Highland Avenue School
Linden, NJ

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

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Biography

Claire Passantino is an independent educational consultant and contractor specializing in the design, implementation, and evaluation of reform projects in science and mathematics education. Her connections to the Merck Institute for Science Education (MISE) were through the Consortium for Policy Research in Education (CPRE) at the University of Pennsylvania. Passantino's work in Philadelphia includes the evaluation of Children Achieving, the evaluation of the National Science Foundation's Urban Systemic Initiatives, and the Franklin Institute's Keystone Science Network. Outside Philadelphia, she has worked with CPRE on studies for the Partnership for Kentucky Schools and the National Center on Education and the Economy's America's Choice whole-school reform model. In New Jersey, much of her work is based at Rutgers University — with the Graduate School of Education, the New Jersey Mathematics Coalition, and the Center for Educational Policy Analysis. Passantino has also worked in schools as a classroom teacher and instructional technology specialist for grades K-8.

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, Siobhan McVay, 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

The Highland Avenue School in Linden, New Jersey has had to overcome numerous obstacles in its quest to develop a rigorous, innovative science program. The school has been in a 10-year partnership with the Merck Institute for Science Education (MISE) to improve the science program. During that time, enrollment has increased by 25%, filling the school to capacity and using all available space. At the district office, the superintendent, science and mathematics supervisors, and other key administrators have changed. The school has had three principals in the past three years. Following a wave of teacher retirements, the more seasoned, veteran faculty have slowly found themselves outnumbered by new hires. Yet, despite these obstacles, Highland Avenue has managed to transform its science program from a textbook-based approach to one rooted in real-life science.

Linden is a diverse, blue-collar community located along the main north-south railways and highways in northern New Jersey. The town has a long history of immigration with different minority populations moving in as workers, seeking a more suburban lifestyle than can be typically found in nearby port-of-entry cities like Newark. The town has 39,000 residents, of which approximately 34% are minority groups. Linden boasts a busy downtown core with small stores and restaurants, rimmed by strip malls and fast food restaurants along major roads, a small municipal airport, and several large industrial facilities such as Exxon refineries, Bellcore labs, a General Motors plant, and Merck. One part of town consists of well-kept single-family homes on small lots; conditions in other parts of town are more crowded. The citizens of Linden represent a wide range of the economic spectrum with a median household income of $46,345.

The School

The Highland Avenue School is one of eight elementary schools in Linden. Parents enthusiastically support the work of the school. Many students come from families that have lived in Linden over several generations. While the majority of students are from the same neighborhood, many are bussed to Highland Avenue from other parts of town as part of a court-ordered desegregation plan established in 1984, or to attend the preschool programs for disabled and autistic students. Others are walked to school by their parents, who are quite visible at the beginning and end of each school day. Their daily presence lends a sense of family involvement and interest. Due to a rising population, the school's enrollment has jumped from 276 to 350 students, an increase of about 25% from 1993 when the school district entered into the partnership with MISE. Over the 10-year partnership, ethnicity has also experienced major changes. From 1994 to 2002, the population of White students has dropped from 68.4% to 52%, the African American student population has decreased from 20.8% to 16.9%, while the population of Hispanic students is on the rise, starting at 8.8% and shooting up to 28.3%.

Parents, students, and staff are particularly proud of the school's association with Merck. On the school's website, it says, "Through a cooperative partnership with Merck & Co., our Science program offers a first rate, hands-on curriculum that challenges and stimulates the students" (Highland Avenue, School # 10, n.d.).

Highland Avenue had a relationship with Merck long before MISE was launched. The district's science specialist was working with a parent volunteer, who was also a Merck employee, to develop hands-on units for use in classrooms. This parent volunteer was also doing demonstration lessons in class-

rooms, and had organized a PTA committee to coordinate school science events, such as science fairs and science nights. Merck was funding "Science-by-Mail" for fourth graders (a program where professional scientists volunteered their time to answer questions from students) and had given additional funding to have several teachers trained in Family Science, and Family Tools and Technology (programs which involve presentations to small groups of parents and students in a series of evening meetings at school). The school had an interest in science, and a history with Merck. The principal, staff, and parents were all highly supportive of MISE, and Highland Avenue seemed poised for success.

