Franklin Elementary School
Rahway, NJ

A case study about the work of the Merck Institute for Science Education

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Biography

Siobhan McVay is a Research Assistant for the Consortium for Policy Research in Education (CPRE) at the University of Pennsylvania. After completing her B.S. in animal science and secondary teaching certification in the areas of chemistry and biology at Michigan State University, she worked as a classroom teacher for six years. McVay initially served as a junior high science teacher in Chicago, Illinois and later as a chemistry teacher in the Rahway Public Schools (New Jersey). She also was connected with the Merck Institute for Science Education (MISE), specifically as a content area specialist instructional team member for Peer Teacher Workshops implemented through the MISE Partnership. Currently, McVay is pursuing a Master of Science in education degree with an emphasis in teaching, learning, and curriculum at the University of Pennsylvania.

CPRE's Evaluation of MISE

CPRE, based at the University of Pennsylvania, was contracted by MISE in 1993 to document the implementation of the initiative and assess its impact on districts, schools, classrooms, and students. Throughout the evaluation, CPRE conducted interviews with teachers, instructional leaders, and district personnel; surveyed teachers; developed case studies of schools; and examined student achievement data in order to provide feedback on the progress of the MISE Partnership.

About this Case Study

This case study is one of four written about schools that have been part of MISE's partnership with school districts over the past 10 years. The case studies are intended to present a story about how the reform has impacted science education in classrooms as well as how it has impacted teachers, schools, and districts. The context for each case study is different as each school and district brings its own unique situation and challenges.

The case studies were written as a result of two or three site visits over the past 10 years, visitations of several days which included classroom observations and interviews with teachers, principals, district administrators, and superintendents. Information was also gathered from evaluation reports by CPRE over this 10-year period, beginning with the 1993-1994 school year and ending with the 2000-2001 school year.

Acknowledgments

Each of the four case studies is the product of dedicated research and evaluation by a sole author. It is also important to recognize the contributions of several individuals who worked collaboratively with the author, offering insight and guidance, to produce informative and accurate depictions of the implementation of MISE in each of the four schools. The author would like to thank Deanna Burney, Tom Corcoran, Patty Kannapel, Claire Passantino, and Kate Riordan for their efforts and contributions to this work.

Ordering Information

Copies of this case study are available from CPRE free-of-charge. To obtain copies, email your request to cpre@gse.upenn.edu, phone us at (215) 573-0700, or write to CPRE Publications, Graduate School of Education, University of Pennsylvania, 3440 Market Street, Suite 560, Philadelphia, PA 19104-3325.

Glossary of Terms

Merck Institute for Science Education (MISE) Partnership — Created in 1993 by Merck & Co., Inc., MISE began a 10-year commitment to the goal of raising student interest, participation, and performance in science. MISE formed partnerships with school districts in Linden, Rahway, and Readington Township in New Jersey, and North Penn in Pennsylvania.

Leader Teacher Institute (LTI) — Launched in 1995 to provide intensive professional development to a select group of teachers from each partner school over a three-year period. These teachers would then become the Leader Teachers within their schools.

Leader Teacher (LT) — Selected teachers who attended LTIs and worked with new teachers by orienting them to the new module-based science curriculum and provided instructional guidance and support.

Peer Teacher Workshops (PTWs) — Launched by MISE in 1996, PTWs provided professional development opportunities open to all K-8 teachers in an effort to engage more teachers in science reform. PTWs were open for voluntary enrollment and each was led by a team consisting of a combination of Leader Teachers, content specialists, instructional specialists, and classroom teachers.

Instructional Team — The main purpose of the instructional team members was to teach at LTIs or PTWs. MISE held workshops for the instructional teams so they could plan their sessions, gather materials, and learn strategies for teaching adult learners. Some sessions were for all of the instructional teams together, and there were breakout sessions to allow each instructional team to focus on their specific PTW.

Principal Institutes — MISE offers a Principal Institute to make sure that principals are remaining informed about various aspects of the reform process.

Science Mentor — This position was designated by the district to pilot the new hands-on modules at all grade levels K-5.

Science-by-Mail — In the MISE districts, this is a program where volunteer pen-pal scientists from Merck interact with teachers and students of participating classrooms to provide supplemental hands-on science lessons to be used in their classes. Originally created by the Museum of Science in Boston in 1998, the program is now administered nationwide.

Full Option Science System (FOSS) — Modules specifically selected for each grade level based on careful examination of the New Jersey Core Curriculum Content Standards for Science. The kits are age-appropriate and cover the range of standards as specified by the state.

The Evolution of the Merck Institute for Science Education

Year	Primary Focus	Major Accomplishments
1992-1993	Launching the initiative	Merck & Co., Inc. created the Merck Institute for Science Education (MISE) with a 10-year, $20-million commitment and the goal of raising student interest, participation, and performance in science.
1993-1994	Building awareness and providing assistance, and setting the groundwork for use of nationally developed curriculum materials	The newly created MISE focused on cultivating relationships with its four partner districts, three in New Jersey and one in Pennsylvania. MISE assisted districts with selection and purchase of new materials for elementary science; and helped local educators envision a new approach to science education by sponsoring their attendance at national conferences, exposing them to state-of-the-art materials and national resources, and encouraging them to visit classrooms with standards-based science instruction. MISE created resource center enabling educators to review and try out new instructional materials.
1994-1995	Taking a more proactive role, evolving into a single Partnership, and designing and implementing the Leader Teacher Institute	MISE focused on improving the quality and accessibility of professional development for teachers. MISE staff assumed a more proactive leadership role and, in the summer of 1995, implemented the Leader Teacher Institute, enrolling more than 140 teachers. This offered a common professional development experience for teams of teachers in the four districts. This helped create a single Partnership -- MISE and the four districts.
1995-1996	Increasing resources through a National Science Foundation grant, implementing the Peer Teacher Workshops, continuing the Leader Teacher Institute, and focusing on local policy alignment	MISE received a National Science Foundation Local Systemic Change grant for the purpose of providing 100 hours of high-quality professional development in science and math to 800 K-8 teachers from the four districts over five years. The second year of the Leader Teacher Institute was held. Peer Teacher Workshops were implemented and more than 160 teachers participated in the first summer. As Leader Teacher teams assumed more professional development roles, MISE staff evolved from a supplier of professional development to a facilitator of schoolwide instructional change.
1996-1997	Continuing the Peer Teacher Workshops, completing the Leader Teacher Institute, and focusing on curriculum frameworks and assessment	Two hundred teachers took part in the Peer Teacher Workshops, which were partially led by Leader Teachers. The final year of the Leader Teacher Institute was held. MISE gave more attention to mathematics. The MISE Resource Center was expanded to include material for elementary and middle school math. All four districts completed draft science curriculum frameworks aligned with state and national standards.
1997-1998	Increasing district responsibility for professional development, expanding assessment work, initiating comprehensive planning, and continuing work with Leader Teachers	The Partnership had evolved into a broad collaboration. Peer Teacher Workshops were expanded with 138 teachers participating. Communication and leadership skills of Leader Teachers were expanded to support them as advocates, coaches, and instructors in their schools. MISE staff worked to gain board approval for district curriculum frameworks. Work on improving student achievement measures started.

