# Science: It's Elementary

# Year Four Evaluation Report

**Eric R. Banilower**
**Sherri L. Fulp**
**Camille L. Warren**

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Submitted to: ASSET Inc.
2403 Sidney Street – Suite 800
Pittsburgh, PA 15203

Submitted by: Horizon Research, Inc.
326 Cloister Court
Chapel Hill, NC. 27514

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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 2009 through June 2010. In the program's fourth 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 fourth 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 on-line module use survey to samples of participating teachers at the middle and end of the school year to examine how teachers are implementing the SIE-supported modules;[1]
- Administered an on-line survey to all participating grades 3–6 teachers at the end of the school year to capture how much instruction they provided on each of the topics on the student assessment and the extent to which that instruction was based on the SIE-supported modules;
- Administered an on-line end-of-year questionnaire to a sample of teachers to gather feedback on the program and factors affecting their module implementation;
- Administered an on-line questionnaire to principals of participating schools;

***Observations***

- Observed a sample of 25 professional development sessions to examine the quality of the training provided to teachers;
- Conducted classroom observations of five teacher leaders and five non-teacher leaders to examine differences in their implementation of the SIE-supported modules;
- Observed the 2010 ASSET Leadership Conference designed to prepare teacher leaders to provide professional development in future years of the program;

***Interviews***[2]

- Interviewed a sample of 15 teachers participating in the SIE program;

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[1] All of the on-line questionnaires were administered with the assistance of each participating school's Support On Site person (SOS). SOSs were asked to disseminate the URL for the survey and follow-up with non-respondents.

[2] For each set of interviews, HRI drew a random initial sample from the targeted population and made repeated attempts to interview everyone in the sample. HRI randomly selected additional participants as needed to compensate for non-response. In an attempt to interview 20 teachers (5 from each cohort), 50 teachers were contacted repeatedly via email and telephone. Forty-seven principals were contacted in an attempt to reach the targeted goal of 20 (two principals responded to the interview request after replacements had already been contacted; thus the total number of principal interviews conducted was 22). HRI contacted 15 teacher leaders and 11 district supervisors in order to get 10 interviews from each group.

- Interviewed a sample of 22 principals whose schools are participating in the SIE program;
- Interviewed a sample of 10 teacher leaders who had been trained by the program and had been serving as teacher leaders for at least two years;
- Interviewed a sample of 10 district science supervisors/curriculum coordinators from Cohort 4 districts;

***Case Studies***

- Conducted classroom observations and interviews with a sample of 10 teachers to examine how they were using the SIE-supported modules and what factors affected that use; and

***Assessments***

- Administered student assessments in each grade 3–6 in all schools participating in the program.

After a brief overview of the SIE program and the evaluation, this report describes the teachers, schools, and districts participating in SIE; the program's work in developing teacher leaders; the nature and quality of the professional development 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 (PDE). 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 currently has five 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 to learn about science education reform and to develop a three-year strategic plan for their school.

2. 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 one-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.

3. 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 later use.

4. 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 will 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.

[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. 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.

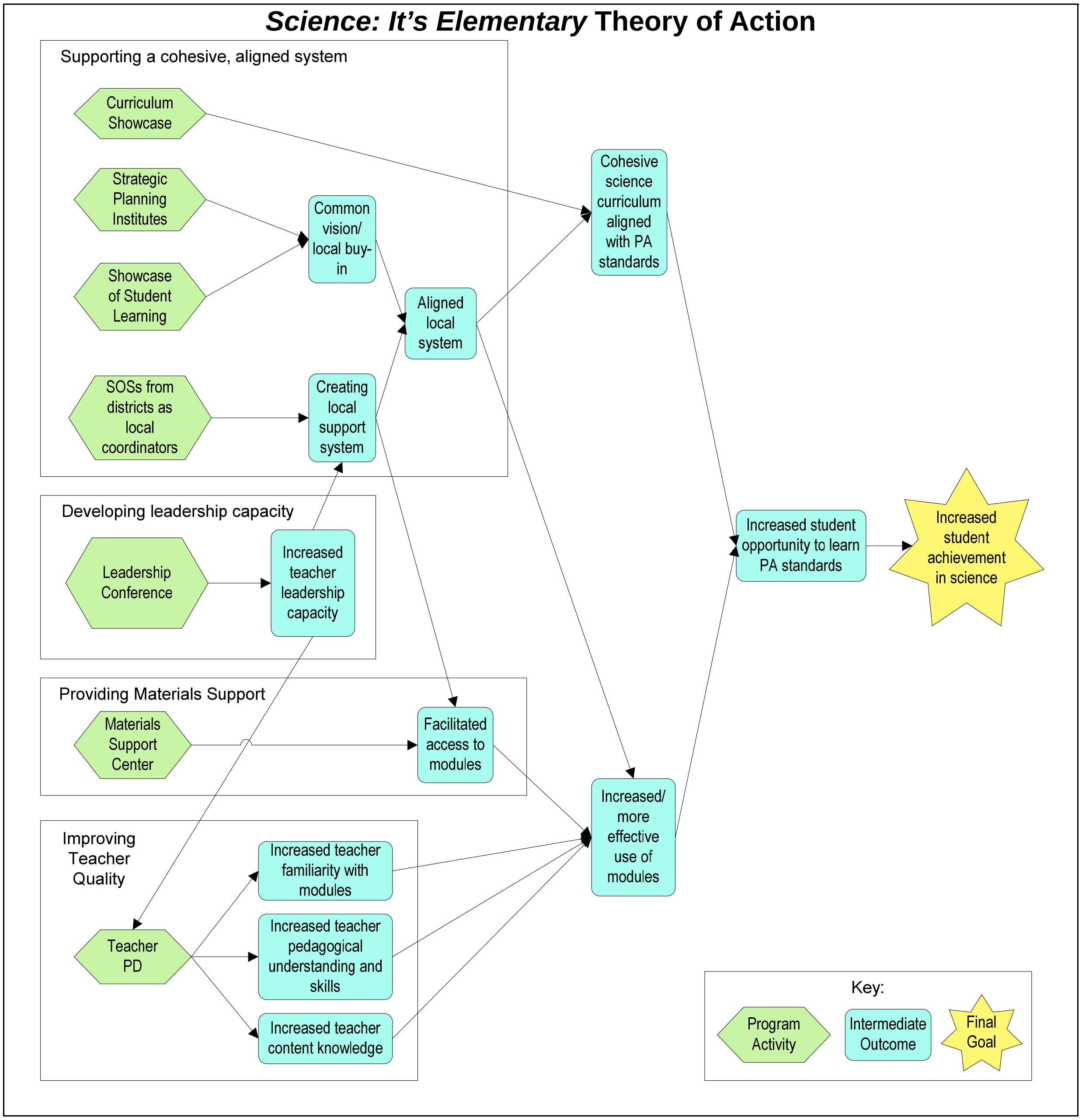


***Figure 1***

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 Four, SIE added another cohort of schools to the program. A number of schools from the previous cohorts, primarily Cohort 1, stopped participating in the program. Anecdotal reports indicate that most of the withdrawing schools did so because they could not afford their share in the cost-sharing required after their third year of participation.  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** | **Cohort 4** |
| East | 1 | 15 | 0 | 7 | 1 | 7 |
| | 2 | 14 | 2 | 3 | 4 | 5 |
| | 3 | 8 | 3 | 3 | 0 | 2 |
| Central | 4 | 17 | 2 | 4 | 6 | 5 |
| | 5 | 16 | 7 | 7 | 1 | 1 |
| | 6 | 22 | 8 | 10 | 1 | 3 |
| West | 7 | 21 | 6 | 11 | 1 | 3 |
| | 8 | 25 | 10 | 8 | 1 | 6 |
| | **Total** | **138** | **38** | **53** | **15** | **32** |

# Overview of the SIE Evaluation

The evaluation plan for SIE was developed by HRI in conjunction with key stakeholders from ASSET and PDE 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 and impact 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 Four.

# 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 4 district supervisors, shed light on how these contexts are impacting SIE's efforts to improve elementary science education.

## Science Programs Prior to Joining SIE

In the first three years, schools joining SIE have described their prior science programs as traditional and uninspiring, with a heavy reliance on lecture, textbooks, and worksheets. It was not uncommon for teachers to report that their schools had little, if any, set science program; decisions about what to teach, for how long, and in what ways were left up to individual teachers. As three teachers reported when describing science instruction in their school before SIE:

> *Kids reading books, doing reports, not really doing a lot of hands on at all...what you would see more in a college setting.*
>
> *Just a book and a workbook; no experiments or anything.*
>
> *We did have a written curriculum in terms of concepts and skills, but the reality of it was that I would say the majority of classes handled it through reading and writing and not actual hands on.*

Principals gave similar descriptions of science instruction prior to SIE. As two reported in interviews:

> *Before, they would read a passage from the textbook and answer questions. I think there were some labs in [the instructional materials], but I don't think the teachers ever did them. They didn't have the materials or maybe didn't know how.*
>
> *They were doing things out of a textbook, but not a lot of hands-on things. The teachers were not as comfortable with the material, so they may not have gone into as much detail as they do now about different topics.*

While schools in Cohorts 1–3 typically saw lots of room for improvement in their science programs, Cohort 4 teachers were generally more positive about the status of science instruction in their schools before joining the SIE program. On the baseline questionnaire[4], teachers were asked an open-ended question about the strengths of their schools' science programs. The most common response, given by approximately 40 percent of the teachers answering the question, was the high quality of instructional materials available for teaching science. Often, these teachers referred to the availability and use of hands-on activities, though a sizeable portion indicated that their textbooks were of high quality. The second most commonly mentioned strength, given by about one-quarter of the respondents, was the flexibility teachers had for selecting topics and creating their own lessons. A similar number mentioned the availability of equipment and supplies for teaching science. Often teachers mentioned multiple strengths. These three comments illustrate the range of teachers' responses:

> *Textbook aligned with standards. Many science materials. Lots of FOSS kits. Staff. Hands on.*
>
> *Very flexible—no required texts, kits, or lesson; teachers had freedom to teach what they know, what they are interested in, and what resources are available in the school/community.*
>
> *We have a science resource room where we are able to gather materials (batteries, baking soda, potting medium) and equipment (microscopes, etc.).*

Although the use of hands-on activities was mentioned by a number of teachers, only about 20 percent of the Cohort 4 teachers indicated having prior experience teaching science with a module like those supported by SIE. Of those with experience teaching with a module, nearly one-third had received no professional development on doing so; a similar proportion received training that lasted fewer than six hours.

The baseline questionnaire also asked Cohort 4 teachers how their schools' science programs could be improved. The three most common needs described by teachers, each mentioned by about one-third of respondents, were more supplies and materials for teaching science, incorporating more hands-on activities, and more instructional time for teaching science. About one-quarter of the respondents indicated that the science curriculum needed to be better aligned with state standards. In the words of four teachers:

> *Science needs to be as important as reading and math and taught daily at all grade levels. Social studies and science are the first programs to be cut/shortened in an effort to spend more time on reading and math.*
>
> *Our science program can be improved by having more resources available for every grade level in our school. I also think that our schedule needs to allow more time in our day for teaching science.*

---

[4] The baseline questionnaire was administered at the beginning of the Foundations courses. Because of the late funding of the program this year, the questionnaire was administered only in workshops that occurred after January 1, 2010. HRI received responses from 487 participants.

*Our school's science program could be improved by having hands-on, easy-to-do science lessons and experiments.*

*It would help if we had materials that matched the state's curriculum. Our textbook is outdated. I acquire my own materials, for the most part, in order to cover the content.*

Interviews with 10 district science supervisors asked how decisions about instructional time were made. Most indicated that these decisions were made at the district level; two said that it was left up to the discretion of individual teachers, and one indicated that building principals made the decision. Eight of the 10 reported that teachers in the upper elementary grades were expected to teach science every day of the school year, while two indicated that teachers were expected to alternate between science and social studies. There was more variation in expectations in the lower elementary grades, with half of the districts expecting teachers to include science instruction every day and half only a few times per week.

The amount of time teachers are expected to devote to science on days when it is taught also varied widely. In the upper elementary grades, the expectation ranged from 30 to 50 minutes per day. In the lower elementary grades, at the lower end of the spectrum, some districts expected teachers to spend 30 minutes per day, three days per week (i.e., 90 minutes per week). At the higher end, some districts expected 40 minutes per day, five days per week (i.e., 200 minutes per week).

However, most Cohort 4 teachers reported spending substantially less time on science than district supervisors' expectations would suggest. Overall, most respondents to the baseline questionnaire indicated teaching science three days per week or fewer, though teachers in grades 3–6 were more likely to report teaching science 4 or 5 days per week. (See Table 2.) In addition, the typical lesson was 30 minutes or shorter; lessons in grades 3–6 tended to be longer, with most being between 21 and 50 minutes in length. These numbers translate into an average of about 19 minutes per day of science instruction overall; 12 minutes per day in grades K–2 and 27 minutes per day in grades 3–6.

**Table 2**
**Amount of Science Taught Prior to SIE**
**by Cohort 4 Teachers, Overall and by Grade Range**

| | Percent of Teachers | | |
|---|---|---|---|
| | **Overall (N = 487)†** | **Grades K–2 Only (N = 269)** | **Grades 3–6 Only (N = 210)** |
| **Days per Week Taught** | | | |
| 0 | 6 | 7 | 4 |
| 1 | 12 | 19 | 3 |
| 2 | 20 | 26 | 12 |
| 3 | 24 | 24 | 23 |
| 4 | 15 | 12 | 20 |
| 5 | 22 | 11 | 38 |
| **Minutes per Lesson** | | | |
| 10 or fewer | 5 | 9 | 1 |
| 11–20 | 19 | 29 | 6 |
| 21–30 | 36 | 45 | 24 |
| 31–40 | 23 | 14 | 36 |
| 41–50 | 12 | 3 | 23 |
| 51–60 | 4 | 0 | 9 |
| 61 or more | 1 | 0 | 1 |

† The overall number of respondents is greater than the number of grades K–2 and 3–6 teachers combined as eight respondents indicated teaching both grade ranges.

## Cohort 4 Schools' Visions for their Science Programs

In addition to characterizing the initial profile of their schools' science programs prior to joining SIE, Cohort 4 principals and district science supervisors were asked in interviews to describe their vision for their science programs. All of the interviewees indicated that they would like to see their science programs incorporate more hands-on activities and become inquiry-based. This result is not surprising given that these schools chose to participate in the SIE program. In addition, all of the interviewed principals indicated a desire to incorporate more reading and writing into science. District science supervisors also mentioned making cross-curricular and real-world connections. Typical responses included:

> *It would be very similar to the ASSET model where students are actually thinking; thinking about science, being posed a question or two, doing some research, getting a hands-on opportunity.* (Principal)

> *We want it to be hands-on, inquiry-based learning for all grade levels with our note-booking as a key component...we also want to infuse non-fiction reading and concepts that support the students on the PSSA.* (Principal)

> *My vision was that we link our science program to our literacy units and that we provide an inquiry-based opportunity for our kids to learn through problem solving and experiments.* (District Supervisor)

District science supervisors were asked what the greatest needs of both teachers and principals in their district were in terms of accomplishing the vision. The most common need for teachers, mentioned by half of the interviewees, was professional development on how to teach science modules using inquiry techniques. Time to collaborate with other teachers and finding time to teach science were also mentioned. Often multiple needs were noted, as in the following example:

> *I would say the biggest problem is training. They don't recognize the value of it. They were all educated in the same way we all did it. They don't know inquiry-based science, so if you don't know it you won't see the value of it and won't teach it that way. But outside of the training, it's time. Give us the time and we'll teach it. The training is the most important thing. Third, would be resources. Science education is not cheap, budgets are tight and we don't have resources.*

In regard to principals' needs, interviewed district science supervisors most often mentioned: (1) time for observing and providing feedback to teachers; and (2) professional development for principals so they could learn about inquiry-based science instruction and give appropriate feedback to teachers. As one supervisor said when describing the needs of principals:

> *They need to understand the philosophy as well. They need to understand what they're seeing, and when they do a walk-through they need to know what to look for, what's being learned, and what questions to ask. They need to be involved and ask questions of the kids…They need to know the philosophy and the way to monitor that kind of learning. If the program is going to be successful, it depends on the building leader.*

Cohort 4 schools reported being at different stages in making their vision a reality before joining SIE. In interviews, most district science supervisors and a couple of principals noted that they had only partially reached their goal. In some cases, interviewees indicated that more progress ha been made in the upper elementary grades as these grades were more likely to include science instruction in the past. In each case though, SIE was seen as a major catalyst for continuing the progress, providing professional development and materials needed for schools to make changes. As a few interviewees reported:

> *Thanks to the grant, we're on our way.* (District Supervisor)

> *We were already moving in this direction prior to the grant, this [SIE] has just given us more resources.* (Principal)

> *It's very laid out for the teachers, so simple for them to implement. They are busy and don't have to go find this and that, the kit is great to have it all ready for them. And the grant replenishes it for them, and that is a benefit. It's all given to them.* (District Supervisor)

## Changes in SIE Schools' Science Programs

In Year Four of the program, Cohort 4 schools were just beginning the process of improving their science programs through participation in SIE, while Cohort 1, 2, and 3 schools were further along in the process. In addition to Cohort 4 district supervisors, samples of teachers and administrators, representing all four cohorts, were asked in interviews to comment on the changes that have occurred in their schools since joining SIE. Nearly all of the Cohort 4 district supervisors and principals from all cohorts who were interviewed indicated that science has become a higher priority in their schools since they joined SIE. However, many indicated that science was still taking a backseat to mathematics and reading/language arts. Representative comments include:

> *The most profound change is the grade level at which we start. We have Kindergarten doing science now, and first and second grade are now doing science, and before, there was not any formal science in those grades.* (Principal)

> *Previously the priority on a scale of 1 to 10, it was a 1—low. Currently, it's an 8 or 9 because we've put focus on it because of the grant.* (District Supervisor)

> *Typically [science] is after math and reading, however we would like to integrate things so that we are more even and we are treating science just as importantly as math and reading.* (Principal)

> *It does not have the same priority as reading and math. At the state level the emphasis is on PSSA reading and math. We've implemented a science test and that has ramped it up a bit, but it doesn't hold the same level as reading or math.* [District Supervisor]

One of the most telling indicators of the priority given to science is the amount of instructional time devoted to it. Based on questionnaire data collected at the end of the school year[5], teachers in all four cohorts reported spending about 22 minutes per day on science instruction, though there is a large difference in the time devoted to science between teachers of grades 3–6 and teachers of grades K–2 (about 28 and 16 minutes per day, respectively). (See Table 3.)

**Table 3**
**Average Number of Minutes per Day Devoted to Science Instruction, Overall and by Grade Range**

| | N | Minimum | Maximum | Mean | Standard Deviation |
|---|---|---|---|---|---|
| Overall | 1753 | 0.00 | 226.67 | 21.72 | 19.18 |
| Grades K–2 | 822 | 0.00 | 75.00 | 16.32 | 11.71 |
| Grades 3–6 | 751 | 0.00 | 226.67 | 27.65 | 23.54 |

[5] This end-of-year questionnaire was completed by 1,580 of the 2,111 teachers sampled, a response rate of 75 percent.

Sixty-eight percent of teachers indicated that they devoted more instructional time to science this year than prior to their school's participation in SIE (73 percent of K–2 teachers, and 61 percent of 3–6 teachers). These teachers were asked how they made more time available for science. As can be seen in Table 4, integrating science with other subjects and reducing instructional time for social studies were each mentioned by over half of the teachers. Only a handful of teachers indicated reducing instructional time for reading/language arts or mathematics; 30 percent indicated cutting back on other subjects.

**Table 4**
**Ways Teachers Adjusted Instruction**
**to Increase Time for Science, Overall and by Grade Range†**

| | Percent of Teachers Who Reported Increased Time for Science | | |
|---|---|---|---|
| | **Overall (N = 1753)** | **Grades K–2 (N = 822)** | **Grades 3–6 (N = 751)** |
| Integrated science into other subjects | 54 | 57 | 48 |
| Spent less time on: | | | |
| Social studies | 53 | 46 | 64 |
| Reading/language arts | 9 | 9 | 8 |
| Mathematics | 8 | 11 | 3 |
| Other subjects | 30 | 33 | 25 |

† Responses add to more than 100 as teachers could select more than one option.

In interviews, both teachers and principals elaborated on the increased time for science instruction:

> *We are devoting quite a bit more time towards science than we had previously. Usually, we would allot 20 minutes a day, three days a week prior [to SIE] and now it has increased quite a bit. We try to teach it 3–4 days and those time frames are longer only because the children need time to explore and get involved with the hands on teaching.* (Teacher)

> *Now, science is being taught in K–2, where it wasn't before. Grades 3–5, time has increased 5 to10 minutes because the activities take longer to complete. Also there wasn't a deliberate teaching of science until we got into the program in grades K–2.* (Principal)

> *Devoting time to science has caused the teachers to spend less time on the other subjects. We're struggling with that now and how to work across disciplines to get that done.* (Principal)

There have been a number of other instructional changes in schools since they joined SIE. Principals report that the way science is taught has changed, and that instruction is now better aligned to state standards. As one principal said:

> *Before [SIE] it was a hit or miss science curriculum. Some topics teachers did and some they ignored because of comfort level. Now with the PD, it has helped and we have*

*gotten proper training on the kits and focused some of our time as a science committee to look at gaps in our curriculum.*

Principals were asked to describe what a typical science lesson in their school looks like now that they are participating in SIE. Although descriptions varied somewhat, all included key components of the teaching approach that is central to SIE: active classrooms, hands-on, inquiry-based, and the use of science notebooks. Each was mentioned by several of the 22 interviewed principals. Typical responses were:

*It would be noisy, all over the place...the teacher moving about, children from life skills class would be involved in kit prep work, lots of documentation on the walls, they [the students] keep their science journal faithfully.*

*Normally, they have an essential question posted and students are working in small groups on some type of experiment. Usually, you see a lot of data collection.*

*Kids are seated in groups. They do a lot of cooperative learning. The teacher is a facilitator. She checks on each group and monitors their progress on whatever activity they do. Inclusion, as special education does this as well. Writing is a big piece with journals. The teacher is facilitating a thoughtful discussion with the class often.*

*They start out with their notebooks. Some teachers have started using notebooks in other subjects, with the guided question. Depending on what it is, they're reading from one of the books that come with it or getting right into the experiment. And discovering the answer to the question without knowing beforehand. Then, they usually meet as a group and talk about the experiment and what they found out and write about it in their journals.*

## Factors Affecting Science Program Improvement

On a questionnaire, principals from each cohort were asked about factors that facilitate or inhibit their schools' science programs.[6] As can be seen in Table 5, nearly all responding principals indicated that state science curriculum frameworks and access to professional development for teachers were facilitating factors. The availability and quality of resources for science instruction (presumably those being provided by SIE) were also frequently seen as helpful. Instructional time available for science and state and district testing in subjects other than science were the most frequently noted inhibitors. These results are very similar to those from previous years.

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[6] 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. From the 138 schools in Cohorts 1–4, HRI received 113 responses to the survey, a response rate of 82 percent.

