half hours of instructional time in Cohort 2 schools.

Table 2
Time Devoted to Science Instruction, by Years of Participation

	Number of Minutes per Day					
	First Year		Second Year		Third Year	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Cohort 1	14.23	11.98	17.62*	12.90	17.85	11.93
Cohort 2	15.83	12.22	17.34*	12.25	—	—
Cohort 3	14.73	13.01	—	—	—	—

* Instructional time significantly different than previous year, $p < 0.05$ (Cohort 1: one-way ANOVA with Tukey HSD post-hoc comparisons; Cohort 2: independent samples t-test).

In some cases, schools have added science to their instructional schedule; in other cases schools have increased the instructional time scheduled for science. The following remarks were typical:

> *In the past, science, you would take it whenever you could…now [teachers] have these kits and they know they will only have them for a certain length of time, so it kind of forces them to have science instruction every day.* [Principal]

> *[Teachers] are doing science. I would love to say they always did, it is in the schedules…but now they are making the time to do it because they see the children's interest…[Science] was definitely not taught to the extent that it is taught now.* [Principal]

> *We used to have a very limited amount of time for science and now we have 40 minutes a day every day with SIE.* [Teacher]

There have been a number of other instructional changes in schools since they joined SIE. Nearly half of interviewed principals noted that teachers are covering science topics in greater depth, with the trade-off that they are covering fewer topics overall. These principals indicated that this change has been a positive one. As one principal explained:

> *I would say that there are actually fewer science topics taught, but the science topics covered are being covered in more depth. So the students are learning more of the scientific principles and the scientific method even though they have fewer topics.*

The instructional strategies that teachers are using to teach science are also changing. Nearly all of the interviewed principals and over half of interviewed teachers indicated that their schools

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[6] When comparing two means, the effect size is calculated as the differences between the two means divided by the pooled standard deviation. Effect sizes of about 0.20 are typically considered small, 0.50 medium, and 0.80 large. Cohen, J. (1988). *Statistical power analysis for the behavioral sciences.* Hillsdale, NJ: Lawrence Erlbaum Associates.

have shifted science instruction to a more hands-on approach since their schools joined the SIE program. Representative comments included:

> *[Science instruction] is not give, give, give all the information and then memorize it and take a test; it is, "Let's discover together."* [Principal]

> *In the past it [science instruction] was pretty much read the book and answer the questions…Now [students] are actually using equipment; it is a hands-on approach, a discovery approach, and so it is much different.* [Principal]

> *It's different now, because we are…doing an experiment every day. The hands-on with the children happens now, where before it was more textbook, or let's read and talk, and less of them doing stuff.* [Teacher]

> *It's all hands-on. I tried to do hands-on, but with time and everything else I could not do as much that I would like. Now every day or every other day they are having a hands-on experience through an experiment.* [Teacher]

The use of notebooks in science was also mentioned by several teachers as a particularly valuable strategy that they now use in their science instruction. As one teacher said:

> *Using the notebook has changed my instruction…Actually giving them a focus question and having them really critically think about it and even write a response. I think it has led to a better understanding of the focus of the lesson, this is what we're going to be learning, and then we come back to it at the end. So I think it makes it more formal, rather than just a class discussion or students sharing thoughts.*

When asked in interviews to identify impacts in their schools as a result of participating in SIE, several principals indicated that teachers are more enthusiastic about and confident in teaching science. For example:

> *The excitement towards education, just as a profession, has increased…The kids are motivated, they get excited, they want to do it so it makes the teachers motivated and they are working harder to have [students] reflect and be challenged.*

> *I just feel that there is an enthusiasm and excitement about teaching science that through all of the training has been passed on to the teachers.*

The overwhelming sentiment among district and school administrators was that they appreciated the SIE program and found it to be very influential in effecting change in their science programs. They indicated that the instructional materials provided by the program were particularly valuable and that SIE was meeting a need for high-quality professional development in science. Comments included:

[The instructional materials] are very good…the teachers, many of them don't have a background in science, they don't feel comfortable teaching it, but these lessons allow them to feel comfortable and to do a good job with it. [Principal]

If you don't have the professional development, you don't have a program quite honestly…If you don't have effective professional development it does not matter what piece of material you have, you have to have someone who is comfortable teaching the content. [District Supervisor]

I have a very good opinion of [the SIE program]. I think that money talks and I think the state made a good investment in a program that delivered…not only quality materials, but quality professional development…Districts that have invested the time…are reaping the benefits of it…We have been very lucky to have participated in it over the last couple of years. [Principal]

Administrators also shared that, in the past, a lack of funding for materials and professional development had limited the quality of their schools' science programs. A few specifically indicated that, without the support of the SIE program, they would not be able to fund a similar program on their own. Several principals were concerned about their schools' ability to sustain the effort given the uncertainty of continuing state funding. In the words of two principals:

It is a very good program. I hope that the state legislators and the governor will be able to find the necessary funding…to allow the state and our students to be able to go through this for years to come.

The only challenge…would be the funding issue…If the governor chooses not to fund the program, it will be difficult for our district to maintain.

Factors Affecting Science Program Improvement

On a questionnaire, principals from each cohort were asked about factors that facilitate or inhibit their schools' science programs.[7] As can be seen in Table 3, nearly all responding principals indicated that state science curriculum frameworks and access to professional development for teachers were facilitating factors. The quality and availability of resources for science instruction (presumably those being provided by SIE) were also frequently seen as helpful. State and district testing in subjects other than science were the most frequently mentioned inhibitors, though each of these was selected by fewer than 1 in 5 principals.

[7] The Principal Questionnaire was a web-based survey administered to the principals of all SIE schools. HRI contacted principals via email, following up with additional emails to non-responders. Of the 135 principals (a few individuals were principals for multiple schools), 100 responded to the survey, a response rate of 74 percent.

Table 3
Principal Opinions of Factors that Affect Science Instruction

	Percent of Responding Principals (N = 99)	
	Facilitates†	**Inhibits**‡
State science curriculum frameworks	92	2
Access to professional development for science	91	7
Quality of resources for science instruction	91	4
Availability of resources for science instruction	89	7
District science curriculum frameworks	88	4
Importance that the district places on science instruction	86	7
State science testing policies and practices	80	8
Consistency of science reform efforts with other district/school reforms	80	5
District science testing policies and practices	71	4
State testing policies and practices in subjects other than science	62	19
District testing policies and practices in subjects other than science	58	12
District grading policies and practices	51	5
District policies for evaluating teachers	51	4
District structures for recognizing and rewarding teachers	27	5

† Includes those indicating "Greatly Facilitates" and "Facilitates Somewhat" on a five-point scale of 1 "Greatly Inhibits to 5 "Greatly Facilitates."

‡ Includes those indicating "Greatly Inhibits" and "Inhibits Somewhat" on a five-point scale of 1 "Greatly Inhibits to 5 "Greatly Facilitates."

In interviews, principals and district supervisors highlighted the role of the state in the development of their science programs through a variety of mechanisms: state standards; the Pennsylvania System of School Assessment (PSSA); and funding the SIE program. As several noted:

> *Definitely receiving the state grant [SIE] has helped…we would not have been able to afford this otherwise.* [Principal]

> *Probably one of the main things that has helped is the state actually having the PSSA with science counting now…It makes it a lot easier to say, "We don't have a choice, this counts."* [District Supervisor]

> *Really, it has been driven by the state standards…with the 4th grade Pennsylvania assessments coming on line, that also kind of gave a little bit of urgency here to get some things moving; it has mostly been driven by state requirements.* [District Supervisor]

Although the introduction of the science PSSA has increased the emphasis science instruction receives, principals and district supervisors also indicated that because the science PSSA does not count toward Academic Yearly Progress, instructional time for science in their schools was still limited. As two stated:

> *The bottom line is AYP, we need to show growth. So, our focus is the language arts area and math and then comes science and then comes social studies.* [Principal]

> *The biggest challenge is really we have to focus so much on the reading and the math just because that is what we are held accountable for…I guess that is our biggest challenge, seeing how science fits in with it and convincing…everyone that science is just as important and that it will help in reading and math, but we are just so narrowed right now.* [District Supervisor]

Principals were also asked what additional services the SIE program could provide that would help them support their school's science program. Ideas and tools for securing resources for science instruction; assessing progress of the school's science program; enhancing teacher collaboration; and tools for providing feedback to teachers were each mentioned by roughly 60 percent of principals. (See Table 4.) (Principals' responses to this questionnaire item disaggregated by cohort can be found in Appendix A.)

Table 4
Principals Indicating that Potential Program Services Would be Very Valuable

	Percent of Responding Principals (N = 100)
Ideas and tools for securing the resources needed for science instruction	59
Ideas and tools for assessing progress of our school's science program	59
Ideas and tools for creating opportunities for teacher collaboration	59
Ideas and tools for observing and providing feedback to teachers about their science instruction	59
Professional development for me to increase my own understanding of how to integrate science with mathematics and literacy	55
Ideas and tools for increasing parental support/interest/involvement in our school's science program	44
Professional development for me to increase my own understanding of effective science teaching	44
Ideas and tools for leveraging other district resources (e.g., professional development days) to support science instruction	44
Ideas and tools for increasing community support/interest/involvement in our school's science program	42
Ideas and tools for making science more of a priority in the school	36
Professional development for me to increase my own science content knowledge	24

Professional development for principals was also seen as important. Fifty-five percent of responding principals indicated that training to increase their understanding of how to integrate science with other subjects would be of value; and 44 percent indicated that professional development to increase their understanding of effective science teaching would be useful. This need was also identified by many district science supervisors. As one supervisor stated:

> *We plan on sending our principals to some professional development as well, because I think they need to understand the whole approach and where we are headed…The Foundations piece in particular…That is the piece we think is so very important for the principal, because if they are going to go in and in any way effectively evaluate a teacher's implementation of this, they need to experience that piece of the professional development.*

THE QUALITY OF SIE PROFESSIONAL DEVELOPMENT

The main goal of the SIE professional development program is to move teachers from mechanical to purposeful implementation of science modules. Many teachers achieve the mechanical use of science modules by following the steps in the teacher's manual and having students complete the activities. Purposeful use involves going beyond just doing the activities to having students make sense of the ideas targeted in a given activity and how those ideas build toward bigger scientific principles. Students should also reflect on how their understanding of the targeted science concepts has changed given their experiences with the module, and be helped to make connections across module activities in the development of science ideas.

Purposeful implementation of a module requires considerable knowledge and skill on the part of teachers. First, teachers need to know and feel comfortable with the mechanics of a module—"what's in the box," i.e., how to manage materials and students while using a module.

Second, before they can effectively teach the science content to students, teachers must themselves understand the content. At a minimum, purposeful use of a module requires that teachers understand the ideas students are expected to learn, and how those ideas fit together in a coherent and cohesive framework. Teachers would also benefit from understanding the content beyond the student level, including how the ideas progress through the K–12 sequence, so they can guide students along productive paths of inquiry.

Third, in order to teach effectively, teachers need to have a clear understanding of how students learn science and an explicit vision of effective instruction. A great deal has been learned in the last few years about how people learn and the implications of research in the cognitive sciences for instruction. Key findings that have emerged from this research indicate that effective instruction provides motivation to learn, elicits students' prior knowledge, intellectually engages students with important science ideas, emphasizes the use of data as evidence to support/critique conclusions, and provides opportunity for students to make sense of the targeted ideas.[8]

For instruction to be purposeful and effective, teachers need to be able to integrate their knowledge of the science content and their familiarity with the nuts and bolts of the module. As a result, teachers would understand the "content storyline," how each of the scientific ideas addressed by the module is developed through specific learning experiences. Ideally, they would be able to trace the development of a scientific idea through a module (e.g., students' initial ideas about a particular idea are elicited in activity 1; the idea is then developed in activity 2; students have an opportunity to practice and master the idea in activity 3).

Similarly, for instruction to be purposeful and effective, teachers need to be able to integrate their knowledge of the science content with their understanding of how students learn science.

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[8] National Research Council. (2000). *How people learn: Brain, mind, experience, and school.* J. D. Bransford, A. L. Brown, & R. R. Cocking (Eds.). Washington, DC: National Academy Press.

National Research Council. (2005). *How students learn: Science in the classroom.* M. S. Donovan & J. D. Bransford, (Eds.) Washington, DC: National Academy Press.

This type of knowledge is commonly referred to as pedagogical content knowledge; it includes recognizing initial ideas students are likely to have that may get in the way of their learning the targeted concepts (often termed “misconceptions” or “naïve ideas”), and specific strategies for helping students develop the correct ideas. For example, students often think that connecting a light bulb to one end of a battery will cause the bulb to light. A specific strategy for helping students move past this idea is to have them try many different configurations of connecting the bulb to the battery, recording which do and do not work, and then carefully analyzing the results to find the commonalities in the configurations that work, and the commonalities in those that do not work.

Finally, it is important to note that general pedagogical skills are necessary for effective teaching of any topic. The SIE program addresses two specific sets of general pedagogical skills: the integration of reading/language arts instruction with the teaching of science (e.g., notebooking strategies) and assessment strategies. Figure 2 shows a progression of how these elements build toward purposeful implementation of a module.

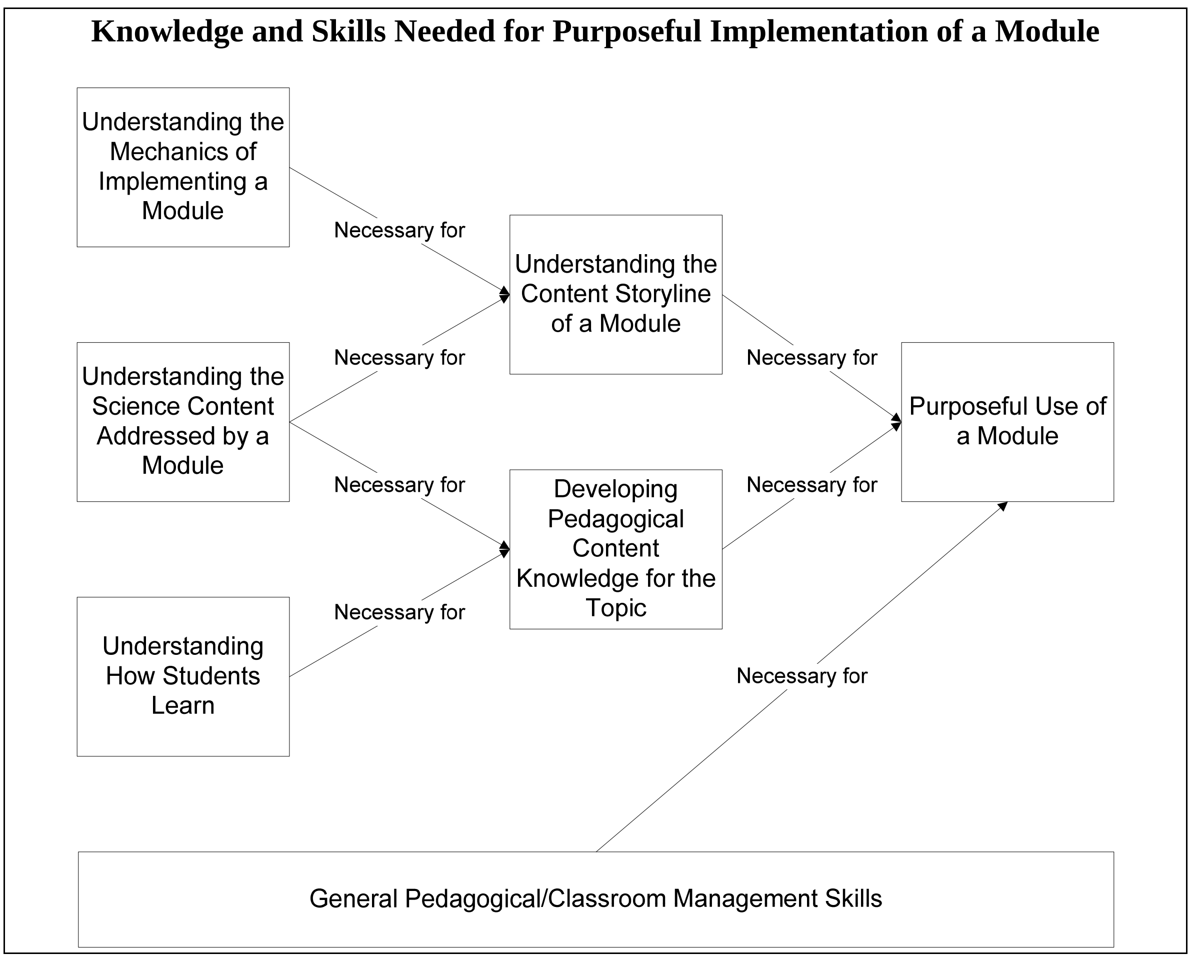


Figure 2

The SIE program is continually reflecting on its work and making changes to ensure that the professional development is as effective as possible in helping teachers reach the goal of purposeful use of the modules. As part of this process, the program has redesigned the Foundations course to focus more explicitly on helping teachers develop a common vision of effective science instruction. HRI observed the revised Foundations course during the 2009 ASSET Leadership Conference, which is described in the next section of this report. This section of the report focuses on data about the Initial Module Trainings and Module Enrichment Trainings.

During Year Three of the program, Cohort 3 teachers attended Initial Module Training for their first module and Cohort 2 teachers attended Initial Module Training for their second module. Cohort 1 teachers, most of whom had taught their first SIE-provided module two times, had the option to attend Module Enrichment Training for that module. A post-professional development questionnaire was administered to everyone attending one of these workshops.[9] Table 5 shows the number of teachers completing the questionnaire at each type of workshop.

Table 5
Responses to Post-Professional Development Questionnaire

	Number of Responding Teachers
Initial Module Training on 1st module	585
Initial Module Training on 2nd module	964
Module Enrichment Training on 1st module	83

Initial Module Trainings

The primary purpose of the Initial Module Trainings is to prepare teachers to use the instructional materials for the first time, including familiarizing them with the activities, the targeted science content, and strategies for engaging students with the content. Data on the quality and impact of the Initial Module Trainings come from questionnaires completed by teachers attending these trainings, interviews with samples of teachers and principals, and HRI's observations of a sample of workshops.