Year	Primary Focus	Major Accomplishments
1998-1999	Expanding professional development offerings, strategic planning in science, developing a Partnership Assessment Plan, sharing the work of the Partnership, influencing New Jersey policy	MISE increased professional development offerings in the summer of 1999 and helped districts organize and deliver 36 Peer Teacher Workshops, thus building internal district capacity. MISE staff worked with district teams to develop strategic plans that focused on curriculum and instruction, student achievement and participation, policies and practices, and parent and community support. The Partnership adopted an action plan for student assessment in science. MISE staff expanded outreach efforts with new publications that outlined their vision and work. An assessment sampler for teachers was developed. MISE staff provided leadership to statewide boards and committees developing science content standards and professional teaching standards.
1999-2000	Continuing the Peer Teacher Workshops, expanding and focusing the work in the middle schools, implementing the Partnership's assessment plan	MISE and the districts offered 31 Peer Teacher Workshops in science and math in the summer of 2000, held in district locations to increase participation. MISE staff expanded and strengthened work in middle schools. Teams of teachers and MISE staff selected, modified, and tested two TIMSS (Third International Mathematics and Science Study) tasks for third and seventh grades.
2000-2001	Expanding the district role in the design and delivery of the Peer Teacher Workshops, implementing the Principal's Institute, working on site in three middle schools, and working on the Performance Assessment project	MISE continued to offer Peer Teacher Workshops. A two-day institute for school principals was held to increase their understanding of high-quality science instruction and their capacity to help teachers provide it. MISE staff continued to work on the development of curriculum frameworks and the selection of instructional materials for the middle grade level. The Partnership Performance Assessment project was replicated in all grade 3 and 7 classrooms.
2001-2002	Continuing the enhancement of local district responsibilities for Peer Teacher Workshops, implementing the Principal's Institute, working on site in three middle schools, initiating work at one partner high school, and enhancing the Performance Assessment project	Peer Teacher Workshops reflected the needs of a context where there is a high level of district commitment to standards-based science. A two-day conference continued the institute for principals to focus on their roles in encouraging good science teaching through teacher observations. MISE staff worked with district committees to establish formal curriculum frameworks for school board adoption. Science reform work was initiated at one partner high school using the selection of instructional materials as the reform focus. The Partnership Performance Assessment project was expanded with tasks administered at grades 3, 7, and 8.
2002-2003	Continuing Peer Teacher Workshops, continuing the Principal's Institute, working on site with middle schools, implementing science reform work at one partner high school, and initiating district-level assessments for science modules	Peer Teacher Workshops responded to the needs of districts committed to standards-based science. A second conference for principals focused on the power of professional dialogue about instruction. Science reform work continued at one partner high school using the selection of instructional materials as the reform focus. Two partner districts cooperated to develop, administer, and interpret summative assessments aligned with instructional modules.

Introduction

For the students of Franklin Elementary School in Rahway, NJ, the name "Merck" is a familiar presence, visible on the smokestacks at the company's corporate headquarters one mile west of the school and emblazoned on overpasses that arc across the town's highways. Because company volunteers are active in their classrooms in most grades, Franklin students also have gotten to know Merck employees personally.

What students may not realize, however, is the impact the Merck Institute for Science Education (MISE) has had on the science instruction they receive at Franklin. Students know they enjoy "doing science." They relish the fact that they get to "be like real scientists" and explore answers to real problems; they just don't realize that without the systemic reform initiated by MISE in 1993, they would not be encouraged to see themselves as youngsters actively engaged in scientific inquiry.

Located in central New Jersey, Rahway is less than 30 miles south of New York City. The town has been described as a "multi-ethnic community" located within a "semi-urban setting." Approximately 48% of Rahway's citizens are members of minority groups. The town's 26,000+ citizens represent a wide range of the economic spectrum with an average household income of $45,256.

The School

Franklin Elementary School had more than 600 students enrolled during the 2002-2003 school year, 37% of whom qualified for free or reduced-price lunch. Observing the school's urban and ethnically diverse student body would give the misleading impression that Rahway is equally diverse. In fact, a disproportionate number of the town's minority and disadvantaged students attend public schools, while many of their White peers go to private or parochial schools. Franklin also serves a more transient population of students — frequent turnover of families moving to and from the community — than do the other three elementary schools in Rahway, which presents unique issues for Franklin's community of learners.