Since 1993, many changes have taken place at Highland Avenue. This is a story of successful classroom reform, and of how an elementary science program has been improved and the improvements sustained in spite of significant obstacles and challenges. Consider the changes that have occurred since the partnership with MISE began:

- In the state: New Jersey adopted new curriculum standards in 1996, followed by curriculum frameworks, and new standardized tests. The district had to adapt to the changes at the state level, and the school had to adjust accordingly.

- At the central office: The superintendent, the science and mathematics supervisors, and other key administrative personnel have changed.

- At the school: There have been three principals since 1993 and the current, third principal has announced that he plans to retire in June 2003.

- In the community: The school population has grown considerably across the district, which has made all the schools more crowded. The school is now at full capacity, and rooms previously used for subjects such as music or art are currently being used as classrooms.

- In the faculty: In 1994, there were 12 classroom teachers in grades Pre-K-5, mostly veteran teachers with an average of 17 years teaching experience in the district. Today, there are 15 classroom teachers on staff, and 10 of the 15 are new to the district since MISE began.

Science Instruction — Then and Now

In spite of all the apparent obstacles to improvement, the overall quality of science instruction at Highland Avenue is undeniably better now than 10 years ago. Formerly, most teachers adopted a conventional approach to science instruction that involved having students read textbook chapters, memorize vocabulary, and answer questions about what had been read.

Today, science instruction looks very different. MISE has provided the school with science modules in the form of kits that are rotated around the district during the school year. By the end of the year, each grade level has completed four modules. Teachers now take responsibility for teaching their own science lessons, using the science specialist for advice and assistance as needed. The district-wide science specialist has been a guiding force behind the science program during the MISE years.

> *My model is Rose [the science specialist]. I've grown a lot...If you told me I'd be doing this in four years I wouldn't have believed you. Building my self-esteem, plus the materials and the experiences every day were just wonderful. Such high quality!*
>
> —Teacher

Classroom instruction is based on "guided inquiry." Teachers pose thoughtful questions and plan hands-on activities for students. Students work with partners, or in small groups, and are required to think, read, and write about what they are doing, sharing ideas and results with other students. Study guides that come with the kits list key vocabulary for students to learn, and there are books to accompany the kits, so that students can read about the topic they are studying. Students are asked to behave "like scientists," investigating ideas and using materials in a safe and purposeful manner.

From the very beginning, MISE made it clear to teachers that it was not enough to just have "fun," but to consider what purposes they were trying to accomplish. In addition, teachers have had to become more sophisticated about assessing what their students are learning. They assess students by observing what they do in class, by reviewing their journals and written work, and by administering various kinds of teacher-designed tests and quizzes. Some suggested assessment activities accompany the kits, and MISE assessment committees worked to design performance-based assessments for teachers to adopt for classroom use. Teachers seem to find their own combination of assessments, working with grade-level partners to select and invent assessment strategies.

The changes in science instruction have not gone unnoticed and have had a wider impact on instruction in other areas. For example:

I can't accept any longer if I see straight rows and round-robin reading. Ten years ago I might have been more accepting, but no more. I expect to see interactive classes in ***all*** *subjects, not just science. But it started with the work we did in science.*

—Former principal

In 10 years, science has gone from being unimportant to very important. It was not liked by many kids, but now it is liked by most kids...I think science is important in all the grades. In this school there are a lot of teachers who were hired after MISE began...and they don't know the old way of science education. They only know that science is important here, and they approach it that way...Now teachers really ***do*** *science, don't just schedule it. They often invite me to see a lesson on science, ask me to stop by. That happens more in science than in any other subject. Most of my invitations to observe are in science. They [the teachers] feel they can show it off.*

—Principal

It's been so long that I have been doing this now! Before, we just had books and a few supplies. Now we have the kits. Everything comes to you and everyone does it...They have updated the manuals and there are even more activities now, and literature connections. I think literature connections are really important.

—Veteran teacher, third grade

I'm a [primary] teacher. My instruction has definitely changed. When I first started teaching, it was all hands-on [for Pre-Kindergarten], but what I learned from Merck, even at the Pre-K level, was to make things more inquiry-based, ask questions to get kids to think, get them to expand. I think my kids ask more questions than kids I taught in the past, because I ask more questions too.