**Table 5**
**Principal Opinions of Factors that Affect Science Instruction**

| | Percent of Principals (N = 113) | |
|---|---|---|
| | **Facilitates†** | **Inhibits‡** |
| State science curriculum frameworks | 92 | 4 |
| Access to professional development for science | 90 | 6 |
| Availability of resources for science instruction | 89 | 6 |
| Quality of resources for science instruction | 89 | 6 |
| Importance that the district places on science instruction | 87 | 6 |
| District science curriculum frameworks | 85 | 4 |
| State science testing policies and practices | 79 | 11 |
| Consistency of science reform efforts with other district/school reforms | 72 | 4 |
| District science testing policies and practices | 65 | 4 |
| Instructional time available for science | 63 | 29 |
| State testing policies and practices in subjects other than science | 54 | 26 |
| District testing policies and practices in subjects other than science | 53 | 15 |
| District grading policies and practices | 48 | 4 |
| District policies for evaluating teachers | 45 | 2 |
| District structures for recognizing and rewarding teachers | 25 | 2 |

† 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 science 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:

> *I think the assessment for the state is driving part of it, with the fourth grade science exam…and just the resources to be able to do this.* (Principal)

> *The PSSA and the standards-aligned system help at the state level because they [teachers] can narrow their focus and know what to teach and be able to sequence in a way that makes since.* (Principal)

Although the state investment in SIE was seen as a positive influence, concerns about continued funding, and the transition to a cost-sharing model, were often mentioned as inhibitors of progress. For example:

> *The cut back on funding and having to cost share; the [school] board said they will pay cost share, but the board can change and I'm not sure how long we'll be able to sustain it.* (Principal)

> *In order to continue participating, we are going to have to kick out a lot of money. I think if it were a small cost, we could do it but because it's probably going to be large, we will not be able to participate.* (Principal)

In addition, although adding science to the PSSA has increased the emphasis on science instruction, principals and district science supervisors indicated mathematics and reading/language arts are still the main priorities in their schools. One district supervisor described what might inhibit progress as follows:

> *The PSSA; that's flat out the answer. Everything boils down to whether the kids can read and do mathematics by grade three…Previously, we cut science out of the program as we needed more time to teach reading…The fact that the science PSSAs don't count makes it so they don't care or try. There are no expectations at this level.*

Principals were also asked what additional services the SIE program could provide that would help them support their school's science program. As can be seen in Table 6, ideas and tools for providing feedback to teachers, securing resources for science instruction, and enhancing teacher collaboration were each noted as potentially helpful by at least 50 percent of responding principals. Ideas and tools for assessing progress of the school's science program and professional development for principals on how to integrate science with mathematics and literacy were also seen as valuable by nearly half of the principals.

**Table 6**
**Principals Indicating that Potential Program Services Would be Very Valuable**

| | **Percent of Principals (N = 113)** |
|---|---|
| Ideas and tools for observing and providing feedback to teachers about their science instruction | 54 |
| Ideas and tools for securing the resources needed for science instruction | 50 |
| Ideas and tools for creating opportunities for teacher collaboration | 50 |
| Ideas and tools for assessing progress of our school's science program | 49 |
| Professional development for me to increase my own understanding of how to integrate science with mathematics and literacy | 48 |
| Ideas and tools for leveraging other district resources (e.g., professional development days) to support science instruction | 42 |
| Ideas and tools for increasing parental support/interest/involvement in our school's science program | 40 |
| Ideas and tools for making science more of a priority in the school | 39 |
| Professional development for me to increase my own understanding of effective science teaching | 38 |
| Ideas and tools for increasing community support/interest/involvement in our school's science program | 36 |
| Professional development for me to increase my own science content knowledge | 20 |

# The Quality and Impact of SIE Leadership Training

In an effort to build capacity within the SIE program, both for providing professional development to a large number of teachers, and to bolster school-level support for the program and elementary science education improvement more broadly, SIE is developing cadres of teacher leaders. This section of the report describes the experiences of teacher leaders selected and trained in past years, including an examination of how their classroom implementation of the SIE-supported modules compares to non-teacher leaders. The following section addresses he quality of the three-day ASSET Leadership Conference (ALC) attended by new teacher leaders, using data from interviews with a sample of teacher leaders who had been trained prior to the 2009–10 school year, classroom observations of a sample of five teacher leaders and five of their non-teacher leader peers, and HRI's observations of the ALC held in May 2010.

## The Role of Teacher Leaders

The primary role of an SIE teacher leader is to provide training and support for other teachers implementing the SIE science modules. Teacher leaders may be asked to do so informally, providing assistance to other teachers in their school and district, or more formally, helping with the facilitation of Initial Module Trainings for teachers around the state. To be successful in this role, teacher leaders need to know how to lead effective professional development, which requires them knowing how to purposefully implement the module themselves.

Purposeful implementation of a module involves going beyond just doing the activities mechanically (i.e., following the steps in the teacher's manual and having students complete the activities) to helping students make sense of the targeted ideas in each activity and how those ideas build toward bigger scientific principles. This type of implementation 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 conceptual 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, engages students intellectually 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.[7]

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; and 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. 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. The specific strategy for helping students move past this idea is to have them try many different configurations of connecting the bulb to the battery. Students record which do and do not work, and then analyze 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.

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[7] 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.

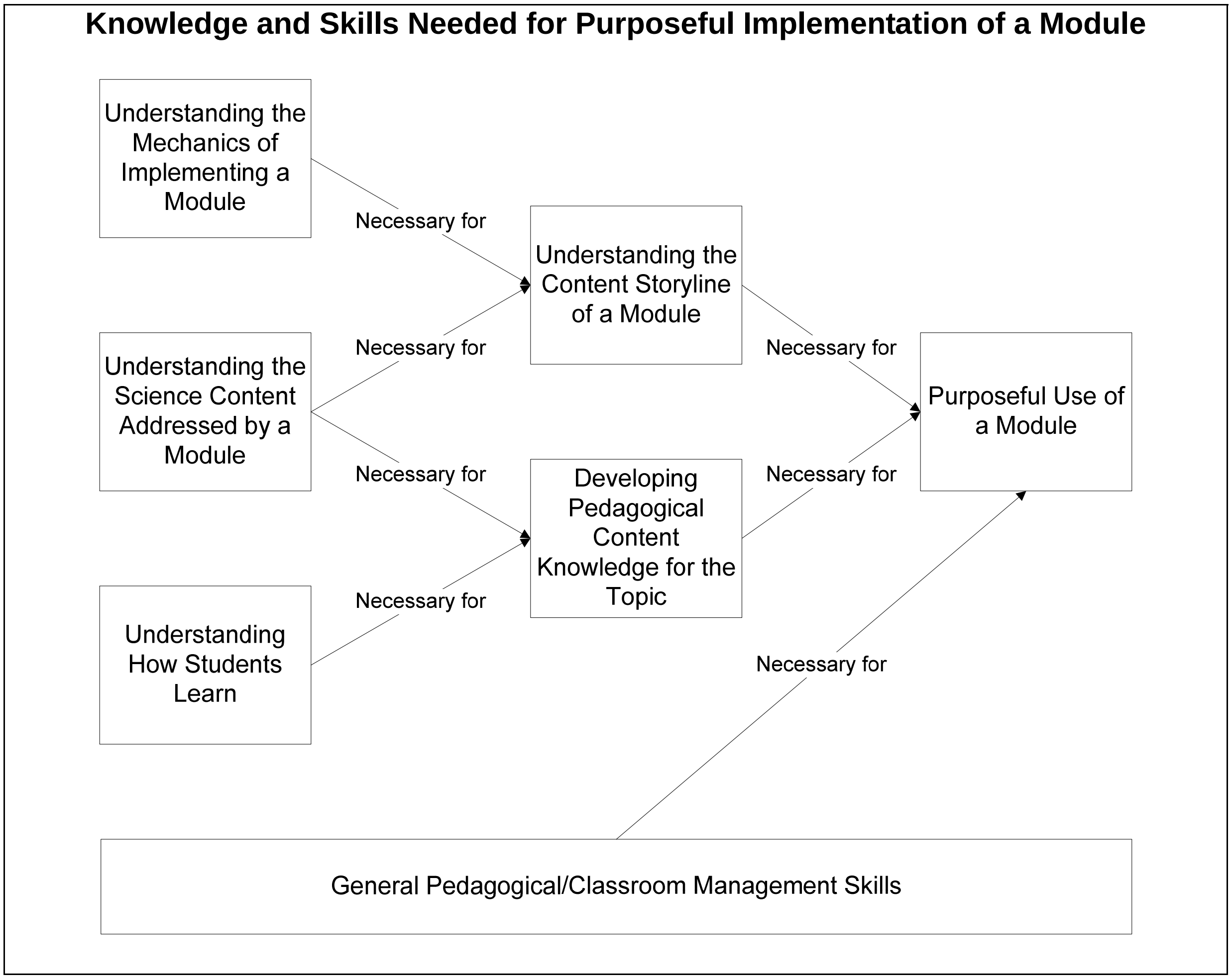


***Figure 2***

In an analogous fashion, teacher leaders need to know how to facilitate an Initial Module Training purposefully. Figure 3 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.

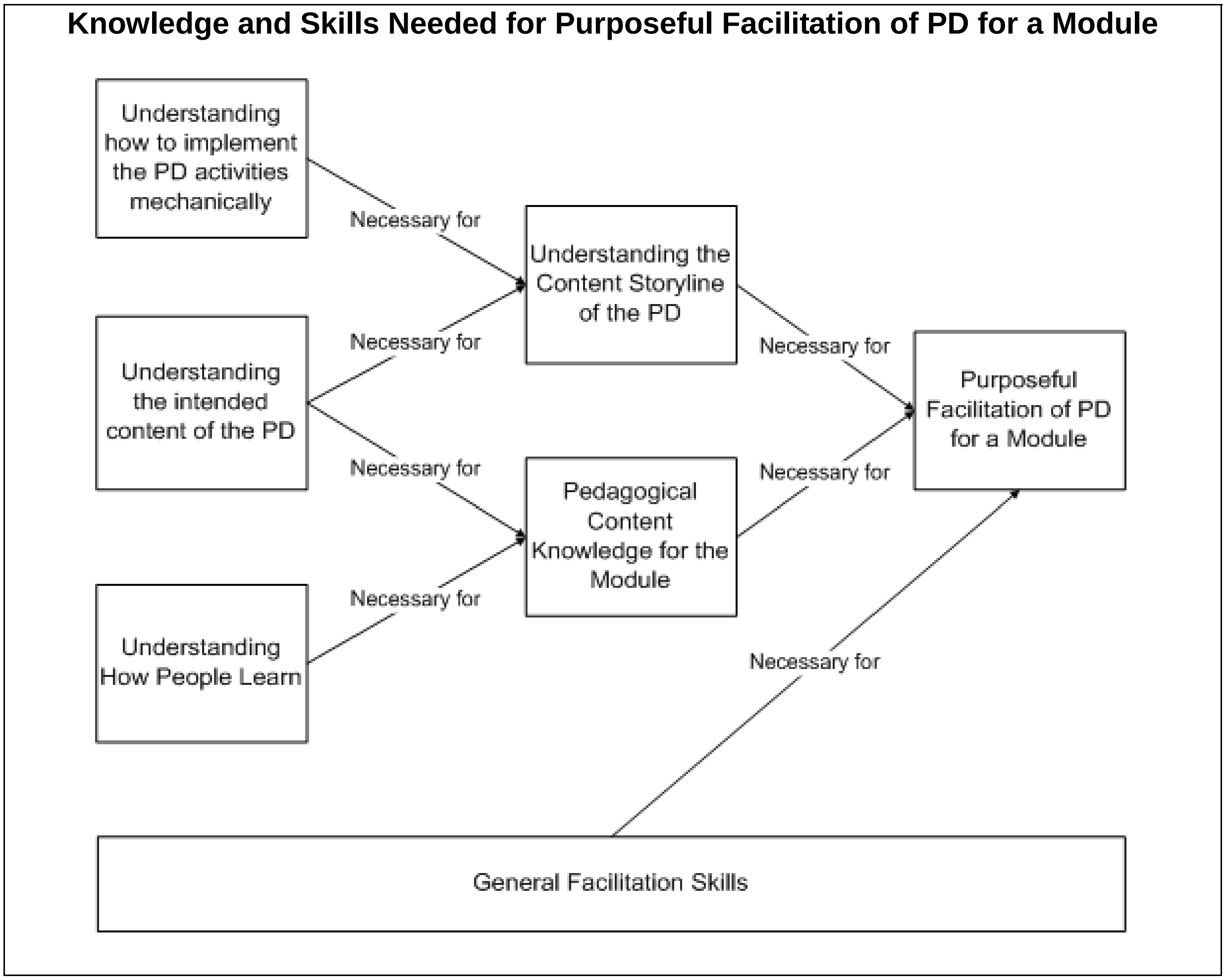


***Figure 3***

In order to help teacher leaders move from novice to purposeful facilitators of an Initial Module Training, the program has developed a Professional Development Facilitator Pathway. The first step in the pathway is attending an initial ALC, after which teacher leaders are asked to reflect on their growth and how they want to move forward. Next, the teacher leaders observe an Initial Module Training session; then, if they feel comfortable, they co-lead a session with an experienced facilitator. When ready, teacher leaders are approved by ASSET to lead professional development on their own.

## The Progression of Experienced Teacher Leaders

Because the success of the SIE program depends, in part, on the success of the teacher leaders, it is important to understand the extent to which the teacher leaders are progressing as expected. To learn about their feelings of preparedness and experiences as teacher leaders, HRI interviewed a sample of 10 who have been teacher leaders for at least two years. All but one of these teacher leaders indicated teaching science at the elementary level prior to their school joining SIE, though only two had prior experience doing so with a module like those supported by SIE. In addition, 3 of the 10 had prior experience leading professional development for teachers, including 1 who had done so in science.

**Teacher Leaders' Preparedness to Lead Initial Module Trainings**

The basic design of an Initial Module Training is to have participants experience the lessons in a module as a learner of both the materials and the science content. The sessions also include discussions of implementation issues and provide a number of suggestions for managing both students and the materials. Overall, teacher leaders indicated that they feel well prepared to lead these trainings, with all 10 interviewees attributing their preparedness to the training they received from ASSET, in some cases noting that their prior experiences with facilitation were helpful as well. As two said about the ASSET trainings:

> *They were the backbone of my knowledge. You learn something new each time.*
>
> *Going to the [ASSET leadership] conference and learning how to train/facilitate, the questions, probing, and rules of collaboration have really set a solid foundation.*

The interviews probed teacher leaders about how well prepared they felt to help teachers in specific areas related to their module: learning the logistics of implementing the lessons; understanding the science content; and figuring out how to teach the module in the limited time available for science. Each interviewee indicated feeling well prepared to address teachers' concerns about the logistics of implementing the module, with most of them attributing that confidence to their own experience teaching the module. A few of the teacher leaders mentioned that watching the ASSET staff model the workshop also contributed to their preparedness. As two shared:

> *I have been teaching this module for three years now and have sort of a buy-in when I tell teachers, "I know this works because I've used it in my classroom."*
>
> *Actually teaching it really helps because you have a real-life experience to share with other teachers.*

There was more variation in regards to comfort addressing teachers' content questions. Only one of the 10 interviewed teacher leaders reported feeling well prepared to address content questions. Several indicated that they were fairly confident, but relied on ASSET staff to address content questions. A few indicated that they felt comfortable with teaching the content to their students, but not addressing deeper content questions. One indicated not being comfortable with the science content in the module. The following quotes illustrate the range of responses:

> *I think I would be able to answer them [content questions] fairly well. On a scale of 10, about a 7 or 8. And I know where to guide them to go for further information.*
>
> *I feel confident with the part of the content that I would present to my first graders, the content base that they need to know. Some of the more advanced things, the "why" behind some of it, the more scientific part, I don't feel as confident because I only teach first grade.*

> *I'm not really strong in science and would want to make sure my facts are all in order. I would say something like, "I think I know, but let me double check."*

Given that the teacher leaders themselves indicate not feeling very confident with the science content, the program should consider ways to continue developing their understanding of the science related to their module, both to improve their own instruction and to be better able to help other teachers

Interviewees were also asked what advice they would give a participant who is concerned about how to complete a module in the time allotted for science instruction. Responses varied greatly. Several indicated that they would simply advise teachers to "do the best you can." Two indicated they would advise teachers to integrate science with reading instruction, in particular the notebooking aspects. One indicated that teachers should do as many of the lessons as they could, without skipping any; another indicated that teachers should pick and choose the lessons they felt most comfortable implementing. Two others indicated that they would advise teachers to pick the lessons most aligned with the state science standards. In the words of a few teacher leaders:

> *I would suggest they do the notebooking as their writing class that day. Or, the readings that some of the modules come with, using that in their reading class.*

> *My comment to that is always do as much as you can in the time you have…make sure you're covering the state standards because time is always an issue.*

> *I would say expose kids to certain parts and use your judgment on what parts to leave out. Instead of hitting things superficially, leave some things out. Do deep instead of covering things fast.*

These comments suggest that many, but not all, teacher leaders understand the program's standpoint that teachers should cover as much of the module as they can sequentially with fidelity in the allotted time. SIE may want to address this issue explicitly in future ALCs and during Initial Module Training preparation meetings with veteran teacher leaders to ensure that participants receive a consistent message about the implementation of the modules.

**Teacher Leaders' Experiences Preparing for and Leading Initial Module Trainings**
The interviews with teacher leaders included questions about how they prepare for, and their experiences in, leading an Initial Module Training. Eight of the 10 interviewees have facilitated at least one Initial Module Training. All of these teacher leaders indicated that they co-facilitated the workshop with an ASSET staff member, leading participants through some of the module lessons. They described their role as guiding participants through a lesson as if they were students, and providing implementation suggestions. For example:

> *I take the teachers through the different strategies for each lesson they are going to be presenting to their students within the module as though they were in their classroom; so they can see what they need to do and they need to have ready before hand; what they need to think about.*

When asked how it was decided what their role in the workshop would be, the teacher leaders indicated that the ASSET staff would typically ask what they felt comfortable doing. As three teacher leaders described:

> *It was really about who felt comfortable doing what at what point. Everyday, we would plan before the next session.*
>
> *The first time, we picked lessons we felt comfortable with.*
>
> *The other person and I would talk it over or someone from ASSET would describe what lesson to do.*
>
> When interviewees were asked what guidance they have received from ASSET regarding designing and implementing a workshop, all but one of the 10 interviewed teacher leaders who had co-led a workshop indicated that they learned primarily from observing and trying to emulate the ASSET staff. Only one teacher leader mentioned the Initial Module Training facilitators' guide as providing guidance for their workshop.

Overall, the interviewed teacher leaders valued the guidance and appreciated the supportiveness of the ASSET staff. In their own words:

> *They are extremely helpful, honest, upfront, supportive, but you also felt like you can ask them a question and they won't be like, "That was a dumb question."*
>
> *I really enjoy how they will sit down with me and give me tips and possible ways to improve, even after I present a session.*

**Teacher Leaders' Implementation of their SIE Module**

To examine the extent to which teacher leaders are purposeful in their implementation of their module, HRI observed five pairs of teachers implementing a lesson from their module. Each pair consisted of a teacher leader who had conducted at least one Initial Module Training in the module being observed and another teacher in the same school, ideally teaching the same module.[8] Information on the teachers and the observed lessons is shown in Table 7.

[8] Because funding for the program this year came through well into the school year, many of the teacher leaders had already completed their implementation of the module for which they provide training. Thus, HRI was not able to randomly sample teacher leaders for this study and the results may not be representative of all teacher leaders.

**Table 7**
**Observed Classroom Lessons**

| School | Teacher Leader | Module | Lesson |
|---|---|---|---|
| A | Yes | Changes | 7: Dissolving Race: Two Forms of Sugar |
| | No | Changes | 4: Mixing and Separating Solids |
| B | Yes | Changes | 13: Gas in a Bag |
| | No | Changes | 10: Separating Mixtures of Color |
| C | Yes | Changes | 2: Freezing and Melting |
| | No | Changes | 2: Freezing and Melting |
| D | Yes | Electric Circuits | 8: Making a Filament |
| | No | Electric Circuits | 15: Planning to Wire a House |
| E | Yes | Mixtures & Solutions | 4.3: Reaction in a Zip Bag |
| | No | Electric Circuits | 13: Constructing a Flashlight |

The classroom observations focused on the extent to which instruction provided opportunity for students to deepen their understanding of the intended science content. Interviews after the observations were used to gather information on the teachers' experiences with the module and the strategies they use when implementing it. The framework HRI used for assessing student opportunity to learn is based on research on how people learn, as described earlier in this report. Intellectual engagement and sense-making are likely the most critical components of this framework, and are the ones teachers tend to struggle with the most. Following are the findings from a comparative analysis of lessons taught by teacher leaders and their non-teacher leader peers in each of these two areas, as well as the extent to which the teachers appeared to understand the content storyline of their module.

***Focusing Students on the Relevant Aspects of the Lesson Activities***

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. Intellectual engagement involves focusing students on the relevant aspects of the lesson activity and understanding how data they are considering are related to targeted concepts. Students must know why they are doing the activity, or collecting the data that they are. In other words, instruction must be "minds-on," not just "hands-on."

In the observed lessons, teacher leaders were more likely to intellectually engage their students with the targeted science ideas than were their colleagues. In the lessons led by teacher leaders, the students were focused on what they were doing in the lesson activity and why they were doing it (i.e., the activity was purposeful). All of the observed teacher leaders utilized focus questions in the lessons, which provided guidance to students about the purpose of activities. For example, in a *Mixtures and Solutions* module lesson, sixth graders were provided the focus question, "What might happen if you put calcium chloride, baking soda, and water in a zip lock bag?" This question let students know that they should be attending to any changes that occur as a result of mixing these components during the lesson.

The teacher leaders' questioning during activities also helped focus students on relevant aspects of the student activities. For example, a teacher leader asked, "What happened when you did that? Why do you think that happened?" In contrast, the observed lessons taught by non-teacher leaders were usually focused on the mechanics of doing the activity, with the teachers' talk focused on procedure (e.g., "What should you do now?" and "Do the next step."). For example, in a *Changes* lesson led by a non-teacher leader, third graders were told they would be "doing the opposite of mixing colors" in a lesson where they added water to ink to separate it into its component colors. Instead of focusing students on the targeted idea that mixtures of liquids can be separated, the teacher focused students on the steps of the activity, saying things like, "Add two drops now." and "Don't let your markers touch."

***Helping Students Make Sense of the Targeted Ideas***

In addition to engaging students with activities that are designed to develop their conceptual understanding, it is 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 developing an understanding of the science involved, turning the lesson into "activity for activity's sake." The SIE professional development provides teachers with a number of sense-making strategies, such as the "line of learning" to help students make connections between the module activities and the content.

In the observed lessons, teacher leaders were more likely to have a class discussion after an activity, They were also more likely to attempt one or more of the sense-making strategies introduced at the SIE trainings, such as having students revisit their initial answers to the focus question, write claims and evidence statements, or use the "line of learning. For example, after observing a chemical change where a gas was produced, third grade students had a brief discussion about what they observed then listened to the teacher (a teacher leader) read a science story. After the story, the students drew a "line of learning" in their notebooks and recorded something new they had learned.