As of November 2002, the school staff included 28 classroom teachers, 13 aides, 16 special area teachers, 1 principal, 1 vice principal, 2 secretaries, 1 librarian/gifted and talented teacher, 1 nurse, and a host of parent volunteers serving the students at Franklin Elementary School. Average class size as reported for the 2000-2001 school year was 22.3 students (the state average was 20.8). The climate in Franklin School can be best described as positive, child-centered, and extremely collegial. When interviewing teachers, a description of the faculty included supportive, encouraging, helpful, open, noncompetitive, and committed to student success. There was an overwhelming sense of community among the staff at Franklin Elementary School:

> *The school is a terrific place. Teachers are very dedicated and concerned about kids.*
>
> —Fifth-grade teacher

> *This is a good staff, hard working, dedicated. They are here early, stay late, teachers get together and talk on their own. It's not cliquey, teachers feel free to go into any classroom, and there is a sharing of ideas.*
>
> —Special education teacher

While teaching staff in urban districts often live at a distance from the school, many of the teachers who work at Franklin live in the community. Several of the teachers interviewed grew up in Rahway, attended Rahway public schools, and continue to reside in Rahway while teaching at Franklin.

Science Instruction — Then and Now

Overall, the teachers in the school are more tuned into the science…
—Science mentor

A visitor to Franklin Elementary School quickly becomes accustomed to walking past open classroom doors, and seeing and hearing students bustling about, working intently on their lessons. Peering into a third-grade classroom, a visitor observes students busily engaged in a science lesson involving leaves they collected at home. To gain a better understanding of the system of veins typical of leaves from different species of trees, the students are making rubbings.

Experimenting with which side of the leaf gives the best rubbing and whether different color crayons yield varying results, the students work excitedly in small groups, displaying their rubbings for all to see. As the teacher asks the students to hold up their leaves, several of them gasp as one boy holds up a jumbo maple leaf — larger than his head. A few call out, "What kind of leaf is that?" Eventually they consult the posters at the front of the room to discover it is a maple leaf with palmate venation.

The children in this room are working on a lesson about texture and experimentation from one of their Full Option Science System (FOSS) kits. The science lesson begins with a teacher-directed focus as the teacher reviews the types of venation and steps required to complete a good rubbing. Once she asks students to examine their leaves, the lesson shifts to a more inquiry-based approach as children create rubbings and observe both their leaves and rubbings to determine venation patterns.

Before the MISE initiative to improve science curriculum began in Rahway's elementary schools, the students at Franklin would rarely participate in a lesson such as the one described. Prior to 1993, there was little science inquiry curricula. Teachers used a Holt textbook series in the primary grades when working on science lessons. Science class was predominantly teacher-centered; experimentation among students was not the norm. Typical lessons involved teachers presenting new vocabulary, and students copying words onto paper, reading sections of the text, and answering questions. Now science has taken on an entirely new meaning. Teacher-directed, textbook-based lessons are still part of the mix, but are intermingled with hands-on experiments and inquiry that originates from the students.

The science curriculum at Franklin Elementary School is based upon completion of the three-to-four FOSS science modules per year. Throughout the school year, each teacher will utilize those modules that have been specifically selected for each grade (see Appendix A), based on a careful examination of the New Jersey Core Curriculum Content Standards for science. The kits are age-appropriate and cover the range of standards as specified by the state. Teachers have access to the kits they will use throughout the instructional year, and most keep them in their classroom as they are packaged neatly in well-labeled boxes. The teachers have the freedom to implement the modules in any order they choose. However, most agree in grade-level planning meetings to stick with a particular sequence to ensure that each class completes similar material at the same time.

When teachers first implemented the science modules through the MISE initiative, they encountered several problems. Some modules were too difficult and others were too easy for particular grade levels. Teachers in the same grade level had to rotate the kits among one another's classrooms and thus felt pressured to complete them within a

specified time in order for the next teacher to get them on schedule. In addition, as the materials in each kit were consumed in the course of the students' investigations, there was no provision for restocking them. These issues were communicated through liaisons to MISE and subsequently addressed.

FOSS modules have grown to become the backbone of the curriculum. Enough kits have now been purchased — with funds from MISE — for most grade-level teachers to have their own set, and rotation of kits is no longer necessary. In addition, one teacher at each school has been selected to be a science mentor and ensures that teachers receive the supplies they need in a timely fashion to restock the kits for future use. This has generated positive reactions from teachers:

Kits facilitate reaching the range of students. They are a great help.
—First-grade teacher

[The FOSS kit] meets everyone's needs in the classroom. You can always allow kids to go off in different directions.
—Fifth-grade teacher

Because faculty from across the Rahway School District have been able to come together to discuss science standards and select grade-appropriate modules, they have been able to eliminate the problem of repetition of topics across grade levels. Before the science modules were adopted, faculty participated as a group at science in-services and workshops. While they found these workshops valuable, the faculty expressed concern that every teacher was duplicating the same activities and topics that were presented in the in-services. As a result, students were exposed to the same concepts over and over again as they progressed through the grades, leaving many students bored. Teachers struggled for new ways to enrich the basic approaches they had been taught. This problem has been eliminated with the modules, which clearly delineate the content and process skills to be taught in each grade level and provide rich experiences and opportunity for inquiry-based instruction at each grade level.

Before teachers might have done a demonstration, kids watched or kids do the same science project. The text is not the focus anymore. It's hands-on. It's fun for the kids. Science didn't come alive (before).
—Former principal

Lessons reflect a new way of viewing science instruction at Franklin School. Professional development has strengthened teachers' content knowledge and ability to use inquiry-based science instruction. Most of the teachers at Franklin say they have now adopted an inquiry-based approach to their science curriculum. They designed instruction methods that allow students to work on science projects with their own hands, experimenting and making sense of what is explored throughout the lesson. Teachers are more focused on having their students learn science processes in addition to vocabulary and discrete facts. As students observe, record data, report findings, analyze information, and communicate conclusions, they uncover the science content embedded in the work.