Teacher Expectations

Understanding the expectations of teachers participating in SIE may help the program better plan to address their needs. Cohort 3 teachers were asked on an open-ended item on the baseline questionnaire to explain what they hoped to gain from participating in SIE professional development. The most common responses, each given by approximately one-third of the respondents, were that they hoped to learn how to use their module and gain new instructional strategies for teaching science. Typical responses included:

[9] Because the post-professional development questionnaire was administered to a captive audience, the response rate should be close to 100 percent.

> *A deeper understanding of content/procedures. Knowledge of the kit that will allow me to organize/implement more efficiently.*
>
> *I wanted to see the materials, how to implement them. I wanted to see how the notebook was utilized, and different things that I could do to make the program successful in my classroom.*
>
> *I'm hoping to gain a better understanding of how to facilitate my students' learning and organize the modules so our time spent in science can be maximized.*

One-fifth of the questionnaire respondents indicated that they hoped to learn how to make science more enjoyable and engaging for their students. As two participants wrote:

> *A better understanding of how to bring all of this information back to my students and understand how to keep their interest in it!!*
>
> *Knowledge and materials that will allow me to excite students and get them to want to learn science.*

Teacher and Principal Perceptions of the Quality of the Initial Module Trainings

Overall, teachers and principals had very positive opinions about the SIE Initial Module Trainings. Teacher responses to a questionnaire administered at the end of each training highlighted the quality of the facilitators. (See Table 6.) Nearly all respondents thought facilitators provided useful tips for successfully implementing the modules, encouraged active participation, and adequately addressed questions about the science content in the modules. In addition, the vast majority of teachers indicated that the Initial Module Training sessions increased their familiarity with the activities in the modules and prepared them to use the teaching strategies promoted by SIE, indicating teachers' expectations for the professional development had been met. Teachers also thought the workshops had increased their understanding of the science content in the modules. (Post-professional development questionnaire data on the Initial Module Trainings are reported by session type in Appendix A.)

Table 6
Teacher Opinions of the Quality of SIE Initial Module Training

	Percent of Responding Teachers Agreeing† (N = 1,545)
The facilitators shared tips and suggestions for successfully implementing the module.	97
The goals of this workshop were clear.	96
This workshop familiarized me with the activities and materials in the module.	96
The facilitators encouraged active participation and investigation by all participants.	95
This workshop increased my understanding of the science content in the module.	95
The various components of this workshop were useful in meeting its goals.	94
The facilitators were well prepared.	94
Question about the science content in the module were adequately addressed by the facilitators.	94
This workshop prepared me to use the teaching strategies promoted by SIE.	94
This workshop was relevant to my classroom instruction.	94
This workshop increased my confidence in my ability to teach using the SIE module.	93
This workshop was worth the time that I invested.	92
I would recommend this professional development to a colleague.	92
This workshop reflected careful planning and organization.	92
The facilitators modeled effective teaching strategies.	92
The facilitators explicitly discussed how, when and why to use different teaching strategies.	91
There were opportunities for participants to express their views and collaborate with peers.	89
Adequate, time, structure, and guidance were provided for participants to discuss the SIE modules and pedagogical strategies with each other.	81
Adequate time, structure, and guidance were provided for participants to reflect individually on the substance of this workshop.	80

† Includes those indicating "Agree" and "Strongly Agree" on a five-point scale of 1 "Strongly Disagree" to 5 "Strongly Agree."

In addition, approximately two-thirds of respondents indicated that the pace of the professional development was appropriate. (See Table 7.) Seventeen percent of participating teachers found the pace of the Initial Module Trainings too slow; 19 percent indicated the pace was too fast.

Table 7
Teacher Opinions of the Pace of SIE Initial Module Trainings

	Percent of Responding Teachers (N = 1,494)
Much too slow	2
Somewhat too slow	15
Appropriate	64
Somewhat too fast	14
Much too fast	5

When asked on the post-professional development questionnaire and in interviews what aspects of the workshops were most effective in preparing them to implement their module, teachers' most common responses were going through the module activities as if they were students, and having experienced classroom teachers facilitate the sessions as they provided many practical implementation tips. In the words of three teachers:

It was most helpful to actually perform each lesson as the student would and discuss ways in which students would respond. It was also helpful to get comfortable with the materials being used.

They did a nice job telling us how to set up each lesson and the notebooks. How important that was, and they did a nice job of getting us excited about it. They did a nice job walking us through the experiments, emphasizing the points we needed to make. I liked how they helped us set up our notebooks. The notebook was key; we referred to it a lot to help us through each lesson.

All the presenters we had were very good, probably because they are in the classroom currently. It's someone who actually does the module.

SIE encourages principals to attend the professional development provided to teachers, and 42 percent of respondents to the Principal Questionnaire indicated they had attended an Initial Module Training during the 2008–09 academic year (in 2007–08, 40 percent of responding principals indicated they had attended one). Nearly all of the interviewed principals who had attended an Initial Module Training noted that they thought the professional development was very effective at preparing teachers to implement their modules. As one principal said:

It was probably the best professional development workshop that they [teachers] have ever attended because it actually got them ready for what is going to happen in the classroom.

Further, many indicated that the sessions increased their own understanding of the modules and what teachers would be doing in the classroom; a few also mentioned that they felt better equipped to help teachers in the classroom. As three principals commented:

I think it is important for administrators to be in the training to see what the teachers are trying to do and what sort of supports and needs they would have. I can't offer support if I don't understand the program.

Well, [attending the training] helped put me on the same playing field as the teachers, so I know what the kits are supposed to look like when they are implemented…[it] provided some common language for us.

[It] helped me to know what I should then be looking for when I am in a classroom and science is being taught.

When asked how the Initial Module Trainings could be more effective, most teachers indicated that they were satisfied and did not see a need for changes. Still, a number of teachers did offer ideas for improvement. The most common suggestion, provided by 25 percent of survey respondents, was to spend more time going through the module activities. This suggestion came from teachers attending both one- and two-day workshops, with many indicating that the trainings did not use time effectively, often rushing through lessons. The following responses were typical of these teachers:

> *Maybe extend the time of the training. It seemed the presenters are crunched into a certain number of days and they had to rush through each lesson, and it was done so quickly that when you do it with your class you have some trouble remembering everything. I say, extend the time to not be so crunched.*
>
> *Trying to get all the info in on one day was hard…They started off doing a nice job walking us through it, but by the end they moved too quickly. They would do an experiment then move onto the next one and we didn't get to write down notes.*

Addressing Teachers' Concerns about Implementing the SIE Program

As part of the baseline and end-of-year questionnaires, HRI administered a set of items developed as part of the Concerns Based Adoption Model (CBAM). The theory holds that when teachers adopt a new curriculum or instructional approach, they progress through a series of concerns about the "innovation." As experience with the innovation grows, early concerns (e.g., being unfamiliar with the curriculum) are resolved, and later ones emerge. The implication of this stage theory is that early concerns must be resolved before later ones can be effectively addressed. The CBAM theory suggests that effective professional development specifically targets the concerns that are likely to emerge at different points in the adoption process. The seven stages of concern are operationalized in a 35-item CBAM questionnaire[10] developed to measure the intensity of each concern:

1. Awareness (e.g., I don't even know what the SIE modules are.)
2. Informational (e.g., I would like to know what resources are available for implementing the SIE modules.)
3. Personal (e.g., I would like to know how my teaching is supposed to change using the SIE modules.)
4. Management (e.g., I am concerned about my inability to manage all that the SIE modules require.)
5. Consequence (e.g., I am concerned about how the SIE modules affect students.)
6. Collaboration (e.g., I would like to develop a working relationship with both our faculty and outside faculty using SIE modules.)
7. Refocusing (e.g., I would like to modify our use of the SIE modules based on the experiences of our students.)

The hypothetical concerns profile in Figure 3 illustrates how early concerns (e.g., informational) are the most intense early in an implementation, but decrease over time, and are replaced by other concerns. It is important to note that in the CBAM theory, the changes depicted in Figure 3 can take two to three years to be observed.

[10] HRI modified the original CBAM questionnaire to tailor it to the SIE program.

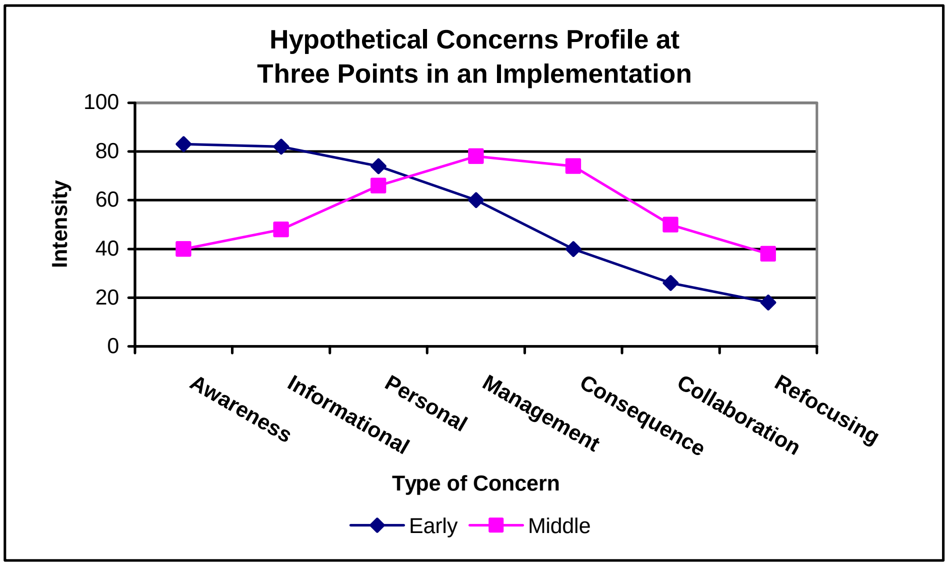
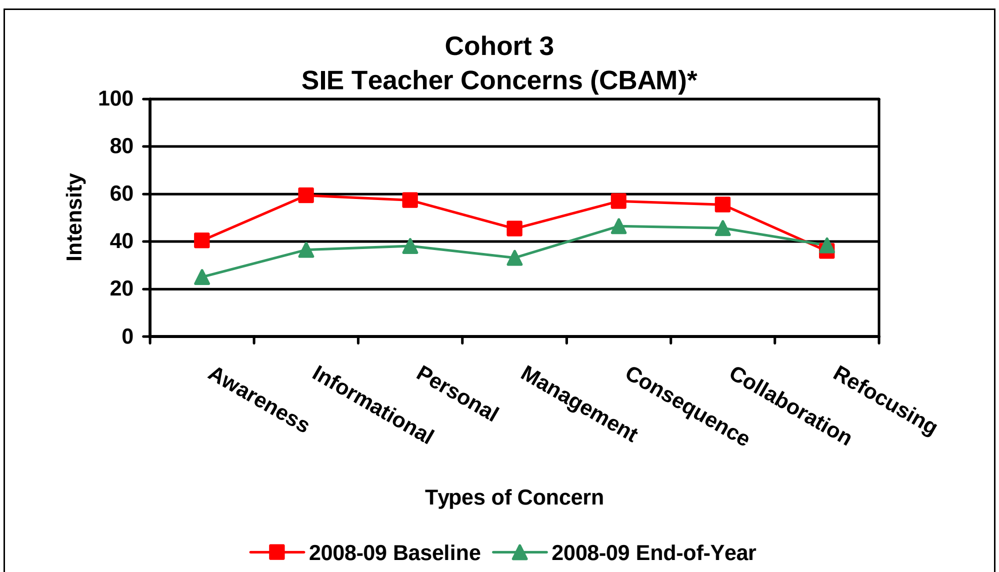


Figure 3

Figure 4 shows CBAM data from Cohort 3 teachers. Based on these data, SIE was successful at addressing these teachers' initial concerns about the program and the implications for classroom practice. This change in the concerns profile is similar to what was observed for Cohorts 1 and 2 teachers during their first year of participation in the program.



* 2008-09 End-of-Year profile is significantly different than 2008-09 Baseline profile, $p < 0.05$ (MANOVA)

Figure 4

Observers' Perceptions of the Quality of the Initial Module Trainings
The SIE Initial Module Trainings are focused largely on familiarizing teachers with the basics of the module. The primary goals for the Initial Module Trainings are to:

1. Prepare teachers to implement the module at the mechanical level;
2. Deepen teachers' understanding of the targeted science content in the module; and
3. Prepare teachers to use instructional strategies that support module implementation.

Evaluation staff observed portions of 28 Initial Module Training sessions between December 2008 and February 2009. HRI attempted to observe Initial Module Trainings for as many different modules as possible. However, a combination of the program providing more sessions for some modules than others, and the fact that HRI tried to maximize the number of workshops observed in each trip, resulted in Initial Module Trainings for certain modules being observed more often than others. Table 8 summarizes the number of sessions observed for each module.

Table 8
Initial Module Trainings Observed

	Number of Sessions
Chemical Tests	2
Changes	2
Ecosystems	1
Electric Circuits	4
Human Body	1
Levers and Pulleys	2
Mixtures and Solutions	2
Motion and Design	2
Plant Growth and Development	1
Rocks and Minerals	4
Solids and Liquids	2
Variables	2
Water	2
Weather	1

HRI utilized a framework based on research on how people learn to examine the extent to which the SIE professional development achieved its goals.[11] This framework asserts that effective science professional development must provide sufficient opportunities for teachers to engage intellectually with important and accurate scientific and pedagogical ideas; reflect on and make sense of the key ideas of the session; and relate the ideas in the session to their work as classroom teachers. An analysis of SIE Initial Module Training professional development for each of its goals follows.

[11] As described previously in this report, HRI's frame for thinking about the quality of instruction for both adult and student learners is based upon the National Research Council's *How people learn: Brain, mind, experience, and school* (1999) and *How students learn: Science in the classroom* (2005).

- *Preparing teachers to implement the module at the mechanical level*

Familiarizing teachers with the activities and materials in the module is an essential step in preparing teachers to implement a module. Based on HRI's observations, the trainings appeared to be very successful at orienting teachers to the materials in the modules they would be using, as well as the mechanics of implementing the various investigations in their classrooms.

The sessions typically started by having the participants walk through the various sections of the teacher's manual, gaining an overview of what was addressed in the module. The teachers then experienced most of the student activities first hand. This design allowed participants to become familiar with the set up and use of materials, as well as the structure and flow of the lessons. Tips for facilitating the use of the module with students were also provided by the facilitators, and in some cases by other participants who had experience with the module. These tips included suggestions for preparing the materials needed to conduct the investigations, efficiently distributing materials to students, and simplifying journaling for beginning writers in early primary grades.

Although the Initial Module Trainings provided a great deal of opportunity for teachers to learn how to set up and conduct the activities in their classrooms, there was less opportunity for them to learn how to debrief the findings from activities and help students draw appropriate conclusions. When sessions did focus on this aspect, the quality was typically good. In these sessions, facilitators modeled and then explicitly discussed with participants how to debrief module activities with students. For example, in an *Ecosystems* session, participants shared their thoughts on what constitutes an ecosystem after completing a student activity. The facilitator modeled how to take the various ideas and put them together to generate a definition for an ecosystem. The facilitator then explicitly pointed out that this collaborative approach for developing vocabulary was a good strategy to use in their classrooms to help students make meaning from their experiences and not just memorize the definition.

Similarly, in a training on the *Mixtures and Solutions* module, the facilitators explicitly discussed how to help students make sense of conflicting data. As the observer described:

> Participants were provided a "mystery chemical" (Epsom salts) to identify, and a data sheet showing various properties of six different substances. Groups wrote out a plan to identify the chemical, implemented their plan, and then reported their results to the large group. The groups noticed a great deal of variation in their results; for example the mass of the mystery chemical needed to saturate 50mL of water ranged from 34 to 46 grams. The facilitators helped participants consider how they could carry out a discussion in their own classrooms when students reported conflicting results. In particular, they discussed appropriate questions to ask students such as, "What might have affected the results?" and the importance of placing some responsibility on the students for searching for possible answers, instead of providing students with the "correct" results.

However, it was more typical in the observed sessions for facilitators, after having participants conduct a hands-on activity, to tell them to think about how they would wrap up lessons with their own students and then immediately move on to the next activity. In these cases, the facilitators neither provided an opportunity for the participants to make sense of the science content as adult learners nor allowed participants to consider how they could help students make sense of the ideas. The facilitators often said things like, "Students should now reflect and write a conclusion in their notebooks," or "Now you would have them [students] look at the focus question and write an answer to it," but did not model or discuss how to carry out the suggestions. Facilitators appeared to understand the importance of reflection and sense-making, as was evidenced by their frequent reference to them during the trainings, but there was rarely adequate time provided for these components. For example:

> During a two-day training on the *Chemical Tests* module, participants engaged with learning how to implement the module activities by working through them as students. At the conclusion of each student activity, the facilitator provided implementation suggestions, such as labeling spoons to match the labels on the bottles of unknown solids to prevent cross-contamination and conducting the lesson on crystals on a Friday to allow evaporation to occur over a weekend. During these discussions, the facilitator also encouraged participants to reflect on their understanding of how to implement the materials and seek clarification, if needed, on any areas of confusion. Comments from the facilitator included, "I want you to reflect as a teacher…How would you run this in your classroom? What types of questions could you ask to guide the discussion?" and "Step back and think as if you were reviewing this with your students. What could you do to get them to reflect on the key ideas related to suspensions and solutions?" Although these prompts from the facilitator would likely lead to useful thoughts on the part of the teachers, the participants were not provided with workshop time to reflect and respond to these prompts. Instead, the facilitator moved onto the next student lesson within a minute or two of posing these questions; teachers were neither given the time to reflect individually nor asked to share their ideas with the group at large.

Overall, familiarizing teachers with the activities in the module, and providing them with practical teacher tips, were strengths of the Initial Module Training sessions. The program should consider ways to ensure that all sessions provide both the structure and the time for teachers to reflect on how to implement all aspects of the activities, including the sense-making/wrap up portions of the lessons.

- *Deepening teachers' understanding of the targeted science content in the module*

Purposeful implementation requires teachers to have a solid understanding of the science content addressed by the module. In order to achieve this understanding, just like students, teachers must be intellectually engaged with the targeted science content and have opportunities to make sense of the content.