—Leader Teacher

Making Change Happen

How did these dramatic changes occur? First, by the arrival of a committed external partner, MISE, which skillfully assessed the reform environment and worked with vigilance toward building the capacity of each district, and each school within the district. At Highland

Avenue, there were other factors that contributed to creating change: collaboration with administrators, new curriculum and new assessments, and professional development.

Collaboration with Administrators

From the very beginning of the partnership, MISE involved administrators in the instructional decisions related to science. MISE invited district administrators and the science supervisor to attend a National Science Resources Center meeting in Washington, D.C. In Linden, the superintendent and his team became interested in using science modules for teaching science, and worked with Merck to select and purchase the first kits.

Administrators also seemed to realize that the key to success would be to build the capacity of classroom teachers to deliver hands-on instruction. Although the science specialist had been modeling this kind of teaching, much more was needed. The district rethought its approach to advancing the skills of teachers, and decided to focus on training classroom teachers to teach science and use the science kits. They accomplished this by supporting and supplementing MISE's professional development offerings, and by changing the role of the science specialist. The science specialist position was created in 1992, and originally worked with an active parent volunteer (and Merck employee) to develop additional hands-on science units for use in classrooms, and visited classrooms once a week to model a more active approach to science.

After changing the role in 1994, the new district-wide elementary science specialist provided overall support to the elementary science program — helping teachers to get started with the kits, scheduling and leading workshops, training teachers and teacher leaders, ordering materials, revising curriculum, and responding to requests from principals and teachers. She also set up a science resource center for the district where science teaching materials were stored, replenished science kits, and readied them for circulation from school to school.

Since beginning as the elementary science specialist, she has worked closely with MISE to plan, implement, and support MISE-sponsored professional development activities. She has served on many instructional teams herself, and in recent years has worked within Linden to train other teachers to lead workshops as part of the effort to build district capacity to support their own science program. At Highland Avenue, for example, one of the Leader Teachers has logged more than 88 hours on instructional teams. There is also a new teacher who is being nurtured as a science leader.

New Curriculum: From Textbooks to Kits

The science modules or "kits," which form the foundation of the science curriculum, were a key factor in re-shaping science teaching. In 1996, New Jersey adopted its Core Curriculum Content Standards. In Linden, the standards were reviewed by a newly formed district science committee, with representatives from across the district, including representation from Highland Avenue. A new science curriculum framework was developed, and kits were added, moved to different grade levels, or deleted entirely to align with the new state standards and frameworks. Encouraged by MISE, there is now great commitment and attention to the alignment of curriculum with standards.

Within all the schools, including Highland Avenue, the change from using textbooks to science kits did not happen

overnight. During 1993-1994, teachers who had been selected by the district as science mentors piloted kits at all grade levels K-5. By 1994-1995, all grades K-5 were using two kits during the school year, and a third kit was being piloted by the science mentors. There are currently four science modules being used at each grade level K-5, one for each quarter. Pre-K is using three. (See Appendix A for a breakdown of which modules are used in each grade level.)

Undeniably, the classroom practices and topics taught have changed dramatically since the onset of MISE. Teachers have adopted hands-on instruction as the standard way to teach science now, using science modules that match new state and district curriculum goals. Nevertheless, several teachers who were interviewed at Highland Avenue (and in other places) mentioned that they would like to have a textbook for their students to use "as a reference."

In response to teachers' requests for more background content information, the developers of the science modules have added teacher guides with content information and teaching ideas, videos to model good pedagogy, and trade books related to topics in the unit. In addition, MISE has tried to accommodate teachers' requests for more content knowledge by incorporating more science content into professional development, and by offering more workshops on ways to use children's literature in the science classroom. The district has responded by purchasing trade books for use in classrooms.

In spite of MISE's attention to building the content knowledge of teachers, the introduction of literature connections, the changes to the kits, and new avenues for finding information over the Internet, teachers' desire for textbooks continues. In reviewing comments from teachers, it appears that this issue is fueled by two concerns: whether students are getting enough science content, and whether teachers themselves have enough background information so they can guide the instruction effectively.