Lessons in the early elementary grades typically begin with the teacher reading a story from the literature collection within the room. One teacher described reading a story about zucchini to her first-grade class while the students were seated on the carpet. After the story was discussed as a class, she showed the students the planters they would be making as part of their science lesson. The students were excited to get to work. Students planted their own zucchini plants and began to keep a written record of the project over time in a journal. The temperature and conditions of the planter were recorded daily and once the plant

emerged from the soil, the students drew pictures, identified the parts of the plant, and made predictions about the expected growth of the zucchini. One child asked, "What will happen if I give the zucchini soda instead of water?" The teacher replied, "Let's try it and see." The next day and subsequent days, the plant was "watered with soda" and the child was able to construct an answer to her own question based on the scientific observations she made over time. A few months later, in the middle of summer vacation, the teacher received a phone call from one of her students. The student grew a zucchini plant at home and wanted to bring the prized zucchini to her teacher as a gift.

In earlier times, when the curriculum was textbook-driven, scenarios such as the one described above were virtually absent from Franklin's science lessons, but now teachers report such outcomes are the norm. Discussions with teachers revealed that students are enthusiastic about this "new science" and are much more engaged in learning. For many, science has become their favorite subject.

One fifth-grade teacher, who is also the science mentor, is working with her students on a unit about motion and design. As an introduction to the topic of structural integrity, she informs her students they have a task to complete today. During this science period (about 35 minutes), the students will be building structures. She elicits some responses from the students about what exactly structures are. After generating some valuable discussion, she presents the activity, "You are going to work as a group to solve a problem. You are going to create a structure made with 21 straws and a box of paper clips. It will be like a building; the straws will be like the beams." She stops to make an analogy of the task-at-hand to the construction of a building adjacent to their school. "Your structure needs to be the tallest in the class. You need to problem-solve in your group. How are you going to build it? What are you going to use? How will you connect it?"

The students have taken the activity very seriously and are strategizing within their groups as the teacher passes out the materials: 21 straws and a box of paper clips per group. Soon construction is underway. Without any prompting from the teacher, the students have begun discussing how best to create a strong foundation and use braces to stabilize the structure. This science talk is casually used by students to communicate their ideas. It is clear to observers that these students are familiar with "doing science" and making sense of the content through an active process. Students have clearly had extensive experience with group work and communicating scientific ideas with one another. It is evident that as students move into the later grades, they are more confident in their science process skills and are therefore more competent while doing inquiry-based science.

When students are asked about the science instruction they receive, their responses are overwhelmingly positive. While standing in the front of a room of elementary students, a researcher from the Consortium for Policy Research in Education (CPRE) asked, "Who likes science?" Immediately every hand shot into the air. The researcher then asked two additional questions:

"Well, what do you like best about science?"

"You get to do a lot of activities, build things."

"We do a lot of projects."

"What makes science different from other subjects? What makes it so special?"

> *"You get to do a lot of experiments and use items you don't normally use to build stuff."*
>
> *"It's like you're a real scientist, doing rubbings."*
>
> *"You get to do stuff you didn't think you could ever do."*

It is clear at Franklin that students are engaged in learning about science. "They love science, it is one of their favorite times of the day," remarked a teacher. The students appreciate being actively involved in their own learning process. Teachers report consistently over the years of involvement in the MISE Partnership that students are more actively engaged in science as a result of using the new science modules. Although special education teachers report that the activities in the modules need to be modified for their classes, they would never advocate going back to the more "traditional" method of instruction. Teachers feel their students are much more successful with the hands-on approach to learning. Teachers have applied this approach to other subjects as they have found it so successful and appealing to students in science. However, this crossover was teacher-reported; CPRE researchers have not observed social studies classes for example, but teachers say they are more often posing problems or questions to students, providing appropriate resources and tools, and then allowing students in groups to use the resources to determine answers to the questions, or solutions to the problems.

> *They [students] love science. It is more interesting and they can touch things more. Student interest has increased tenfold and as a result students are getting more content and pedagogy.*
>
> —Second-grade teacher

Assessment

> *The kid who would fail the test now can pass, and you know they know something and have some understanding. You are now testing more on a broader range of knowledge and skills than was done in the past with just a paper-and-pencil test.*
>
> —Fourth-grade teacher

> *Some things are easy to assess, like weighing in metrics, where I can see if they know what they're doing.*
>
> —Fourth-grade teacher

> *When they do the experiments I'll just ask some questions."Why do you think this is happening?" If they give me an off-base answer, I'll know maybe they're not getting it…I make mental notes as I walk around.*
>
> —First-grade teacher

Through professional development activities, MISE has worked with teachers and administrators to develop new assessment tools that can be used in conjunction with the science modules. District teachers have worked together to assemble a series of assessments aligned with state standards and the district's curriculum. Teachers have attended MISE workshops that have focused on assessment in science during summer breaks.

In the process, teachers also have moved away from traditional "paper-and-pencil" type of assessments. Teachers report that they have incorporated observational assessments in science class. Teachers circulate around the room while students are engaged in hands-on activities and observe their performance on tasks, work with peers, discussion of key concepts, and explanation of outcomes. Teachers also ask students to complete science journals as an assessment component in which they record their observations, predictions, answers to questions,

data, and diagrams. Teachers reported they review these journals periodically to assess specific students' progress.

Still, more progress could be made in the area of assessment. Despite MISE's efforts to improve the quality and type of assessments, from the observational and interview data collected by CPRE researchers, it is apparent that many teachers are still using assessment strategies similar to ones they used in 1994. Teachers use informal observation and review of journals to collect information about student learning, and although they typically do not administer paper-and-pencil tests, they are not implementing other varied assessment strategies such as portfolios, a range of performance-based assessments, presentations, and projects.

Leadership

The progress of the MISE science initiative at Franklin School can be attributed not only to the enthusiastic response of teachers, but also to a principal who understands and supports inquiry-based science. This "new science" brought changes within the classroom climate. Because students were more involved and moving about instead of quietly reading, the noises of scientists began to trickle out into the hallways. As more and more teachers became trained in inquiry-based science and in the corresponding pedagogical techniques and theory, classrooms became noisier, kits piled up in classrooms, and experiments found their way to different corners of the school. To the untrained eye, things might look a bit chaotic. The principal, however, has signaled her willingness to tolerate greater noise in exchange for promoting greater interest and involvement in the science curriculum.