The Initial Module Trainings used a number of strategies to engage teachers with the science ideas in the module. One successful strategy was having teachers engage with the targeted science content by completing the module activities as if they were students. Another good strategy was the use of focus questions at the beginning of activities provide participants with a purpose for the lessons. These focus questions helped to ensure that teachers were intellectually engaged with the targeted content as well as the mechanics of the module activities they completed. For example, the focus questions for an investigation in the *Water* module were: (1) "Does water always flow downhill?" and (2) "How does changing the slope or quantity of water change the speed at which it flows downhill?" These questions were directly linked to the activity involving manipulating the angle of the slope of a ramp on which water was dropped, as well as the amount of water running down the slope.

However, in several sessions, the facilitators short-circuited participants' intellectual engagement with the targeted science ideas by telling them what should be learned from the activity before they had the opportunity to analyze their data and think about the science ideas in the activity. For example:

> The participants in an Initial Module Training on the *Electric Circuits* module completed a lesson in which they tried to light a bulb with a battery and wire. The targeted concept to be learned from this lesson was that a complete circuit includes an energy source and allows electric current to flow only if it has a complete loop through which it can pass. As the participants were collecting data on which arrangements of the materials would and would not light the bulb, the facilitator told the participants, "The wire has to be touching the bulb on the bottom and side." By giving the participants the answer before they finished the activity and had an opportunity to draw conclusions from their data, the facilitator rather than the teachers did the intellectual work.

Furthermore, in order for teachers to learn the targeted science ideas, the science content they engage with must be accurate. In most of the sessions, the science content teachers were engaged with was accurate; however, a few observed trainings included content inaccuracies that hindered participants' ability to learn the science concepts. For example, in a number of observed sessions of the *Electric Circuits* module training, the term "electricity" itself was not clearly defined and it was often used interchangeably for "electric current" and "electric energy." Although these terms may appear similar, they represent very different scientific phenomena. In another case, the facilitator of a *Motion and Design* training defined inertia as, "an invisible force that keeps your momentum going." This statement is problematic for a number of reasons. First, inertia is not a force. Second, this statement implies that a force is required to maintain motion. Both the definition of a force and the effect of a force on motion are ideas that students have difficulty learning, and research has shown that students (and adults) have misconceptions about these ideas that are very resistant to change. By not being careful with their language, the facilitators decreased the likelihood that the teachers would develop the correct scientific understanding themselves, much less be able to help students learn those ideas.

In addition to being intellectually engaged with the targeted science concepts, learners need opportunities to make sense of those concepts in order to develop a sound understanding. Opportunities for participants to reflect on the meanings of the activities were inconsistent in the observed sessions. In some cases, participants were provided structured time to discuss and reflect on the science concepts targeted by the module activities. For example, in a *Levers and Pulleys* session the participants applied what they had learned about levers in a new context in order to deepen their understanding of the various classes of levers:

> During a module activity, the participants had a group discussion regarding how the human arm can be classified as a lever. After the facilitators explained the types of levers the arm can act as, teachers provided their own examples of instances where the arm would be classified each way. For example, one participant said that the arm would be a Class-1 lever when throwing a javelin and the explanation for this classification agreed with the targeted concept that a class-1 lever has the fulcrum between the load and the effort. Another explained that the arm would be classified as a Class-3 lever when throwing a discus with the explanation supporting the idea that a class-3 lever has the effort between the fulcrum and the load.

Focus questions, used to engage students with the activities, were also often used as reflection questions at the end of the activities to help the teachers make meaning of the activities. Sometimes the dual use of these questions worked well. For example, the focus questions described previously for an investigation in the *Water* module (i.e., "Does water always flow downhill?" and "How does changing the slope or quantity of water change the speed at which it flows downhill?") directly asked about the science ideas to be learned. By revisiting these questions at the end of the activity, the participants were helped to make sense of the targeted concepts: (1) water flows downhill; (2) larger amounts of water flow more quickly; and (3) increasing the slope over which water flows makes it flow more quickly.

In other cases, the focus questions related to the procedures of the activity, rather than the science idea. For example, in one observed session the focus question for a lesson in the *Rocks and Minerals* module was: "How can we use simple tools to determine how much light passes through a mineral?" This question was also used as the reflection question, and participants' responses centered on the mechanics of using a light pen to look through a mineral rather than the more important idea of how scientists could use the way light passed through a mineral to help identify it. Especially if the SIE program wants to use the same prompts as both focus and reflection questions, it will be important to ensure that the prompts be about the targeted science ideas, rather than the mechanics of an investigation. Otherwise, the professional development facilitators should be provided with separate reflection questions for helping participants make sense of the science content.

The lack of sense making about the science ideas in an activity was fairly common in the observed sessions. In many cases, after participants did the activities from the module, the facilitators simply moved on to the next activity. Often, the facilitators told teachers that it was important that they help students reflect on the science, indicating they were aware of the importance of sense-making, but they typically did not take the time to make sure that the teachers understood the science. In cases where the facilitators did lead a post-activity discussion, the conversation was often centered on the mechanics of implementing the activity in the classroom rather than on the science content. Addressing participants' concerns about implementation is a necessary and important component of the training; however it needs to be done in addition to, not instead of, helping teachers make sense of the science.

➢ *Preparing teachers to use instructional strategies that support module implementation*

Another goal of the Initial Module Trainings was to prepare teachers to use specific pedagogical strategies to implement the modules effectively. Understanding what strategies to use, as well as when and why to use each of those strategies, will help teachers implement the modules in a purposeful manner.

Overall, the trainings appear to have provided teachers with many opportunities to learn the instructional strategies that will help them implement the module. For example, every observed session included explicit discussions on how to set up and use science notebooks, an important way to integrate literacy skills into science teaching. Participants both kept their own science notebooks and participated in discussions on using various notebooking strategies with their students. In some sessions, facilitators shared questions teachers could ask students to probe their understanding, for example, "How did you get that result?" and "Why do you think that is true?"

Although many strategies were shared, observers rarely saw discussions of when a strategy should be used, or why a particular strategy would be appropriate in a given situation. For example, while "power conclusions" were discussed in several observed sessions, it was not made clear to participants when a power conclusion should be used, i.e., at the end of a series of lessons, not at the conclusion of the intermediate lessons. For more purposeful use of instructional strategies, SIE should introduce strategies on a "need to know" or "just in time" basis and be explicit about the purpose of the strategy (e.g., this strategy is a way to help students make sense of the content, this strategy is useful in eliciting students' initial ideas).

Overall, the Initial Module Trainings appeared to be providing the participants with ample experiences to engage them with the set up and implementation of the module activities, the content within the modules, and instructional strategies to facilitate science instruction. The elements of effective professional development were present in sessions; however the time dedicated to and quality of the reflection on what science is being taught through the module activities and how to best help students understand that science were inconsistent. Participants in SIE professional development would benefit from the facilitators incorporating explicit reflection on the teaching and learning of the targeted science ideas into the sessions.

One effective strategy to structure reflection for participants, which has been used in some SIE sessions, is the "learner hat/teacher hat" approach. This strategy consists of teachers first engaging in a module activity from the student perspective, including providing opportunities to make sense of the science content, and then discussing the design and facilitation of the activity from the teacher perspective. The use of this method creates a structure to, and expectations for, professional development that increases the likelihood that all goals will be addressed adequately, and that the science content will not get lost. Although some SIE sessions have employed this strategy to some degree, the program would benefit from the use of this strategy in a more formal and consistent manner. Following is an example of a *Levers and Pulley* training session where this strategy was used:

> Before engaging participants with any of the module activities one facilitator made the follow remarks regarding the two perspectives that participants would be taking during the training:
>
> Facilitator: "You are going to be wearing two different hats today, teacher hat and adult learner, not a 5th or 6th grade learner. [Later when starting with the first investigation] Let's close our manual and put on our adult learner hat."
>
> Throughout the two-day session, participants would complete student activities as learners focusing on understanding the science content, then talk about teaching tips, and on occasion instructional strategies or what concepts were being covered, from the teacher's point of view. The facilitators were explicit about when the participants were switching between their role as learner and as teacher. For example, one facilitator addressed the group by saying, "We are going to go through some power point slides with some content…It is always good when the teacher knows more about what they are teaching than the students…This is not something you would share with you students…Once again this is knowledge for you, not your students."

Using the learner hat/teacher hat approach has implications for time allotments during a session. Using this approach requires facilitators to go slower through individual module activities, spending time both modeling lessons (learner hat) and debriefing lessons (teacher hat). Consequently, facilitators may not be able to cover all lessons in a module using this approach in a two-day session.

Given that not all lessons may be covered during the two-days, the trainings might be structured so that this approach is used only for selected lessons, i.e., those that cover science ideas that are particularly challenging and/or important, and those that are the most difficult to implement from a logistics standpoint. For other lessons, facilitators would go faster, perhaps simply describing the lesson briefly or asking participants to review it on their own (e.g., in the evening after the first day). If SIE decides to take this approach, it will be important that a plan for the Initial Module Training for each module be developed that makes optimal use of the available time.

Lastly, in some sessions, facilitators dealt with science content beyond the student level, though they did not always make a clear distinction between what content was meant for students and what content was meant only for the participants. Moreover, in a few instances, teachers were encouraged to share age-inappropriate content information with students. For example, a facilitator leading a *Water* module training used a PowerPoint presentation to describe the molecular properties of water. The facilitator noted that the module did not teach the molecular structure of water and suggested that the teachers use supplemental activities and PowerPoint slides to illustrate the structure and arrangement of water molecules in each different phase of matter. However, an understanding of molecules and their structure is not part of the 4th grade standards in Pennsylvania, and is likely developmentally inappropriate for students who would be receiving instruction with this module. It will be important for the program to make sure that all the facilitators point out to participants what content information is for their own benefit and what is appropriate for students.

Module Enrichment Trainings

Cohort 1 teachers were offered a two-day Module Enrichment Training on their initial module. The Module Enrichment workshops are intended to move teachers further along the continuum from mechanical to purposeful implementation of the SIE-supported modules by deepening teachers' understanding of the science content, the content storyline, and pedagogical content knowledge related to their module. The Module Enrichment workshops were offered for the first time during the 2007−08 school year, and about half of Cohort 1 teachers eligible to attend a Module Enrichment Training did so. The remaining Cohort 1 teachers were invited to attend the Module Enrichment Trainings this year; HRI received completed post-professional development questionnaires from 83 participants.

This section of the report describes the quality of the SIE Module Enrichment professional development using data from teacher questionnaires and teacher interviews. HRI did not observe any Module Enrichment sessions this year given the timing of the sessions and the program's decision to focus observation efforts on the Initial Module Trainings.

Teachers' Needs and Expectations

Six out of the 10 interviewed Cohort 1 teachers had attended a Module Enrichment Training. When asked what they had hoped to get out of the training, these teachers had varying expectations. Several said they had hoped to have time to debrief and share their own experiences with the module; others did not know what to expect; and one wanted implementation tips to improve their use of the module.

The fact that teachers did not have a clear understanding of the purpose of the Module Enrichment Trainings may explain the relatively low attendance at these sessions, as teachers are not aware of what the value added of attending would be. The program may want to consider ways to clarify and communicate the goals of the Module Enrichment Trainings.

Teachers' Perceptions of the Quality of the Module Enrichment Trainings

A majority of participating teachers expressed positive opinions about the Module Enrichment Trainings on a post-professional development questionnaire administered at the end of each training. Responses were similar to those from teachers who had attended the Initial Module Trainings. For example, nearly all thought that facilitators were well prepared, encouraged active participation, shared tips for implementing the module, and adequately addressed questions about the content in the modules. (See Table 9.)

Table 9
Teacher Opinions of the Quality
of SIE Module Enrichment Professional Development

	Percent of Responding Teachers Agreeing† (N = 83)
The facilitators were well prepared.	99
The facilitators encouraged active participation and investigation by all participants.	98
The facilitators shared tips and suggestions for successfully implementing the module.	98
Question about the science content in the module were adequately addressed by the facilitators.	98
This workshop reflected careful planning and organization.	98
The goals of this workshop were clear.	96
There were opportunities for participants to express their views and collaborate with peers.	96
Adequate, time, structure, and guidance were provided for participants to discuss the SIE modules and pedagogical strategies with each other.	95
Adequate time, structure, and guidance were provided for participants to reflect individually on the substance of this workshop.	95
The facilitators explicitly discussed how, when and why to use different teaching strategies.	95
The facilitators modeled effective teaching strategies.	95
This workshop was relevant to my classroom instruction.	95
The various components of this workshop were useful in meeting its goals.	94
This workshop increased my understanding of the science content in the module.	93
This workshop prepared me to use the teaching strategies promoted by SIE.	93
This workshop increased my confidence in my ability to teach using the SIE module.	89
This workshop familiarized me with the activities and materials in the module.	87
I would recommend this professional development to a colleague.	85
This workshop was worth the time that I invested.	84

† Includes those indicating "Agree" and "Strongly Agree" on a five-point scale of 1 "Strongly Disagree" to 5 "Strongly Agree."

A majority of teachers found the pace of the sessions to be appropriate; although 1 in 5 thought the pace of the workshop was too slow. (See Table 10.)

Table 10
Teacher Opinions of the Pace of SIE Module Enrichment Trainings

	Percent of Responding Teachers (N = 83)
Much too slow	2
Somewhat too slow	18
Appropriate	75
Somewhat too fast	1
Much too fast	4

Teachers were asked which aspects of the training were most effective. The most frequent response to this open-ended question, given by 38 percent of respondents, was the opportunity to share their experiences and ideas for implementing the module. One-quarter of the respondents noted that the discussions of the big ideas and concepts students should learn in the modules were very helpful. Other fairly common responses highlighted the quality of the facilitation, the deepening of their content knowledge, and the instructional strategies learned.

Interviews with participants illustrate these findings. In the words of four attendees:

> *The instructors gave me many useful ideas and tips which will enable me to do a much better job teaching [the module]. My use of the notebook was also enhanced. This workshop was very valuable in explaining [content of module].*

> *What we really, really liked about the enrichment was being able to talk to other teachers in other schools and finding out the ways they did the modules that worked. We got more ideas. We shared ideas.*

> *Finding out (determining) the big ideas and learning goals that I need to be sure my students understand is a very valuable bit of information! Focus questions (shared from a peer) were very helpful. The presenters also had us use several strategies that we can now use with our classes.*

> *I really liked the clarification of the "big ideas" in the module. It will also be helpful to have a better understanding of exactly what the students are to get from each lesson. I have to admit that I have skipped lessons before. Now, I realize the importance of them all and how they relate to each other.*

Participants were also asked to reflect on aspects of the workshop that they thought could be improved upon. More than half of the respondents (54 percent) indicated that they did not think the workshop needed any improvement. Of the suggestions for improvement that were offered, the most common, each given by 21 percent of the respondents, were to spend more time sharing implementation tips and debriefing the use of the modules. For example:

> *More time with peers to share tools, tips, materials that enrich the module, i.e. encourage participants to bring samples and enrichment materials.*

Build time into the workshop for us to talk about what we did with the modules and share how to solve situations, problems that come up. Some others might have come up with a good way to handle things like how to get all the materials to 30 kids and do the experiments in a short time. I wanted to hear more from others.

Teachers also suggested, both on the questionnaire and in interviews, that the Module Enrichment sessions could eliminate activities that were redundant with the Initial Module Training. In the words of two teachers:

This workshop was just a review. It definitely needs to be more challenging. We need to share ideas with each other, not review. This is enrichment not the first workshop!

We basically did the same thing over again…If that second one would be not so much of a repetition, but add more to what you are learning, it would be better.

Cohort 1 and 2 teachers were asked in interviews if they planned on attending a Module Enrichment Training the next time they are offered, and, if so, what they hoped to gain from that training. Most indicated they would attend when these trainings were next offered, indicating that they hoped to learn implementation tips on how to better use the modules. Of those teachers indicating they would not attend, travel logistics was the primary reason.

THE ASSET LEADERSHIP CONFERENCE

In an effort to accommodate the growing number of participants in the SIE program, and to bolster school-level support for the program and elementary science education improvement more broadly, SIE is developing a cadre of teacher leaders. The program aims to develop these teachers for two purposes: (1) to serve as facilitators of SIE Initial Module Training; and (2) to be advocates for science education reform in their local settings. The main venue for accomplishing these goals is the ASSET Leadership Conferences (ALC). This section of the report is based on HRI's observations of the three-day ALC held in April 2009; it focuses on the quality of the teacher leaders' professional development experience for each purpose.

Development of Teacher Leaders: Facilitators of Initial Module Training

ASSET values teachers teaching teachers, and as SIE continues to expand to more schools across the state, the plan is to develop a subset of SIE teachers as facilitators of Initial Module Training. These teacher leaders have participated in SIE-provided professional development and they have implemented at least one module in their own classroom. The teacher leaders have also observed Initial Module Trainings from the leader perspective, and in some cases have already helped co-facilitate sessions with ASSET staff.

In thinking about the development of teachers as facilitators of Initial Module Training, it is helpful to consider what knowledge and skills are needed for this task. Figure 5 shows what HRI believes teacher leaders need to know and be able to do to be successful in this role. The essential components needed for purposeful facilitation of an Initial Module Training are the same as those required for purposeful implementation of a module, with the focus being the content and activities of a workshop rather than a module.