In contrast, the observed lessons led by non-teacher leaders tended to end with a recap of the activity experienced, but did not include structured time for sense-making of the targeted concept. For example, at the end of a second grade *Changes* lesson, the teacher asked students what they observed. A student replied that they had separated their mixture of salt and gravel. The teacher then asked students to clean up their stations and then sent them to recess.

This differential focus on sense-making came through in the post-observation interviews as well. When asked what strategies presented at the IMTs had been most helpful in their implementation of the module, teacher leaders were more likely to mention strategies focused on uncovering student thinking and helping students reflect on the activity, while non-teacher leaders tended to mention time and/or materials management strategies. The following quotes illustrate the differences:

> *Before I went through this program, often I would just have a kid answer and say okay good answer. Now, I am like, "Well, tell us a bit more"…I think kids need to hear kids answer things in their language sometimes versus the teacher telling them everything…I wait better, I am not so interested in giving my information, I need to know what they know…they are not always learning when we think they are, but if you let them talk you can kind of move away some of those misconceptions.* (Teacher Leader)

> *What I found most helpful were the time management skills…I actually make up the science kit on their trays for them so that when I have a half hour to teach science at least that part is ready to go.* (Non-Teacher Leader)

Although teacher leaders were more likely to attempt sense-making, observers noted that they struggled to help students make the connections between what they did and the science ideas. Wrap-up discussions typically focused more on simply sharing observations from the activity and making sure students had the correct data. For example, in one teacher leader's lesson the class discussion focused only on debriefing students' results and did not progress to a thoughtful discussion about the meaning of their data. As the observer described

> Students in a lesson from the *Changes* module dissolved two forms of sugar (i.e., granules and a cube) to see which would dissolve faster. The idea to be learned from this activity was that a substance's properties, such as size, determine, in part, if and how quickly it will dissolve. The post-activity discussion included:
>
> Teacher: Okay, I think we are ready to discuss our results. What did your group find?
> Student: The sugar cube won.
> Teacher: How about your group?
> Student: The grains. Oh, no, no; the cube.
> Teacher: Was it close or a long time?
> Student: It was close.
> Teacher: How about your group?
> Student: We couldn't tell, it looked like a tie.
> Teacher: If we did it again, would we get the same results?
>
> Some students say yes, some say no. The teacher went on to point out the group that had different people stirring each cup and noted that they might have different results if one person stirred both cups. The lesson ended without the class reaching the targeted idea and the teacher indicated that they would move on to the next lesson.

***Understanding the Content Storyline of the Module***

For both groups of observed teachers, the lessons focused more on completing the activity rather than on the concepts targeted by the lessons. In order for sense-making to occur, teachers must understand what science concepts are addressed by each lesson. One reason for the inadequate sense-making in the observed lessons may have been that the teachers did not have a clear understanding of which science concepts were targeted in the module lessons. When asked during interviews what they hoped students would learn from the observed lesson, most respondents, both teacher leaders and non-teacher leaders, described what students did in the lesson rather than a science concept or process skill. For example, one teacher leader indicated that the goal was for students to see a chemical reaction, rather than the idea that chemical reactions result in new substances. A non-teacher leader cited the purpose of the observed lesson was for students to, "Start constructing a flashlight with as little instruction as possible" instead of understanding the trade-offs of series and parallel circuits when designing a flashlight.

The findings from these observations and interviews suggest that teachers participating in SIE would benefit from an increased emphasis on the science ideas targeted by the modules, as well as a clear understanding of what students should know and/or be able to do as a result of each lesson. Given the central role teacher leaders have in delivering professional development, the program may want to consider adding a check point to the Professional Development Facilitator

Pathway that asks teacher leaders to demonstrate an understanding of the content storyline of their module.

## Training a New Cadre of Teacher Leaders

To continue building capacity to provide professional development to a large number of teachers, SIE recruited and begun the training of an additional cadre of teacher leaders this year. One major change to the process this year was the method for recruiting teacher leaders. In previous years, teacher leaders were often selected by administrators and sent to the leadership training without knowing what they were getting into. Consequently, the attrition rate for teacher leaders was fairly high. This year, aspiring teacher leaders completed an application process, which the program believes will result in greater buy-in and, thus, higher retention.

Approximately 30 teachers selected to be part of this new cadre of teacher leaders attended a three-day ASSET Leadership Conference in May 2010. The program's goals were to help teacher leaders:

- Enhance their understanding of effective facilitation skills and reflect on areas of growth;
- Develop an awareness of how five learning blocks are embedded in the modules; and
- Begin a professional development pathway to follow throughout the 2010–11 school year.

To accomplish these goals, the conference was structured around five key learning blocks:

1. Leadership and Facilitation;
2. Content;
3. Inquiry;
4. Literacy; and
5. Assessment.

With the exception of the content block which was dealt with only in module-specific breakouts, each block was addressed in a whole-group plenary session, and applied in module-specific breakout sessions. Following is an analysis of the extent to which the ALC met each of these goals based on HRI's observations of the conference.

**Enhancing Teacher Leaders' Understanding of Effective Facilitation Skills and Reflecting on Areas of Growth**

The plenary session on leadership and facilitation was the first of the conference and was comprised of two main parts. The first hour was devoted to the characteristics of effective leadership. During this portion, the teacher leaders were introduced to traits of effective leaders. They then watched a clip from a movie and were asked to identify how each of those traits was exemplified by the characters in the film. Finally, the teacher leaders were asked to select one trait to focus on during the conference, and were given opportunities throughout to reflect on how they have been developing that skill. They revisited this trait on the last day of the conference, reflecting on how this leadership skill will help them both as a teacher and as an advocate for science education.

The focus on effective leadership provided a foundation for the new teacher leaders' role as leaders.  Trying to identify the leadership skills shown in the film clip allowed the teacher leaders to reflect on the traits of an effective leader, pushing them to think beyond the viewpoint of a classroom teacher. Not unexpectedly, there was a great deal of variation in their interpretation of the film, with different teacher leaders interpreting the same action in the film as demonstrating different leadership qualities. Although each of the interpretations was valid, because multiple traits were present in each scene of the film, the distinctions among the traits may have been blurred. However, discussions about the traits later in the conference indicate that the teacher leaders were able to identify these traits correctly.

At the beginning of the second part of this plenary session, the teacher leaders were briefly introduced to the norms of collaboration,[9] the elements of effective science instruction,[10] and effective questioning to promote understanding. After this introduction, they engaged in a nearly two-hour long "fishbowl" activity focused on facilitation of an Initial Module Training. The teacher leaders sat around the room and watched two ASSET staff members role-play the parts of facilitators preparing for and implementing an Initial Module Training. Other ASSET staff played the parts of participants in the Initial Module Training. The role play included a number of issues that commonly arise in professional development, such as participants who were off task or resistant to learning about the module. At various points of the role play, the ASSET staff would pause and ask the teacher leaders questions about what they observed, how the norms of collaboration or elements of effective instruction were being exemplified, or how facilitators handled tricky situations.

The fishbowl activity was effective at highlighting the importance of session preparation, general facilitation moves, and working with a co-facilitator. It also provided the teacher leaders with a concrete example of the expectations for the look and feel of an Initial Module Training. However, teacher leaders were introduced to a lot of new information (i.e., the norms, the elements) and it appeared to be overwhelming. For example, during the "pauses" in the role play, when asked which norm was being used, teacher leaders would respond by naming one of the elements of effective instruction, or simply describe what the workshop "participants" had been doing. The program may want to consider ways to give new teacher leaders more time to process the different ideas, perhaps by asking them to read the relevant articles prior to attending

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[9] The seven norms of collaboration are: (1) pausing; (2) paraphrasing; (3) probing for specificity; (4) putting ideas on the table; (5) paying attention to self and others; (6) presuming positive intentions; and (7) pursuing a balance between advocacy and inquiry. From: Garmston R. & Wellman, B. (1999) *The adaptive school: A sourcebook for developing collaborative groups* (pp. 37-49), Norwood, MA: Christopher-Gordon.

[10] The elements of effective science instruction drawn from research on how people learn are: motivation; eliciting students' prior knowledge; intellectual engagement; use of evidence to critique claims; and sense-making. From: 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.

the ALC, possibly noting ideas that they thought were particularly important and questions they had based on their reading.

The new teacher leaders may have also benefited from a slightly more structured and detailed framing of the conference. Many of the teacher leaders' comments and questions in this session were focused on the mechanics of preparing for and running an Initial Module Training. For example, questions included: "Do I need to bring my own module materials?" and "What time do I have to show up?" Although the program planned to (and did) address these issues later in the conference, the teacher leaders were not aware of this plan. The teacher leaders' concerns about these issues may have interfered with their ability to focus on more advanced skills like instituting the norms of collaboration or highlighting the elements of effective science instruction.

Teacher leaders' questions about their role were addressed on the last day of the conference via a Lead Teacher panel discussion. The panel of six veteran teacher leaders answered questions that had been submitted by the new teacher leaders during the leadership conference. Many of the questions dealt with logistical issues and the responses were helpful. For example:

> Question: How far can you defer from scripted facilitator's guide?
> Response: Not at all. You can add your own style, but one should cover the material as written.
>
> Question: How much notification do we get before a session?
> Response: ASSET tries to give10 days notice.
>
> Question: When do you get a facilitator's guide?
> Response: After your first observation. When doing a session, you get the guide and PowerPoints.

Other questions focused more on the substance of facilitating a workshop. In contrast to the logistical questions, the responses to these were sometimes vague. For example:

> Question: How do we present module lessons? Do we do them as students or talk and discuss strategies?
> Response: You'll know when to walk participants through a lesson or when to just discuss it. You'll see for yourself when it is appropriate to do each.

It is difficult to decide when and how to deal with the myriad of needs new teacher leaders have, and there typically are pros and cons of each approach. The program may want to consider incorporating a session on logistical concerns early in the ALC to allow teacher leaders to get these pressing needs addressed. Doing so may allow teacher leaders to better engage with the more challenging, substantive aspects of leadership and facilitation.

**Developing Teacher Leaders' Awareness of How the Five Learning Blocks Are Embedded in the Modules**

While the leadership and facilitation block focused primarily on preparing teacher leaders to lead IMTs, the other blocks were intended to deepen their understanding of how to effectively teach their module. Improving their understanding of and ability to teach the module to students would also serve the teacher leaders well in leading IMTs.

The content block focused heavily on helping teacher leaders understand the content storyline of their module. Teacher leaders began by exploring their own prior knowledge of the content by responding to a formative assessment probe about the content in their module. Then the teacher leaders engaged in one of the hands-on activities from the module, followed by the introduction of the storyline of the module, and a discussion of where the activity fits conceptually in the module. The storyline was represented on concept maps the program has created (and which are used in the Module Enrichment professional development). At the end of the session, the group reviewed the PowerPoint slides about the science content in their assigned module.

The inquiry block began with a plenary session that provided a definition of inquiry and an overview of the FERA learning cycle,[11] which is used in about half of the SIE-supported modules. During the Inquiry break-out sessions, teacher leaders examined a module lesson, identifying the FERA components, and then discussed the features of inquiry in their module.

The literacy block focused on the connections between science and language arts. The plenary session had teacher leaders identify and create posters to visually represent what they saw as the connections. They shared their thoughts in a "gallery walk" during which the teacher leaders rotated around the room examining others' posters. They also discussed the process of scientific argumentation and the importance of making thinking public for learning, which can be done through various written strategies. In the break-outs, teacher leaders examined ways to use science notebooks with their modules. The teacher leaders learned about how they could use the line of learning, claims and evidence, and power conclusion strategies with their module.

The plenary for the assessment block included a discussion of both summative and formative assessment, with an introduction to a number of key components of formative assessment.[12] During the assessment breakout session, teacher leaders revisited the probe they had completed in the content block and discussed the use of probes to assess students' thinking. They also discussed the importance of teachers stating the learning intentions of the module lessons and providing feedback to students as important components of assessment.

Breaking into module-specific groups as part of each block was an effective strategy. It was a good way for the teacher leaders to see the materials (e.g., PowerPoint slides, notebook prompts, formative assessment probes) they will be using to facilitate an Initial Module Training. In addition, these break-out groups allowed the teacher leaders to work with the ASSET staff they will likely be paired with in leading an Initial Module Training, thus developing a connection with their future co-facilitators.

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[11] The steps of FERA cycle are: *Focusing* on the content at hand through observations and questions; *Exploring* these ideas with hands-on experiences; *Reflecting* on what students have observed or measured to make meaning from their experiences; and *Applying* and extending their findings to new questions or problems.

[12] The key components of formative assessment that were considered are: (1) learning expectations and criteria for success; (2) questioning; (3) feedback; (4) self-assessment; and (5) peer-assessment. From, Black, P. & Wiliam, D. "Inside the black box: Raising standards through classroom assessment," *Phi Delta Kappan*, October 1998, pp. 139–44, 146–48.

Overall, the learning block approach was sound. However, the inadequate science content knowledge of many of the teacher leaders may have interfered with their ability to engage with the blocks. For example, in one of the inquiry break-out sessions, the teacher leaders spent a lot of time attempting to complete and make sense of the selected module activity. Their struggle indicated a lack of understanding of the science in the module, and the session facilitator spent most of the time reviewing the content. The facilitator made the appropriate decision, as the teacher leaders could not have engaged with the discussion about inquiry in a meaningful way without understanding the content. However, by the time the teacher leaders understood the content ideas, there was little time left to discuss how the lesson exhibited the features of inquiry. Thus, the facilitator simply identified the components of FERA and process skills covered in the lesson for the teacher leaders. Given that many of the teacher leaders, past and present, have limited experience in science, the program may want to increase the time allotted for the content block in the ALC or consider other means for deepening the teacher leaders' content knowledge.

The different blocks provided the teacher leaders with a great deal of information and strategies they can use to supplement the teaching of their module. However, there was little guidance provided on when, in what ways, or how often these tools should be used in the IMTs. Given how much the IMTs need to accomplish, the teacher leaders would likely benefit from guidance in this area. The program may want to develop a storyline for each module's Initial Module Training that specifies when and for what purpose to use each of the tools.

Finally, as was the case with the leadership and facilitation block, the teacher leaders asked many questions about the logistics of their role throughout these blocks. The questions were good ones, and the ASSET staff did a nice job answering them, but these questions and answers diverted the focus from of the intended purposes of the blocks.

**Helping Teacher Leaders Begin a Professional Development Pathway to Follow Throughout the 2010–11 School Year**

On the first day of the ALC, the teacher leaders were introduced to the PD Facilitator Pathway. This session provided the teacher leaders with an overview of what training and support they would receive and the program's expectations for them. Quite naturally, the session generated many questions from the teacher leaders. Most of the questions focused on the logistics of how the scheduling of the various aspects of the pathway would work (given their already busy lives as teachers). If the program decides to incorporate a session to address logistical concerns earlier in the conference, adding it to this session may be a natural fit.

# The Quality of SIE Professional Development

The primary aim of the SIE program is to enhance student learning of science in K–6 classrooms by providing high-quality instructional materials and professional development to help teachers implement those materials well. The consensus view among experts in the field is that professional development needs to be sustained over time, situated in teachers' classroom practice, and focused on issues of curriculum and pedagogy related to the learning of specific content.[13] Professional development should also model and then explicitly discuss effective instruction, and should involve multiple stakeholders within schools.

The design of the SIE professional development program incorporates this wisdom of practice by providing teachers with a sequence of opportunities to move from mechanical (novice use) to purposeful implementation (expert use) of the instructional materials. The program includes three components. The Foundations course, intended for teachers new to the program, focuses on helping teachers develop a common vision of effective science instruction. Initial Module Training is intended to help teachers attain at least a mechanical use of the module, and to lay the groundwork for further professional development that will move them toward more purposeful use. Module Enrichment Training, offered to teachers after they have used a module for two years, is intended to deepen their understanding of the content storyline of the module and their pedagogical content knowledge around the topic of the module.

During Year Four of SIE, Cohort 4 teachers attended the Foundations course and an Initial Module Training for their first module. Cohort 3 teachers attended an Initial Module Training for their second module, and Cohort 1 attended Initial Module Training for their third module. Cohorts 1 and 2 teachers, most of whom had taught an SIE-provided module for two years, had the opportunity to attend a Module Enrichment Training for that module. A post-professional development questionnaire was administered to teachers attending these workshops.[14] Table 8 shows the number of teachers completing the questionnaire at each type of workshop.

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[13] See for example: Elmore, R. F. (2002). *Bridging the gap between standards and achievement: The imperative for professional development in education.* Washington, DC: Albert Shanker Institute.

Banilower, E. R., Boyd, S. E., Pasley, J. D., & Weiss, I. R. (2006). *Lessons from a decade of mathematics and science reform: A capstone report for the local systemic change through teacher enhancement initiative.* Chapel Hill, NC: Horizon Research, Inc.

[14] Due to a delay in funding, post-professional development questionnaires were administered only to SIE workshops held after January 1, 2010 and do not represent the entire population of SIE workshop attendees in Year Four. Because the post-professional development questionnaire was administered to a captive audience, the response rate should be close to 100 percent.

**Table 8**
**Responses to Post-Professional Development Questionnaire**

| | *Number* of Responding Teachers |
|---|---|
| Initial Module Training | 1,047 |
| Module Enrichment Training | 57 |

This section of the report describes the quality of each component of the SIE professional development program. Data sources include the baseline and post-professional development questionnaires, observations by HRI, and interviews with principals and teachers.

## Foundations Course

The primary purpose of the Foundations course is to develop a common vision of effective science instruction for those teachers new to the SIE program. After an introduction to the SIE program, participants are asked to record their own ideas of what effective science instruction looks like. The participants post their ideas around the room, conduct a "gallery walk" (i.e., participants circulate around the room reading everyone's postings), and then discuss what they read. Next, participants watch segments from the video "Minds of Their Own" in which MIT and Harvard graduates are asked questions about basic science concepts such as how to use a wire, bulb, and battery to create a complete circuit, revealing their lack of understanding of the basic concept of the flow of electric current despite their formal education. The video includes interviews with science education researchers that highlight the fact that there is a link missing between what teachers teach and what students learn. Participants also watch a video clip in which a high school physics teacher provides a clear and accurate explanation of what a complete circuit is, but at the end of instruction his brightest student still does not understand how current flows in a simple circuit.

After watching and discussing the videos, participants are introduced to the elements of effective science instruction: motivation; elicitation; intellectual engagement; claims and evidence; and sense making. For the remainder of the session, participants engage as learners in a science activity on electromagnets that models these elements. After the activity, the facilitators highlight when and where they modeled each element of effective instruction. The session ends with participants watching a final video clip of the high school physics teacher's class and how his instruction had changed because of what he discovered about how students learn.

There were a number of strengths in this year's Foundations courses. In particular, the group discussions of participants' own ideas of effective science instruction and video examples were effective at highlighting the SIE program's vision. For example, participants were observed in one session having a thoughtful discussion about how they entered the training believing that the modules were primarily about having students do hands-on activities. They noted that the discussion about effective science instruction and the video clips changed their opinion; they indicated that because of the Foundations course, they understand that the program was promoting a higher level of student intellectual engagement in learning science. As one participant stated:

> *Given the time to now see what this is really about, I now understand you have a different view. It's not just, "Here are all the materials now go experiment." It needs to be more in-depth.*

However, there was considerable variation both within and across sessions in the facilitators' skill at leading this training. In many of the observed sessions, the participants struggled with the electromagnets activity due to a lack of initial guidance for the task. In sessions where the activity worked well, the facilitators took time at the beginning of the activity to review what a complete circuit is and how electric current flows in an electromagnet.

In other sessions, because participants did not understand how an electromagnet worked, they struggled with how to assemble the electromagnet and understanding why the variables being investigated would make any difference in the strength of the electromagnet. In these sessions, the participants tended to fall behind, struggling with the activity, and the facilitators faced a difficult choice of pressing ahead to stay on schedule, or slowing down but having to cut something from later in the session. Typically, the facilitators chose to move forward, which resulted in some participants not having the opportunity to get beyond the mechanics of the activity and consider how the activity could illustrate the elements of effective instruction.

Although it is a good idea for participants to engage with an idea where they do not necessarily know the correct outcome, the program may want to include a brief explanation of electromagnets as a standard part of this activity. Alternatively, the program may want to consider selecting an activity for which teachers are more likely to have the prerequisite knowledge in order to illustrate the elements.

Variation in the skill of the facilitators was also observed in the portion of the session that discussed how the electromagnets activity illustrated the elements of effective instruction. In some sessions, the facilitators were able to guide participants to correctly identify the elements. For example, in the discussion about the elements in one session, the facilitator first reminded the participants what each element was then asked them for examples from the activity using questions to check for understanding:

| | |
|---|---|
| Facilitator: | Now you need to keep the kids intellectually engaged. That is, keep them focused. Where did we use intellectual engagement? |
| Participant 1: | When we did the lesson. |
| Participant 2: | The hands-on. That's engaging. |
| Facilitator: | Okay. The hands-on; the doing the activity. Can you say more? Did just doing the hands-on work keep you focused? |
| Participant 2: | We were focused on doing the work. |
| Facilitator: | But you need to be focused on the work and on? |
| Participant 3: | The science? |
| Facilitator: | Yes, the science. Kids need to not just do the activity but be doing the science. The questions we gave you helped keep you focused on the science when you were doing the hands-on. |

However, in other sessions, the elements were sometimes misrepresented. For example, in one session the facilitator told participants, "Building the electromagnet was the engagement." As the purpose of the activity was to determine the factors that influence the strength of an electromagnet, simply building an electromagnet was not an example of "intellectual engagement." Rather, the controlled testing of the different factors, and the careful recording and organization of data were the key parts of the activity that allow the learner to engage with the targeted idea.

To help ensure greater consistency in the quality of these sessions, it will be important for the program to consider ways to help all facilitators of the Foundations course develop a clear understanding of the elements themselves and of how the selected activity exemplifies those elements.

## Initial Module Trainings

The primary purpose of the IMTs is to prepare teachers to use an SIE-supported module for the first time, including familiarizing them with the activities, the targeted science content, and strategies for engaging students with the content. The workshops often use the "learner hat/teacher hat" approach in which participants engage with an activity from the module as learners and then discuss the activity as teachers. The sessions also provide participating teachers with opportunities to learn a variety of instructional strategies that can be used when implementing the module; in particular, the workshops emphasize the use science notebooks as a way to integrate literacy skills into science teaching. Data on the quality and impact of the IMTs 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**
Knowing what participants' needs and expectations are for a professional development experience can provide valuable insight for understanding their perceptions of the quality of that experience. An open-ended item on the baseline questionnaire asked teachers new to SIE what they hoped to gain from participating in SIE professional development. The most common response, given by approximately one-third of the respondents, was that they wanted to learn hands-on activities and experiments to use in their science teaching. Over one-quarter of the questionnaire respondents indicated that they wanted to learn how to make science more enjoyable and engaging for their students. Typical responses included:

> *Knowledge of easier science experiments that are effective.*
>
> *Methods/techniques to get kids and staff excited about teaching a "hands on" science program.*
>
> *I'm hoping to walk away with new and fun ways to teach science, as well as, resource materials to use.*

**Teacher and Principal Perceptions of the Quality of the Initial Module Trainings**
Teacher feedback on the post-professional development questionnaire administered at the end of each training was overwhelmingly positive. One area in which the workshops continue to receive high ratings is the quality of the facilitation. Nearly all responding teachers thought the

facilitators provided useful suggestions for successfully implementing the modules, encouraged active participation, and helped address 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. Teachers also indicated that the workshops had increased their understanding of the science content in the modules. (See Table 9.)