Fortunately, the principal has been involved with the MISE Partnership from its beginning. Mrs. Braxton was a kindergarten teacher at Franklin School when the Partnership began. Although she was not a Leader Teacher, she was aware of the new methods being employed as she spoke with individual Leader Teachers at Franklin School. Soon after MISE partnered with Franklin, Mrs. Braxton became an administrator in the school. She served as the vice principal for two years and then was promoted to Franklin's principal, a post she has held for six years. Inspired to know more about the innovative techniques being used in science education and motivated to understand how to evaluate teachers using such methods, she attended the Principal Institutes offered by MISE for the principals in the Partnership schools. She found these institutes offered helpful opportunities for understanding inquiry-based science instruction and for networking with colleagues. The ties formed during the institutes were critical as she began working with teachers to help them become successful in the new pursuit.

> *Mrs. Braxton is always willing to let you try something new. She encourages the science classes being a cooperative group. You have to be aware when students work in groups that there are noise-level issues. She encourages that.*
>
> —Fifth-grade teacher

Mrs. Braxton reported that teachers had very positive perceptions of the MISE Partnership. She was not surprised because the Partnership's activities are of such high quality and the materials are excellent. She did say, however, that teachers periodically felt overwhelmed with the magnitude of work involved in using the modules. While teachers are no strangers to the work involved in setting up their classrooms or preparing lessons, some felt intimidated by the material they were presenting. Some believed they could not do justice to the content, or that it was just too much to handle. Mrs. Braxton told CPRE researchers that she believes it should be left up to the discretion of teachers to determine what is

developmentally appropriate for their students and to cover the material in detail. She is concerned that students be fluent in the process of science, but does not want her teachers to feel undue pressure. She feels in some grade levels it would be more effective to have fewer kits and to spread them out in order to cover concepts in detail. Teachers appreciate the respect they are given as professionals and this helps sustain open lines of communication between the teachers and administrators in Franklin School.

The principal explained to CPRE researchers that she is committed to seeing that teachers have all the resources necessary to be effective in their classrooms. If teachers come to her requesting supplies and have a rationale as to why and how they will use them, the principal says she will see to it that the requests are fulfilled. Teachers know that Mrs. Braxton will purchase supplies for their rooms. During interviews, one of the kindergarten teachers was enthused about the new equipment in her classroom and about the principal's willingness to provide the resources teachers need.

Powerful Professional Development

It was nice. A whole day. It took you away from your normal atmosphere and was with teachers on your grade level. When you are treated as a professional, it is nice sometimes.

—Fifth-grade teacher

Professional development needs to be institutionalized. Professional development needs good planning, as much as daily instruction. I also learned that teachers can teach other teachers, if given opportunities to do so.

—Superintendent

When MISE began its involvement with the Partnership districts, one of the goals was to "provide teachers with the support they need to change their practice and revise curriculum in order to teach science more effectively" (CPRE, 1994). The transition from textbook-based instruction to the hands-on science modules posed challenges for many teachers. Teachers found that as they implemented the new curriculum, they were uncomfortable with some of the lessons because they lacked deep content knowledge needed to effectively teach them. Among the goals of MISE was to provide support for teachers; thus, professional development initiatives became a major priority in the work with the districts.

To address this need, MISE instituted the Leader Teacher Institute (LTI) in the spring of 1995 to provide intensive professional development for a select group of teachers from each school. It was designed to develop a group of teachers who would then become the "science leaders" within their schools. The Leader Teachers would become well versed, over a three-year period, in the pedagogy of inquiry science and in the relevant content within the three main strands of science: earth, life, and physical. Ideally, the Leader Teachers would work with new teachers by orienting them to the new module-based science curriculum, highlighting content for all teachers, modeling lessons, and working with teachers to increase the use of inquiry-centered techniques to teach science. Franklin School had five teachers attend the LTI (one as a member of the instructional team and four as participants). Three of the five Leader Teachers are still on staff at Franklin School.

It was great to be treated like a professional. I got great ideas and an opportunity to talk with other teachers.

—Second-grade teacher

Those who participated in the LTI were surveyed before, during, and after the institute. The teachers showed gains in content knowledge in both science and math, knowledge of inquiry-based instruction, and assessment knowledge. The anecdotal response from teachers regarding the LTI remains positive. The training was structured to include not only instruction on content and issues of pedagogy, but also ample time for group discussion and collaboration with colleagues. The teachers widely agreed that this was the highest quality professional development they had ever received.

When teachers returned to their schools after completing the Leader Teacher training, the extent to which they were used as science leaders varied widely by school. In Franklin School, the teachers met on a regular basis to plan and discuss issues related to teaching and assessing inquiry-based science. Both the teachers and principal reported that while the new science leaders informally shared what they had learned and what they were doing in their classrooms, none felt confident to present new approaches to the entire faculty. Although the intent of the LTI was to prepare teams of Leader Teachers to "be instructional change agents within their schools and districts by serving as role models, advocates, coaches, and instructors" (CPRE, 1998), the discomfort Leader Teachers at Franklin felt in demonstrating inquiry-based approaches to their peers in any formal way meant that not enough widespread change had occurred.

Spreading Good Practice

It's (the Partnership that has) helped Rahway realize that professional development is key to building teacher capacity.

—Former supervisor of mathematics and science, Rahway Public Schools

In the past, workshops were something that was done to them (teachers). Now teachers are teaching others in the school, selecting their own topics for training. Also, there is a level of excitement by teachers, because they see children are learning.

—Former principal

During the summer of 1996, MISE began a series of professional development opportunities called Peer Teacher Workshops (PTWs). PTWs were open for voluntary enrollment to all pre-K-8 teachers in Partnership districts. These workshops worked to "broaden the scope of the Partnership's work and engage more teachers in the reform of science and mathematics education" (CPRE, 1998). A team consisting of some combination of Leader Teachers, content specialists, instructional specialists, and classroom teachers facilitated the PTWs. The response to the PTWs by participants was overwhelmingly positive. Teachers found that their content knowledge developed as did their ability to implement and design new assessment and inquiry strategies. Because the PTWs reached many more teachers than the LTI, use of a hands-on approach to science began to spread throughout Franklin School.