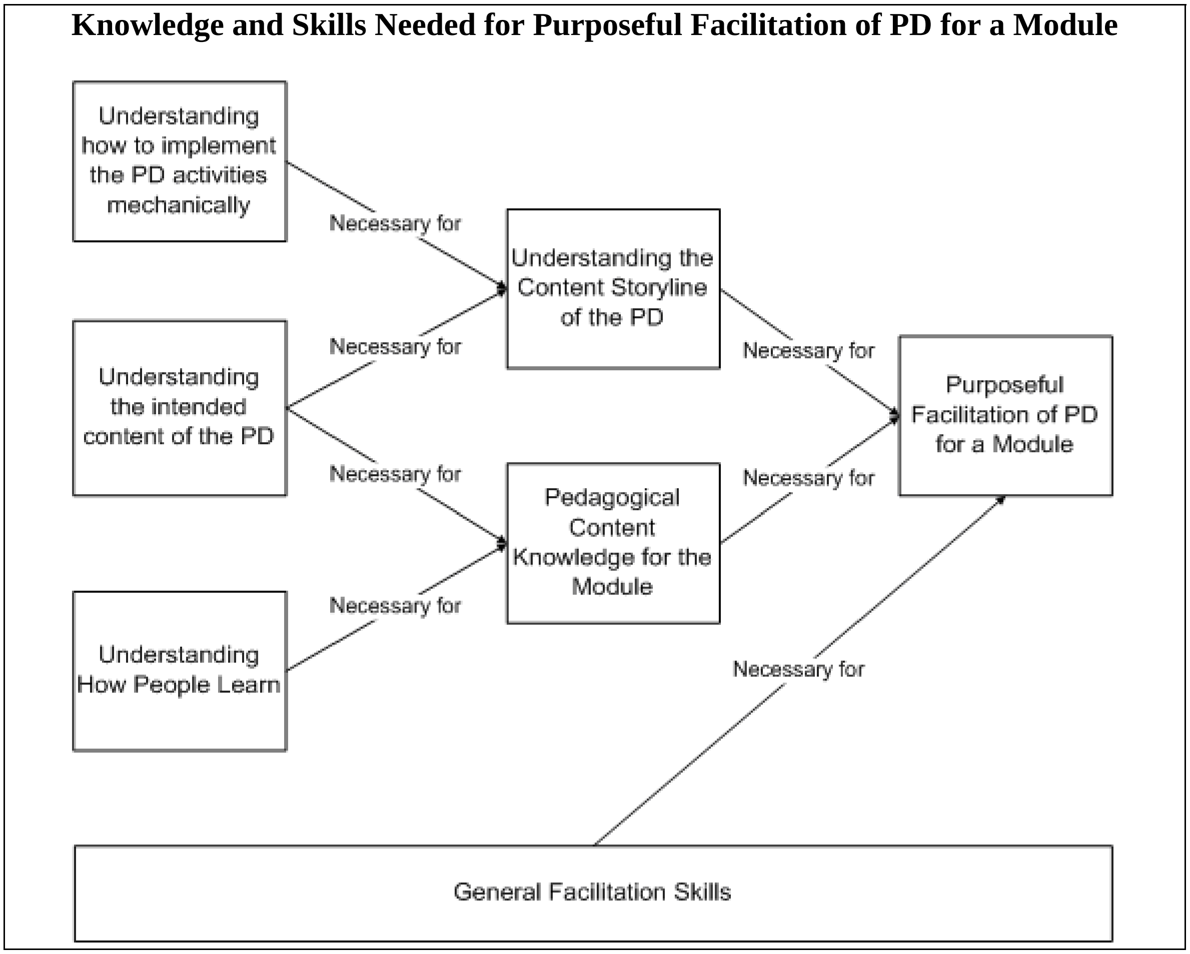


Figure 5

At the 2009 ALC, ASSET devoted a day to piloting the revised Foundations course. The new Foundations course focuses on the elements of effective science instruction:[12] motivation, eliciting students' prior knowledge, intellectual engagement, use of evidence to critique claims, and sense-making. Having the teacher leaders experience this revised course helped orient them to SIE's vision and deepened their own understanding of the elements of effective science instruction.

The revised Foundations course also emphasized the importance of science content in a number of ways. The *Minds of Our Own* video clips illustrated that simply doing hands-on activities is not sufficient to develop students' understanding of important science concepts. This idea came up again later in the session, during the electromagnet investigation. As the group was discussing the discrepancies in the data they had collected, one teacher leader asked, "Does it matter who's right as long as [students] support their claims with evidence and are being problem solvers?" The facilitators took advantage of this opportunity to point out that one

[12] Banilower, E., Cohen, K., Pasley, J. & Weiss, I. (2008) *Effective science instruction: What does research tell us?* Portsmouth, NH: RMC Research Corporation, Center on Instruction.

reason for having students make their claims and evidence public is so discrepancies in data collection can be resolved. The facilitators noted that, "You can't just let [the discrepancies] go. You've got to get the right answer," explaining that the investigation lays the foundation for learning additional concepts in subsequent lessons. The message was clear: content matters.

A logical next step for the SIE program is to make sure that all teacher leaders have the knowledge and tools needed to keep the focus of the sessions they lead on the science content. Encouraging the teacher leaders to attend the Module Enrichment Training was a smart move, as engaging them with the content storyline of their module would also help ensure a consistent focus on the science content in the Initial Module Trainings. Another resource SIE may want to make available to teacher leaders is a series of books published by NSTA entitled *Stop Faking It!* These books offer an accessible overview of the key concepts related to a variety of science topics.

The ALC also provided teacher leaders with an opportunity to reflect on how the design of the Initial Module Training incorporates the elements of effective science instruction. The grade-level groups had rich discussions, with facilitators asking probing questions that encouraged teacher leaders to apply their new knowledge of the elements of effective science instruction to analyze the design of the Initial Module Training. For example, the importance of sense-making about both the content in the module and the content storyline of the module were discussed.

This activity provided a good opportunity for teacher leaders to start thinking about the implications of what is known about effective science instruction for their work as professional development facilitators. However, the teacher leaders have varied backgrounds (in terms of science content knowledge, teaching experience, and extent to which they have progressed from mechanical to purposeful implementation of the modules in their own classrooms) and therefore will need different kinds and amounts of assistance. One way to help support the teacher leaders and increase the quality and consistency of the Initial Module Trainings would be to update the facilitation guides previously created to include detailed information about how and when to highlight the elements of effective instruction. These updates could include:

- Providing a suggested agenda, including time estimates for each portion of the training;

- Making it explicit when teachers should be experiencing the module training activities as learners much like their students will be doing (i.e., "learner hat"), and when teachers should be reflecting on the training activities as teachers, considering the implications for their implementation of the module (i.e., "teacher hat");

- Providing a rationale for design decisions (e.g., Do Lesson 3 with teachers from start to finish because it is logistically challenging and the sense-making is essential to the success of the subsequent lessons.);

- Highlighting the science content students are intended to learn as a result of each lesson; and

- Indicating which lessons would be good candidates for discussing the elements of effective instruction with participants, including a description of why each of those lessons would be a good choice.

Another major component of the ALC was the introduction of the "conversation tool." Recognizing the importance of ongoing leadership development and the need to support teacher leaders in their facilitation of Initial Module Trainings, SIE has developed a strategy for on-site support in which a facilitation coach will observe these trainings and provide feedback using this tool. The tool guides both the coach's observation and the subsequent discussion, and focuses on four components of facilitation: ease in working with adult learners; ease in working as a team member/co-facilitator; competency with pedagogy and module delivery; and positive attitude about science.

The teacher leaders were introduced to this tool through the use of a "fishbowl," in which the ASSET staff who led the Foundations course sat in the center of the room and were debriefed by another staff member, modeling for the teacher leaders how the tool would be used. During this session, the ASSET staff emphasized that the tool was to help them continuously improve their work and that it was non-evaluative. The way the tool was introduced helped put teacher leaders at ease and established a culture of being reflective practitioners.

This strategy has strong potential for helping further develop the knowledge and skills of the teacher leaders. In addition, it provides a mechanism for the program to monitor the quality of Initial Module Trainings. If the program decides to update its facilitator guides for the Initial Module Trainings, the conversation tool could also be used to further the teacher leaders' understanding of the design rationale for these sessions.

Overall, the ALC appears to have been successful at pushing the teacher leaders to take on the role of facilitator and increasing their comfort with switching from "teacher hat" to "facilitator hat." The conversation tool activity, in particular, highlighted the importance of thinking about design decisions, general facilitation moves, and working with a co-facilitator. For example, the debriefing pointed to ways to curb sidebar conversations during a training while still honoring participants' contributions to discussions. It also provided guidance on what to discuss with a co-facilitator prior to implementing a training together (e.g., discussing whether you are comfortable with the co-facilitator jumping in during your facilitation).

Teacher leaders were also encouraged to think as facilitators when they were asked to identify the ways in which the elements of effective instruction could be highlighted for teachers in the Initial Module Training. The facilitator of one small group noted, "We tend to go right back to the classroom because it's about the students, but we're going to try to stay in the facilitator role [during this discussion]." This task forced participants to set aside their "teacher hat" and take on the perspective of a facilitator, thinking about how to engage teachers with important ideas about teaching and learning.

Development of Teacher Leaders: Leaders of Science Education Reform in Their Districts

In addition to preparing teacher leaders for their role as facilitators of Initial Module Trainings, the ALC focused on strengthening the participants' leadership skills so they could act as advocates for science education improvement in their schools and districts. For this goal, the ALC had two main objectives:

1. Helping the teacher leaders understand the different ways leadership can be exhibited; and
2. Deepening teacher leaders' understanding of factors that affect system-wide science education improvement.

Helping the teacher leaders understand the different ways leadership can be exhibited was addressed in a number of ways throughout the conference: the presentation and discussion of attributes of famous leaders; the administration and discussion of results of a survey designed to assess the teachers' natural leadership qualities; and the sharing of leadership successes teacher leaders have had at their schools.

These activities appeared to be successful at helping the teacher leaders understand that there are different styles of leadership, and that leadership can occur on different scales (e.g., leadership can be exhibited in a school, district, state, or nation). The ALC also appeared successful at alleviating the teacher leaders' concerns about their own leadership roles, helping them understand that they could contribute leadership in a number of different ways. In particular, the presentations by some of the more experienced teacher leaders as to how they have worked to improve science education beyond their own classrooms gave their colleagues an opportunity to see how small steps can affect change.

The SIE program may want to consider ways to foster ongoing dialogue among the teacher leaders, both for the sharing of ideas for improving science education and to provide a support network among the teacher leaders. By sharing concerns and successes, the teacher leaders will continue to grow in their ability to act as science advocates in their schools and districts. One possibility is to hold a series of face-to-face meetings to allow for this cross-pollination of ideas. Another possibility is to utilize a web-based tool (e.g., listserv, discussion board). There are pros and cons to both approaches; for example the face-to-face meetings are more costly, while it can be difficult to sustain the conversation with a web-based approach given how busy teachers leaders are. Regardless of the mode, on-going discussion and support would likely be useful to the teacher leaders.

The main activity for deepening teacher leaders' understanding of factors that affect system-wide science education improvement was the Building Systems for Quality Teaching and Learning in Science game. Nearly the entire second day of the ALC was devoted to this game, with about equal amounts of time spent playing and discussing the game. During the game, groups of teacher leaders attempted to guide a fictional school, and its faculty, through the process of improving its science program. The teacher leaders had to consider issues such as the alignment of standards, curriculum, assessments, and instructional materials; building a common vision for the school's science program; the professional development needs of teachers; garnering support of stakeholders; and dealing with people resistant to change. The groups could spend resources to engage the teachers and administrators at the school in different types of activities (e.g., workshops on science content, observing each others' classes, examining results from science assessments). The game was "won" when all of the teachers in the fictional school were brought on board and had reached a sufficient level of expertise.

Overall, this game was very engaging to the teacher leaders. It raised a number of critical issues regarding the process of school-wide change, and provided a simulation environment in which the teacher leaders could try different strategies and observe the results. However, a number of the teacher leaders pointed out that they are not in a position in their schools to make the types of decisions involved in the game. Consequently, these teacher leaders struggled to see the relevance of the game. The game may have been more effective for these teacher leaders if their school principals had been involved.

Another issue that arose was the competitiveness of the game. On the one hand, a healthy rivalry among the groups can help keep them focused and on-task. On the other hand, an overcharged race to the end can result in the messages being lost. Because the game allowed each team plenty of "resources" for their school, teams were able to simply try different combinations of activities quickly until they hit upon one that worked without being as thoughtful and deliberate as one needs to be when attempting to enact change in a real school. Finding the right balance is tricky, and may be different for different groups of participants. The program's decision to stop the game process at different points and reflect on the issues was a good one, as it allowed the facilitators to re-direct participants as necessary. Doing so also allowed the facilitators to highlight and reinforce the key messages of the game.

A next step the program may want to consider is providing the teacher leaders with tools that they can use to begin implementing what they learned from the game at their schools, much like the way the program supports schools in implementing the Showcase of Student Learning. Providing such tools would, if the tools were well designed, increase the likelihood that the teacher leaders will be successful advocates for science education improvement in their schools and districts.

IMPACT OF SIE ON TEACHERS AND TEACHING

This section of the report focuses on how the SIE program has impacted teachers, including their preparedness to use their SIE-provided module and their classroom teaching. Data come from teacher and principal questionnaires and interviews, as well as classroom observations of module implementation.

Teacher Preparedness

One of the primary goals of the SIE program is to prepare teachers to use the SIE-provided modules. All interviewed teachers, across all cohorts, shared that they felt well prepared to teach the modules in their classrooms as a result of participating in the SIE professional development. As two teachers said:

> *I felt ready to go. [The SIE professional development] made me feel comfortable and at ease with what to teach.*

> *[The professional development] lets you know just what materials you are going to need so you have a chance to get everything ready, and in the training they let you know, "This is what you need," and "This is what is in the kit."*

In addition to feeling comfortable with the materials and activities in the modules, teachers need to know how to enact the pedagogical approaches promoted by the program. The post-professional development questionnaire included a series of items aimed at assessing teachers' perceptions of their preparedness to use the teaching strategies promoted by SIE (e.g., the inquiry-based teaching strategies embedded in the SIE module, science notebooks, a learning cycle). To assess impacts, teachers were asked about both their current preparedness and their preparedness prior to the professional development session. This "retrospective pre" approach is useful when respondents are likely to change their perceptions of initial knowledge/preparedness as they learn more about the topic (i.e., they didn't realize how much/little they knew about a topic until after their participation in the program).

Responses to these items were combined into a composite variable (called "perceptions of pedagogical preparedness") to reduce the unreliability associated with individual survey items.[13] Each composite has a minimum possible score of 0 and a maximum possible score of 100. A score of 0 would indicate that a teacher selected the lowest response option for each item in the composite, whereas a score of 100 would indicate that a teacher selected the highest response option for each item.

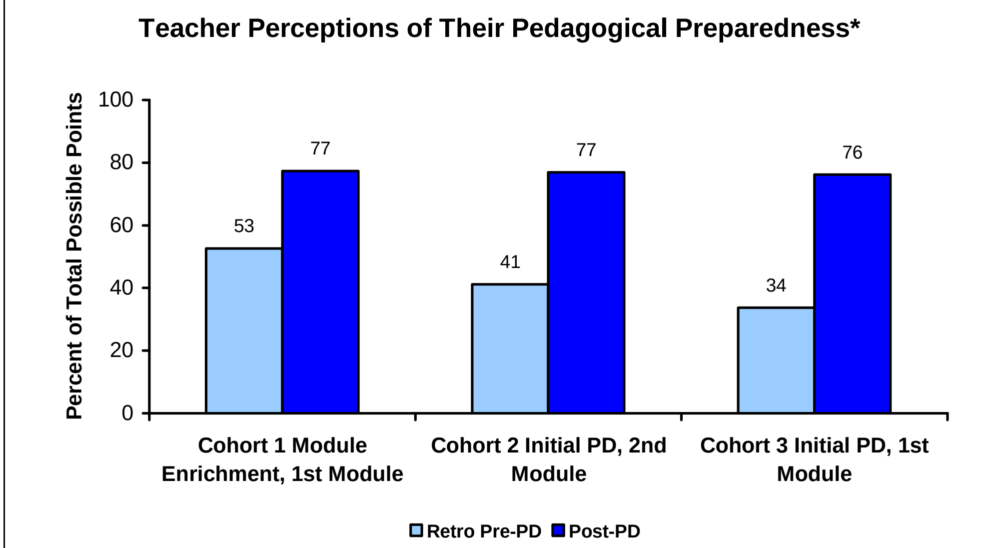
These longitudinal data have a nested structure, with time points nested within individual teachers. Statistical techniques that do not account for such nested data structures can lead to

[13] Definitions of this and other composites described in this report, a description of how the composites were created, and reliability information are included in Appendix B.

incorrect estimates of the relationship between independent factors and the outcome. Hierarchical regression modeling[14] is an appropriate technique for analyzing nested data and was used to examine trends in teachers' composite scores.

Across all workshop types, there were significant increases in teachers' perceptions of their pedagogical preparedness. (See Figure 6.) The mean composite scores for Cohort 1 teachers attending a Module Enrichment Training for their first module increased from 53 to 77, a large effect of 1.21 standard deviations. Similarly, scores of Cohort 2 teachers who attended an Initial Module Training for their second module increased from a mean of 41 to a mean of 77, a very large effect of 1.75 standard deviations. Cohort 3 teachers' scores increased from 34 points to 76 points as a result of the Initial Module Training; this 42-point increase corresponds to a very large effect of 2.09 standard deviations.

The difference in retrospective pre scores among the three cohorts is likely due to the fact that Cohort 1 and 2 teachers have been in the program longer and have attended trainings in previous years. Despite the differences in pre-workshop scores, teachers' perceptions of pedagogical preparedness after attending their respective workshops, across all cohorts, were very similar.



* Teacher scores changed significantly over time, $p < 0.05$ (HLM)

Figure 6

The post-professional development questionnaire also asked teachers about their understanding of the student learning goals in the SIE module, the science content in the SIE module at a deeper level than what students are expected to learn, and ideas (either correct or incorrect) that

[14] Bryk, A.S. & Raudenbush, S.W. (1992). *Hierarchical linear models: Applications and data analysis methods.* Newbury Park, CA: Sage Publications.

students are likely to have about the content prior to instruction. These items were combined into a composite titled "perceptions of pedagogical content knowledge."

The analysis indicates that teachers' perceptions of their pedagogical content knowledge were significantly greater after the SIE professional development. (See *Figure 7*.) Scores for Cohort 1 teachers attending Module Enrichment Training increased over 20 points, a large effect of 1.04 standard deviations. The 27-point increase for Cohort 2 teachers attending their Initial Module Training for their second module corresponds to a large effect of 1.34 standard deviations; the 43-point increase in scores for Cohort 3 teachers corresponds to a very large effect of 2.09 standard deviations.