**Table 9**
**Teacher Opinions of the Quality of SIE Initial Module Training**

| | **Percent of Teachers Agreeing (N = 1,045)** |
|---|---|
| This workshop familiarized me with the activities and materials in the module. | 99 |
| The facilitators encouraged active participation and investigation by all participants. | 97 |
| The facilitators shared tips and suggestions for successfully implementing the module. | 97 |
| The goals of this workshop were clear. | 97 |
| The various components of this workshop were useful in meeting its goals. | 97 |
| This workshop increased my understanding of the science content in the module. | 97 |
| There were opportunities for participants to express their views and collaborate with peers. | 96 |
| This workshop reflected careful planning and organization. | 96 |
| Question about the science content in the module were adequately addressed by the facilitators. | 95 |
| The facilitators modeled effective teaching strategies. | 95 |
| The facilitators were well prepared. | 95 |
| This workshop increased my confidence in my ability to teach using the SIE module. | 94 |
| This workshop prepared me to use the teaching strategies promoted by SIE. | 94 |
| This workshop was relevant to my classroom instruction. | 94 |
| I would recommend this professional development to a colleague. | 93 |
| The facilitators explicitly discussed how, when and why to use different teaching strategies. | 93 |
| This workshop was worth the time that I invested. | 93 |
| Adequate time, structure, and guidance were provided for participants to reflect individually on the substance of this workshop. | 89 |
| Adequate, time, structure, and guidance were provided for participants to discuss the SIE-supported modules and pedagogical strategies with each other. | 89 |

† Includes those teachers agreeing or strongly agreeing with each statement.

In addition, approximately three-fourths of respondents indicated that the pace of the workshop was appropriate. (See Table 10.) Fourteen percent of participating teachers thought that the pace of the IMTs was too slow; 12 percent indicated the pace was too fast.

**Table 10**
**Teacher Opinions of the Pace of SIE Initial Module Trainings**

| | **Percent of Teachers (N = 1,027)** |
|---|---|
| Too slow | 14 |
| Appropriate | 74 |
| Too fast | 12 |

When asked on the post-professional development questionnaire which aspects of the IMTs were most effective in preparing them to implement the module, over 60 percent of respondents to this open-ended item highlighted going through the module activities as if they were students. Receiving useful suggestions for implementation from the facilitators was mentioned by about one-third of the respondents. These sentiments were echoed in interviews with teachers. In the words of three:

> *I enjoyed being able to go through step-by-step the different lessons in the module. It gave me a clearer understanding of what my kids are expected to do.*

> *I really like the way they walk us through the lessons…so we can actually see it in action. I really appreciate that because when I walk into my classroom I feel like I have already seen it, I am comfortable with it, and I can execute it…I like the fact that they had teachers coming to do the training because they have actually done it in the classroom and they know what works and what does not work, so it was a lot more realistic point of view.*

> *They [the facilitators] were very knowledgeable about the content of the module and offered tips for the best way to implement it in the classroom.*

When asked how the IMTs could be more effective, teachers' most common response was that no changes were needed. When teachers did have suggestions for improvement, the most common were to lengthen the workshop to allow a more in-depth coverage of the module and to allow more time for teachers to collaborate with their peers. As two wrote:

> *A little more modeling of course questions or at least discussion after [the activity]…A little more wait time to write in notebook. The second day seemed very rushed.*

> *More discussion between other teachers/districts on how they would adapt with how much time they have to teach science.*

Another indicator of the quality of the professional development is what concerns participants had about implementing the module in their classroom after the training. Very few participants had concerns about their ability to teach the module. The most common concern, mentioned by nearly half of the participants responding to this open-ended question, centered on time; either finding instructional time for science or finding time to prepare all the materials needed to use the module. Managing the materials that come with the module was mentioned by about 1 in 5 respondents. As two teachers wrote:

> *There is not enough space in my classroom for all this material! We are also on a very tight schedule and there will not be enough time to complete all activities. At this point, we are lucky to have one day a week to fit in science—not ½ hour each day as suggested.*

> *Being able to fit all of the lessons into the time that will be left over after teaching other core subjects.*

**Observers' Perceptions of the Quality of the Initial Module Trainings**

Evaluation staff observed at least a portion of each of the 16 Initial Module Training sessions between January and February 2010. HRI attempted to observe IMTs for as many different modules as possible, at the same time maximizing the number of workshops observed in each trip. Table 11 summarizes the number of sessions observed for each module.

**Table 11**
**Initial Module Trainings Observed**

| | Number of Sessions |
|---|---|
| Changes | 1 |
| Ecosystems | 1 |
| Electric Circuits | 3 |
| Levers and Pulleys | 2 |
| Magnets and Motors | 1 |
| Motion and Design | 1 |
| Organisms | 1 |
| Plant Growth and Development | 1 |
| Rocks and Minerals | 1 |
| Variables | 1 |
| Water | 1 |
| Weather | 1 |
| Wood and Paper | 1 |

HRI's observations focused on the extent to which the IMTs: (1) prepared teachers to implement the modules at the mechanical level; (2) deepened their understanding of the content in the module; (3) made teachers aware of the science content students should learn in each module lesson (i.e., the content storyline); and (4) deepened their understanding of effective science instruction.

As described previously, the main professional development strategy used in many of the IMTs was the learner hat/teacher hat approach. In this approach, participants first engage in a module activity from the student perspective and then discuss the design and facilitation of the activity from the teacher perspective. This approach is particularly well suited for the Initial Module Training sessions because of their multiple goals of deepening teachers' content knowledge and preparing teachers to implement the modules. The use of this method creates a structure to, and expectations for, the professional development that increases the likelihood that all goals will be addressed adequately, and that the science content will not get lost.

As with any approach, this one involves a number of trade-offs. One is that it 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. One way to address this issue is to use this approach only for selected lessons, 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).

In some of the observed IMTs, the facilitators used the learner hat/teacher hat approach quite skillfully. In these sessions, the facilitators were very deliberate and clear about when teachers should be in which hat. The facilitators also made sure to devote enough time to each phase for the participating teachers to engage meaningfully in the substance of that mode. In addition to "cueing" the participants as to when they were in learner mode or teacher mode, the most successful sessions addressed each of the targeted goals through the use of the learner hat/teacher hat strategy.

One example of the effective use of the learner hat/teacher hat strategy was observed in an *Ecosystems* session. In this session, the facilitator led the participants through the activity and made sure they made sense of the science content themselves before stepping into teacher mode to talk about implementation issues. As the observer described:

> In the learner hat mode, participants completed the student activities of reading from the science text that accompanies the module about gas exchange between plants and animals. They also created a web to visually represent the relationships among the biotic and abiotic things in an aquarium they had set up based on evidence from the reading and observations. The group then looked at the focus question for this lesson, "How do snails, fish, and plants together affect their environment?" The facilitator introduced the sense-making strategy of writing a "claims and evidence" statement, by providing the sentence starters, "I claim that…I know this to be true because…" Participants shared their own claims and evidence statements, and the facilitator discussed what was good about their statements and what was missing. Part of the discussion included:
>
> > Participant: Plants are important to fish because fish are alive.
> > Facilitator: Good claim, but you need to cite some type of evidence. How do you know that plants are important to fish? Why are they important to fish?
> > Participant: They give off oxygen in photosynthesis.
> > Facilitator: And what does oxygen do for the fish?
> > Participant: They breathe it.
> > Facilitator: Good, so do you want to try your claim and evidence again with this information?
> > Participant: I claim that plants are important to fish because plants give fish oxygen to breathe.
>
> Several other participants made claims and evidence statements, with the facilitator pushing them to cite their evidence appropriately. The facilitator then switched the conversation to teacher hat mode, and stressed that, "You shouldn't let them [students] say, 'because I know it.' Students have misconceptions and you can get to them if you ask them their reasons why."
>
> The facilitator also provided information on why the "claims and evidence" strategy is useful for sense-making and specifically how to use it in this lesson.
>
> > Facilitator: Leave these webs up and you're seeing if they can interpret these webs…A lot of times kids will put up arrows [to show relationships on the web] and they don't know what's going on, but the writing is getting at what they really know and understand. The writing is really crucial for learning.
>
> The facilitator also suggested that the teachers model making claims and evidence statements first and do them as a whole class, then transition to having students do them in pairs before having them do it individually.

In another case, the facilitator of a *Changes* workshop made use of the teacher hat mode to make sure the participants understood what students should learn from the lessons they just experienced:

> Facilitator: Think about the three lessons that we've already done. The change cards, then the freezing of the ice cube. We saw that the water from the Petri dish [disappeared]. What was the content in this investigation?
> Participant 1: Gases
> Participant 2: Evaporation
> Facilitator: Right, so we wanted to show them that water can change from a liquid to a gas—the water cycle. So what exactly would you want your students to understand after these three lessons?
> Participant 3: The three properties of matter: solid, liquid, gas.
> Facilitator: So the three states of matter: solid, liquid, and gas, and the water cycle.
> Participant 4: How do we show them the back again? The gas to a liquid?
> Facilitator: We showed them that when we put the cup over the warm water and saw the condensation. What else?
> Participant 5: Heat.
> Facilitator: When you apply heat or take heat away is what changes the properties of the states of matter. So that's what you want them to know…There's a lot of learning in these lessons.

In a workshop on *Electric Circuits*, the facilitators used specific reflection questions during the teacher hat phase to help participants think about purposeful implementation of the module:

> After having participants complete an activity as students, the facilitators asked the participants to consider the following questions about the teaching of the lesson:
>
> - How will your students reflect?
> - What will your students record in their notebooks?
> - How will you teach this lesson?
> - How does this lesson connect to previous lessons and the big ideas?
> - What are key vocabulary words?
>
> After participants had time to think about the questions individually, the facilitators led a short discussion about the participants' thoughts. The following is an excerpt from the discussion:
>
> Facilitator: How does this lesson connect to previous lessons?
> Participant: You have to know how to do this to do this. [gestures on paper]
> Facilitator: She's saying previously in their drawings when they were talking about the complete pathway, they were using the bulb, the cell and the wires…they are using the same components but now with the secret language.
>
> These questions and the discussion helped the participants reflect on how they were going to implement the lesson and provide structure to help students learn the intended concepts.

However, there was a great deal of variation across the observed sessions in implementing the learner hat/teacher hat approach. In some sessions, the facilitators were not careful about transitioning between the two hats, quickly moving back and forth between the two within a single lesson, which made it difficult for participants to fully engage as either learners or teachers.

In other sessions, the learner hat phase was implemented effectively, allowing participants to experience the module lessons and engage with the content as students would, but the teacher hat phase was not used to its full potential. In some of these cases, the facilitators used the teacher hat phase primarily for discussing logistical issues, spending little, if any, time on reinforcing the targeted science ideas or how the lesson develops those ideas. In other cases, the facilitators shared a strategy for helping students make sense of the targeted ideas, but neither modeled or discussed an appropriate use of that strategy. For example, in a *Motion and Design* session, participants put on their teacher hats to learn about a specific strategy but were not provided adequate guidance on the proper use of the strategy:

> The participants in this session completed a lesson from the module where they attached a falling weight system to a toy car and adjusted the force pulling the car by adding metal washers to the falling weight. The facilitator introduced the "claims and evidence" strategy at this point by describing it as "a sense-making and reflection on what we've done that's not in your manual." A handout was given to participants that described the strategy and included the sentence starters, "I claim that…I know this to be true because…" The facilitator then instructed participants to, "Take a look at your data collected and see if you can make a claim to explain your results." After a couple of minutes for individual writing, a few participants shared their statements:
>
> Participant 1: I claim that the more force, the vehicle will move faster and faster. I know this to be true because my data table showed it going faster.
> Participant 2: I claim that more washers will increase the speed of the car. I know this to be true because when I added more washers the speed increased.
>
> After these statements were shared, the facilitator stated, "I claim that increasing the force will increase the speed because more washers made the car move faster." The facilitator then moved on to the next part of the workshop, with no discussion of these different claims and evidence statements (all of which contained the misconception that force is related to speed as opposed to the correct idea that force is related to a change in speed). Nor was there any discussion of what the teachers should do with students' claims and evidence statements.

The purpose and proper use of various instructional strategies, such as the "claims and evidence" strategy described, may seem obvious to the facilitators, but it is unlikely that participants will intuit the proper use without further assistance. Providing teachers with concrete examples of what students might say or do when using the strategy and what the desired outcome is (e.g., not only what a correct "claims and evidence" statement is but also why it is correct) would increase the likelihood that teachers will be able to implement these strategies effectively in their own classrooms.

Because of time constraints, little time was left after the learner hat phase. Moreover, what little time there was for considering the lessons from the teacher perspective was primarily devoted to logistical issues. Consequently, there were few opportunities to reinforce participants' understanding of the elements of effective science instruction. Several of the IMTs modeled the elements during the "learner hat" phase, and occasionally a facilitator would explicitly discuss them. However, the discussion tended to be shallow. For example:

> Facilitator: Where did we have motivation?
> Participant: That was the focus question.
> Facilitator: Where did we see intellectual engagement?
> Participant: That was the activity.

While not incorrect, the responses to the questions are vague and did not allow the facilitator to know if the participants understood what aspect of the activity was key for engaging students with the targeted science idea.

In a few cases, the facilitators did not consistently model effective instruction during the learner hat phase. For example, in an *Electric Circuits* session, the participants were asked to respond to the question, “How are the parts of a light bulb important for making it light?” after completing an investigation in which they examined the inside of a light bulb. Two participants shared their responses to the question, and then the facilitators moved on to the next lesson without checking whether all participants had a common understanding.

In other cases, participants were not given the opportunity to make sense of the science in an activity at all. Sometimes the facilitators would tell the participants that it was important that they help students reflect on the science, saying, “This would be a good place to answer your focus question,” or “a claims and evidence could be done here.” These comments indicated 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 another example, the facilitator’s questioning focused on having the participants report what they had observed but without asking them to interpret their observations or draw conclusions.

SIE appears to be on the right track with the learner hat/teacher hat approach. However, it needs to continue to work with all current and potential facilitators to make sure they have the knowledge and skills to implement it effectively.

## Module Enrichment Trainings

Cohort 1 and 2 teachers, after having taught a module at least two times, had the opportunity to attend a one-day Module Enrichment Training for that module. These workshops are intended to move teachers further along the continuum from mechanical to purposeful use of the modules. The focus is on deepening teachers’ understanding of the content storyline of a module, as well as their pedagogical content knowledge (e.g., what misconceptions student have about the content in the module and how teachers might help them change their ideas). The program’s stated goals for these workshops are to:

1. Uncover and address teachers’ concerns about the module;
2. Examine a module specific storyline that connects instructional tasks, learning goals, and big ideas;
3. Establish a clear understanding of what we expect students to learn in that lesson, how we know what they learned, and what we can do if learning has not occurred;
4. Discuss “science misconceptions” and identify any that may affect the learning goals of the module; and
5. Link storyline content to the PSSA.

The enrichment sessions begin with teachers sharing and discussing concerns about the modules based on their experiences using them. After this discussion, the participants engage in an activity to learn how to read a "concept map" of their module. The maps, created by the project, included instructional tasks (things students do in the module) linked to learning goals (ideas students will learn) linked to the big ideas of the module. After the introduction to the map, participants spent the majority of the session in a lesson-by-lesson review of the module, mapping lessons to the learning goals. There are also discussions about science misconceptions students may hold and how teaching the module assists students in answering PSSA questions.

This section of the report describes the quality of the SIE Module Enrichment professional development using data from teacher questionnaires, teacher interviews, and observations of a sample of Module Enrichment sessions.

**Teachers' Perceptions of the Quality of the Module Enrichment Trainings**

A majority of participating teachers had positive opinions about the Module Enrichment Trainings. On a post-professional development questionnaire administered at the end of the training, participants indicated that they considered the facilitators to be of high quality. For example, nearly all participants thought that facilitators were well prepared, encouraged active participation, shared tips for implementing the module, and addressed questions about the content in the modules. (See Table 12.)

**Table 12**
**Teacher Opinions of the Quality of SIE Module Enrichment Professional Development**

| | Percent Agreeing† (N = 57) |
|---|---|
| There were opportunities for participants to express their views and collaborate with peers. | 95 |
| Adequate, time, structure, and guidance were provided for participants to discuss the SIE-supported modules and pedagogical strategies with each other. | 93 |
| The facilitators were well prepared. | 91 |
| Adequate time, structure, and guidance were provided for participants to reflect individually on the substance of this workshop. | 88 |
| The facilitators encouraged active participation and investigation by all participants. | 88 |
| The goals of this workshop were clear. | 88 |
| This workshop reflected careful planning and organization. | 88 |
| This workshop was relevant to my classroom instruction. | 86 |
| This workshop prepared me to use the teaching strategies promoted by SIE. | 85 |
| Question about the science content in the module were adequately addressed by the facilitators. | 84 |
| The facilitators shared tips and suggestions for successfully implementing the module. | 80 |
| The various components of this workshop were useful in meeting its goals. | 80 |
| This workshop increased my confidence in my ability to teach using the SIE module. | 80 |
| The facilitators explicitly discussed how, when and why to use different teaching strategies. | 78 |
| This workshop familiarized me with the activities and materials in the module. | 75 |
| The facilitators modeled effective teaching strategies. | 73 |
| This workshop increased my understanding of the science content in the module. | 73 |
| This workshop was worth the time that I invested. | 71 |
| I would recommend this professional development to a colleague. | 68 |

† Includes those teachers agreeing or strongly agreeing with each statement.

Although participants' ratings of the enrichment sessions were positive, they were quite a bit lower than the ratings for the Initial Module Trainings. Only slightly more than two-thirds of respondents indicated that the workshop was worth the time invested or that they would recommend the workshop to colleagues (compared to nearly 90 percent for the IMTs). Most of the participants thought the pace of the enrichment training was appropriate, though those who disagreed generally indicated that the pace was too slow. (See Table 13.)

**Table 13**
**Teacher Opinions of the Pace of SIE Module Enrichment Trainings**

| | Percent of Teachers (N = 57) |
|---|---|
| Too slow | 28 |
| Appropriate | 70 |
| Too fast | 2 |

Participants were also asked to reflect on which aspects of the Module Enrichment they found to be the most effective. The most frequent response, mentioned by about one-third of the teachers, was the opportunity to share their experiences and ideas for implementing the module. One-fifth of the respondents noted that the visual maps of the module learning goals were very helpful. These sentiments also came up in interviews. As three teachers described:

> *I found it helpful to share ideas with my colleagues and take things they use with their [module title] module to use with mine in the future. It was interesting and informative to spend the day with [facilitator names]—both very well prepared.*
>
> *Sharing with everyone: ideas, strategies, content, assessment, materials, and classroom management.*
>
> *I found the visual map to be very helpful in aiding me in planning my lessons so that my instructional tasks can lead me in the right direction to reach my learning goals.*

When asked what aspects of the session could be improved, the most common answer, given by one-quarter of participants responding to this open-ended question, was to spend more time talking about resources that could be used to supplement the modules. Other suggestions included increasing the amount of time for interacting with colleagues, reducing the time for sharing experiences and increasing the focus on the science content, though neither was given by more than three respondents. Example responses included:

> *I would have liked to hear more activities or supplements I could use in my classroom to further engage my students.*
>
> *More time to talk with teachers from other schools.*
>
> *The facilitators were dry. I would have liked more information to deepen my understanding of the science concepts in [Module].*

Teachers were also asked at the conclusion of the Module Enrichment trainings what their greatest concerns were about implementing the SIE-supported modules. Given the teachers' level of experience and training at this point in the program, it is not surprising that about one-quarter of responding teachers did not identify any concerns. Of those respondents who did indicate some concerns, most reflected the same concerns about time and materials management teachers reported at the end of the Initial Module Trainings. As three wrote:

> *Making sure we are able to finish each investigation before the time we need to return our kits. How will it effectively impact our students to their fullest potential?*
>
> *I wish we had more time in the school day. It seems like every time we turn around something new is added that we need to do on a daily, weekly, monthly, or yearly basis.*
>
> *Time to effectively teach the lessons appropriately.*

**Observers' Perceptions of the Quality of the Module Enrichment Trainings**

Evaluation staff observed portions of three Module Enrichment (ME) trainings. HRI utilized the same framework used to assess the quality of the Initial Module Trainings to examine the extent to which the ME professional development achieved its goals. The analysis of observation data from the ME Trainings focuses on the major goals of the sessions.

***Uncovering and Addressing Teachers' Concerns about the Module***

Teachers had an opportunity at the ME sessions to voice concerns and problems they had when implementing the modules. They were provided time to put their questions and concerns on chart paper, and talk with other participants about these issues. The sessions also provided time for the facilitators to address the issues. For example, in one session when expressing classroom management concerns, a teacher asked, "What do we do if students finish early?" The facilitators suggested they give these students materials to sort for upcoming activities or have them do extra readings on the topics. In a response to a comment that the vocabulary in the module is too difficult, the facilitators suggested the use of a word wall, adding pictures to vocabulary, and making science words a part of spelling lists.

However, there were other instances when teachers' concerns were not addressed. For example, in one observed session, when issues regarding time management were raised, (e.g., the length of time it takes to assemble materials for an activity, or not being able to complete an activity in the time available for science), no helpful advice was provided. The facilitators' comments included, "Yes, time is an issue," and, "We can't control your school's schedule." Although participants appreciated the empathy of the facilitators, it was clear that they were frustrated by the lack of concrete suggestions. Given the regularity with which time and materials management questions are raised, the program should make sure all workshop facilitators are prepared to address these concerns.

There were also instances when teachers' questions about the science content in their module were not adequately addressed, and in some cases, the responses they received were inaccurate and could lead to reinforcing common misconceptions. For example, in the *Water* session, when discussing the expansion of water when heated, it was suggested that teachers use microwave popcorn to demonstrate that molecules when heated, like kernels of corn, will expand. This example could promote the misconception that the molecules themselves "puff up" as opposed to their moving farther apart. These instances reinforce the need to continue to work with facilitators to make sure they have a solid understanding of the science content in their module.

***Examining a Module Specific Storyline that Connects Instructional Tasks, Learning Goals, and Big Ideas***

After the discussion of teachers' concerns about the module, the participants engaged in an activity to learn how to read a "concept map" of their module. They were given three sheets of paper, one with a list of instructional tasks, one with a list of learning goals, and one with a list of big ideas. After reviewing and coming up with a description of what was on each paper, the participants were given the content map for their module that linked the instructional tasks, learning goals, and big ideas.