Each subsequent summer, a series of PTWs has been offered to the teachers in Partnership districts. Franklin teachers have taken advantage of these opportunities. All but one full-time classroom teacher has participated in at least one PTW. The teachers feel that working during the summer with the science modules, having time for collaboration, and participating in inquiry themselves have increased their comfort and familiarity with inquiry-based science. More teachers are using the activities and strategies modeled in the PTWs in their classrooms and the student response and engagement has been increasing.

The workshops have really helped me take another step in hands-on.

—Special education teacher

Toward the tail end of my teaching career, that's when MISE came into the district. I was able to benefit from two years of that…It opened up a lot of doors for me. When I went to the training, I got into it. If I didn't have that [the PTWs], I don't think I would have used the kit effectively.

—Principal

Teachers raised a few complaints about the content covered in the PTWs. Early on, the workshops were divided into grade-level groups. For example, one of the workshops offered to teachers in grades 3 to 5 was on the topic of *Matter*. Teachers were left feeling that parts of the workshop did not pertain to their grade level and that there would be considerable overlap if teachers were using the same topics across three grades. In response to these concerns, grade-specific peer workshops were developed. Some teachers also objected to the lack of variety offered from one summer to the next. As the workshops became more centered on modules and less on general topics within a specific area of science, they had a tendency to become more repetitive over the years. On the other hand, some of the veteran teachers at Franklin School who taught specific modules for over five or six years wanted more workshops with a focus that was broader than the individual kits. As a result, some recent workshops have integrated language arts or technology topics with science modules, while others have focused largely on assessment. The faculty of Franklin School felt it was particularly helpful that classroom teachers served as part of the instructional team for the PTWs. This grounded the workshops in classroom practice and ensured topics were grade-level specific.

The response to the professional development opportunities by the faculty of Franklin School has been positive. Franklin teachers have logged over 3,700 hours of professional development time related to science. The teachers are proud of their involvement and feel the peer workshops have benefited their knowledge of content and pedagogy and thus enhanced student learning.

More materials, more workshops, these have been terrific. I've been to some terrible workshops, but these have been very useful, something the kids appreciate and that we appreciate. Someone should do these kinds of things for every subject.

—Special education teacher

The model of the PTWs has been enthusiastically received. Teachers like that the workshops are offered in the summer so they do not have to spend time away from their classrooms. The seven hours (per day) of work over the course of four days (including breakfast, lunch, and snacks) seems to work well for most teachers. Teachers also feel that the two follow-up sessions during the academic year help them to stay connected with colleagues and focused on student needs. Teachers enjoy that the workshops are planned and facilitated by a team of teachers and specialists. Many Franklin teachers mentioned that they feel they have done such an extensive amount of professional development related to science, they would like to see the peer workshop format used to cover topics on mathematics, reading, and other subjects in the curriculum.

In the past few years, the three Leader Teachers remaining on staff in Franklin School have taken on many of the leadership roles previously mentioned. All three Leader Teachers regularly attend summer PTWs and two have served as instructional team members at these workshops. One Leader Teacher has held

the position of science mentor since it was established in Franklin School, and one of the Leader Teachers has moved from her position as a traditional classroom teacher to an instructor of basic skills. The two other Leader Teachers who originally participated in the LTI from Franklin School have left the district for personal reasons.

The teachers in Franklin School are not the only participants in PTWs. The school's librarian has been an avid participant in the workshops since they began. She attends the workshops each summer, learning valuable strategies to use with her gifted and talented students while gaining exposure to various topics that help provide knowledge for purchasing literature for the library. As a result of the MISE efforts with Franklin School, the science section in the library has grown and students are now much more likely to find a book related to the material studied in science than in the past.

Effects of Professional Development

> *[Changes in professional development are] a little more truthful and responsive to real needs as opposed to impulsive, spur-of-the-moment needs. It's caused teachers to step away from the classroom, reflect on what they're doing and, more importantly, anticipate what skills they need.*
>
> —Superintendent

Mrs. Braxton remarked that the peer workshop structure offers time for collaboration with colleagues and has helped teachers become more cohesive in grade-level planning groups. Formerly, a division was sometimes seen between new and more veteran teachers, but now with the shared experience of the PTWs, the teams share a closer bond. Mrs. Braxton sees that the teachers coming to her present more of a "united front" than they did before by insisting on common planning time or requesting supplies. Requests are more frequently honored when an entire team is making a request rather than an individual. This greater sense of collegiality and respect for the abilities of their peers has been an additional benefit of the peer workshops.

Changing School Structures to Create Ways for Change

There is a structure in place at Franklin to encourage and increase collaboration among teachers of similar grade levels. Because both the teachers and administration see this collaboration as essential to the efficacy of instruction, some creative scheduling was used to allow teachers of similar grade levels to meet together during lunch while their students are in the cafeteria and on the playground. However, not all grades were able to receive common planning time during the school day, but most teachers emphasized the importance of making time to plan together. Each week there is one day set aside for after-school faculty meetings. Mrs. Braxton tries to reserve at least two of these one-and-a-half-hour meetings every month for grade-level teams to plan. During this time, the teachers share ideas, plan new units or themes, and discuss issues affecting students in their classes. While these meetings did not arise directly out of the MISE Partnership, the principal feels that the professional development provided by MISE has contributed to an enhanced sense of community, professionalism, and collaboration, and has led to requests by teachers for planned meeting time.