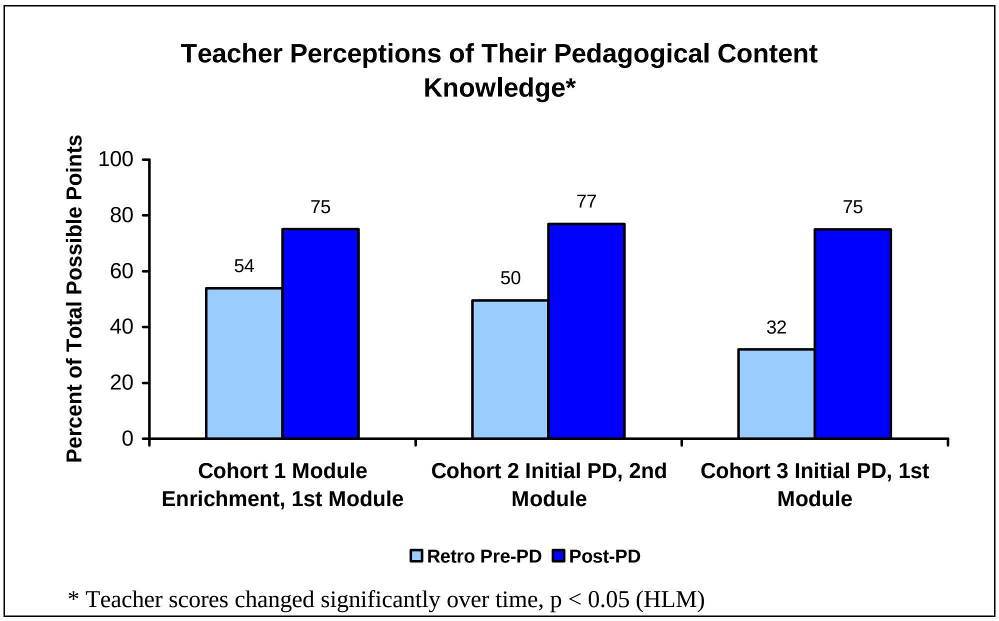


Figure 7

In interviews, teachers indicated that the Initial Module Training helped them understand the science content in their module. In the words of two teachers:

> *It was nice that they went through and could explain the why of some of the experiments, which the teacher's book doesn't really explain. The book is very, very limited at explaining. It was good because the presenters gave us notes to make sure the kids get the big idea of the lesson to get the concept that goes with the activity. It's good to understand the concept they're supposed to be learning.*

> *I definitely came away understanding the concepts quite well and feeling that I was prepared to explain the concepts to the kids.*

Module Implementation

In Year One, SIE offered support for 11 different modules, and in Year Two SIE introduced a second set of 11 modules. During their first year in the program, each cohort selects one module to implement at each grade level. In their second year, each cohort adds a second module. No new modules were added in Year Three.

As part of the student achievement study (described more fully later in this report), teachers complete a "module use" survey that asked them to indicate how much instructional time was devoted to each module they taught, and the extent to which they supplemented the module with other instructional materials. As can be seen in Table 11, teachers are basing substantial portions of their science instruction on the SIE-provided modules, with the average ranging from 83 to 95 percent of their instructional time depending on the grade level and module.[15]

Table 11
Percent of Instructional Time based on Module

	Cohort 1			Cohort 2			Cohort 3†		
	N	Mean	Standard Deviation	N	Mean	Standard Deviation	N	Mean	Standard Deviation
Grade 3									
Chemical Tests	27	95.33	10.36	23	94.13	8.21	—	—	—
Plant Growth and Development	75	85.57	14.77	85	85.32	14.39	—	—	—
Rocks and Minerals	66	91.17	9.31	87	92.41	10.13	17	92.12	12.50
Grade 4									
Electric Circuits	80	92.83	9.36	100	91.77	12.70	16	95.31	6.45
Human Body	34	93.59	9.80	54	83.26	21.75	—	—	—
Grade 5									
Ecosystems	29	88.97	12.40	46	86.59	16.16	—	—	—
Environments	35	88.20	19.99	24	88.96	19.39	—	—	—
Levers and Pulleys	33	89.52	13.90	35	94.51	7.48	—	—	—
Motion and Design	28	90.93	11.55	43	85.35	19.38	20	92.75	12.62
Grade 6									
Experiments with Plants	17	75.24	17.54	13	86.85	16.46	—	—	—
Magnets and Motors	11	92.18	8.68	11	89.09	11.79	—	—	—
Mixtures and Solutions	32	91.47	11.03	18	92.50	12.75	—	—	—
Variables	20	89.95	11.99	24	89.17	18.55	—	—	—

† Cohort 3 teachers had only a subset of modules available to them in their first year in the program. In addition, in order to maintain teacher anonymity, data are not shown for modules that only a small number of teachers implemented.

In interviews, Cohort 1 and 2 teachers who had taught a module at least twice were asked to reflect on how their teaching had changed since the first time they taught a module. All of these interviewees indicated that their use of these modules had changed for the better as preparation for the lessons had become easier. These teachers noted that they were able to set up the

[15] Data were collected about the 13 modules that were a focus of the student achievement study. Of the 22 modules supported by SIE, 6 are for grades K–2 and 3 for grades 3–6 focus mainly on science process skills; these modules were not included in the student achievement study.

activities more quickly and to anticipate issues that might arise during instruction. As three teachers said:

> *It's quicker and easier set up. I know what I need to do for this lesson. I know what works best. Just getting all the supplies ready before we start. It gives me a better time frame and I know how to plan.*
>
> *I know what turned out [well] and what failed and I try to adapt to that. I feel that since I've taught it already, by the third time, I'm not as dependent on my notes. I'm more familiar with it. It becomes easier each time.*
>
> *You are more familiar with it and more on top of it. You understand where it's going and the important aspects. When doing it cold, it's not having the whole view of the total organization of the unit. The second time was much smoother.*

Cohort 1 and 2 teachers also indicated that they had less instructional time to implement the modules this year either because they had to return the module earlier than the previous year and/or because they were carving out instructional time to prepare for the PSSAs. Roughly half of the interviewed teachers said they were still able to cover all the module lessons, but that they spent less time on each lesson. As one teacher stated:

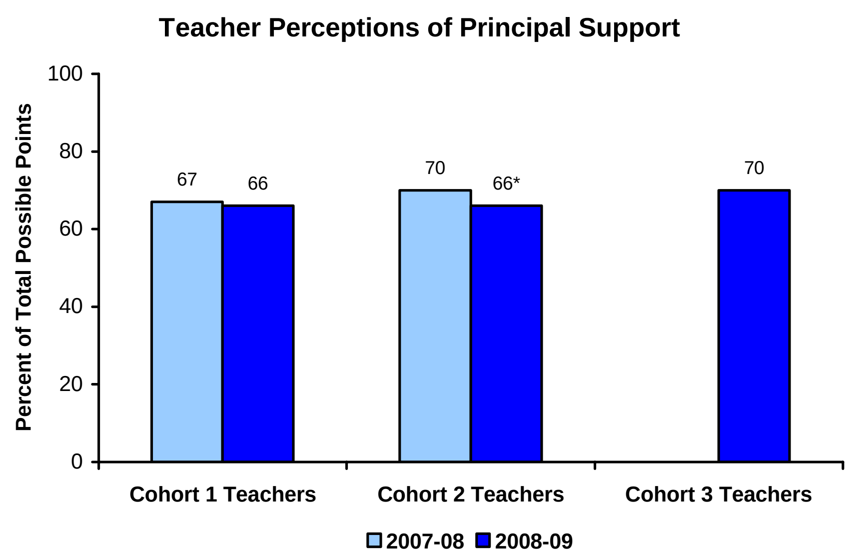
> *We pushed [the module] along quicker this year, because six weeks is a hard time to give up when we have the PSSAs…I really followed the outline they gave me…We covered it all, but did it a little faster.*

The remaining half of the interviewed teachers reported that they ended up covering less of the module because of the time crunch. In the words of two teachers:

> *Well sometimes it's hard to get to all the lessons. They now make us do it in a shorter amount of time. If the kit has to be back in a week, I would know which ones to skip.*
>
> *This year we didn't get to complete [the module] because we ran out of time and had to send it back. If we could have kept the kit longer, I would have finished. It would be nice to have more time with the kits, to not feel rushed.*

The program design calls for schools to incorporate a third science module in their fourth year in the program. In interviews, Cohort 1 teachers were asked about the feasibility of implementing a third module. Teachers' opinions were mixed, with about half saying they would not have enough instructional time to fit another module in and the others saying they would make it work. SIE should consider how it might help teachers manage the implementation of three modules, perhaps by re-examining the module delivery and pick-up schedule, and perhaps by providing suggestions to teachers on which lessons in a module are critical and which can be omitted if they are pressed for time.

One factor that may influence teachers' implementation of the modules is their perceptions of principal support. SIE teachers were asked a series of items on the end-of-year questionnaire about the extent to which their principal supported their science teaching and the SIE program. These items were combined into a composite titled, "perceptions of principal support." As can be seen in Figure 8, scores on this composite were fairly high across the three cohorts, indicating that teachers felt that their principals support their implementation of the SIE program.[16] Cohort 2 teachers' perceptions changed significantly from their first to second year in the program, though the decrease is relatively small (an effect size of 0.24 standard deviations).



*Cohort 2 teachers had significantly different perceptions of principal support in Year Two than in Year One, $p < 0.05$ (Independent samples t-test)

Figure 8

Most interviewed teachers also reported that they felt supported by their administration in implementing the modules. In some cases, this support was in the form of dedicated blocks of time for science instruction being set aside and protected from competing priorities. In other cases, principals provided funds for teachers to purchase materials needed to implement extensions to the module lessons.

Teachers and principals were asked on questionnaires about other factors that may have affected, positively or negatively, teachers' use of the modules. Table 12 and Table 13 show teacher and principal responses to these questions from this and last year.

Nearly all responding teachers and principals in both years thought that the training provided by SIE facilitated the use of the modules. In addition, most respondents indicated that the support of fellow teachers and the SOS facilitated use of the modules. Interestingly, although the SIE program does not have any formal mechanisms for assisting teachers outside of the workshops,

[16] This set of items was added to the end-of-year questionnaire in 2007–08; thus there is no baseline data for Cohort 1 on this factor.

approximately one-quarter of the teachers and more than half of principals indicated that teachers received extra assistance that helped them implement their module. (Teachers' and principals' responses to these questionnaire items disaggregated by cohort can be found in Appendix A.) In addition, the percentage of teachers indicating that their own science background and their SOS facilitated their use of the modules increased significantly from last year to this year, though the changes were fairly small (an effect size[17] of 0.12 for each change).

Table 12
Teacher Opinions of Factors Affecting
Their Use of the SIE-Provided Module, by Year

	Percent of Responding Teachers Agreeing†		Effect Size
	2007–08 (N = 1,748)	2008–09 (N = 1,561)	
Factors Facilitating Use			
The training I received from SIE made it easier for me to use the modules.	95	94	—
Other teachers in my school provided a support system for use of the modules.	86	88	—
My own science background was helpful when I was teaching from the module.*	77	82	0.12
My SOS facilitated my use of the modules.*	73	78	0.12
I received assistance from SIE outside of the workshop that helped me to use the modules.	26	25	—
Factors Inhibiting Use			
The pressures to teach mathematics and/or reading inhibited my use of the modules.	51	51	—
The amount of time required to prepare for instruction with the SIE modules was problematic.*	55	46	-0.18
There was not enough instructional time for science to effectively use the SIE modules.*	52	45	-0.14
I am not able to cover all of the science topics I am supposed to because of the time it took to implement an SIE module.	43	42	—
I did not have the modules for long enough to use as much of them as I wanted to.*	29	41	0.25
The amount of time I was required to be out of the classroom was problematic.*	26	14	-0.30
My lack of experience in science made it more difficult for me to teach from the module.*	15	10	-0.15

† Includes those indicating "Agree" and "Strongly Agree" on a four-point scale of 1 "Strongly Disagree" to 4 "Strongly Agree."
* The percentage of teachers agreeing with statements at the end of the 2008–09 school year was significantly different than at the end of the 2007–08 school year (two-tailed z-test, $p < 0.05$).

[17] When comparing percents, the effect size is calculated using the difference between the arcsine transformation of the percents.

Table 13
Principal Opinions of Factors Affecting
Teacher Implementation of the SIE-Provided Modules, by Year

	Percent of Responding Principals Agreeing[†,‡]	
	2007–08 (N = 93)	**2008–09 (N = 100)**
Factors Facilitating Use		
The training teachers received from SIE made it easier for them to use the modules	99	99
Teachers provided each other with a support system for using the modules	98	96
Our Support on Site (SOS) facilitated teachers' use of the modules	85	93
Teachers received assistance from SIE outside of the workshop that helped them to use the modules	61	58
Factors Inhibiting Use		
The amount of time teachers were required to be out of the classroom was problematic	57	40
The time of year that teachers received their modules was problematic	—	38
There was not enough science instructional time for teachers to complete the SIE modules	26	38
Teachers did not have the modules for enough time to complete all of the lessons	19	37
The pressures to teach mathematics and/or reading inhibited teachers' use of the modules	38	33
Teachers were not able to cover all of the science topics they were supposed to because of the time it took to implement an SIE module	30	25
The amount of time required to prepare for instruction with the SIE modules was problematic for teachers	23	22
Too much time elapsed between the module training and module delivery	—	18
Teachers' lack of science content knowledge made it more difficult for them to teach from the modules	12	16
Teachers' lack of experience in science made it more difficult for them to teach from the modules	12	13

† Includes those indicating "Agree" and "Strongly Agree" on a four-point scale of 1 "Strongly Disagree" to 4 "Strongly Agree."
‡ The percentage of principals agreeing to each statement in 2008–09 is not significantly different than in 2007–08, $p \geq 0.05$ (two-tailed z-test).

In terms of inhibitors, time remained the major concern of both teachers and principals. Similar to last year, about half of the responding teachers indicated that pressures to teach mathematics and/or reading, the amount of time required to prepare for instruction with the SIE module, and the lack of instructional time for science inhibited their use of the module. There was, however, a small decrease in the percentage of teachers indicating these latter two issues were problematic this year. The amount of time teachers are required to be out of the classroom was also a concern of 4 out of 10 principals; only 14 percent of teachers indicated that this issue was a concern, a significant decrease from the 26 percent who identified it as a concern last year (a small effect of -0.30).

One concern that has grown in magnitude among teachers this year was the amount of time they have with the module. In 2008–09, 41 percent of teachers indicated that this factor inhibited their use of the SIE modules, up from 29 percent in 2007–08 (a small effect of 0.25). This finding is likely due to the module delivery and pick-up schedule this year, which provided teachers less time to implement the module than last year.

In interviews, teachers and principals elaborated on factors that inhibited their use of the modules. As two teachers reported:

> *Obviously, PSSA state testing. We have to spend more time in reading and math to get them ready. That's the big one; that's our big speed bump that we have to go over every year.*
>
> *We had a problem with the kits being taken from us too early. Some [of my colleagues] were not finished with the kit and it was due back before they were able to finish teaching it thoroughly.*

Finally, as described previously in this report, responses to this item highlight a tension between wanting instruction to go in depth on a smaller number of topics versus covering all of the content in the state science standards. Forty-three percent of responding teachers and 25 percent of responding principals expressed concern that teachers are not able to cover all of the science topics they are supposed to because of the instructional time it takes to implement an SIE module. In the words of two teachers:

> *I do not think that students are getting the science content that they need to cover the PA state science standards.*
>
> *I find it difficult to explore the other areas of science for the state test because so much time is consumed with the SIE Program. I love the program, but feel that some of the repetitive material could be removed.*

As the program moves forward, it should consider ways of addressing this concern; e.g., identifying for teachers which module lessons they could skip or truncate when pressed for time. It would be imperative that trained program staff identify these lessons, not the teachers themselves, to ensure that the modifications to the modules to be purposeful and not exclude key concepts.

Student Opportunity to Learn

To gain insight into how the modules and the associated professional development were being translated into classrooms, members of the evaluation team observed a sample of 12 participants teaching a lesson from a module, 8 in Fall 2008 and 4 in Spring 2009. The Fall observations focused on Cohort 1 teachers, each of whom had participated in the Initial Module Training and were implementing the module for the third time. The four modules from which lessons were observed were: *Electric Circuits*; *Levers and Pulleys*; *Mixtures and Solutions*; and *Motion and Design*. In the Spring of 2009, four Cohort 3 teachers were observed teaching their first SIE module for the first time. The four modules from which lessons were observed in the Spring were: *Changes*; *Levers and Pulleys*; *Mixtures and Solutions*; and *Motion and Design*.

The classroom observations focused on the quality of the instruction in terms of opportunity for students to deepen their understanding of the intended content. Interviews after the observations were used to gather information on the teachers' experiences with the module and with SIE professional development. As was the case in observations of the SIE professional development, the framework HRI used for assessing student opportunity to learn is based on research on how people learn. Following is an overview of the analysis of the observed lessons in relation to this framework, as well as an analysis of factors that may have affected student opportunity to learn.[18]

Extent to Which the Classroom Culture/Learning Environment Facilitated Student Opportunity to Learn

Learning is facilitated by a classroom culture that encourages student participation and exhibits high expectations for all students. The classroom culture was a strength of most the observed lessons; a majority of the lessons had supportive learning environments characterized by a collegial atmosphere that encouraged student participation. For example, in a 6th grade *Mixtures and Solutions* lesson, the teacher used multiple strategies to involve all students:

> At the start of the lesson, the teacher set the tone that all students were expected to participate in the lesson by saying to the class, "We are going to do an experiment today, but first I want to address something. Yesterday, when I was asking questions and nobody was answering, that bothered me. Let's make sure we talk and participate." During the activity, the teacher circulated around the room, making sure all students worked with the materials. The teacher also made sure to call on different students during the class discussion, which got many students involved in the conversation. The teacher's efforts seemed to pay off, as students appeared comfortable providing responses to the teacher's prompts. For example, when the teacher was wrapping up the lesson, many students shared their ideas without prompting by the teacher.

The culture of one lesson interfered with students' opportunity to learn; this lesson appeared to be the exception and not the rule. In this classroom, the teacher struggled with classroom management and the students were subsequently off task, which negatively impacted the opportunity to learn.