These maps provide a visual means of illustrating the science content in the module and providing links between the instructional tasks and the content ideas. The maps also emphasize that the purpose of doing the activities in the module is for students to learn science, not just for them to have fun. Finally, the maps show how lessons build on one another and reveal how skipping a lesson can get in the way of students learning a key concept.

Although the maps have a great deal of potential, observers of the ME sessions noted that some of the maps contained content errors and/or omitted key ideas. For example, one of the learning goals on the *Motion and Design* map states: "Transfer of energy creates an unbalanced force." Although an energy transfer can occur at the same instant a force is applied, they are both the result of objects interacting and one does not cause the other. The program may want to consider having the maps reviewed by content experts to ensure both accuracy and completeness. Ideally, these experts would have experience in education to make sure their suggestions are appropriate for teachers of elementary students.

***Establishing a Clear Understanding of What Students Are Expected to Learn in a Lesson, How Teachers Know What They Learned, and What Teachers Can Do If Learning Has Not Occurred***

After the introduction to the content map, participants engaged in a lesson-by-lesson review of the module in order to map specific lessons to the learning goals. The focus questions for the review, which participants were to respond to for each module lesson, were:

1. What were the students to learn in this lesson/part? (this should be tied back to the storyline learning goals)
2. What strategies would provide evidence that the students learned the intended content?
3. What can you do if learning has not occurred? (strategies, extensions, interventions)

The participants were divided into groups and the lessons in the module were divided up among the groups. The groups were assigned the task of answering the three questions listed above for each of their lessons. The groups worked for about one hour, recording their responses on chart paper.  The facilitators then led a large group sharing of each group's findings, one lesson at a time, through the entire module.

This activity was effective in helping participants understand that there are specific ideas that are intended to be developed in particular module lessons.  The opportunity to examine each lesson, thinking about what activities students do and what concepts they are learning, is a valuable activity that many teachers do not have the time to do during their busy work schedule.  Another strength of this activity is that it provided participants with a visual representation of how some concepts are addressed several times during a module while other concepts are developed in only one or two lessons.  This observation reinforced the program's stance that teachers should not skip lessons during their implementation.

Although this portion of the workshop was well received by participants, two areas stand out as needing improvement.  First, when participants were asked to link module lessons to the learning goals on the module storyline maps, they tended to link lessons to many learning goals, with most of the connections being tangential.  For example, one group of teachers in the *Weather* Module Enrichment linked Lesson 11 "Exploring Puddles" to the learning goal "Weather may be measured using tools."  When the facilitator asked why, the teachers indicated that an umbrella is a weather tool.  There was no further discussion and the group left the lesson linked to that idea.  As a result, the activity may have been counterproductive, giving teachers the impression that all the activities address most of the learning goals and making it unlikely they would be able to help students make sense of the primary intended content.  In addition, the teacher may have gotten the impression that skipping or modifying activities is permissible as students will learn all the ideas with just a few lessons.  To avoid this problem, the program may want to consider modifying the prompt given to teachers, perhaps having them associate only those lessons that directly teach an idea.  In addition, providing an example of an appropriate link and one of an inappropriate link may help participants with the activity.

The second issue identified in the observations was that most of the teachers did not appear to have enough knowledge to engage meaningfully with the second and third prompt.  Teachers misinterpreted the task and responded to the questions in a manner different than one would expect.  For example, teachers responded to the question about assessing learning by listing activities from the module lesson (e.g., sort and identify cloud pictures, record cloud cover daily) rather than ways they could determine if students had learned the intended content.

Teachers also appeared to misinterpret the third question, about what to do if the students had not learned the targeted ideas.  In a *Weather* session, the participants shared extension activities, such as books to read or websites on the topic.  In a *Motion and Design* session, teachers' suggestions were more about modifying activities to make them easier for students rather than on interventions they could use if learning had not occurred.  Teachers listed strategies like limiting the number of building pieces, providing a model prior to construction, coloring diagrams for students, adapting open-ended questions to be multiple choice, and using a line of learning.

This portion of the workshop might benefit from the inclusion of one or two module-specific exemplars that model appropriate responses to these questions.  An exemplar could, for a key lesson, outline what students should learn from the activity, point out misconceptions students might have about the content, suggest a formative assessment prompt, and describe appropriate interventions for different student responses. To highlight the important aspects of the formative assessment and interventions, the workshop might also show an example that, while topically aligned with the targeted idea, is unlikely to elicit student ideas or provide opportunities to move their understanding forward.

***Discussing "Science Misconceptions" and Identifying Any that May Affect the Learning Goals of the Module***

In the observed Module Enrichment Trainings, teachers were provided an opportunity to reflect on the meaning of the term "science misconceptions," how children begin to form misconceptions, and how teachers can address students' science misconceptions. The discussion focused on science misconceptions in general and not those specific to the content of the module. At the end of the discussion, the teachers received a handout that included information on how children might form misconceptions and ways teachers can address these ideas. Participants then had a short discussion of student misconceptions specific to the content of the module.

Understanding common science misconceptions is a key part of pedagogical content knowledge that can help teachers implement their modules more purposefully. Participating teachers likely benefited from the opportunity to think about the fact that students often come to school with incorrect ideas that get in their way of learning the correct ones. In addition, providing teachers with examples of misconceptions related to their particular module content both alerted them to the importance of paying attention to student ideas and gave them specific ideas to be on the lookout for.

The participants would likely benefit from a greater focus on the misconceptions specific to the module content. While providing participants with a list of common misconceptions is a good start, a more in-depth treatment of why students might hold each of them, what students might say or do that would indicate they held on to these ideas, and how to specifically address each one would be beneficial. Of course, spending more time in the workshop on one topic would require a reduction in another. It will be important for the program to consider what is most important for teachers and what can be done well in the limited time available

***Linking Storyline Content to the PSSA***

The Module Enrichment Trainings emphasized that the content in the modules can be applied to help students answer PSSA questions in other content areas as well. Participants were provided with copies of released PSSA science items and discussed the question: "How does the teaching of this module assist students in the answering of these PSSA questions?"

This activity highlighted the importance of making connections between the module activities and the targeted content. It also gave the message that the concepts their students are learning in the modules can be applied to other content/broader concepts being tested on the PSSA. Seeing how students can take content they learned in the module and apply it to answer test questions about science content not directly linked to the module may have addressed teachers' concerns that teaching science with modules means covering fewer topics.

# 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 and the pedagogical approaches promoted by the program. In interviews, teachers indicated that the workshops were successful at preparing them to implement the modules. Several teachers also noted that as a result of the professional development, they adopted a new and more effective way to provide science instruction. In the words of two teachers:

> *In a nutshell, just the whole concept of teaching science in a different way. I felt more prepared to walk into my classroom and actually teach what I want my students to learn…all the things I learned in the training I have used in my classroom.*

> *I got a better sense of how to teach science, how to better question students.*

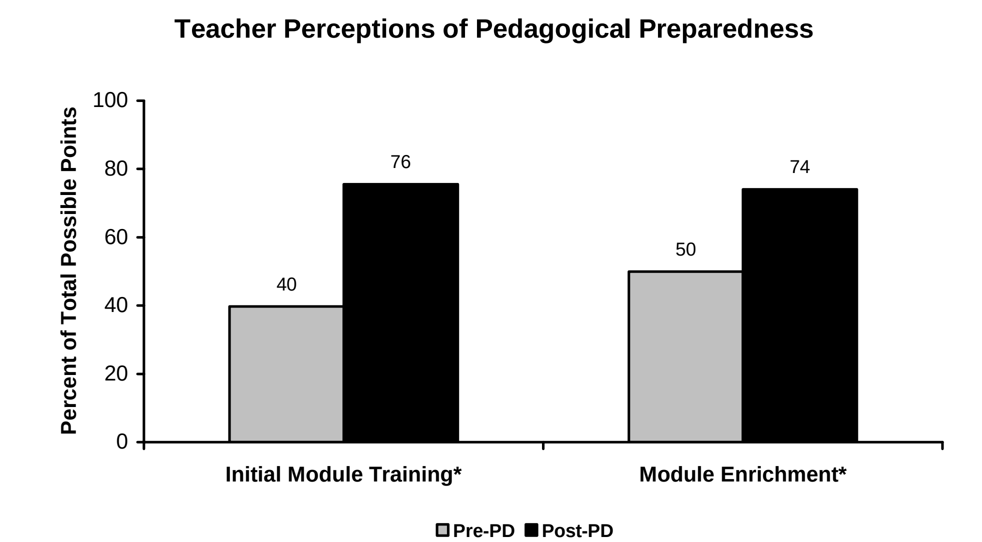
In addition to feeling comfortable with the materials and activities in the modules, teachers need to know how to enact the pedagogical approaches promoted by the program. The post-professional development questionnaire included a series of items aimed at assessing teachers' perceptions of their preparedness 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 they participated 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.[15] 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.

[15] 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.

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 incorrect estimates of the relationship between independent factors and the outcome. Hierarchical regression modeling[16] is an appropriate technique for analyzing nested data and was used to examine trends in teachers' composite scores.

Across both workshop types, there was a significant increase in teachers' perceptions of their pedagogical preparedness (See Figure 4). The mean composite score for teachers attending an Initial Module Training increased from 40 to 76 (a large effect[17] of 1.92 standard deviations). Scores for teachers attending Module Enrichment increased from 50 to 74 (a large effect of 1.27 standard deviations).




* Post-workshop scores significantly different than pre -workshop scores (2-tailed paired samples t-test, $p < 0.05$).

***Figure 4***

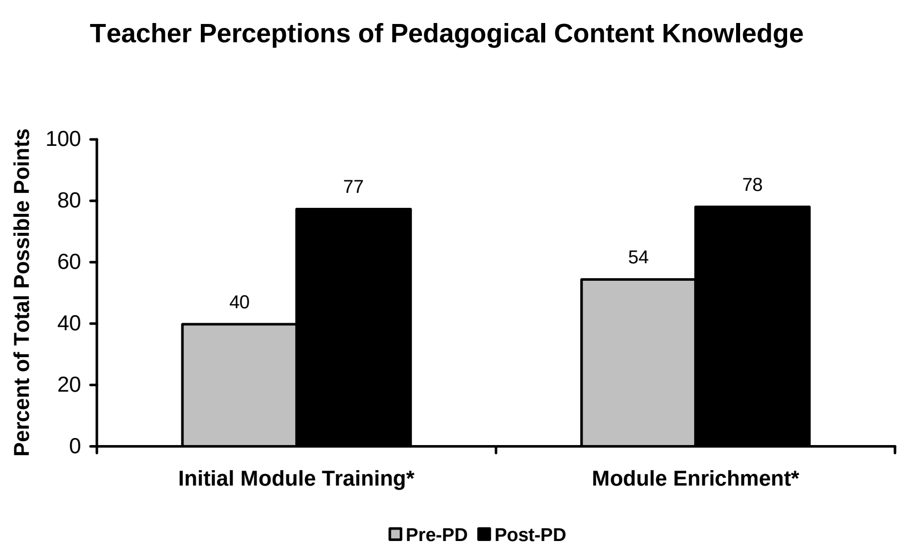
The post-professional development questionnaire also asked teachers about their understanding of the student learning goals in the SIE module, the science content in the SIE module at a deeper level than what students are expected to learn, and ideas (either correct or incorrect) that

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

[17] The effect size for the comparison of two adjusted means is calculated as the difference between the means divided by the pooled standard deviation. Effect sizes of about 0.2 are typically considered small, 0.5 medium, and 0.8 large. Cohen, J. (1988). *Statistical power analysis for the behavioral sciences.* Hillsdale, NJ: Lawrence Erlbaum Associates.

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 5.) Scores for teachers attending Initial Module Training increased from 40 to 77 points, a large effect of 1.89 standard deviations. Scores for teachers attending Module Enrichment increased 24 points, a large effect of 1.36 standard deviations.




* Post-workshop scores significantly different than pre-workshop scores (2-tailed paired samples t-test, $p < 0.05$).

***Figure 5***

## Teachers' Use of Instructional Strategies Promoted by SIE

The SIE program encourages teachers to use a number of instructional strategies intended to enhance their implementation of the modules. In interviews, teachers were asked to comment on their use of several of those instructional strategies. Specifically, teachers were asked to describe their use of the science notebooks, focus questions, and sense-making strategies presented in the professional development. All of the interviewees indicated that they were using science notebooks in their teaching. In addition, each indicated that the use of the notebooks enhanced student learning. As three described:

> *Our district has purchased the science notebooks. We journal, we predict, we do everything, we use the science journals all the time…the first thing we do is we write the lesson, we write the focus question. I have them predict and then they'll write their observations, they'll do scientific drawings. Sometimes they'll do a "before" and they'll do an "after" drawing, a scientific drawing.*

*We use our notebooks for every lesson, for every experiment. We always start with a focus question and then I have them make a prediction…and then they would put them aside, we would do the experiment and then we would bring them back out and look at the prediction and talk about what we thought was going to happen and then write in what did happen.*

*The notebooks helped to focus them [students] on what the day's lesson was…it really made them responsible, they knew they were going to be checked…They were really helpful.*

All of the interviewees also indicated that they use at least some of the focus questions provided in the professional development. As with the notebooks, teachers thought that the use of focus questions improved the learning experience for students. In the words of two:

*I think it really helps them focus in on the key skill or concept that we are doing for the day and have them really concentrate on that when we are doing the lesson as opposed to all the other things that could be going on. It makes them know what they need to pay attention to and at the end of the day they are able to say, "Okay, this is what I was supposed to figure out and this is what I did figure out."*

*I don't think I would do it without using the focus questions…[It] sort of guides the whole thing, so if we didn't use the focus question…[they] wouldn't really know what we were doing or why we were doing it.*

Just over half of the interviewed teachers noted that they used some of the sense-making strategies that were presented in the trainings such as the "line of learning" or "claims and evidence." These teachers indicated that these strategies help students think more deeply about the science ideas or helps the teacher and student know what they have learned. As two reported:

*It really forces them to think about what they did because I think often in science classes we would go through activities and talk about them, but we really have not taken it the highest level of analysis. Working with the line of learning…that is what it was, really taking the activity to the next level of analysis.*

*I think the line of learning kind of sums it all up for them…It shows them what the main ideas or main concept is that they were supposed to get out of the experience.*

Lack of instructional time was the main reason teachers gave for not using these strategies.

## Module Implementation

During their first year in the program, each school selects one module to implement at each grade level. In their second year, the school adds a second module at each grade. No new modules are added in the third year, but the schools select an additional module in the fourth year.

As part of the student achievement study (described more fully later in the report), teachers were asked 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 14, teachers reported spending, on average, between 8 and 18 hours of instructional time on the topic covered by their module.[18] Most of this instruction was based on the SIE-supported module, ranging from 67 to 96 percent of their instructional time. Taken together, these data indicate that teachers are basing substantial portions of their science instruction on the SIE-provided modules.

**Table 14**
**Instruction on Topic, by Module**

| | Number of Responding Teachers | Hours of Instructional Time | | Percent of Instructional Time Based on Module | |
|---|---|---|---|---|---|
| | | Mean | Standard Deviation | Mean | Standard Deviation |
| **Grade 3** | | | | | |
| Chemical Tests | 68 | 10.94 | 5.52 | 92.34 | 11.56 |
| Plant Growth and Development | 142 | 10.21 | 5.80 | 84.61 | 16.80 |
| Rocks and Minerals | 189 | 11.16 | 7.12 | 87.87 | 14.93 |
| Structures of Life | 17 | 8.86 | 7.41 | 95.82 | 6.87 |
| **Grade 4** | | | | | |
| Animal Studies | 34 | 11.28 | 6.09 | 81.53 | 21.09 |
| Electric Circuits | 182 | 11.65 | 6.82 | 91.11 | 13.67 |
| Human Body | 93 | 8.10 | 5.61 | 86.26 | 19.06 |
| **Grade 5** | | | | | |
| Ecosystems | 68 | 14.13 | 8.57 | 82.99 | 20.36 |
| Environments | 65 | 10.45 | 9.54 | 82.78 | 20.90 |
| Floating and Sinking | 26 | 10.96 | 4.92 | 91.38 | 15.72 |
| Levers and Pulleys | 51 | 13.18 | 9.30 | 92.62 | 15.82 |
| Motion and Design | 91 | 11.73 | 9.37 | 85.68 | 18.39 |
| **Grade 6** | | | | | |
| Experiments with Plants | 32 | 12.15 | 10.76 | 67.58 | 28.04 |
| Magnets and Motors | 17 | 17.71 | 10.57 | 89.06 | 16.75 |
| Mixtures and Solutions | 47 | 16.72 | 18.10 | 88.07 | 13.67 |
| Variables | 46 | 17.25 | 11.04 | 87.45 | 19.90 |

In interviews, teachers were asked to reflect on how their implementation of their module went. The vast majority indicated that their implementation had gone very smoothly, with many specifically noting that the teacher's manual was easy to follow and facilitated module implementation. Teachers' comments included:

[18] The survey asked about only those modules related to topics on the student assessment and is not a complete list of modules offered by SIE.

*It's really amazing and the binder is terrific, with the background information and everything.*

*I think it went really well, I think that the students enjoyed it, I enjoyed teaching it.*

Teachers also noted that having implemented a module multiple times made the process easier, and that their implementation improved each time. As one teacher stated:

*I feel more comfortable, it goes a lot smoother; I kind of know what to expect. The time to set it up is faster because I know exactly what I'm supposed to be doing instead of having to rely on the manuals and things like that.*

In addition, HRI administered a survey to samples of teaches at the end of the second and fourth quarters of the school year, asking teachers to indicate for each lesson in the module they just taught whether they implemented the lesson as written, implemented it with modifications, or skipped it. For a subset of the lessons modified or skipped, teachers were asked how/why. The survey also asked about teachers' use of the reading selections and extension activities included in the modules.

Overall, teachers reported implementing 50 percent of the lessons in their modules without modifications and an additional 29 percent with modifications. Nearly two-thirds of teachers reported implementing all of the lessons in their module. About 70 percent of teachers reported using at least one of the extension activities in their module, and roughly 90 percent indicated using some of the readings.

As can be seen in Table 15, the predominant reason for not implementing a lesson, reported by teachers for 73 percent of skipped lessons, was not having enough instructional time. The next most common reasons, both given for fewer than 10 percent of skipped lessons, were that the lesson was too difficult conceptually or that the teacher had an alternative lesson for the same idea that s/he preferred.

**Table 15**
**Reasons Given for Skipping Module Lessons**

| | Percent of Skipped Lessons[†] |
|---|---|
| There is not enough instructional time devoted to science to implement the Lesson/Investigation | 73 |
| The Lesson/Investigation is too difficult (conceptually) for my students | 7 |
| I have a different Lesson/Investigation covering the same concept that I prefer using | 6 |
| I have classroom management concerns with the Lesson/Investigation | 5 |
| I don't have the necessary equipment/supplies | 5 |
| It is too difficult to get the Lesson/Investigation to work as desired | 4 |
| The Lesson/Investigation is not engaging for my students | 2 |
| The Lesson/Investigation is too easy (conceptually) for my students | 2 |
| I am not confident in my own understanding of the science | 2 |
| I have safety concerns with the Lesson/Investigation | 1 |
| I am not confident in my ability to set up the equipment properly | 1 |

[†] Percentage adds to more than 100 as teachers could select multiple reasons.

Teacher reports of modification were more varied. About one-third of the modified lessons were changed to make the lesson more structured for the students. In about one-quarter of the modified lessons, the teacher shortened or cut-out the small group investigation portion. Combining a lesson with another and reducing/skipping the whole group discussion were each reported for about 1 in 5 of the modified lessons. (See Table 16.)

**Table 16**
**Modifications Made to Module Lessons**

| | Percent of Modified Lessons† |
|---|---|
| I made the Lesson/Investigation more structured to make it appropriate for my students | 31 |
| I shortened/cut part of the individual/small-group investigation time | 23 |
| I integrated pieces of this Lesson/Investigation into another one | 21 |
| I shortened/cut part of the whole-class discussion time | 18 |
| I used it as a demonstration rather than as a student activity | 15 |
| I made the Lesson/Investigation less structured to make it appropriate for my students | 11 |
| I substituted equipment/supplies | 9 |

† Percentage adds to more than 100 as teachers could select multiple modifications.

The most common reason given for not implementing more readings and extensions was lack of instructional time. (See Tables 17 and 18.) Preferring to use readings/extensions from outside the module and the difficulty level were the next most important factors.

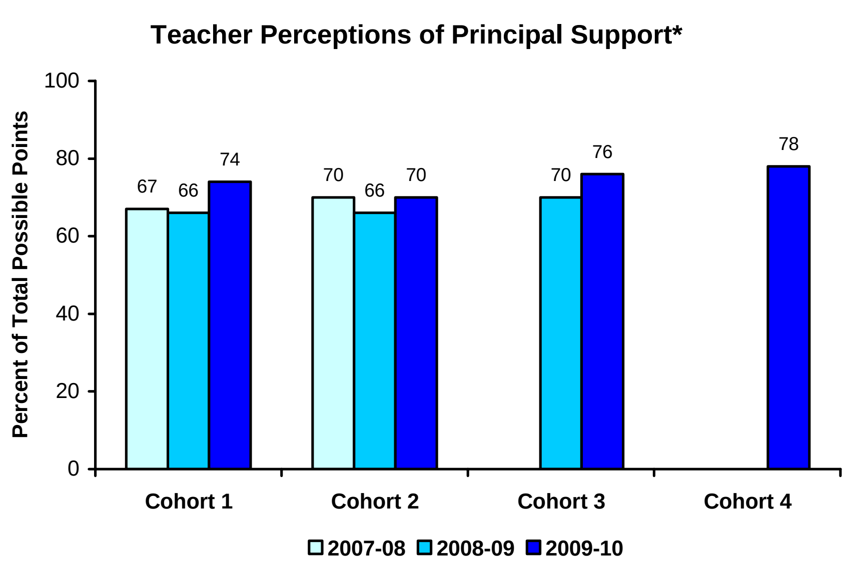
**Table 17**
**Factors Affecting Teachers' Use of Readings**

| | Not at All | Somewhat | Moderately | To a Great Extent |
|---|---|---|---|---|
| Not enough instructional time to use the reading selections | 10 | 24 | 18 | 49 |
| Preferred using other readings | 54 | 29 | 12 | 5 |
| Reading level was too difficult for my students | 67 | 25 | 6 | 3 |
| The content in the readings were too difficult for my students | 69 | 24 | 5 | 2 |
| Uncertain in my own understanding of the science concepts | 87 | 9 | 3 | 0 |
| Reading level was too easy for my students | 92 | 7 | 1 | 0 |
| The content in the readings were too easy for my students | 91 | 7 | 2 | 0 |

**Table 18**
**Factors Affecting Teachers' Use of Extension Activities**

| | Not at All | Somewhat | Moderately | To a Great Extent |
|---|---|---|---|---|
| Not enough instructional time to use the extensions | 4 | 18 | 17 | 60 |
| Preferred using other extension activities | 49 | 34 | 13 | 3 |
| The extensions are too advanced for my students | 48 | 38 | 11 | 3 |
| Classroom management concerns | 64 | 24 | 9 | 3 |
| Lack of the necessary equipment/supplies/materials | 66 | 25 | 7 | 2 |
| Lack of connection/application to what I was teaching in other subject areas | 71 | 22 | 6 | 2 |
| Uncertain in my own understanding of the content | 73 | 18 | 7 | 1 |
| The extensions are too easy for my students | 86 | 10 | 3 | 0 |

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 6, scores on this composite were fairly high across the four cohorts, indicating that teachers felt that their principals support their implementation of the SIE program.[19] Feelings of support were higher in 2009–10 across teachers in Cohorts 1–3.