In addition to strong principal engagement in science reform efforts, the faculty members of Franklin Elementary School have also benefited from the district's supportive response to the initiated science reform. Before MISE began its initiative with Rahway, teachers' main resource for science direction was through one supervisor of science who held both district and administrative duties, as well as teaching responsibilities at the high school. This supervisor had little contact with the teachers unless they specifically contacted him with questions or requests for materials. During the past several years, there has been a restructuring of the central office staff in Rahway. A full-time administrative position was created for grades K-12 and this person served as the science/math supervisor. Soon after, that position was divided into two positions, one for science and math grades K-8, and the other for grades 9-12.

In September 2002, the district also promoted an elementary teacher from within the district who was very involved with the MISE Partnership activities to hold the new position of Helping Teacher. This teacher's main role has been to provide classroom support to new K-8 teachers throughout Rahway in the areas of math and science. The Helping Teacher models lessons for teachers and collaborates with teachers to design more effective lessons for their classes. In addition, the Helping Teacher plans new teacher induction workshops during which veteran teachers act as instructional leaders. These leaders present the science modules to new teachers during workshops and the group works through questions and issues together.

We're trying to cultivate our own people, teachers teaching teachers.

—Former supervisor of mathematics and science, Rahway Public Schools

Impact Beyond Science

It's (the Partnership that) made us much more educated in terms of what our curriculum should be. And it's influenced what we look for in new teachers, and that's influenced us beyond science and math.

—Assistant Superintendent

The impact of the MISE Partnership has not been limited to science classrooms within Franklin School. The reform effort has had the kind of systemic impact that the MISE initiative sought to achieve from the beginning. MISE has changed the dynamic of Franklin Elementary School in other ways beyond science instruction including the administrative structure, hiring practices and orientations for new teachers, student achievement on standardized tests, and parental involvement.

Throughout the Rahway School District, the administration has followed the Instructional Team Model — consisting of teachers considered experts on instruction and/or management, content experts from high schools, and other such experts from within the school or district — instituted by MISE. Each school has commissioned a professional development committee to assess the needs of the faculty, plan in-service training, and recruit faculty or specialists to present professional development opportunities for the whole staff. MISE's impact is seen throughout the district in this regard. Teachers have been empowered to become leaders and take charge of their practice by designing and facilitating opportunities for professional development throughout the district.

Hiring practices within schools were also affected by the initiative. Because schools now have clear leaders among the ranks of teachers, several teachers have been involved in the interview

process for new hires. It is also made clear during interviews that new hires will be expected to utilize inquiry-based instruction methods and to attend ongoing professional development. Administrators feel these stipulations have made the district more appealing to new graduates seeking to teach in districts on the cutting edge of school reform and teacher professionalization.

The MISE initiative also influenced the structure of the orientation process for new teachers. Administrators found that new teachers were seeking more than a one-hour welcome meeting and sought more in-depth analysis of curricula and orientation to the district. Although MISE was not designed to be part of new teacher orientations, Rahway modeled their orientation programs after the peer workshops to some extent, and included an intensive look at the science modules for new elementary teachers as part of the orientation.

> *When we interview people, we ask them, "What do you know about inquiry-based instruction, inquiry-based (teaching), performance-based (assessments)? Are you willing to come to training?"*
>
> —Assistant Superintendent

It is also clear that Franklin students have done better on standardized tests in science since the reform was implemented. Teachers credit this success to the close alignment between the science modules and the New Jersey state standards. Students are not only getting the required content, but they are also learning to be critical thinkers and problem-solvers. When children are adept at problem-solving, their success on standardized tests will likely increase.

Parental involvement in science education has developed through interactive programs established by the initiative. The school works with other schools in the district to hold events which draw families to participate with their children in annual Family Science Nights. These evenings began when the MISE Partnership became central in the school. As children and teachers participated in more hands-on science, the avenue for sharing this new science with families was born. Family Science Night is a voluntary activity during which teachers set up mini-experiments and science lessons for the children to complete with the help of their family participants. The response to Family Science Night has been very positive. Families who participate are overwhelmingly enthusiastic about the science their children are doing in school.

Parents often remark that the science is very different from what they learned during elementary school. Nevertheless, they are pleased with the current curriculum. When their children are at home, they see them making more connections to the topics they study in class. One parent told a story of her child explaining how fog is created, "He came home from school and pulled a two-liter soda bottle from the recycling. He filled it with a little bit of warm water, capped it, and put it in the freezer. A few minutes later, he was showing us fog and talking about the weather unit they had studied." The parent said these connections did not happen every day, but she could see her son making many more real-world connections than he had ever done before.

Lessons Learned

As a result of the systemic reform implemented during the 10-year partnership with MISE, science instruction has changed dramatically in Franklin Elementary School. Teachers who primarily used textbooks as the main focus for teacher-directed lessons have moved to student-centered lessons in which children are now actively engaged in "doing science," using inquiry-based and hands-on techniques. Students demonstrate a

greater motivation to do science because they now find it fun, interesting, and connected to their lives. As a result, teachers have seen gains in student achievement and mastery of content. In addition to the changes seen in science instruction, growth in terms of teachers' confidence in their own content knowledge has spurred collaboration and increased professionalization among the faculty at Franklin.

Examination of the MISE Partnership with Franklin School has highlighted several key factors upon which this successful reform effort has hinged. The need for high-quality professional development was crucial to the success of teachers when implementing new science pedagogy. From the very beginning, MISE focused on training teachers in both science content and pedagogy that would facilitate the use of inquiry-based techniques. The Leader Teacher Institute involved five teachers at Franklin School, three of whom are still on the faculty. Those teachers were trained to become model science teachers, but they were somewhat uncomfortable spreading their newly acquired knowledge to others. In order to reach more teachers, MISE moved beyond their reliance on Leader Teachers to spread methods throughout the school. By developing Peer Teacher Workshops, they could offer a greater number of faculty high-quality professional development opportunities of which the majority of teachers took advantage. It was by using such quality workshops to attract and train the vast majority of teachers that hands-on science ultimately spread throughout Franklin School.

A supportive and collegial school environment was critical to the success and maintenance of innovative techniques. Without the support and engagement of teachers within grade levels, the availability of common planning time, and a principal who was actively engaged in the reform effort, science instruction may not have undergone such dramatic and positive changes in Franklin School.