Extent to Which All Students Were Intellectually Engaged with the Targeted Ideas in the Lesson

In order for students to learn new ideas, they must be intellectually engaged with those ideas, thinking and talking about the science content, and responsible for doing the intellectual work. In other words, instruction must be "minds-on," not just "hands-on." In addition, the science content with which they are engaged must be accurate. Of the 12 lessons observed, in only half were students engaged with mostly accurate content; the other half had major inaccuracies that likely prevented students from learning the targeted science ideas. For example, in one lesson students were allowed to use "water" and "liquid" interchangeably, which might lead the students to believe that water is a different substance than ice or water vapor. In another lesson, the teacher interchanged the words "force" and "energy" a number of times, which likely caused the students to think the two are synonymous. (Research on student ideas about science has found that this incorrect idea is resistant to change.) Interestingly, all of these teachers indicated that they had a fairly good understanding of the content in the module they were teaching. Even those lessons taught by teachers who had attended Module Enrichment contained substantial

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[18] More information on the Fall 2008 observations can be found in: Fulp, S.L. & Banilower, E.R. (2008). Fall 2008 Classroom Observation Study. Chapel Hill, NC: Horizon Research, Inc.

content errors, indicating that teachers need additional content support, even though they may not recognize that need themselves.

In addition to looking at the accuracy of content, observers looked at other aspects of intellectual engagement with the targeted content. For example, observers noted whether students seemed to understand what they were doing and why, were talking about the targeted concepts, and were responsible for doing the intellectual work. In each of the observed lessons, students were actively participating in the activities and appeared to be enjoying themselves. However, only 2 of the 12 observed classes provided a great deal of opportunity for students to intellectually engage with the learning goals; in these lessons, students spent time thinking, talking, and writing about the targeted concepts. In one of these lessons, the teacher used a whole-class discussion to focus students on the important science ideas:

> The purpose of a fifth grade *Motion and Design* lesson was for students to understand that engineers develop, modify, and improve designs to meet specific requirements, and that design requirements specify how a product must perform. Students were able to share their thoughts on force and motion and the design of their vehicles with the whole class during the class discussions. For example, one group shared that their vehicle was originally too top-heavy and would fall over when they pushed it, so they made modifications to decrease the weight. Another group discussed their observation that the location on the vehicle where the force was applied had more of an impact on the distance it traveled than the actual design of the vehicle.

In the other lesson, the teacher used note-booking strategies to intellectually engage the students with the targeted science content:

> In a sixth grade *Mixtures and Solutions* lesson, students were to begin to develop the idea that after the evaporation of a liquid, some solids form crystals which have distinctive patterns. Students made observations about salt crystals evaporated from a salt-water solution during the lesson. Students wrote about the properties of crystals in their science journals. They each described what they observed in words, and then made a scientific drawing on which they labeled the observed properties of the salt crystals.

However, in the other observed lessons intellectual engagement with the targeted ideas was low. In several lessons, the students were not attempting to answer an important science question and were simply going through the motions of the activity rather than conducting a purposeful inquiry. For example, the goal of an observed *Levers and Pulleys* lesson was for students to learn about the three classes of levers. The students in this lesson spent a disproportionate amount of time manipulating the materials instead of thinking and talking about the targeted concepts:

> These fifth grade students had learned about a Class 1 lever in a previous lesson. In this lesson they explored different classes of levers by moving the fulcrum, effort, and load. The majority of class time was spent allowing students to build the different classes of levers. Students were not required to take measurements, make observations, or record the different configurations in their notebooks. They simply were required to place the load, effort, and fulcrum in each of the different positions without any mechanism to focus students on how and for what reasons one would create and use the different classes of levers.

A second way intellectual engagement was limited was by students collecting inaccurate data, hindering their ability to draw scientifically appropriate conclusions from the data. For example:

> In a different lesson from the *Levers and Pulleys* module, students were supposed to learn that the greater number of ropes supporting a load, the smaller the effort that is needed to lift it. Students worked in groups for half an hour to create four pulley systems, gathering data on each. Data collection was not done carefully. Students were observed using the spring scales incorrectly, resulting in inaccurate data. In several groups, the rope came off of the pulley track, catching between the pulley and the pulley holder, which also impacted measurements. The teacher moved from group to group, helping students correct data collection mistakes, but she did not catch many of them. As a result, the data collected did not support the accepted scientific idea that the effort required decreases as the number of supporting ropes increases.

Third, in several cases students were observed engaging with just a subset of the targeted concepts in the lessons. For example, in a *Motion and Design* lesson the teacher successfully engaged students with the idea that a force is a push or pull, but not that a force can change the speed of an object.

These data indicate a need to help teachers understand all of the targeted ideas for each lesson in a module, both those that are explicit in the module and those that are implicit (i.e., concepts that are embedded in a lesson, but which the teachers' guide does not explicitly tell teachers to emphasize). Teachers would also benefit from a deeper understanding of how each activity contributes to the development of the science ideas. In addition, teachers would likely benefit from suggestions on how to help students attend to the targeted ideas during instruction. The focus questions provided to teachers during the Initial Module Trainings are a good start, but given the difficulties observed in focusing students on the concepts behind the activities, including additional tools, such as specific questions teachers might ask to gauge student thinking during the activities, should also prove beneficial.

Extent to Which Students Used Evidence to Support and Critique Conclusions

Understanding how scientific knowledge is generated is an important aspect of learning science. Students need to know that science involves the drawing of conclusions based on evidence, not the memorization of a series of facts. The SIE-supported modules are designed with the principle that students will construct scientific ideas based on evidence gathered from first-hand experiences. Accordingly, the extent to which students used evidence to support and critique conclusions was examined in the observed lessons.

In only 1 of the 12 observed lessons did the teacher emphasize drawing and supporting conclusions with evidence. In this lesson from the *Motion and Design* module, students were learning that the greater the force pulling on a vehicle, the greater the change in speed of the vehicle.

> Students connected a string to cars, hung the string off the table with washers on it. Students collected data on the speed of the car with the addition of washers. After the students had completed the activity in the lesson, the teacher led a class discussion about their results. During the discussion, the teacher asked questions such as, "What happened to the speed from two washers to four washers?" The teacher then used the student response that "the speed increased" as a basis for asking them what they noticed about what was happening as the number of washers increased, and connected the increasing speed to an increase in the pull on the vehicle. In this way, the conclusions from the activity were generated from the data the students collected about the speed of their vehicles.

It is important to note that although the teacher accurately modeled the building of scientific knowledge from evidence, the conclusion students were drawing about the relationship between mass and speed was incorrect. Although the activity focuses students on the speed of the car by having them rank the speed in each trial, force is related to the rate of change in speed, not speed itself.

In the majority of observed lessons, the development of scientific knowledge was not portrayed as a process based on drawing and critiquing conclusions using evidence. In several observed lessons, students collected data, but did not use those data to draw conclusions. For example, in a *Mixtures and Solutions* lesson, students made observations about what they saw when they mixed calcium chloride, baking soda, and water in a zip bag. Students were asked to report what they had observed but were never asked to come to a conclusion about whether a chemical reaction had occurred (the targeted concept for the lesson). Similarly, in a lesson from the *Electric Circuits* module, students constructed circuits with a diode. Students drew diagrams of the circuits that worked in their science notebooks, but these diagrams were not used as evidence to support any conclusions about the role of a diode in a circuit.

To help teachers develop a better understanding of the process by which scientific knowledge is generated, it will be important that the professional development they receive from the SIE program: (1) consistently and accurately model this process; and (2) explicitly reflect on the process with teachers after they work through the activities as learners.

Extent to Which Students Were Given the Opportunity to "Make-Sense" of the Targeted Ideas

It is clearly important for students to be engaged with activities that are designed to develop their conceptual understanding and to use evidence in constructing those ideas. It is equally important that students be given opportunities to make sense of the targeted science concepts. Without this sense-making, students may simply do the activities without ever understanding the science ideas and how they connect to previously learned ideas.

The observed lessons provided little opportunity for students to make sense of the targeted ideas. Many times this lack of sense-making was because the teacher modified the lesson. In a number of cases, it was due to the teacher modifying the wrap-up discussion by focusing the conversation simply on students' observations rather than on the targeted science ideas and how the observations supported those ideas.

In some cases, lessons engaged students with only a subset of the targeted concepts. As a result, sense-making occurred for some ideas but not for others. For example, in a lesson from the *Mixtures and Solutions* module, students mixed chemicals in order to learn that chemical reactions produce new substances that are different from the reactants, and that not all chemicals react when they are mixed. The lesson calls for students to test the precipitate from the final reaction with vinegar to determine if it is chalk. The teacher modified the lesson by having students skip this part of the lesson. Without the results of this test, students would not be able to determine if new substances were formed as a result of their experiment, one of the key learning goals of the lesson.

There was some indication that the reason for these modifications was lack of teacher understanding of the purpose of the lesson. During the post-observation interviews, teachers were asked what they hoped students would learn from the lesson. Only 5 of the 12 teachers stated goals that were aligned with the goals identified in the modules. Most of the teachers either mentioned only a subset of the targeted concepts and/or named goals that were not the same as those identified for the lesson.

Finally, in some lessons sense-making could not occur because of content inaccuracies, which as described previously, were a major problem in several of the observed lessons. During the post-observation interviews, all of the teachers indicated that they believed their students “got” the targeted concepts of the lesson. These responses provide further evidence that the teachers did not have a solid understanding of what students are supposed to learn from the activities or how to judge whether students mastered the intended content.

Overall Extent to Which the Lessons Provided Students with an Opportunity to Learn the Targeted Ideas

All of the observed lessons included some elements of effective practice, though few “put it all together.” Strengths of the lessons included collegial interactions among students and respectful contact between the students and the teacher. Students engaged in many hands-on activities, but the amount of intellectual rigor required of the students in most lessons was generally low. In addition, many lessons lacked adequate sense-making of the targeted science ideas. These findings may be a result of the Initial Module Trainings focusing heavily on familiarizing teachers with the lesson activities, often with limited time for teacher reflection on the targeted science being taught through the module activities and how to help students understand that science. An increased focus on sense-making of the science content during the professional development would likely lead to an increase in teachers incorporating this element in their own instruction.

IMPACT OF SIE ON STUDENTS

Although the main emphasis of the program's activities is on teachers and their instruction, the ultimate goals of the program is to improve student attitudes toward and learning of science. The evaluation addressed this aspect more systematically through two activities, one aimed at assessing the impact of the program on student attitudes toward science, the second examining the program's impact on student learning.

To assess the impact of the program on student attitudes toward science, teachers were asked a series of items in the end-of-year questionnaire about their students' attitudes toward science and the extent to which they attributed those student attitudes to the SIE program. As can be seen in Table 14, the vast majority of teachers indicated that students had positive attitudes for science, with over 9 in 10 agreeing that students were enthusiastic about science class, enjoyed learning about science, and wanted to learn more science. In addition, 70 percent of respondents indicated that their students liked science more than previous ones they had taught. In addition, teachers attributed these positive attitudes to the SIE program. (See Table 15.)

Table 14
Teacher Opinions about Students' Attitudes toward Science

	Percent of Responding Teachers Agreeing† (N = 1,520)
Students…	
Were enthusiastic about science class	97
Enjoyed learning about science	96
Were interested in science	95
Wanted to learn more science	93
Were eager to explore science on their own, outside of the classroom	85
Liked science more than previous students I have taught	70

† Includes those indicating "Agree" and "Strongly Agree" on a four-point scale of 1 "Strongly Disagree" to 4 "Strongly Agree."

Table 15
Teacher Report of Impacts on Students

		Percent of "Agreeing" Teachers Attributing Impact to SIE		
	N†	**Not at all**	**To some extent**	**To a great extent**
Students…				
Enjoyed learning about science	1,440	1	34	65
Were interested in science	1,416	2	39	59
Were enthusiastic about science class	1,449	1	43	56
Liked science more than previous students I have taught	1,032	1	52	47
Wanted to learn more science	1,388	1	54	45
Were eager to explore science on their own, outside of the classroom	1,270	3	68	29

† The "N" represents the number of teachers out of the 1,520 included in Table 14 who agreed with each statement about their students. The percent of teachers attributing the impact to SIE is based on the number of teachers agreeing with the statement.

To examine the impact of the program on student learning, HRI, with the assistance of the Pennsylvania Department of Education (PDE), designed and implemented a student achievement study. Specifically, this study examined the relationship between teacher participation in SIE professional development and their implementation of the science modules and student achievement. For Year Three, the study was modified in several important ways from the student achievement studies implemented in the first two years of the program. Because of the increasing number of SIE-supported modules schools were implementing, it was no longer feasible to administer an assessment before and after each module a teacher implemented; too much instructional time would be lost due to testing. Consequently, a grade-specific assessment was developed for each grade 3–6 that covers all of the modules supported by SIE at that grade that focus on developing science conceptual understanding (modules that focus on developing science process skills were not included).

This Year Three study design sought to answer the following questions:

1. Is there a relationship between the extent to which science instruction is based upon the SIE- supported modules and student achievement?

2. Is there a relationship between teacher participation in SIE-provided professional development and student achievement?

3. Are there gender or race/ethnicity differences in student achievement, and if so, does the extent to which instruction is based on the SIE-supported modules and/or teacher participation in SIE-provided professional development reduce those differences?

Instrumentation

HRI developed the four assessment scales that were used in this study, with each scale corresponding to the science modules at a grade level provided by the SIE program. The modules that were addressed by the assessment at each grade level were:

Grade 3	1. Chemical Tests (STC); 2. Plant Growth and Development (STC); 3. Rocks and Minerals (STC); 4. Sound (STC); 5. Structures of Life (FOSS);
Grade 4	6. Animal Studies (STC); 7. Electric Circuits (STC); 8. Human Body (FOSS); 9. Landforms (FOSS);
Grade 5	10. Ecosystems (STC); 11. Environments (FOSS);

12. Floating and Sinking (STC);
13. Levers and Pulleys (FOSS);
14. Motion and Design (STC);

Grade 6

15. Experiments with Plants (STC);
16. Food and Nutrition (FOSS);
17. Magnets and Motors (STC);
18. Mixtures and Solutions (FOSS); and
19. Variables (FOSS).

Because of the large number of students involved in the SIE program, and the timeframe in which results were needed, it was also decided to use only selected-response (i.e., multiple-choice) items rather than including open-ended or performance items. For each grade, HRI developed a pool of assessment items that covered the concepts included in both the modules and the *Pennsylvania Science and Technology Standards*. All items went through a stringent, internal review to ensure both alignment with the targeted content and language accessibility. When possible, cognitive interviews were conducted with elementary students to help ensure that students interpreted the items as intended, and that student responses were appropriate given their understanding of the content (i.e., those students who understood the content responded correctly, and those who did not understand the content selected an incorrect response). The items were then reviewed for content accuracy by Ph.D. scientists with expertise in the relevant topic area; any items with content issues were revised or removed from the item pool. HRI also sent each item pool to PDE for review and approval. These steps provide some assurance of content validity of the assessments.

In addition, statistical analyses can be used to examine the validity and reliability of items. Factor and dimensionality analyses help determine whether a set of items form a scale (i.e., a set of items that measure the same ability or trait, for example knowledge of levers and pulleys). These analyses resulted in the dropping of a small number of items. In addition, Differential Item Functioning (DIF) was used to examine whether items showed evidence of gender or race/ethnicity bias. No items had to be dropped due to bias concerns. Table 16 shows the number of items out of the original set for each scale that were retained for these analyses, as well as the reliability for each set of items.[19]

Table 16
Assessment Scale Reliabilities

	Number of Items Retained	Reliability
3rd Grade	29 of 30	0.74
4th Grade	29 of 30	0.77
5th Grade	37 of 40	0.81
6th Grade	34 of 40	0.83

[19] Reliability ranges from 0 to 1; typically, a reliability ≥ 0.60 is considered acceptable for assessments used to evaluate a program.

Race/ethnicity and gender data were also collected from students. Finally, teachers provided information about their classes, including the amount of instruction they provided on each of the topics on the assessment and the extent to which that instruction was based on an SIE-supported module.

The Sample

For the 2008–09 student achievement study, all schools participating in the SIE program that contain any of the grades 3–6 were asked to participate. Of these 137 schools, 99 (44 Cohort 1, 42 Cohort 2, and 13 Cohort 3 schools) returned pre- and post-test data in time to be included in these analyses. The great majority of data returned were included in the analyses; however, data from a number of classes were excluded due to assessment administration errors (e.g., some teachers did not follow the instructions for distributing answer sheets, making it impossible to link student pre- and post-test data for those classes). Table 17 shows the number of classes that were expected to be part of the study for each assessment scale, as well as the number of classes included in the final analyses.

Table 17
Number of Classes in the Study, by Cohort

	Cohort 1		Cohort 2		Cohort 3	
	Expected	Included in Analyses	Expected	Included in Analyses	Expected	Included in Analyses
3rd Grade	156	126	178	149	44	41
4th Grade	167	140	174	149	48	39
5th Grade	177	169	126	110	48	45
6th Grade	140	126	98	87	20	18

Table 18 provides demographic information for the students included in these analyses. Overall, the classrooms contained the same proportions of females and males. Most students classified themselves as White; nearly all students indicated that English was their primary language.

Table 18
Student Demographic Data

	Percent of Students			
	3rd Grade (N = 5,086)	4th Grade (N = 5,631)	5th Grade (N = 5,686)	6th Grade (N = 3,934)
Gender				
Female	50	50	50	49
Male	50	50	50	51
Race/Ethnicity†				
American Indian/Alaskan Native	1	0	1	1
Asian	1	1	1	1
Black/African-American	11	10	9	12
Hispanic/Latino	2	2	3	3
Native Hawaiian/Other Pacific Islander	0	0	0	0
White	87	87	89	86
English Language Learner	1	1	1	2

† The total percent may add to more than 100 as students could select more than one category.

Analysis and Results

Item response theory (IRT) was used to compute difficulty and discrimination parameters for each item. These parameters were then used to calculate "true test scores" for each student, an IRT-based score that takes into account the relative difficulty of each item. Using the true test score removes the error associated with day-to-day fluctuations in student performance, and is a better estimate of student knowledge than a raw score such as number or percent correct. The true test scores were scaled to have a minimum of 0 and a maximum of 100. Table 19 shows the true test scores for each assessment scale.