* There was a significant different in composite scores across the time points (ANOVA, $p < 0.05$).

***Figure 6***

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

Teachers and principals were also asked on questionnaires about other factors that may have affected, positively or negatively, teachers' use of the modules. Tables 19 and 20 show teacher and principal responses, respectively, to these questions over the past three years.

Nearly all responding teachers and principals thought that the training received from SIE facilitated their use of the modules. In addition, most respondents indicated that the support of fellow teachers and the SOS facilitated use of the modules. Further, although the SIE program does not have any formal mechanisms for assisting teachers outside of the workshops, one-quarter of the teachers and more than half of principals indicated that teachers received extra assistance that helped them implement their module. Although there has been some variation in responses across the last three years, the overall pattern has been stable.

## Table 19
## Teacher Opinions of Factors Affecting Their Use of the SIE-Provided Module, by Year

| | Percent of Teachers Agreeing† | | |
|---|---|---|---|
| | **2007–08 (N = 1,748)** | **2008–09 (N = 1,561)** | **2009–10 (N = 1,350)** |
| **Factors Facilitating Implementation** | | | |
| The training I received from SIE made it easier for me to use the modules. | 96 | 94 | 94 |
| It was easy to get all of the equipment and supplies necessary to use the modules. | — | — | 85 |
| Other teachers in my school provided a support system for use of the modules. *[2, 3] | 86 | 88 | 82 |
| My own science background was helpful when I was teaching from the modules. *[1, 2] | 77 | 82 | 81 |
| My SOS facilitated my use of the modules. *[1, 3] | 73 | 78 | 73 |
| I received assistance from SIE outside of the workshop that helped me to use the modules. | 26 | 25 | 25 |
| **Factors Inhibiting Implementation** | | | |
| There was not enough instructional time for science to effectively use the SIE-supported modules. *[1, 3] | 52 | 45 | 53 |
| The amount of time required to prepare for instruction with the SIE-supported modules was problematic. *[1, 2] | 55 | 46 | 46 |
| The pressures to teach mathematics and/or reading inhibited my use of the modules. *[2, 3] | 51 | 51 | 40 |
| I am not able to cover all of the science topics I am suppose to because of the time it took to implement an SIE module. *[2] | 43 | 42 | 38 |
| I did not have the modules for long enough to use as much of them as I wanted to. *[1, 2, 3] | 29 | 41 | 37 |
| The time of year that I received my module was problematic. ‡, *[3] | — | 39 | 33 |
| Too much time elapsed between the module training and module delivery. ‡ | — | 24 | 25 |
| The amount of time I was required to be out of the classroom was problematic. *[1, 2] | 26 | 14 | 14 |
| My lack of experience in science made it more difficult for me to teach from the modules. *[1, 2] | 15 | 10 | 9 |

† 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 the statement differs across years (chi-square test with FDR adjustment, $p < 0.05$).

[1] 2007–08 significantly different than 2008–09.
[2] 2007–08 significantly different than 2009–10.
[3] 2008–09 significantly different than 2009–10.

‡ Item was not asked in 2007–08.

**Table 20**
**Principal Opinions of Factors Affecting Teacher Implementation of the SIE-Provided Modules**

| | Percent of Principals Agreeing[†,‡] | | |
|---|---|---|---|
| | **2007–08 (N = 93)** | **2008–09 (N = 100)** | **2009–10 (N = 112)** |
| **Factors Facilitating Use** | | | |
| Teachers provided each other with a support system for using the modules | 98 | 96 | 96 |
| The training teachers received from SIE made it easier for them to use the modules | 99 | 99 | 95 |
| Our Support on Site (SOS) facilitated teachers' use of the modules | 85 | 93 | 92 |
| Teachers received assistance from SIE outside of the workshop that helped them to use the modules | 61 | 58 | 47 |
| **Factors Inhibiting Use** | | | |
| The pressures to teach mathematics and/or reading inhibited teachers' use of the modules | 38 | 33 | 42 |
| The time of year that teachers received their modules was problematic[§] | — | 38 | 42 |
| The amount of time teachers were required to be out of the classroom was problematic | 57 | 40 | 40 |
| Teachers did not have the modules for enough time to complete all of the lessons | 19 | 37 | 36 |
| There was not enough science instructional time for teachers to complete the SIE-supported modules | 26 | 38 | 34 |
| 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 | 38 |
| The amount of time required to prepare for instruction with the SIE-supported modules was problematic for teachers | 23 | 22 | 24 |
| Teachers' lack of experience in science made it more difficult for them to teach from the modules | 12 | 13 | 15 |
| Too much time elapsed between the module training and module delivery[§] | — | 18 | 15 |
| Teachers' lack of science content knowledge made it more difficult for them to teach from the modules | 12 | 16 | 14 |

† 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 with each statement is not significantly different across years (chi-square test using the false discovery rate adjustment for multiple comparisons, $\alpha = 0.05$)
§ Item was not asked in 2007–08.

The data in Table 19 are further supported by responses from teachers on an open-ended questionnaire item. When asked what the greatest benefit of the SIE program has been, most teachers' responses were the professional development and the fact that SIE provides the furbished modules. Teachers' comments included the following:

> *Professional development was the single most important thing that I did with the SIE program, with regards to teaching my children to the best of my ability!*

> *The greatest benefit was actually having gone through the training myself and keeping the notebook. I found the notebook to be a tremendous asset to my teaching. It helped refresh my memory and my students enjoyed seeing my examples.*

> *The training I received before having to teach the material to the students. Having all the materials needed was great.*

Principal feedback echoed these sentiments. As two said in interviews:

> *The training they go to is terrific, they love it and I have some seasoned teachers and they really enjoy it. They also come back with some new strategies.*

> *The PD they are required to attend makes going through the activities easy because they've done it before. So not a whole lot of confusion, they know the outcome they need to have.*

In terms of inhibitors, principals and teachers indicated pressure to focus on mathematics and reading, because those subjects count toward Adequate Yearly Progress and science does not, inhibited the use of the SIE-provided modules. About forty percent of both teachers and principals responding to questionnaires noted that pressure to teach mathematics and/or reading had a negative impact on use of the modules. (See Tables 19 and 20.) Interestingly, although still prevalent, this year fewer teachers indicated that this factor was an inhibitor than in past years.

The pressure to focus on mathematics and reading is most likely responsible for the perceived lack of time for science instruction, which was cited as an inhibiting factor by over half of the teachers and one-third of the principals. In addition, 37 percent of teachers indicated that they did not have the modules long enough. Teachers and principals elaborated on these issues in interviews and in response to open-ended questionnaire items. As three reported:

> *Right now, the PSSA testing schedule has really impacted us…we spent two weeks in testing mode which really impacted our time during that period…we lost a good two weeks of instruction to testing.* (Teacher)

> *It would be very beneficial if we could have more time allotted for use of the kit. A great amount of time isn't considered due to emergencies, assemblies, testing, breaks, days off, etc.* (Teacher)

> *Time; [teachers] need more time and there is no time. Time management. They need to be much better time managers than they have in the past, and need to be very discriminating in what they do with that time. There's no room anymore for the fluff and the nonsense. They really need to focus.* (Principal)

To better understand how these and other factors are influencing day-to-day instruction, HRI conducted 10 case studies, sampling 10 teachers from Cohorts 1–3 to participate. Teachers were asked to allow an observer to visit their classroom during their implementation of a lesson from a module, and then participate in an in-depth interview about their experiences with the module. The lessons observed spanned all grades K–6, and most occurred toward the end of the teachers' implementation of the module.

Instructional time for science, or the lack thereof, was a recurring theme among these teachers. In several cases, the lack of time was due to the scheduling of module delivery/pickup and the state testing.  Teachers reported that they lost several weeks of instruction due to the testing, but that they were not able to keep their modules for more than the allotted nine weeks.

All of the case study teachers emphasized the impact the SIE professional development had on their ability to implement the module. Most indicated that they rely heavily on the science notebook they created at the professional development, as they were able to capture many suggestions for implementing the lessons.  The teachers also found the information in the teacher's guides to be helpful, indicating that they typically read the "background" section before teaching a lesson.

Overall, the case study teachers implemented the lessons with fidelity.  Several made minor changes to adjust the lesson for the needs of their students or to fit the lesson in the time available.  For example, one teacher had students respond to the activity questions in a whole-class discussion rather than first having them write answers to the questions individually. Another teacher had students practice the technique they would use in the lesson prior to starting the investigation to ensure the activity would be successful.

The two lessons with the biggest modifications were taught by teachers who had stronger science backgrounds and more experience teaching science.  These teachers supplemented the materials in the module to help lift out the science in the activities.  These lessons were among the more purposefully implemented ones and helped focus students on, and reinforce, the targeted science ideas.  Appendix A includes a vignette about each teacher that illustrates the most salient factors affecting their module implementation.

# IMPACT OF SIE ON STUDENTS

Although the main emphasis of the program's activities is on teachers and their instruction, the ultimate goal 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 21, the vast majority of teachers indicated that students had positive attitudes toward science, with nearly all respondents agreeing that students enjoyed learning about science, were enthusiastic about science class, were interested in science, and wanted to learn more science. In addition, 71 percent of respondents indicated that their students this year liked science more than previous students they had taught. In addition, teachers often attributed these positive attitudes to the SIE program.

**Table 21**
**Teacher Report of Impacts on Students**

| | Percent of Teachers Agreeing† (N = 1,348) | Percent Attributing Impact to SIE‡ | | |
|---|---|---|---|---|
| | | Not at all | To some extent | To a great extent |
| **Students…** | | | | |
| Enjoyed learning about science | 99 | 1 | 37 | 62 |
| Were enthusiastic about science class | 99 | 2 | 39 | 59 |
| Were interested in science | 99 | 2 | 39 | 59 |
| Wanted to learn more science | 97 | 4 | 44 | 52 |
| Were eager to explore science on their own, outside of the classroom | 89 | 11 | 51 | 38 |
| Liked science more than previous students I have taught | 71 | 16 | 41 | 43 |

† Includes those teachers agreeing or strongly agreeing with each statement.
‡ The percentage of teachers attributing the impact to SIE is based on the teachers agreeing with the statement.

As part of its evaluation of the SIE program, HRI, with the assistance of the Pennsylvania Department of Education , designed and implemented a study to examine the impact of SIE professional development and teachers' implementation of the science administered in each grade 3–6. Each assessment addresses content from 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 study 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. Table 22 shows the number of items out of the original set for each scale that were retained based on these analyses, as well as the reliability for each set of items.[20]

**Table 22**
**Assessment Scale Reliabilities**

| | Number of Items Retained | Reliability |
|---|---|---|
| 3rd Grade | 29 of 30 | 0.75 |
| 4th Grade | 30 of 30 | 0.79 |
| 5th Grade | 37 of 40 | 0.81 |
| 6th Grade | 34 of 40 | 0.84 |

Race/ethnicity and gender data were also collected from students. Finally, teachers provided information about their classes, including the amount of instruction 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 2009–10 student achievement study, 38 schools from Cohort 1, 53 schools from Cohort 2, and 15 schools from Cohort 3 were asked to participate.[21] Of these 106 schools, 88 returned pre- and post-test data in time to be included in these analyses (30 Cohort 1, 44 Cohort 2, and 14 Cohort 3 schools). 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 23 shows the number of classes that

[20] Reliability can range from 0 to 1; typically, a reliability $\geq 0.60$ is considered acceptable for assessments used to evaluate a program.

[21] Although Cohort 4 schools were asked to complete the assessments, due to the late funding of the program this year, Cohort 4 schools were not able to complete the pre-test until January 2010 (the other cohorts completed the pre-test at the beginning of the school year). Because the timing of the pre-test was very different for Cohort 4, which could affect assessment results, it was decided to exclude Cohort 4 data from these analyses.

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 23**
**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 | 129 | 74 | 192 | 136 | 53 | 47 |
| 4th Grade | 145 | 99 | 200 | 142 | 58 | 49 |
| 5th Grade | 138 | 104 | 185 | 146 | 57 | 39 |
| 6th Grade | 101 | 84 | 111 | 86 | 37 | 24 |

Table 24 provides demographic information for the students included in these analyses. Overall, the classrooms contained about the same number of females and males. Most students classified themselves as White; nearly all students indicated that English was their primary language.

**Table 24**
**Student Demographic Data**

| | Percent of Students | | | |
|---|---|---|---|---|
| | 3rd Grade (N = 4,125) | 4th Grade (N = 5,136) | 5th Grade (N = 5,041) | 6th Grade (N = 3,402) |
| **Gender** | | | | |
| Female | 48 | 50 | 50 | 50 |
| Male | 52 | 50 | 50 | 50 |
| **Race/Ethnicity†** | | | | |
| American Indian/Alaskan Native | 1 | 1 | 1 | 1 |
| Asian | 1 | 1 | 1 | 1 |
| Black/African-American | 9 | 10 | 11 | 11 |
| Hispanic/Latino | 1 | 2 | 3 | 3 |
| Native Hawaiian/Other Pacific Islander | 0 | 0 | 0 | 0 |
| White | 89 | 88 | 87 | 87 |
| **English is Primary Language** | 99 | 99 | 99 | 99 |

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

## Analysis and Results

Item response theory (IRT) was used to score the assessments. IRT takes into account the relative difficulty of each item such that more difficult items contribute more to students' scores. In addition, using IRT 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. Scores were calculated on a scale of 0 to 100. Table 25 shows the scores for each assessment scale.

**Table 25**
**Student Assessment Scores**

| | Minimum | Maximum | Mean | Standard Deviation |
|---|---|---|---|---|
| **3rd Grade** | | | | |
| Pre-Test | 0 | 71 | 30.12 | 12.93 |
| Post-Test | 0 | 100 | 44.27 | 16.95 |
| **4th Grade** | | | | |
| Pre-Test | 0 | 86 | 35.67 | 14.63 |
| Post-Test | 0 | 100 | 48.58 | 16.06 |
| **5th Grade** | | | | |
| Pre-Test | 0 | 84 | 36.70 | 14.94 |
| Post-Test | 0 | 100 | 46.88 | 17.58 |
| **6th Grade** | | | | |
| Pre-Test | 0 | 100 | 43.48 | 16.31 |
| Post-Test | 0 | 99 | 51.94 | 17.98 |

The student assessment data have a nested structure, with test administration (pre-test and post-test) nested within students nested within classes. Consequently, HLM was used to analyze the data. 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 surveys administered to teachers at the middle and end of the school year.[22] These surveys 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 instruction on the topics covered by the assessment: the number of 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 26, the amount of science instruction on the tested topics was relatively low, ranging from an average of about 16 hours over the course of the year in 4th grade to roughly 30 hours in 6th grade. There was a fair amount of variation in instructional time 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.

[22] Because not all teachers completed these surveys, the number of classes included in this analysis is smaller than the total number of classes returning pre- and post-test data.

**Table 26**
**Science Instruction in SIE Classes**

| | Minimum | Maximum | Mean | Standard Deviation |
|---|---|---|---|---|
| **3rd Grade (N = 213)** | | | | |
| Number of Assessed Topics Taught | 0 | 5 | 2.53 | 1.18 |
| Instructional Hours Using SIE-Supported Modules | 0 | 77 | 18.23 | 13.70 |
| Instructional Hours Using Non-SIE Materials | 0 | 27 | 4.46 | 6.21 |
| **4th Grade (N = 213)** | | | | |
| Number of Assessed Topics Taught | 0 | 4 | 2.80 | 1.00 |
| Instructional Hours Using SIE-Supported Modules | 0 | 65 | 15.74 | 12.28 |
| Instructional Hours Using Non-SIE Materials | 0 | 55 | 7.57 | 10.32 |
| **5th Grade (N = 197)** | | | | |
| Number of Assessed Topics Taught | 0 | 5 | 3.20 | 1.29 |
| Instructional Hours Using SIE-Supported Modules | 0 | 105 | 26.06 | 21.82 |
| Instructional Hours Using Non-SIE Materials | 0 | 43 | 6.07 | 8.29 |
| **6th Grade (N = 122)** | | | | |
| Number of Assessed Topics Taught | 0 | 5 | 2.47 | 1.09 |
| Instructional Hours Using SIE-Supported Modules | 0 | 104 | 30.17 | 22.89 |
| Instructional Hours Using Non-SIE Materials | 0 | 39 | 8.09 | 10.48 |

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, the data were collapsed into two categories: White/Asian vs. non-Asian minority.[23]

Because classes are not randomly assigned to different levels of instruction on the assessed topics, it is possible that any differences in post-test scores may be due to initial differences among classes. To examine this possibility, the analyses examined the initial equivalence of classes relative to the instructional variables included in the study. In grades 3 and 5, there were no significant differences overall on pre-test scores among classes with different amounts of instruction based on SIE-supported modules. There were some differences in pre-test scores in grades 4 and 6. In both grades, students in classes covering a greater number of assessed topics had lower pre-test scores. In grade 6, students in classes that experienced more of their science instruction from SIE-supported modules had slightly higher pre-test scores. In addition, non-Asian minorities scored 6 to 8 points lower on the pre-test than their White/Asian classmates at each grade level.

Post-test scores were significantly higher than pre-test scores at all four grade levels, ranging from an 8-point increase in grade 6 to a nearly 14-point increase in grade 3. More importantly, the amount of growth was, at each grade, significantly related to the amount of instructional time based on the SIE-supported modules. Table 27 shows how a typical student would be expected

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

to score in classes receiving different amounts of instruction 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 (effect sizes less than 0.20).

**Table 27**
**Expected 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 | 40.87 | 44.12 | 46.22 |
| 4th Grade | 47.71 | 48.02 | 48.22 |
| 5th Grade | 43.91 | 46.22 | 47.59 |
| 6th Grade | 45.37 | 51.51 | 55.45 |

The non-Asian minority vs. White/Asian achievement gap did not change significantly from pre- to post-test in grades 3 and 6. The gap widened slightly in grades 4 and 5. The amount of instructional time based on SIE-supported modules was not related to this change.

- ***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 increase the statistical power (i.e., the probability of detecting a difference if one truly exists) of the analysis. As can be seen in Table 28, the majority of grades 3–6 teachers in this study have attended an Initial Module Training, and almost half have attended two or more; about one-quarter of the teachers have attended a Module Enrichment session.

**Table 28**
**Teacher Attendance of SIE Professional Development**

| | Percent of Teachers (N = 747) |
|---|---|
| **Initial Module Trainings** | |
| 0 | 7 |
| 1 | 46 |
| 2 | 37 |
| 3 or more | 11 |
| **Module Enrichment** | |
| 0 | 77 |
| 1 | 23 |

The analysis found that 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 fewer of these sessions.[24] Effect sizes were relatively small (i.e., under 0.20 standard deviations). There were no differences between classes of teachers who had attended a Module Enrichment session and those who had not. Figures 7–10 show test scores of typical students at each grade level for teachers with different levels of attendance at SIE-provided professional development.

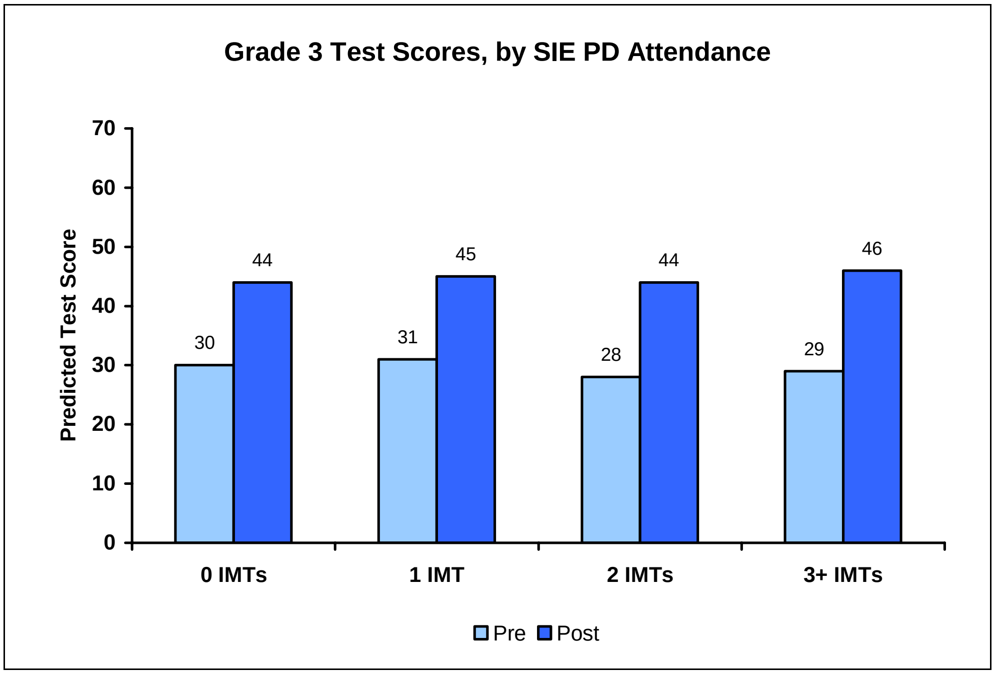



***Figure 7***

[24] Specifically, students of teachers who attended three IMTs had greater growth than students of teachers who attended zero IMTs. In addition, students of teachers who attended two or three IMTs had greater growth than students of teachers who attended one IMT.