Literacy and mathematics in the elementary grades have been the focus of the work for most teachers at Franklin School. Even with the intense professional development and increase in materials for science, elementary teachers still report their instructional emphasis remains on reading and math. This illustrates the need for sustained work with schools in order to support deep changes in practice. Many teachers feel that without the continued support from MISE, including workshops, materials, and mentoring, science would have been pushed to the backburner as literacy and mathematics receive the bulk of instructional time. Because the partnership between MISE and the Rahway School District was substantial, teachers feel that school, district, and teacher focus have kept the growth of science education progressing steadily.

Despite the substantial positive changes that are seen in science instruction at Franklin School, continued support for science education is still needed to move teachers toward the use of more innovative and varied assessment strategies, and more student-driven inquiry projects in all classrooms.

Careful examination of Franklin Elementary School reveals how the partnership between MISE and the Rahway Public Schools has driven an effective science reform effort. This relationship can be used as an example of how collaboration between the school, administration, faculty, students, community, and the business sector is necessary to obtain positive results. The work of MISE and the dedicated staff of Franklin Elementary School have come together to create a science culture centered on inquiry, collaboration, professionalism, and dedication to science process that will certainly thrive in the future.

They (Merck) made a commitment for 10 years and it's going to continue. They're standing behind their commitment. It grows each year, takes us more in depth.
—Former principal

It has been wonderful; they see things, have done things, experienced things that they would not have done without Merck.
—Fourth-grade teacher

They [Merck] really care for the kids. Not just for science, but for the kids to be what they really can be.
—Fifth-grade teacher

I think in the couple of years, the town has made great strides in moving forward in science, mathematics, and technology. They have made tremendous strides and should keep the speed. It is amazing what they have done and I don't think it could be done without Merck.
—Fifth-grade teacher

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Appendix A. Usage of Science Modules in Partnership Districts

Grade	Linden	North Penn	Rahway	Readington
K	Senses (Insights) Balls and Ramps (Insights) Animals 2x2 (FOSS) Paper (FOSS)	Senses (Insights) Living Things (Insights) Paper (FOSS)	Animals 2x2 (FOSS) Paper (FOSS) Balls and Ramps (Insights) Senses (Insights)	Senses (Insights) Paper (FOSS) Animals 2x2 (FOSS)
1	New Plants (FOSS) Balance and Motion (FOSS) Insects (FOSS) Weather (STC)	Weather (STC) The Life Cycle of Butterflies (STC) Solids and Liquids (STC)	Solids and Liquids (FOSS) Air and Weather (FOSS) New Plants (FOSS) Balance and Motion (FOSS)	Weather (STC) Balls and Ramps (Insights) From Seed to Plant (DSM)
2	Solids and Liquids (FOSS) The Life Cycle of Butterflies (STC) Balancing and Weighing (STC) Soils (STC)	Organisms (STC) Balancing and Weighing (STC) Soils (STC) Changes (STC)	Pebbles, Sand, and Silt (FOSS) Insects (FOSS) Balancing and Weighing (STC) Investigating Objects in the Sky (BSCS)	Soils (STC) The Life Cycle of Butterflies (STC) Solids and Liquids (FOSS)
3	Structures of Life (FOSS) Magnetism and Electricity (FOSS) Earth Materials (FOSS) Investigating Objects in the Sky (BSCS)	Electric Circuits (STC) Chemical Tests (STC) Animal Studies (STC) Water (FOSS)	Magnetism and Electricity (FOSS) Human Body (FOSS) Water (FOSS)	Structures of Life (FOSS) Physics of Sound (FOSS) Earth Materials (FOSS) Balance and Motion (STC)
4	Human Body (FOSS) Physics of Sound (FOSS) Land and Water (STC) Investigating Ecosystems (BSCS)	Plant Growth and Development (STC) Rocks and Minerals (STC) Land and Water (STC) Designing Structures (BSCS)	Earth Materials (FOSS) Structures of Life (FOSS) Physics of Sound (FOSS) Investigating Ecosystems (BSCS)	Electric Circuits (STC) Land and Water (STC) Levers and Pulleys (FOSS) Human Body (FOSS) Water (FOSS)
5	Environments (FOSS) Mixtures and Solutions (FOSS) Solar Energy (FOSS) Motion and Design (STC)	Microworlds (STC) Ecosystems (STC) Motion and Design (STC) Investigating Weather Systems (BSCS)	Mixtures and Solutions (FOSS) Environments (FOSS) Motion and Design (STC)	Magnets and Motors (STC) Mixtures and Solutions (FOSS) Environments (FOSS) Food and Nutrition (FOSS) Oceans (DSM)
6	Diversity of Life (FOSS) Weather and Water (FOSS) Mirrors/Color Analyzers/ Refraction (Boston Science Museum/GEMS/local)	Magnets and Motors (STC) Measuring Time (STC) Solar Energy (FOSS) Light and Color (Project Aries)	Diversity of Life (FOSS) Weather and Water (FOSS) Mirrors/Color Analyzers/ Refraction (Boston Science Museum/GEMS/local)	Experiments w/ Plants (STC) Planetary Science (FOSS)
7	Populations and Ecosystems (FOSS) Planetary Science (FOSS) Energy, Machines, and Motion (STC)		Populations and Ecosystems (FOSS) Planetary Science (FOSS) Energy, Machines, and Motion (STC)	
8	Environmental Issues (local) Earth History (FOSS) Properties of Matter (STC)		Environmental Issues (local) Earth History (FOSS) Properties of Matter (STC)	

FOSS = Full Option Science System
STC = Science and Technology for Children
BSCS = Biology Sciences Curriculum Study
Insights = Insights: Inquiry-based Elementary School Science Curriculum
GEMS = Great Explorations in Math and Science
Project Aries = Astronomy Resources for Inter-curricular Elementary Science
DSM = Delta Science Modules