Table 19
True Test Scores

	Minimum	Maximum	Mean	Standard Deviation
3rd Grade				
Pre-Test	20.72	79.05	33.51	8.62
Post-Test	20.72	87.69	43.11	12.73
4th Grade				
Pre-Test	23.34	79.35	40.57	10.24
Post-Test	23.52	89.05	50.92	12.71
5th Grade				
Pre-Test	20.90	86.22	37.13	10.49
Post-Test	20.90	90.23	46.07	14.11
6th Grade				
Pre-Test	23.58	85.18	49.26	13.34
Post-Test	23.58	89.91	55.50	15.00

The student assessment data have a nested structure, with test administration (pre-test and post-test) nested within students nested within classes. Statistical techniques that do not account for potential grouping effects (e.g., all students in a class having common instructional experiences) in nested data structures can lead to incorrect estimates of the relationship between independent factors and the outcome. Hierarchical (multilevel) regression modeling was used to examine student assessment scores. Results for each model follow, organized by research question. Regression coefficients and standard errors are presented in Appendix C.

- ***Is there a relationship between the extent to which science instruction is based upon the SIE- supported modules and student achievement?***

To answer this question, HRI used data from the Module Use Surveys administered to teachers at the middle and end of the school year. This survey asked teachers which SIE-supported modules they implemented, how many science lessons they taught on the assessed topics, and what proportion of instructional time was based on the modules. These data were used to create three variables for the analyses that summarize their instruction on the topics covered by the assessment: the number of assessed topics for which the teacher provided instruction; the amount of instructional time using SIE-supported modules; and the amount of instructional time using non-SIE materials. As can be seen in Table 20, the amount of science instruction on the tested topics was relatively low, ranging from an average of about 18 hours in 3rd grade to roughly 36 hours in 6th grade. There was a fair amount of variation in instructional time among classes though, as evidenced by the relatively large standard deviations. In addition, the high maximum values indicate that some teachers spent a great deal of time teaching the assessed topics.

Table 20
Science Instruction in SIE Classes

	Minimum	Maximum	Mean	Standard Deviation
3rd Grade (N = 245)				
Number of Assessed Topics Taught	0.00	5.00	2.28	1.14
Instructional Hours Using SIE-Supported Modules	0.00	76.50	13.47	10.70
Instructional Hours Using Non-SIE Materials	0.00	90.30	4.98	9.62
4th Grade (N = 256)				
Number of Assessed Topics Taught	0.00	4.00	2.49	1.12
Instructional Hours Using SIE-Supported Modules	0.00	75.83	13.89	12.23
Instructional Hours Using Non-SIE Materials	0.00	75.00	8.98	12.51
5th Grade (N = 229)				
Number of Assessed Topics Taught	0.00	5.00	2.89	1.30
Instructional Hours Using SIE-Supported Modules	0.00	78.25	23.13	15.29
Instructional Hours Using Non-SIE Materials	0.00	65.25	6.25	10.88
6th Grade (N = 160)				
Number of Assessed Topics Taught	0.00	5.00	2.36	1.05
Instructional Hours Using SIE-Supported Modules	0.00	85.00	27.72	18.37
Instructional Hours Using Non-SIE Materials	0.00	88.00	8.26	15.54

The regression models examined changes from pre- to post-test scores, and the extent to which the three variables characterizing teachers' instruction related to those changes. The models also examined whether achievement gaps existed by gender and race/ethnicity, and if there was adequate class-level variation, the models investigated whether the instructional variables were related to changes in any existing gaps. Because the number of students classifying themselves as any race/ethnic group other than White was small, student race/ethnicity data were collapsed into two categories: White/Asian vs. non-Asian minority.[20]

At all four grades, there were no significant differences overall on pre-test scores among classes with different amounts of instruction based on SIE-supported modules. However, there were some achievement gaps. Non-Asian minorities had lower pre-test scores on average than their White/Asian classmates at each grade level. In addition, females scored slightly lower than males on the 4th and 5th grade pre-tests.

Post-test scores were significantly higher than pre-test scores at all four grade levels. In addition, the amount of growth was significantly related to the amount of instructional time based on the SIE-supported modules. Table 21 shows the predicted post-test scores (i.e., the expected score for a typical student controlling for demographics and other factors included in the analysis) for students in classes receiving varying amounts of instructional based on the SIE-supported modules. These results show a positive relationship between the amount of instructional time based on SIE-supported modules and student achievement, though the effect is relatively small.

Table 21
Predicted Post-Test Scores,
by Amount of Instructional Time Based on SIE-Supported Modules

	1 Standard Deviation Below the Mean Amount of Instructional Time	Mean Amount of Instructional Time	1 Standard Deviation Above the Mean Amount of Instruction Time
3rd Grade	44.33	45.58	46.35
4th Grade	51.54	52.09	52.41
5th Grade	49.10	51.38	52.95
6th Grade	59.00	61.36	63.00

All of the achievement gaps on the pre-test also existed on the post-test. The amount of instructional time based on SIE-supported modules was not related to these gaps at either time point (i.e., instruction based on the SIE-supported modules neither increased nor decreased the achievement gap).

- ***Is there a relationship between teacher participation in SIE-provided professional development and student achievement?***

HRI also examined whether the extent of teacher participation in SIE-provided professional development was related to student achievement. For these analyses, HRI used program records of teacher attendance at SIE Initial Module Trainings and Module Enrichment sessions to classify teachers by the number of trainings they attended related to the topics assessed. Because there was limited variation in the professional development attendance at each grade level, HRI combined data across the four grade levels to have sufficient statistical power (i.e., the

[20] Asian students typically outperform all other groups of students, and are often grouped with White students in these types of analyses.

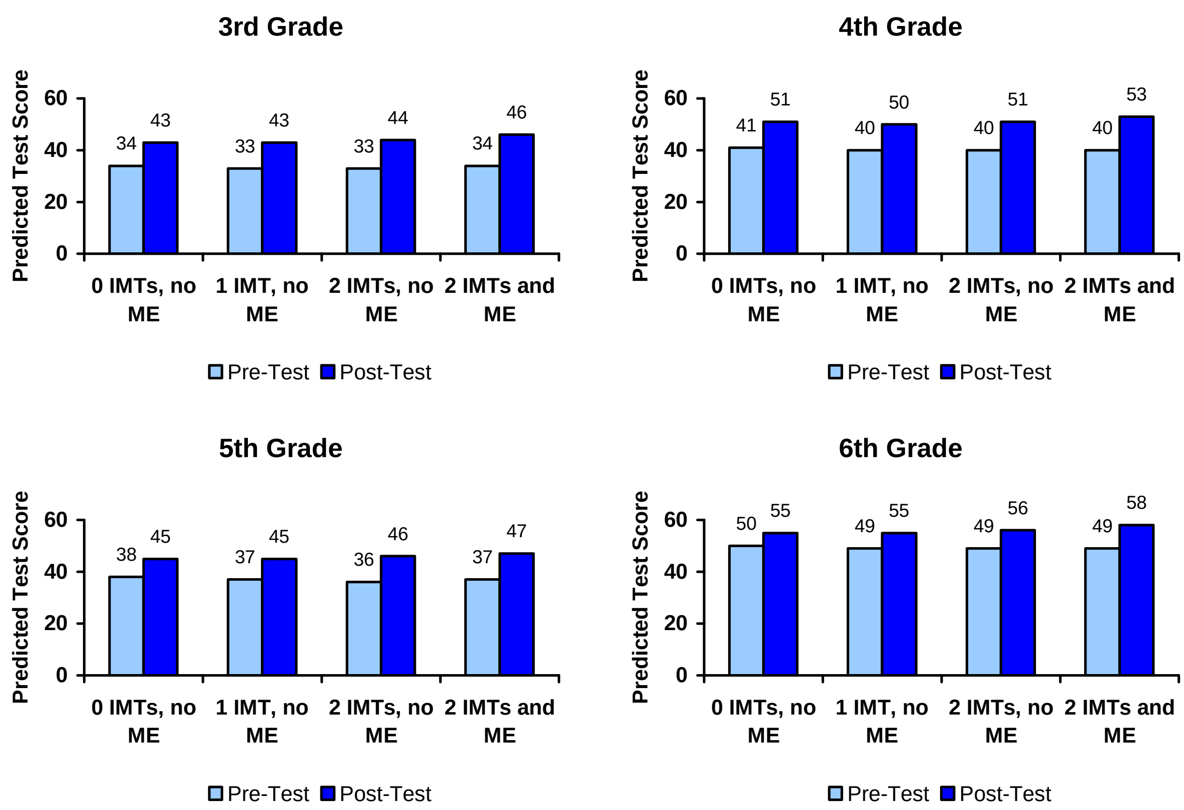
probability of detecting a difference if one truly exists) of the analysis. As can be seen in Table 22, the majority of grades 3–6 classes in this study were taught by teachers who had attended an Initial Module Training, and almost half were taught by teachers who had attended two or more; about one-quarter of the classes were taught by teachers who had attended a Module Enrichment session.

Table 22
Teacher Participation in SIE Professional Development

	Percent of Classes (N = 1,001)
Number of Initial Module Trainings Attended	
0	5
1	51
2 or more	44
Number of Module Enrichment Trainings Attended	
0	76
1	24

Students of teachers who had attended two or more Initial Module Trainings had significantly greater growth from the pre- to post-test than students of teachers who had attended zero or one of these sessions by 0.15 and 0.13 standard deviations, respectively. In addition, students of teachers who had attended Module Enrichment gained, on average, 0.06 standard deviations more than students of teachers who had not attended. Figure 9 shows predicted scores at each grade level for students of teachers with different levels of attendance at SIE-provided professional development.

Predicted Test Scores,
by Teacher Participation in SIE Professional Development*



* Across all grades, post-test gains of students of teachers attending 2 Initial Module Trainings significantly different than students of teachers attending 0 or 1 Initial Module Training, $p < 0.05$ (HLM). In addition, students of teachers attending Module Enrichment had significantly different gains than students of teachers who had not attended Module Enrichment, $p < 0.05$ (HLM).

Figure 9

Overall, these results provide additional evidence that the SIE program is having a positive impact on students. Teachers are reporting improved student attitudes toward and interest in science, and attribute these outcomes to the SIE program. In addition, student learning gains are greater in classes where the teachers base more of their instruction on the SIE-supported modules. Similarly, greater teacher participation in SIE-provided professional development is positively associated with greater learning gains.

SUMMARY AND RECOMMENDATIONS

In its third year, the SIE program can be credited with a number of accomplishments. The program has brought a third cohort on board and provided a Strategic Planning Institute for those schools. In terms of teacher training, SIE has provided three days of professional development to Cohort 3 teachers, and has continued to offer professional development to teachers in Cohorts 1 and 2. The program has also increased the number of science modules being provided to schools. In addition, SIE has hosted a Vision Conference for both current and prospective schools, provided additional leadership training for a cadre of teacher leaders, and assisted schools with conducting their Showcase of Student Learning.

By providing these services, SIE has played a key role in helping participating districts make progress toward updating their science programs. Evaluation data indicate that participating schools have increased the amount of instructional time devoted to science. In addition, SIE has helped schools shift their science instruction from a predominantly textbook-/worksheet-based program to a more hands-on, inquiry-based one. According to school and district administrators, these changes have led to an increased interest and enthusiasm for science among both students and teachers. However, although SIE (and the introduction of the science PSSA) has increased emphasis on science, administrators in participating schools also indicated that science continues to take a back seat to reading and mathematics as those are the subjects that count toward Adequate Yearly Progress.

Overall, the professional development provided by SIE has been well received by teachers and principals. Participating teachers reported that the Initial Module Trainings had given them the knowledge and skills they need to implement a science module for the first time. The trainings have also generated a great deal of enthusiasm among teachers for teaching science, a subject many have shied away from in the past. Teachers who have attended Module Enrichment Training indicated that these sessions have been helpful in improving their implementation of the module. Participants in both types of professional development have had an increase in their perceptions of pedagogical preparedness and pedagogical content knowledge.

Classroom observations of teachers implementing the modules provided additional insight into the impacts of the program. The enthusiasm generated in the professional development has carried through into the classroom. In all of the observed lessons, students were excitedly conducting the hands-on science activities, collecting and recording data and discussing what they observed. The classroom observations also revealed that, while the process of improving science instruction has begun, teachers need continued support to complete the transformation. In particular, teachers would benefit from additional professional development on the science content in the module and how to best use the activities to help students engage with and make sense of the targeted science ideas.

In terms of student outcomes, there are multiple pieces of evidence that the SIE program is having positive impacts. Teachers reported a high level of student interest in and enjoyment of science, and the vast majority of teachers attributed these positive attitudes to the SIE program. In addition, analyses of student achievement data found a positive relationship between the extent to which teachers base their science instruction on the SIE-supported modules and student learning in science. The analyses also found that, on average, the more SIE-provided professional development teachers participate in, the greater the change in their students' scores from the pre- to post-tests.

To assist the program in achieving its goal of continuous improvement, HRI offers the following recommendations:

- **Teachers have expressed concerns about not having the modules for a long enough period of time to implement all of the lessons. The program should consider increasing the length of time the modules are in the schools.**

By providing instructional materials and professional development to teachers, SIE has been successful at initiating substantive changes to the way science is taught in participating schools. However, there have been a number of factors that have limited teachers' use of the modules, including not having the modules for a long enough period of time. In fact, the percentage of teachers indicating that the length of time they had the module was problematic increased significantly from 2007–08 to 2008–09. The program is already planning to implement a new module delivery system for the next school year, which will address the problem to some extent. It will also be important for the program to take school calendars into account when deciding module delivery and pick-up dates. For example, teachers reported losing several days of instructional time when they had the module due to school holidays and the PSSA administration. This issue will be particularly salient for Cohort 1 schools that will be implementing a third module next year.

- **Consider ways to support districts, schools, and teachers in developing articulated curricula that incorporate the SIE-provided modules and that also ensure that all state science standards will be addressed.**

Another reality that schools and teachers have to contend with is how to address all of the state science standards when the modules engage students with fewer topics than traditional instructional materials. One strategy to address this issue would be for SIE staff to identify specific modifications to the modules (e.g., lessons that can be shortened or skipped altogether), but would still allow for students to develop the key concepts. Unless the state substantially reduces the number of science standards, this issue will continue to confront teachers as they attempt to implement the materials and instructional strategies supported by the SIE program.

- **SIE professional development should both model and make explicit for teachers the type of science teaching that will most likely result in students learning important science ideas.**

Overall, the Initial Module Trainings have been successful at preparing teachers to implement the modules at a mechanical level. These trainings have provided teachers with ample experiences to engage with the set-up and implementation of the module activities. However, classroom observations have found that teachers struggle with providing appropriate sense-making opportunities for their students. To help teachers implement the modules more purposefully, the program may want to adopt the "learner hat/teacher hat" model. By using this model, the trainings would provide opportunities for teachers to engage with and make sense of the science ideas first as learners. Then, the professional development would have them step back and consider how they would implement the lesson as teachers.

- **SIE should focus professional development on helping teachers understand each of the targeted concepts in the instructional materials and how the instructional activities develop those concepts.**

In addition to increasing the emphasis on helping teachers make sense of the science content targeted by the modules, the professional development should help teachers understand the content storyline of their module. To implement a module purposefully, teachers need to know what ideas are intended to be taught by each lesson (both those that are made explicit and those that are implicit). In addition, teachers need to understand how each idea is developed through the module, so that the activities are implemented purposefully and do not end up being "activity for activity's sake." The program's work to develop content frameworks and storylines, and integrate these tools into its professional development, are steps in the right direction. Making sure that the Module Enrichment Trainings consistently engage teachers with the content storyline will be an important next step to continue teachers on the path towards purposeful implementation of the modules.

- **As the program continues to grow and evolve, and as new professional development providers are brought on board, it should consider ways to codify key elements of its work to ensure consistent high-quality implementation.**

The SIE program has built its foundation on the long history and accumulated knowledge of ASSET and its staff. A major challenge any organization faces is maintaining its institutional knowledge and sharing that knowledge with new team members. One mechanism for preserving this knowledge is to create artifacts which codify key elements of the program and its work. The program has begun this process by creating content storylines for the modules it supports, which illustrate which science ideas are developed in the modules, and how each activity contributes to the development of those ideas. Sharing these content storylines with teacher leaders responsible for leading Initial Module Trainings will help ensure a consistent focus on the science content in those sessions. As these storylines are shared with all teachers participating in the program, one would expect a greater focus on the science ideas when the modules are implemented in classrooms.

In addition, updating the facilitation guides for each module's Initial Module Training to include explicit suggestions for when and how to use different strategies such as "learner hat/teacher hat" will both develop the knowledge and skills of the teacher leaders and help ensure consistency in these workshops. The newly-developed conversation tool would be an excellent vehicle through which the program can help the teacher leaders deepen their understanding of these strategies and of the design rationale for the professional development.

- **Develop additional ways to support teacher leaders in their role as science education advocates in their districts.**

The ASSET Leadership Conference was successful at building the teacher leaders' enthusiasm for science education improvement. To maintain this momentum, and to support the teacher leaders in this role, the SIE program may want to consider ways to provide support to teacher leaders throughout the school year. Allowing the teacher leaders to share successes and challenges may provide both motivation and ideas for continuing the work. One option for this sharing would be to hold a series of face-to-face meetings; another option would be to utilize a web-based tool. Although there are pros and cons to both approaches, on-going discussion and support would likely be useful to the teacher leaders.

Another tactic the program may want to consider would be to provide the teacher leaders with tools that they could use in their role as science education advocates. For example, a number of teacher leaders reported that they have been asked to make presentations about the program to their school boards. Providing a template for such a presentation (including PowerPoint slides or overheads) would reduce the preparation burden on the teacher leaders, help ensure a consistent message about the program is being delivered, and increase the likelihood that the teacher leaders experience success.