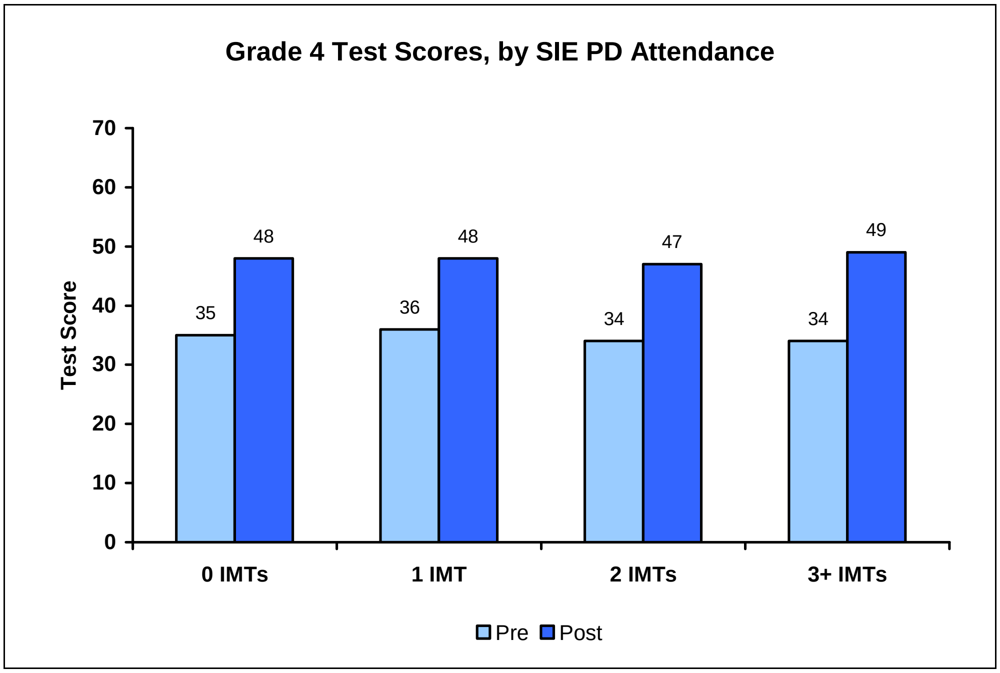



*Figure 8*

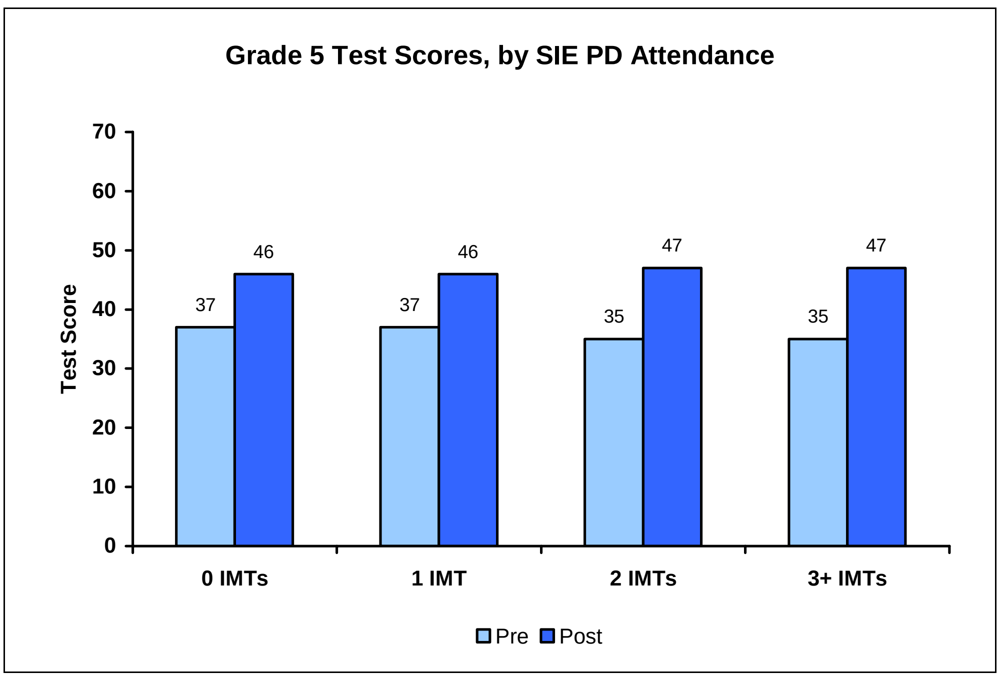



*Figure 9*

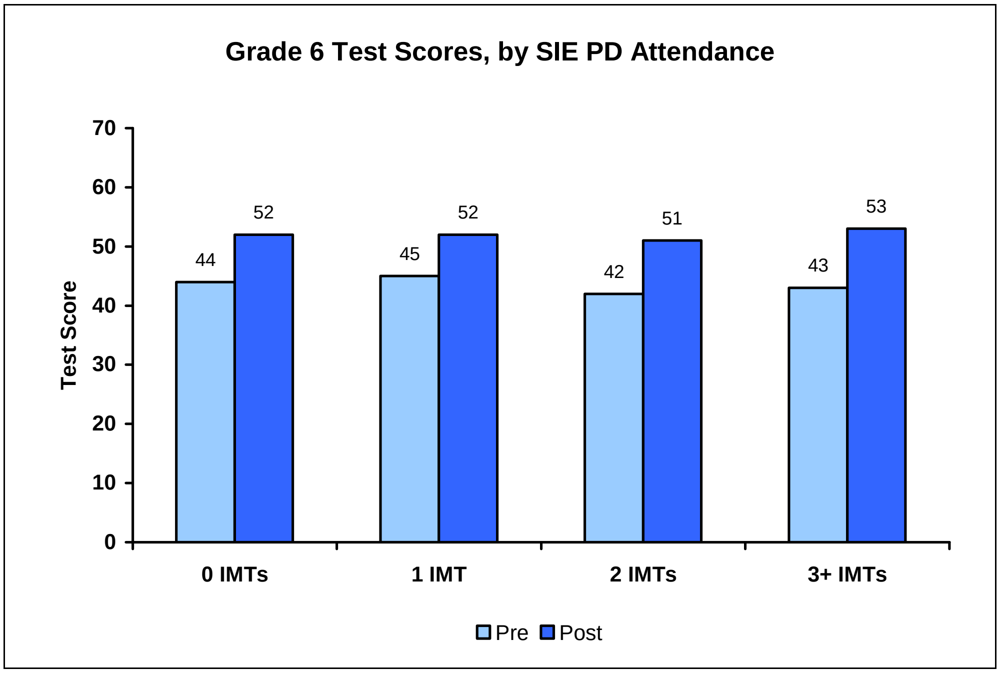

Grade 6 Test Scores, by SIE PD Attendance
Test Score
70
60
50
40
30
20
10
0
44
52
45
52
42
51
43
53
0 IMTs
1 IMT
2 IMTs
3+ IMTs
Pre
Post

***Figure 10***

# SUMMARY AND RECOMMENDATIONS

In its fourth year, the SIE program continues to make progress in bringing inquiry-based science instruction to students across Pennsylvania. The program has added a fourth cohort of schools and provided a Strategic Planning Institute for those schools. In terms of teacher training, SIE has provided three days of professional development to Cohort 4 teachers, and has continued to offer professional development to teachers in Cohorts 1–3. In addition, the program has provided leadership training for a new 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. 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 backseat 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 both 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. Although farther along the continuum to purposeful implementation than non-teacher leaders, teacher leaders also appear to need additional support to reach this goal. Both teacher leaders and other teachers would likely 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:

- **Continue developing all SIE professional development providers' understanding of, and skill at implementing, the "learner hat/teacher hat" approach.**

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 has adopted the learner hat/teacher hat model for the Initial Module Trainings. Still, the effectiveness of its implementation varied greatly. It may be that, as facilitators gain more experience with this approach, their implementation of it will improve. This process would be helped by providing facilitators with opportunities for feedback and reflection.

Another reason for the variation in quality of implementation may be that facilitators feel obligated to have participants experience every lesson in the module as learners, leaving little time for discussion of teaching issues beyond logistical ones. One solution might be to use this approach only for selected lessons: 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 the program decides to take this approach, it will be important that a detailed plan for the Initial Module Training for each module be developed and that all facilitators be expected to follow the plan for their module.

- **Continue to refine the Module Enrichment Trainings so that they focus on the skills and knowledge that will be most beneficial to teachers of the SIE-supported modules.**

The Module Enrichment Trainings helped teachers feel better prepared to teach the module and use the instructional strategies promoted by the SIE program. However, there is not enough time in the sessions to address each of its goals in sufficient depth. While each goal has value, it may be better to postpone treatment of some of them in order to address others more effectively. The program should choose those goals that it believes will have the biggest impact on teachers' ability to implement the module purposefully. Data from the classroom observations suggest that developing teachers understanding of the science content in the module and what each activity adds to the content storyline would be good candidates for additional emphasis.

- **Increase opportunities for teacher leaders to deepen their understanding of the content in their module, as well as its content storyline.**

Teacher leaders play a very important role in SIE, allowing the program to provide professional development to a greater number of teachers. Because of the multiplying effect of teacher leaders (each teacher leader will train many teachers), the potential for impacting the entire program in a positive or negative manner is great.  In order for the program to reach its goal of preparing teachers to provide high quality science instruction, it must ensure that the people leading the professional development are able to lead workshops effectively.  Many of the teacher leaders, new and veteran, have a tenuous understanding of the science content in their module.  Finding ways to further support the teacher leaders in this area should be a high priority for the program.

- **Consider ways to help teachers find the time needed to implement the modules well.**

Lack of instructional time for science is a recurring theme in much of the evaluation data.  The SIE program may want to consider ways that it can help teacher make the most of the time they have.  When creating the schedule for module delivery and return, the program should be sure to take into account major events that would prevent teachers from using the modules, including holidays and PSSA testing.

The program may also want to consider creating an implementation guide for each module that illustrates how the module could be used most effectively with different amounts of instructional time.  Doing so would help ensure that teachers are selecting the most important activities to complete when they are forced to pick and choose due to time constraints.  Identifying which lessons are most important for helping students master the state's science standards would be a good approach for developing these guides.

# Appendix A

## Case Study Vignettes[i]

[i] Pseudonyms are used to protect teacher identities.

## Vignette 1: Using Science to Teach Other Subjects

Mr. Taylor is a veteran primary school teacher who has been teaching for 32 years, 20 of which have been as a Kindergarten teacher. He has addressed science in his daily instruction for approximately ten years. His school is in its second year of participation in SIE, and Mr. Taylor uses two SIE-supported science modules in his instruction. The observation took place in the spring of 2010 during his implementation of the FOSS *Wood and Paper* module; he had implemented this module once before, in the previous year.

Science instruction is a high priority for Mr. Taylor. Although it is not mandated by the district to do so, he teaches science three times a week for approximately 45 minutes. As with most primary teachers, Mr. Taylor teaches in a self-contained classroom and has some flexibility in his daily schedule, which allows him the opportunity to adjust the amount of time devoted to science instruction.

With the exception of a few science education courses, Mr. Taylor has had no formal science coursework or instruction during his adult education. Even though he has limited coursework in science, Mr. Taylor indicated that he feels confident with the science ideas addressed in the *Wood and Paper* module. When asked if there were any ideas or lessons that he found difficult to address, Mr. Taylor indicated that there was nothing in the module that was conceptually difficult, either for himself or his students. However, he did note that because he has such a large classroom and no teaching aides, often the logistics of implementing the module lessons are challenging.

Having attended only the Initial Module Training for the *Wood and Paper* module, Mr. Taylor indicated that the training was extremely helpful in familiarizing him with how to implement the module. He specifically noted that walking through the lessons as a learner helped him better understand how to address each lesson with his own students. He further noted that as he prepared to implement the module lessons in his classroom, he relied heavily on both the notebook he prepared at the training and the teacher's manual. These two materials are the only things he uses to prepare for teaching with the module, indicating that the teacher's manual is particularly helpful.

When asked to reflect on the quality of the instructional materials provided by SIE, Mr. Taylor indicated that he really likes the modules. He appreciates that all of the materials are provided and notes that this availability makes doing hands-on science much easier. In the past, the majority of his science instruction was text-based and any materials he had for activities were those that he brought in himself. He also noted that he likes the readings provided in the module, stating that he has addressed all of the Science Stories in the *Wood and Paper* module. Remarking that Kindergarten students are doing more and more reading now, Mr. Taylor indicated that he tries to bring in additional readings that relate to the topics in the modules.

In addition to the readings, Mr. Taylor makes an effort to incorporate some of the extension activities into his classroom. In fact, the observed lesson was an art extension activity. In Investigation 4.2 students had constructed paper mache bowls. The observed lesson involved students painting and decorating their bowls.

With the exception of additional readings, Mr. Taylor indicated that he teaches the module lessons as they are written. However, he did indicate that he skips around in the module. In his classroom, several students had special needs and/or behavioral problems. The varying abilities in his classroom contributed to his shuffling the modules lessons, picking those lessons that he thought would be easier for students to engage with to do first. When discussing the varying abilities of his students, Mr. Taylor made the point that the modules seem to level the playing field for students with special needs. For example, he noted that one student struggles to stay abreast with his contemporaries in reading and writing and gets very frustrated. However, in science, this student excels and is clearly more engaged.

Overall, Mr. Taylor is implementing the *Wood and Paper* lessons as they are written, but out of sequence. He is making cross-curricular connections to the module in other subjects, such as reading and art. The greatest influences on his preparations for implementing the module are the materials he received from SIE, specifically his notebook and teacher's manual. Next year, Mr. Taylor indicated that he would like to try to implement the module in sequence and as written and noted that he will feel more confident to do so having implemented the module two times at that point.

## Vignette 2: Making Changes to Increase Student Interest

Ms. Martin has taught music for much of the past 25 years. For the last two years she has been at her current school as a learning support teacher for students in Kindergarten, 1st, and 2nd grade. She is in her second year of using two SIE-supported science modules, which she typically teaches in collaboration with a 1st grade teacher in the classroom next door. The first year using the modules, Ms. Martin provided assistance as the 1st grade teacher led the lessons. This year, the two teachers took turns leading the lessons.

Ms. Martin has the flexibility to decide when to teach science and for how long. She indicated that she is able to use any instructional materials she wants, but that she exclusively uses the SIE-supported modules to teach science. When she has a module, Ms. Martin teaches science every day for approximately 45–60 minutes. When she does not have a module she instead teaches social studies.

Before coming to her current school, Ms. Martin did not teach science. She has not taken any college science courses, and the only science professional development she has attended is the Initial Module Training for the *Weather* module. Ms. Martin commented that she enjoyed the training and that it was very helpful for preparing her to teach the module. She also indicated that the module itself is very easy to use. She noted that the module is accessible to her students because it is hands-on and allows them to learn through their own observations. Ms. Martin has especially embraced the Initial Module Training emphasis on having students make observations using all five senses.

One factor that impacts Ms. Martin's implementation of the module is the amount of time she is allowed to keep it. Ms. Martin reported that, even though the module was in the school for nine weeks, because of the PSSA she had only a few weeks in which to implement the module. She indicated that she had to rush to get through all of the investigations in this short period of time. To make the most out of the time she had with the module, Ms. Martin collaborated with the three 1st grade teachers in the building to plan how they would implement the module. They decided to combine some lessons, shorten others, and cut some out entirely. She indicated that their decisions were based on what they thought were the most important things for the students to learn. For example, they combined several lessons that focused on thermometers into one, choosing to have students measure temperature only in degrees Fahrenheit (excluding temperature measurement in degrees Celsius). The limited time also prohibited her from using any of the extension activities in the module.

A second factor that impacts Ms. Martin's implementation of the module is the diverse learning needs of her students. Ms. Martin is a learning support teacher and many of her students have unique learning styles as well as behavioral issues. Thus, she modifies the instruction based upon her perceptions of student ability and interest. For instance, she often spends extra time on the reading and literacy components of the science lessons because she believes this supplemental instruction will help them in their lives. She also skips many of the provided module readings in favor of her own reading selections that she thinks will be more interesting to her students.

Ms. Martin was observed teaching Investigation 12: Testing Rainy Day Fabrics from the *Weather* module. She generally followed the experimental procedures as written with a limited number of modifications. For example, Ms. Martin extended the lesson introduction in order to incorporate some literacy strategies. She wrote the list of materials on a flip chart and asked students to help her read the words aloud. She also helped students sound out each word and then held up the corresponding object once they read the word correctly. The Initial Module Training's emphasis on making observations with all five senses was evident in this lesson; she prompted students to describe the various fabrics used in the investigation in terms of how they felt, what they looked like, and what they smelled like.

Ms. Martin's focus on maintaining student interest was very evident toward the end of the lesson, which included more substantial modifications of the lesson. One change was during the class discussion of their results. Rather than using the prompts provided in the module that focused on which types of fabric keep people dry in the rain, she questioned students about which types of fabric they would like to wear in the rain. As a result, the students were unable to explain which fabric was the most waterproof (one of the goals of the lesson). Additionally, rather than using the module reading that also focused on types of material used to keep humans and animals dry in the rain, she chose to read from a story about a dry place where everyone longed for rain and felt happy when it arrived. She thought the brightly-colored pictures in the story would hold student attention better than the module reading.

## Vignette 3: First Timer Learning the Ropes

Ms. Butler has been a teacher for four years, including two years at her current school. The majority of her teaching career has been in a 6th grade classroom, but four months into this school year she voluntarily switched from 6th to 2nd grade to fill a teaching vacancy. She admitted that it was difficult to make this transition, but she made the change because she wanted to help fill a need at her school.

This year was her first time teaching with an SIE-supported module. Ms. Butler has very little formal training in science content other than one science teaching class in her Master's program and the Initial Module Training for the *Changes* module. She never taught science before this year, though she indicated that she feels confident to teach the content because of the way the module is structured. She said that the Initial Module Training was extremely helpful in preparing her to teach because everything was modeled and she was able to experience the investigations step-by-step. Ms. Butler stated that teaching the module is, "Kind of like a no-brainer if you remember what happened" in the training. During the Initial Module Training, Ms. Butler also created a science notebook that she uses to help her prepare to teach the lessons.

Ms. Butler has complete control over the science instruction and science curriculum in her classroom. She typically teaches science three or four times each week for up to 45 minutes per lesson. Additionally, she plans all of her own instruction. Before Ms. Butler received the *Changes* module, she taught science lessons that she pieced together by consulting assorted books and websites. She described the struggle to find science topics and activities that she was confident and competent teaching. She is very happy with the *Changes* module because it has eliminated much of her anxiety about teaching science. She indicated that the module is teacher-friendly and is not a burden for her to prepare because everything is provided.

Ms. Butler strives to implement the module as it is written. She teaches the module lessons in order and does not make modifications to individual lessons. Although she occasionally selects an additional reading, she always has her students use the module readings. To ensure that she is following the module during a lesson, Ms. Butler prepares to teach each lesson by reading the teacher background information and then writing the steps of the investigation on an index card. She uses this index card as a reminder of the lesson procedure while she is teaching.

Ms. Butler was observed while teaching Investigation 10: Separating Mixtures of Color from the *Changes* module. Adherence to the module was evident during classroom observation as she methodically led students through the investigation. For instance, Ms. Butler had students count to four aloud as they made ink dots on filter paper and then blow on the dots to help them dry. This procedure was performed exactly as written in the teacher's manual. Ms. Butler was also observed holding an index card throughout the lesson and she referred to it for guidance several times as students transitioned from one step to the next.

In accordance with the Initial Module Training she attended, Ms. Butler typically instructs her students to write predictions and observations in their notebooks before, during, and after each science lesson. However, the students did not use their notebooks during the observed lesson. Several students pointed out that the notebooks were missing and Ms. Butler explained that she chose not use them due to the water and permanent markers being used in the investigation. She instead asked students to write on worksheets that would later be stapled into their notebooks. This modification seemed appropriate for the given situation.

Although Ms. Butler followed the experimental procedures as written, she altered the introduction of the observed lesson from what was provided in the module. Ms. Butler began the hands-on investigation without explaining that ink could be separated into its hidden colors. While students were able to identify specific colors they saw after water was dropped onto the ink dots, it was unclear whether or not they understood that ink was a mixture of these different colors. The omission of this one idea may have made it difficult for students to connect the changes they observed in the activity to the larger idea of colors being mixtures. Ms. Butler is typical of a teacher new to teaching science with modules. She was very concerned with implementing the mechanics of the module activity, but would benefit from guidance on how to focus students on the relevant aspects of the lesson, in this case pointing out to students that the ink is an example of a mixture of liquids.

## Vignette 4: Combining Lessons to Complete the Module in the Allotted Time

Mr. Smith has been teaching 3rd grade for his entire four-year career at the same school. He teaches a self-contained class of 25 students, several of whom are pulled out to receive Title 1 reading instruction on Tuesdays and Thursdays. Because he does not want students to miss science, Mr. Smith chooses to teach science on Mondays, Wednesdays, and Fridays; lessons are typically 45 minutes each.

This year is Mr. Smith's second teaching the STC *Plant Growth and Development* module. Mr. Smith believes he is adequately prepared to teach the module despite having only one general science course in college. He indicated that the Initial Module Training and the teacher's manual provided the content knowledge needed to teach the module. He highlighted the influence of the Initial Module Training on his use of the module, in particular the emphasis at the workshop placed on the importance of going through every lesson in the module sequentially. In addition, he noted that the nature of the module content (i.e., following the growth cycle of the plants) does not permit him to rearrange or skip the lessons. However, due to his decision to teach science only when his entire class was present, he does not have the module long enough to do every lesson as written before having to return the module. As a result, he has chosen to combine three similar lessons about pollination rather than not get to the end of the module. Otherwise, Mr. Smith tries to implement each lesson as laid out in the module.

During the observation, Mr. Smith taught Lesson 15 of the *Plant Growth and Development* module, which focuses on interpreting information from graphs. Students were given two growth charts. One was a bar graph of the Wisconsin Fast Plant they had been working with that illustrated the height of the plants over time; the other was a bar graph showing height versus time of a fictional girl on a farm. Following a set of questions on a module worksheet, students examined the graphs, noting important aspects such as axis titles and units of measurements. They also examined trends in the data to draw conclusions. Mr. Smith followed the lesson nearly exactly as written in the module, making only minor modifications to allow the class to finish the lesson in the time allotted. For example, rather than having students work on answering the questions individually, he had them working on this task as a whole class. These modifications did not appear to hinder the students' opportunity to reach the objective of the lesson, as Mr. Smith made a point to call on most of the students in the class during the discussion and allowed the students to formulate responses themselves. The whole-class discussion likely contributed to students' knowledge on how to interpret graphs.

When asked what he hoped his students would know after completing the module, Mr. Smith explained that he hoped his students would understand the entire life cycle of the plant from a seed growing into a plant and ultimately producing more seeds. He also hoped students would understand the different factors involved in that process, such as the role bees play in pollination. He thinks the majority of his students will arrive at these understandings because, in his opinion, the module does a good job of communicating the objectives in a way students can understand while challenging students in critical thinking and problem solving skills.

## Vignette 5: Beefing Up the Content in the Module

Mr. Anderson has been teaching science for 15 years, and has been at his current school teaching 4th grade for the last three years. He teaches science to two different groups of students, with each group engaging in the same lesson each day. This is his second year teaching the FOSS *Human Body* module.

Mr. Anderson reported having a strong science content background, and places a high priority on continuing to develop his disciplinary content knowledge. In his undergraduate studies, Mr. Anderson took every opportunity to study science, taking biology, chemistry, earth and space science as his elective courses. He also attended both the Initial Module Training and the Module Enrichment Training to become more familiar with the SIE-supported modules he teaches as well as the science content in the modules. Mr. Anderson indicated he is very comfortable with the content of the modules he teaches.

When asked about influences on his teaching of the modules, Mr. Anderson stated that the biggest issue is not being given enough time to complete the modules. Typically, Mr. Anderson's school has the module for 13 weeks, but this year his school received the spring module a month late, and his implementation was further delayed due to state testing. Because of these delays, Mr. Anderson chose to make significant modifications to the implementation of the *Human Body* module.