Appendix A

Selected Teacher and Principal Questionnaire Tables
Disaggregated by Cohort

Table A-1
Principals Indicating that Potential Program Services Would be Very Valuable

	Percent of Responding Principals		
	Cohort 1 (N = 50)	**Cohort 2 (N = 37)**	**Cohort 3 (N = 13)**
Ideas and tools for securing the resources needed for science instruction	65	51	58
Ideas and tools for assessing progress of our school's science program	64	53	58
Ideas and tools for creating opportunities for teacher collaboration	54	68	54
Ideas and tools for observing and providing feedback to teachers about their science instruction	54	62	69
Professional development for me to increase my own understanding of how to integrate science with mathematics and literacy	58	53	46
Ideas and tools for making science more of a priority in the school	28	43	46
Ideas and tools for increasing parental support/interest/involvement in our school's science program	46	44	38
Professional development for me to increase my own understanding of effective science teaching	44	49	31
Ideas and tools for leveraging other district resources (e.g., professional development days) to support science instruction	44	46	38
Ideas and tools for increasing community support/interest/involvement in our school's science program	42	43	38
Professional development for me to increase my own science content knowledge	20	27	31

Table A-2
Teacher Opinions of the Quality of SIE Initial Module Training, by Type of Training

	Percent of Responding Teachers Agreeing†	
	Initial Module Training on 2nd Module (N = 961)	**Initial Module Training on 1st Module (N = 584)**
The facilitators shared tips and suggestions for successfully implementing the module.	97	97
The goals of this workshop were clear.	95	97
This workshop familiarized me with the activities and materials in the module.	95	97
This workshop increased my understanding of the science content in the module.	95	96
The facilitators encouraged active participation and investigation by all participants.	94	97
This workshop was relevant to my classroom instruction.	94	93
The various components of this workshop were useful in meeting its goals.	93	96
The facilitators were well prepared.	93	95
Question about the science content in the module were adequately addressed by the facilitators.	93	95
This workshop prepared me to use the teaching strategies promoted by SIE.	93	95
This workshop increased my confidence in my ability to teach using the SIE module.	93	94
This workshop was worth the time that I invested.	92	94
The facilitators modeled effective teaching strategies.	91	92
The facilitators explicitly discussed how, when and why to use different teaching strategies.	91	92
I would recommend this professional development to a colleague.	90	94
This workshop reflected careful planning and organization.	90	93
There were opportunities for participants to express their views and collaborate with peers.	88	91
Adequate, time, structure, and guidance were provided for participants to discuss the SIE modules and pedagogical strategies with each other.	80	82
Adequate time, structure, and guidance were provided for participants to reflect individually on the substance of this workshop.	78	83

† Includes those indicating "Agree" and "Strongly Agree" on a five-point scale of 1 "Strongly Disagree" to 5 "Strongly Agree."

Table A-3
Teacher Opinions of the Pace of
SIE Initial Module Trainings, by Type of Training

	Percent of Responding Teachers	
	Initial Module Training on 2nd Module (N = 933)	**Initial Module Training on 1st Module (N = 561)**
Much too slow	3	1
Somewhat too slow	16	13
Appropriate	62	66
Somewhat too fast	13	16
Much too fast	6	4

Table A-4
Teachers' Opinions of Factors Affecting
Their Use of the SIE-Provided Module, by Cohort

	Percent of Responding Teachers Agreeing†		
	Cohort 1 (N = 455)	**Cohort 2 (N = 675)**	**Cohort 3 (N = 431)**
Factors Facilitating Use			
The training I received from SIE made it easier for me to use the modules.	95	94	91
Other teachers in my school provided a support system for use of the modules.	86	88	91
My own science background was helpful when I was teaching from the module.	82	81	82
My SOS facilitated my use of the modules.	77	77	79
I received assistance from SIE outside of the workshop that helped me to use the modules.	29	21	24
Factors Inhibiting Use			
The pressures to teach mathematics and/or reading inhibited my use of the modules.	53	52	43
The amount of time required to prepare for instruction with the SIE modules was problematic.	52	45	37
I did not have the modules for long enough to use as much of them as I wanted to.	50	37	37
There was not enough instructional time for science to effectively use the SIE modules.	46	47	39
I am not able to cover all of the science topics I am supposed to because of the time it took to implement an SIE module.	42	44	39
The amount of time I was required to be out of the classroom was problematic.	15	15	11
My lack of experience in science made it more difficult for me to teach from the module.	9	10	10

† Includes those indicating "Agree" and "Strongly Agree" on a four-point scale of 1 "Strongly Disagree" to 4 "Strongly Agree."

Table A-6
Principals' Opinions of Factors Affecting Teachers' Implementation of the SIE-Provided Modules, by Cohort

	Percent of Responding Principals Agreeing[†]		
	Cohort 1 (N = 50)	**Cohort 2 (N = 37)**	**Cohort 3 (N = 13)**
Factors Facilitating Use			
The training teachers received from SIE made it easier for them to use the modules	98	100	100
Teachers provided each other with a support system for using the modules	94	100	92
Our Support on Site (SOS) facilitated teachers' use of the modules	88	100	92
Teachers received assistance from SIE outside of the workshop that helped them to use the modules	52	68	54
Factors Inhibiting Use			
The amount of time teachers were required to be out of the classroom was problematic	38	44	38
The time of year that teachers received their modules was problematic	50	27	23
There was not enough science instructional time for teachers to complete the SIE modules	40	35	38
Teachers did not have the modules for enough time to complete all of the lessons	46	35	8
The pressures to teach mathematics and/or reading inhibited teachers' use of the modules	34	31	38
Teachers were not able to cover all of the science topics they were supposed to because of the time it took to implement an SIE module	18	32	31
The amount of time required to prepare for instruction with the SIE modules was problematic for teachers	20	24	23
Too much time elapsed between the module training and module delivery	20	19	8
Teachers' lack of science content knowledge made it more difficult for them to teach from the modules	14	14	31
Teachers' lack of experience in science made it more difficult for them to teach from the modules	12	8	31

[†] Includes those principals agreeing or strongly agreeing with each statement.

Appendix B

Composite Definitions

To facilitate the reporting of large amounts of survey data, and because individual questionnaire items are potentially unreliable, groups of survey questions that measure similar ideas can be combined into “composites.” Each composite represents an important construct related to science teaching or professional development. Cronbach’s Coefficient Alpha is a measure of the reliability of a composite (i.e., the extent to which the items appear to be measuring the same construct). A Cronbach’s Alpha of 0.6 is considered acceptable, 0.7 fair, 0.8 good, and 0.9 excellent.

Each composite is calculated by summing the responses to the items associated with that composite and then dividing by the total points possible. In order for the composites to be on a 100-point scale, the lowest response option on each scale was set to 0. As a result, someone who marks the lowest point on every item in a composite receives a score of 0, and someone who marks the highest point on every item receives a score of 100. It also assures that 50 is the true mid-point. The denominator for each composite is determined by computing the maximum possible sum of responses for a series of items and dividing by 100; e.g., a nine-item composite where each item is on a scale of 0–4 would have a denominator of 0.36.

Table B-1
Composite: Teacher Perceptions of Pedagogical Preparedness

Preparedness to:	**Post-PD (Prior)**	**Post-PD (Now)**
Use the inquiry-based teaching strategies embedded in the SIE module	Q8a-p	Q8a-n
Use science notebooks to support student learning of the content in the SIE module	Q8b-p	Q8b-n
Use the FERA (Focus, Explore, Reflect, Apply) and 5 E (Engagement, Exploration, Explanation, Elaboration, Evaluation) Learning Cycles to teach using the SIE module	Q8c-p	Q8c-n
Manage the logistics of the SIE module	Q8d-p	Q8d-n
Handle classroom management issues with the SIE module	Q8e-p	Q8e-n
Use questioning strategies to elicit student thinking about the science concepts in the module.	Q8f-p	Q8f-n
Examine student work to assess student thinking about the science concept in the module.	Q8g-p	Q8g-n
Teach the science concepts addressed in the module.	Q8h-p	Q8h-n
Number of Items in Composite	**8**	**8**
Reliability (Cronbach’s Coefficient Alpha)	**0.95**	**0.94**

Table B-2
Composite: Teacher Perceptions of Pedagogical Content Knowledge

Understanding of:	**Post-PD (Prior)**	**Post-PD (Now)**
Student learning goals (big ideas) in the SIE module	Q7a-p	Q7a-n
Science content in the SIE module at the level that the students are expected to learn it	Q7b-p	Q7b-n
Science content in the SIE module at a deeper level than what students are expected to learn	Q7c-p	Q7c-n
Ideas (either correct or incorrect) that students are likely to have about the content in the SIE module before instruction	Q7d-p	Q7d-n
How the activities in the module connect conceptually with one another.	Q7e-p	Q7e-n
How the activities in the module contribute to understanding the big ideas of the module.	Q7f-p	Q7f-n
Real-world connections to the science content in the module.	Q7g-p	Q7g-n
Number of Items in Composite	**7**	**7**
Reliability (Cronbach's Coefficient Alpha)	**0.95**	**0.93**

Table B-3
Composite: Teacher Perceptions of Principal Support

My Principal…	**End-of Year Questionnaire**
Makes attending the SIE professional development a priority	Q14a
Provides opportunities for teachers participating in SIE to meet and share ideas	Q14b
Is not very knowledgeable about the SIE program	Q14c
Is enthusiastic about the SIE program	Q14d
Makes science teaching a priority	Q14e
Is supportive of teachers participating in SIE	Q14f
Encourages implementation of the SIE modules	Q14g
Encourages the use of innovative science instructional strategies	Q14h
Accepts the noise associated with the activity based SIE modules	Q14i
Encourages teachers to integrate science and literacy	Q14j
Number of Items in Composite	**10**
Reliability (Cronbach's Coefficient Alpha)	**0.90**

Table B-4
Composite: Teacher Perceptions of Student Attitudes

My students…	**End-of Year Questionnaire**
Enjoyed learning about science	Q15a
Were interested in science	Q15b
Liked science more than previous student I have taught	Q15c
Were eager to explore science on their own, outside of the classroom	Q15d
Were enthusiastic about science class	Q15e
Wanted to learn more science	Q15f
Number of Items in Composite	**6**
Reliability (Cronbach's Coefficient Alpha)	**0.81**

Appendix C

Student Assessment
Regression Coefficients and Standard Errors

Table C-1
HLM Student Assessment Analysis Results – Module Use

	Regression Coefficients (and standard errors)							
	Grade 3		Grade 4		Grade 5		Grade 6	
Intercept	33.60	(0.21)	40.51	(0.23)	37.19	(0.20)	49.18	(0.43)
Cohort [1]								
Cohort 1	0.39	(0.45)	-1.04*	(0.48)	-0.37	(0.58)	0.12	(0.99)
Cohort 3	0.85	(0.70)	0.84	(0.82)	2.30*	(0.87)	6.27*	(1.52)
Number of Topics Taught	-0.13	(0.23)	0.53	(0.30)	-0.08	(0.24)	-0.76	(0.54)
Amount of Time Spent Using SIE Modules	0.02	(0.15)	-0.12	(0.13)	-0.11	(0.18)	0.34	(0.30)
Amount of Time Spent Using Other Resources	-0.41	(0.29)	-0.51	(0.34)	-0.17	(0.32)	-0.46	(0.58)
Female	0.17	(0.31)	-1.21*	(0.32)	-0.71*	(0.35)	0.13	(0.51)
Cohort [1]								
Cohort 1	—	—	—	—	-0.24	(0.70)	-0.97	(1.17)
Cohort 3	—	—	—	—	2.23*	(1.07)	-2.47	(1.77)
Number of Topics Covered	—	—	—	—	-0.38	(0.30)	0.49	(0.64)
Amount of Time Spent Using SIE Modules	—	—	—	—	-0.15	(0.22)	0.00	(0.36)
Amount of Time Spent Using Other Resources	—	—	—	—	0.14	(0.39)	-0.10	(0.67)
Non-Asian Minority	-4.15*	(0.52)	-5.65*	(0.55)	-5.10*	(0.60)	-7.31*	(0.85)
English Language Learner	-1.23	(1.44)	-0.20	(1.59)	-0.55	(1.66)	-1.81	(2.37)
Growth from Pre to Post	9.69*	(0.31)	10.73*	(0.26)	8.74*	(0.29)	6.54*	(0.35)
Cohort [1]								
Cohort 1	-0.97	(0.67)	-0.46	(0.54)	-0.42	(0.63)	-0.99	(0.80)
Cohort 3	-0.02	(1.03)	-0.61	(0.92)	-0.75	(0.95)	-0.51	(1.23)
Number of Topics Covered	0.92*	(0.35)	-0.53	(0.34)	0.60*	(0.26)	0.58	(0.43)
Hours of Instruction Using SIE Modules	0.61*	(0.22)	0.35*	(0.15)	1.02*	(0.20)	0.73*	(0.25)
Hours of Instruction Using Other Materials	-0.57	(0.43)	0.84*	(0.38)	-0.66	(0.35)	-0.55	(0.47)
Female	0.29	(0.29)	0.00	(0.30)	0.15	(0.30)	0.39	(0.42)
Cohort [1]								
Cohort 1	—	—	—	—	—	—	0.12	(0.95)
Cohort 3	—	—	—	—	—	—	0.69	(1.45)
Number of Topics Covered	—	—	—	—	—	—	0.10	(0.52)
Hours of Instruction Using SIE Modules	—	—	—	—	—	—	0.32	(0.30)
Hours of Instruction Using Other Materials	—	—	—	—	—	—	-0.58	(0.55)
Non-Asian Minority	-2.20*	(0.61)	-1.56*	(0.60)	-1.87*	(0.58)	0.08	(0.74)
Cohort [1]								
Cohort 1	1.73	(1.31)	3.24*	(1.24)	0.02	(1.15)	1.96	(1.58)
Cohort 3	3.84	(1.97)	4.58*	(2.11)	-0.44	(1.80)	-1.78	(2.25)
Number of Topics Covered	-1.30	(0.77)	-1.13	(0.74)	0.20	(0.49)	-1.78*	(0.84)
Hours of Instruction Using SIE Modules	0.11	(0.46)	0.40	(0.35)	-0.25	(0.36)	0.61	(0.43)
Hours of Instruction Using Other Materials	0.64	(0.91)	0.49	(0.86)	0.23	(0.72)	0.92	(0.98)
English Language Learner	-1.25	(1.48)	-0.65	(1.72)	0.49	(1.82)	2.75	(1.96)
Cohort [1]								
Cohort 1	-0.85	(3.14)	3.26	(4.03)	-3.47	(3.68)	—	—
Cohort 3	2.78	(3.65)	4.41	(4.72)	-4.15	(5.16)	—	—
Number of Topics Covered	2.18	(1.55)	1.74	(2.20)	-0.57	(1.39)	—	—
Hours of Instruction Using SIE Modules	0.67	(1.17)	0.40	(1.02)	0.12	(1.02)	—	—
Hours of Instruction Using Other Materials	-0.49	(2.02)	-2.43	(2.16)	0.21	(2.11)	—	—

* $p < 0.05$.
Note: All variables were grand-mean centered except the Growth from Pre to Post variable which was uncentered.
[1] Versus Cohort 2 schools

Table C-2
HLM Student Assessment Analysis Results –
Teacher Participation in SIE Professional Development

	Regression Coefficients (and standard errors)	
Intercept	-0.31	(0.04)
Cohort [1]		
Cohort 1	-0.08*	(0.02)
Cohort 3	0.10*	(0.04)
Grade Level [2]		
Grade 3	-0.21*	(0.03)
Grade 4	-0.22*	(0.03)
Grade 5	-0.13*	(0.03)
Initial Module Training [3]		
1 Initial Module Training	-0.05	(0.05)
2+ Initial Module Trainings	-0.10*	(0.05)
Module Enrichment Training	0.05	(0.03)
Female	-0.03	(0.06)
Cohort [1]		
Cohort 1	0.00	(0.03)
Cohort 3	0.09	(0.05)
Grade Level [2]		
Grade 3	0.01	(0.04)
Grade 4	-0.08	(0.04)
Grade 5	-0.07	(0.04)
Initial Module Training [3]		
1 Initial Module Training	-0.02	(0.06)
2+ Initial Module Trainings	-0.02	(0.07)
Module Enrichment Training	0.01	(0.04)
Non-Asian Minority	-0.42*	(0.02)
English Language Learner	-0.11	(0.06)
Growth from Pre to Post	0.62*	(0.05)
Cohort [1]		
Cohort 1	-0.10*	(0.03)
Cohort 3	0.02	(0.04)
Grade Level [2]		
Grade 3	0.43*	(0.03)
Grade 4	0.43*	(0.03)
Grade 5	0.21*	(0.03)
Initial Module Training [3]		
1 Initial Module Training	0.03	(0.05)
2+ Initial Module Trainings	0.15*	(0.05)
Module Enrichment Training	0.06*	(0.03)
Female	0.00	(0.06)
Cohort [1]		
Cohort 1	0.01	(0.03)
Module Enrichment Training	-0.01	(0.03)
Grade Level [2]		
Grade 3	0.02	(0.04)
Grade 4	-0.02	(0.04)
Grade 5	-0.03	(0.04)
Initial Module Training [3]		
1 Initial Module Training	0.01	(0.06)
2+ Initial Module Trainings	0.05	(0.06)
Cohort 3	-0.01	(0.05)
Non-Asian Minority	-0.11	(0.09)
Cohort [1]		
Cohort 1	0.12*	(0.05)
Cohort 3	0.10	(0.08)
Grade Level [2]		
Grade 3	-0.12	(0.07)
Grade 4	-0.05	(0.06)

Grade 5	-0.11	(0.06)
Initial Module Training [3]		
1 Initial Module Training	-0.04	(0.10)
2+ Initial Module Trainings	0.07	(0.10)
Module Enrichment Training	-0.05	(0.07)
English Language Learner	0.07	(0.16)
Cohort [1]		
Cohort 1	0.05	(0.14)
Cohort 3	0.06	(0.18)
Grade Level [2]		
Grade 3	-0.24	(0.17)
Grade 4	-0.27	(0.17)
Grade 5	-0.08	(0.16)
Initial Module Training [3]		
1 Initial Module Training	-0.01	(0.18)
2+ Initial Module Trainings	-0.17	(0.20)
Module Enrichment Training	0.09	(0.17)

* $p < 0.05$.

Note: All variables were grand-mean centered except the Growth from Pre to Post, Initial Module Training, and the Module Enrichment Training variables which were uncentered.

[1] Versus Cohort 2 schools

[2] Versus Grade 6 students

[3] Versus teachers attending no Initial Module Trainings