Mr. Anderson relied on his own science content background and the state science standards when deciding how to modify his use of the module in order to meet time limitations. He compared the state's standards to the module lesson content and chose to implement those lessons he believed meet the standards. Mr. Anderson provided the example that he determined that his students needed to cover the fourth lesson in the *Human Body* module, which covers the function of joints and the opposable thumb in particular, to meet a state standard. In order to accomplish this, he condensed Lessons 1–3 into a single lesson (deciding those lessons were not as vital) and used it as an introduction to Lesson 4.

Mr. Anderson also supplements the module with resources that he believes benefit his students. In particular, he places a high importance on technology in the classroom and uses a SmartBoard in most classes. He also brings in visual aids. For example, to supplement a lesson on joints, Mr. Anderson brought an actual cow knee joint into his classroom.

Mr. Anderson's modifications were evident in the observed lesson. The main objective of the lesson was for students to gain an understanding of a bone's function based on its shape and size (i.e., form relates to function). According to the manual, students are to take a package of model rodent bones and sort them according to an illustrated worksheet. Next, students are to reconstruct and display a skeleton using glue to attach the model bones. Finally, students are instructed to make entries to their word banks and answer a series of questions such as, "How are bones of rodents like those of humans? How are they different?" and "Can you tell the function of a bone by its shape?"

The teacher made several changes to this design. First, students were questioned about bone shapes and names during the sorting activity, which is beyond the scope of the lesson. Next, the students assembled the bones as intended, and sketched the bone structures (they did not glue the bones together, most likely to save time). Mr. Anderson supplemented the lesson by showing the skeleton of the animal on the SmartBoard and discussing how the bones allowed specialized functionality in the animal. These modifications, in particular the more in-depth discussion about the functionality of bones, most likely increased students' opportunity to learn the content.

## Vignette 6: Simplifying Lessons and Adding Content for Students

Ms. Barber has been teaching 4th grade math and science for four of her five years teaching, all of which have been at her current school. This is her second year teaching the FOSS *Motion and Design* module, though she has taught the content included in the module for all five years of her career. Ms. Barber attended the Initial Module Training, and she indicated she feels "somewhat comfortable" teaching the module content. She has also gained content knowledge by reading textbooks and the internet. She teaches science to two different groups of students four days a week, with each class approximately 45 minutes in length.

Ms. Barber noted that she was instructed during the Initial Module Training to teach all the module lessons in order, going through each lesson step-by-step. She indicated that after teaching the module the first year, she found it necessary to modify and/or supplement certain aspects of the lessons to better meet the needs of her students. Therefore, lesson modifications are a regular part of her implementation of the module. For example, in Lesson 8 students work with a rubber-band powered vehicle and are instructed to narrow the frame of the vehicle in order to increase friction. Ms. Barber explained that it is difficult for students to clearly observe this change and now leaves this portion of the lesson out. Instead she uses her own experiment about friction, having students slide objects across different surfaces, including ice, tile, and carpet. She also includes a lesson on Newton's three laws of motion prior to starting the module to make sure students understand the science.

Another area in which Ms. Barber supplements the module is assessment. Her school requires the assignment of grades; therefore, she has created a rubric for assessing students on the lessons. Time is also a factor affecting Ms. Barber's use of the module. She indicated several lessons that she finds difficult to teach in a single science period. As a result, she makes modifications such as splitting lessons over two days, and having students answer questions in groups rather than individually to save time. Despite the additional lessons and the modifications to the module, Ms. Barber indicated she is able to finish the module in the allotted time.

Ms. Barber did not make any major modifications on the day of observation, during which she taught the final lesson in the *Motion and Design* module. In this lesson, which is not typical of the other lessons in the module, student teams present their solutions to vehicle design challenges they had been previously assigned (e.g., design a vehicle that will move 100 cm in the least amount of time). The rest of the class then evaluates each team's solution and asks questions. Ms. Barber followed the lesson plan fairly closely, though she did place more emphasis than called for in the module on having students in the classroom ask questions. Typical questions students asked included, "Why did you name your vehicle the way you did?" "What was the hardest part?" and "Did you have fun?"

## Vignette 7: The Class' Ecosystem Disturbed by State Testing

Ms. Gilbert is a veteran teacher, with 25 years of classroom experience. Fourteen years of her career have been devoted to teaching the 5th grade. Ms. Gilbert has an extensive background in science education, in particular environmental science, and has a passion to foster in her students an appreciation for the world around them. Ms. Gilbert holds two degrees, one in elementary education and the other in environmental education. She has taken upwards of 10 college courses that relate to the content addressed in the *Ecosystems* module. Ms. Gilbert has always made science a priority in her instruction by ensuring that it is part of her daily schedule. She stated that she has addressed science every day for the duration of her time as a 5th grade teacher.

When preparing for the lessons, Ms. Gilbert indicated that she relies on her teacher's manual, the student activity sheets, the notebook she prepared during the Initial Module Training for this module, as well as the textbook used in her classroom when they do not have an SIE-supported module. Ms. Gilbert noted that she uses all of these materials to identify the ideas addressed pulling in as much detail as she can. When there are connections that she can make in their regular textbook, she does so, often in the form of readings. Ms. Gilbert noted that she accesses the teacher background information in the module to brush up on the content and vocabulary. She finds the student activity sheets to be particularly helpful when preparing for lessons because they focus on what the student needs to do.

In discussing her implementation of the *Ecosystems* module, Ms. Gilbert indicated that she teaches the lessons in order and for the most part as they are written. She noted that it would not make sense to skip around in the module because the lessons build on one another. She stated that she sometimes makes minor adjustments to the lessons when she wants to highlight a particular idea.

Ms. Gilbert noted that time for science is always a concern. At her school, there is a block of time set aside for science each day, but it is up to individual teachers to decide when to use that block of time. Ms. Gilbert's block of time for science is bisected by lunch, which she said often results in her having to break up the lessons and make adjustments as to how much she can get through in one day. In addition, the modules were delivered during the PSSA testing period this year, resulting in a loss of three weeks of instructional time with the module. Ms. Gilbert noted that she struggles to get through all of the lessons in the time available; she has not had the opportunity to use any of the module extensions or strategies introduced at the trainings, such as Power Conclusions, because of her compressed timetable. She did note however, that she makes the point to address all of the readings in the module and coordinates as much as she can with her reading program. This class will get through as much of the module as they can before the end of the year, but Ms. Gilbert noted they will not finish given that they lost so much time due to state testing.

The observed lesson was Lesson 8: Upsetting the Stability, in the *Ecosystems* module. Prior to the observation, students had constructed eco-columns by connecting two soda bottles. In the upper soda bottle, they constructed a terrarium and in the lower bottle they had constructed an aquarium. In the observed lesson, students made some observations of their eco-columns and discussed what a disturbed ecosystem is and what factors might cause an ecosystem to become disturbed.

Ms. Gilbert's passion for science was apparent in her instruction. Throughout the observed lesson Ms. Gilbert made an effort to honor students' observations and inspire a sense of wonder about what was happening in their eco-columns by prompting careful and thoughtful observation. Moreover, she encouraged the students to take ownership of their learning by suggesting that they write everything they observed down and then do some research on their own about what they observed if they had any questions.

There were minor adjustments made in the observed lesson that allowed the teacher to expand on particular ideas. One adjustment was that the teacher had students list and share both natural and human-made disturbances to an ecosystem. (The lesson as designed has the class list human-made disturbances only.) Another adjustment the teacher made was to not tell the students which liquid they were testing was water and which was vinegar and hope they figure it out by measuring of the pH of each. Other than these few minor adjustments, the teacher implemented the lesson as written in the module.

## Vignette 8: Adjusting Implementation for Low-Ability Students

Ms. Davis has been teaching 5th grade for her entire eight-year tenure as a teacher; in fact, she has been in the same classroom throughout her career. As a member of a Cohort 3 school, Ms. Davis has been involved in the SIE program for two years and implemented two modules this year. Ms. Davis was observed as she addressed a lesson from the FOSS *Ideas and Inventions* module, a module she implemented once before, during her first year in the SIE program.

Although finding time to fit science instruction into the daily schedule is often a struggle for teachers, Ms. Davis makes an effort to address science every day. As a result of participating in the SIE program, the administration at Ms. Davis's school saw the need to increase the amount of time devoted to science instruction. As of this year, science and social studies are taught on a rotating six-day block schedule; science is taught every other day for one hour. On those days when it is not on the block schedule, science is taught for 30 minutes.

In addition to the increase in time devoted to science in her school's daily schedule, another major influence on Ms. Davis's science instruction has been the adoption of the SIE-supported modules. Ms. Davis indicated that the teacher manuals are very easy to follow. She had attended the Initial Module Training for both of the modules she teaches and commented that the training for the *Ideas and Inventions* module in particular was very thorough and helpful.

When asked how she prepared for implementing lessons from the module, Ms. Davis indicated that she relied heavily on her teacher's manual, science notebook, and colleagues. Her science notebook was created at the Initial Module Training for this module and includes the tips and strategies she gleaned from the training along with her own thoughts. In addition, the teachers at this school have shared grade-level planning time that Ms. Davis indicated is very valuable to her. During this time, she and her colleagues sit down with their materials and go through each lesson, discussing how they are going to implement them and what alterations they may need to make for particular groups of students. Ms. Davis also noted that she accesses the teacher background information in the teacher's manual to prepare her to answer students' questions about the content.

Of the many factors that affected Ms. Davis's implementation of the *Ideas and Inventions* module, the most salient factor was her students' reading ability. At her school, students are grouped based on their reading ability. Ms. Davis teaches the group with relatively low reading ability, requiring substantial extra support and structure compared to the other students in the school. As a result, Ms. Davis has found it necessary to adjust her instruction with the SIE-supported modules. Although she implements the investigations as written and in sequence, she found that she has had to slow down the pace and split investigations across several class periods. Ms. Davis also noted that she has had to provide extra support in terms of materials management and notebook entries. For example, she often goes through the lesson directions with her students and has them use highlighters to emphasize the most important portions. Another thing she noted doing was having students practice several of the techniques used in the module investigations before actually doing the investigation. These extra structures were clearly evident in the observed investigation. Although Ms. Davis followed the manual and implemented the investigation as written, she adjusted how the materials were distributed and walked students through the activity providing extensive support with the directions.

When asked about the readings and extension activities provided in the module Ms. Davis noted that she really liked the readings and included them all. She also noted that when it was appropriate she would bring in supplemental readings that related to the content of the module. For example, she had her students read a book about inventions by children at the beginning of the *Ideas and Inventions* module. She also made an effort to incorporate at least one extension activity per investigation. Because she did not feel she could give up class time to address them, and to keep the investigations as straightforward as possible, Ms. Davis selected those extensions that students could do on their own and assigned them as homework. Other than additional readings and the extension activities she selected in the module, Ms. Davis did not supplement the module with any other instructional materials. In fact, due to her slowed pace and because the module was delivered a bit late, she doesn't think she will be able to get through the last set of investigations this year.

## Vignette 9: Fidelity to Module/Flexibility to Meet Student Abilities

Mr. Jones has been teaching for 29 of his 32-year career at his current school. For the last five years, he has taught 5th grade science and mathematics to both classes of 5th graders in his school. (The other 5th grade teacher is responsible for reading/language arts and social studies). His school is in its third year of participation in SIE, and Mr. Jones teaches two SIE-supported science modules. The observation for this case study took place in the spring while he was implementing a lesson from the FOSS *Variables* module. This year was his second time teaching this module.

Mr. Jones had taken some science courses in college, and felt confident in his understanding of the science topics he teaches. He had attended both the Initial Module Training and the Module Enrichment sessions for the *Variables* module, and indicated that both were extremely helpful in understanding and teaching the module. He also reported that both professional development sessions emphasized the importance of implementing all of the lessons in the module, in the order they are written, and that he had taken this message to heart.

When asked his opinion of the module, Mr. Jones indicated that it is very well organized, and the background material included is very thorough and easy to find. In addition, he noted that the individual lessons are well structured, and that the module comes with all of the supplies he needs, making it easy for him to implement each lesson. However, he thought the module lacked adequate resources for assessing student learning. He indicated that parents in his district want to know why students receive the grades they do, and wanted to see student scores from assignments and tests. Mr. Jones noted that FOSS sells additional assessment materials, which he thinks are of high quality and would like to use, but that these materials are not included with the modules he receives from SIE.

Other than adding assessments, Mr. Jones indicated that he does not feel the need to supplement the module. He noted that his implementation of the module is aided by the flexibility he has in his day-to-day schedule. He normally has 30 minutes a day, four days a week, for science. However, he and the social studies teacher are able to trade time—on some days he will take more than his allotted time for science, and will give the time back on other days—allowing him to complete lessons from the module that take more than 30 minutes to implement. On Fridays, the school has "integrated language arts," and the teachers on each grade-level team share the time to further student literacy skills. By utilizing some of this time, he is able to implement a couple of the extension activities or reading selections included with the module.

One factor that has a large impact on Mr. Jones' implementation of the module is the number of weeks he is allowed to keep the module. Although having a module for nine weeks is sufficient during the fall semester, he indicated that it is not sufficient time to implement an entire module in the spring when the administration of the state assessments takes away large chunks of instructional time. In this situation, he noted that he still implements the lessons in order, getting as far in the module as he can. For the *Variables* module, this meant getting through less than three-quarters of the module.

The ability level of a class also affects his implementation of the module. Of the two groups of 5th grade students Mr. Jones works with, he described one group as being more advanced than the other, noting that they take more initiative during experiments and need less guidance. Although Mr. Jones indicated that he follows the module exactly as it is presented in the teacher's manual, without skipping any lessons, he thinks it is okay to make modifications to individual lessons to fit the needs of a particular group of students.

Modifications to meet the needs of a particular class were evident on the day of the observation, during which Mr. Jones was teaching Lesson 2 of Investigation 3: Plane Sense to his advanced class. The lesson continued an experiment in which students had built a rubber-band powered airplane and were investigating the plane's flight along a piece of fishing line. The lesson plan called for small groups to first determine how many times they had to wind the rubber band to cause the plane to travel the entire length of the string. Next, the students were to regroup as a class and discuss their findings, reviewing the different variables that may have affected the flight of the planes. Students were then supposed to go back to their small groups to determine how many rubber-band winds it would take to fly the plane half-way across the string. Because he was teaching his more advanced class, Mr. Jones decided to combine these three steps into one, having students determine the number of winds in takes to move the plane both distances without the intermediate discussion. For this class, the approach taken by Mr. Jones appeared to be effective. Though the step-by-step procedures from the manual were not followed verbatim, the teacher's modifications to the lesson seemed appropriate as students engaged with the all of the important aspects of the lesson.

## Vignette 10: Teacher Modifications Help Students Focus on Content

Mr. Garner is an experienced teacher of 35 years, 13 of which has been spent teaching 6th grade. Mr. Garner holds a bachelor's degree in elementary education, which included taking several science education courses, but not any science courses. Even with his lack of formal education in science, Mr. Garner indicated that he has always been very interested in and passionate about science. He has been involved in several science education initiatives in his school over his career and has taught science every year in his daily instruction since becoming an elementary educator. Currently, Mr. Garner teaches science every day for approximately 50 minutes, despite the pressure from his principal to spend more time on reading and mathematics.

Although he has implemented the FOSS *Mixtures and Solutions* module only twice since his school joined SIE, Mr. Garner indicated that he is particularly comfortable with the content addressed given that he has taught the topic many times prior to receiving the SIE-supported module. Mr. Garner attended both the Initial Module Training and the Module Enrichment Training for the *Mixtures and Solutions* module, which he stated has further increased his confidence with the content in the module. He noted that when preparing for a lesson in this module, he typically looks at all of the materials in his teacher's manual and the notebooks he created during each SIE training on this module. He noted that the notebooks are particularly helpful in providing implementation tips and strategies, and that the teacher background section in the module is also particularly helpful for refreshing his memory on the content.

Mr. Garner's philosophy as to how students learn best influences his implementation of the module. He suggested that students often have to see things for themselves to believe it, and that as a teacher he can not just tell the students something and expect them to understand it. He explained, "This process takes time;" and, although he typically follows the manual very closely, he often has to break lessons up across multiple class periods. Typically, in one class period Mr. Garner will provide the class a focus question, a list of vocabulary, and have students make predictions. In the next class period, he continues the lesson with the activity. Noting that he really likes the open-ended nature of the questions in the module, Mr. Garner also breaks up lessons to free up time for more discussions about the class's findings. He particularly likes the questions in the module because they place the onus for coming to a conclusion on the students, pushing them to think more deeply about their findings and the key ideas in the module.

Mr. Garner did note that his students struggled with some concepts in the module, which also influences his implementation of the module. He indicated that the ideas most difficult for his students were those related to what a solution is, that solutions can not be separated by filtration, and what a saturated solution is. Mr. Garner noted that those lessons dealing with saturation and solutions were not only conceptually difficult for students, but were also logistically challenging for the instructor and were very material-intensive. He plans time to reinforce those ideas once he knows how students respond to the lessons.

Given the way Mr. Garner spreads out lessons across several class periods, he expects to finish the third set of investigations in the *Mixtures and Solutions* module but not get to the fourth and final set that address chemical reactions. He indicated that both times he has implemented this module he has not gotten to the fourth set of investigations.

Other than introducing the vocabulary at the beginning of the lesson rather than at the end, as the module suggests, Mr. Garner stated that he implements the module lessons in sequence and as they are written. He does not add much to the module, especially given his already limited amount of time for science. In an effort to make cross-curricular connections to reading and mathematics, he has students do in-depth analyses of the Science Stories that come with the module. Mr. Garner also noted that he has been unable to incorporate many of the module extensions into his implementation and addresses only those that he has materials readily available for and that are easy to do. Typically, he assigns the extensions as extra-credit assignments.

The observed lesson was Investigation 3.1 from the *Mixtures and Solutions* module, Concentration: Soft Drink Recipes. The purpose of this lesson is for students to explore the concept of concentration (i.e., amount of solute dissolved in a given volume of solvent).

The observed lesson followed the structure as outlined in the module, but Mr. Garner added a few elements that helped students focus on the targeted content. For example, they used a balance to compare the weights of two pitchers prior to and after different amounts of a soft-drink powder had been added to each. Moreover, the teacher involved the students more directly in the investigation than outlined in the module by calling on pairs of students to come to the front to make the solutions. Throughout the lesson, the teacher kept the focus on the targeted ideas by asking questions like, "Is this a solution?" and, "Can I filter it?"  At the conclusion of the investigation, the teacher had prepared a worksheet and overhead he had prepared that that had images of solutions with dots representing the solute dissolved, underneath was a continuum showing that the solution was either more or less concentrated and more or less dilute moving in one direction.  Students were instructed to pick whether the solutions were getting more or less concentrated and more or less diluted based on the direction of the arrow.  This activity was a way for students to visualize the inverse relationship between concentrated and diluted.  These modifications appeared effective at helping students focus on the targeted idea.

# 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)** | **0.93** | **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)** | **0.96** | **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)** | **0.92** |

# 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 (pre-test score) | 29.79 | (0.32) | 34.86 | (0.36) | 35.86 | (0.47) | 42.61 | (0.72) |
| Number of Topics Taught | -0.23 | (0.35) | -0.88* | (0.44) | 0.11 | (0.42) | -1.71* | (0.76) |
| Square Root of Hours of Instruction Using SIE Modules | -0.08 | (0.21) | -0.39 | (0.22) | 0.20 | (0.23) | 1.50* | (0.43) |
| Cube Root of Hours of Instruction Using Other Materials | 0.13 | (0.44) | 1.89* | (0.48) | -0.03 | (0.56) | -2.18* | (0.96) |
| Female | -0.06 | (0.46) | -0.90 | (0.46) | -0.96 | (0.49) | 0.61 | (0.67) |
| Non-Asian Minority | -5.83* | (0.84) | -6.23* | (0.79) | -7.90* | (0.87) | -7.45* | (1.16) |
| Growth from Pre to Post | 13.82* | (0.44) | 13.11* | (0.33) | 10.01* | (0.40) | 7.95* | (0.42) |
| Number of Topics Covered | 0.40 | (0.48) | 0.04 | (0.40) | 0.14 | (0.36) | 1.15* | (0.44) |
| Square Root of Hours of Instruction Using SIE Modules | 1.60* | (0.28) | 0.54* | (0.20) | 0.56* | (0.20) | 0.70* | (0.26) |
| Cube Root of Hours of Instruction Using Other Materials | 1.14 | (0.61) | 0.27 | (0.44) | -0.48 | (0.48) | -0.98 | (0.56) |
| Female | 0.08 | (0.45) | 0.62 | (0.40) | -0.14 | (0.48) | 0.12 | (0.55) |
| Number of Topics Covered | — | — | — | — | 0.53 | (0.40) | — | — |
| Square Root of Hours of Instruction Using SIE Modules | — | — | — | — | -0.18 | (0.22) | — | — |
| Cube Root of Hours of Instruction Using Other Materials | — | — | — | — | -0.44 | (0.53) | — | — |
| Non-Asian Minority | -1.62 | (0.89) | -2.91* | (0.70) | -1.75* | (0.75) | -0.94 | (0.89) |

* $p < 0.05$.

Note: All variables were grand-mean centered except the Growth from Pre to Post variable which was uncentered.

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

| | **Regression Coefficients (and standard errors)** | |
|---|---|---|
| Intercept (pre-test score) | -0.37 | (0.01) |
| *Grade Level* [1] | | |
| Grade 3 | -0.05 | (0.04) |
| Grade 5 | 0.11* | (0.04) |
| Grade 6 | 0.17* | (0.04) |
| *Initial Module Training* [2] | | |
| 1 Initial Module Training | 0.02 | (0.06) |
| 2 Initial Module Trainings | -0.11* | (0.06) |
| 3+ Initial Module Trainings | -0.08 | (0.07) |
| Module Enrichment Training | 0.03 | (0.03) |
| Female | -0.02 | (0.01) |
| Non-Asian Minority | -0.36* | (0.03) |
| Growth from Pre to Post | 0.71* | (0.01) |
| *Grade Level* [1] | | |
| Grade 3 | 0.08* | (0.03) |
| Grade 5 | -0.21* | (0.03) |
| Grade 6 | -0.30* | (0.04) |
| *Initial Module Training* [2] | | |
| 1 Initial Module Training | -0.01 | (0.05) |
| 2 Initial Module Trainings | 0.08 | (0.05) |
| 3+ Initial Module Trainings | 0.16* | (0.06) |
| Module Enrichment Training | 0.03 | (0.03) |
| Female | 0.01 | (0.01) |
| *Grade Level* [1] | | |
| Grade 3 | 0.01 | (0.04) |
| Grade 5 | -0.02 | (0.04) |
| Grade 6 | -0.03 | (0.04) |
| *Initial Module Training* [2] | | |
| 1 Initial Module Training | -0.03 | (0.06) |
| 2 Initial Module Trainings | 0.02 | (0.05) |
| 3+ Initial Module Trainings | -0.12 | (0.06) |
| Module Enrichment Training | -0.03 | (0.03) |
| Non-Asian Minority | -0.11* | (0.02) |

* $p < 0.05$.
Note: All variables were grand-mean centered except the Growth from Pre to Post.
[1] Versus Grade 4 students
[2] Versus teachers attending no Initial Module Trainings