> *The next step [for improving science] might be to review textbooks to see what is out there and if it could be incorporated with the kits.*
>
> —Teacher

Teachers' requests for a textbook may pose risks. It is conceivable that veteran teachers might slip back into the "old" way of doing things, despite their best intentions to continue with hands-on instruction and having students "do" science. Although reading about science is part of doing science, there is understandable concern that, if textbooks are reintroduced, once again teachers will rely too heavily on textbooks and students will regard science as a body of facts and vocabulary words that need to be memorized. More worrisome, perhaps, is that it seems new teachers are not receiving the kind of pre-service training that supports inquiry-based teaching. The current principal's support for new classroom approaches is another validation of MISE's decision to provide professional development for administrators, as well as teachers.

Interestingly, the current principal, trained in the MISE approach, would prefer to see a little more ferment and a little less rigidity in the classroom:

> *The teaching style around here is still pretty traditional, even with the newer teachers. They emphasize quiet and order...With cooperative learning, for example, the kids may be sitting in fours, but they are sitting there with their hands folded. In one of the observations I did, this was my criticism: Things were too structured and too quiet...This is the way it is, and it's not because of me. It is especially true with the non-tenured and new teachers. I see the trappings of the*

right thing, but I'm not really sure the right thing is happening...There has to be more noise and moving around.

—Principal

New Assessments

Improving assessment practices related to science has been an ongoing focus with MISE — not only in schools like Highland Avenue, but also at the district, state, and national levels. No matter how engaged students seem to be in science instruction in classrooms, at the end of the day, everyone wants to know if students are really learning.

How has my practice changed in the last five years? It has dramatically changed — from using the book to actual hands-on science, inquiry-based lessons, and so on — a real turnabout for me. The kids say they like science the most of all their subjects. It's so different from other lessons. We use small groups, they talk to their friends, and learn too, all at the same time. The majority of students stay on task and want to be successful...But assessment is probably the biggest challenge.

—Veteran teacher

At Highland Avenue, the fact that the state was about to start testing science on the Elementary School Proficiency Assessment (ESPA) was another driving force behind the changes to the science program. This meant that fourth graders would be tested for science, the same way they are tested for the traditional high-stakes subjects like language arts and mathematics. Science suddenly attained a higher prominence in everyone's thinking. The ESPA science test was administered for three years, in the spring of 1999, 2000, and 2001. On the last administration of the test in 2001, after eight years of working with MISE, 96% of Highland Avenue students scored at the "proficient" or "advanced proficient" level. This topped the state level of 91%.

Teachers are seeking better assessments for classroom use, too, for both formative (ongoing methods such as homework and observing performance) and summative (assessments that occur at the end of a unit or course to determine mastery of skills and content) evaluations of what students know and understand. Teachers seem to be caught between wanting more traditional paper-and-pencil kinds of assessment methods and also wanting newer, more performance-oriented measures. The developers of the kits have tried to address teachers' needs by including vocabulary lists, suggestions for journal entries, sample worksheets, and assessments of various types.

At Highland Avenue, the teacher guides and materials that come with the kit seem to be the first place that teachers look for guidance on the question of assessments. MISE worked for two years with a committee of teachers and consultants from the Educational Testing Service to develop a comprehensive set of assessment binders for classroom use, one for each grade level K-8. While these are helpful, they seem to be underutilized at Highland Avenue even among the more veteran teachers. Although a full set of binders was provided to each school, using them has not become part of the school culture.

Professional Development and Developing a Professional Community

In Linden and other partner districts, MISE worked to develop a system of professional development that included intensive, curriculum-based workshops and on-site follow-up and support. Beginning with Leader Teacher Institutes (LTIs) in 1995, MISE organized an outstanding professional development program that has institutionalized hands-on instruction and continues to build teacher expertise to this day.

LTIs consisted of three weeks of professional development each summer for three years in a row: 1995, 1996, and 1997. Teachers from all grade levels K-8, were assigned to cross-grade groups for purposes of learning the "big ideas" of physical science, life science, and earth science in all grades. After three years, all Leader Teachers had experienced all three areas of science and had amassed at least 300 hours of professional development time. Working with nationally recognized master teachers and other experts from universities across the country, the MISE "experts" skillfully planned and implemented the workshops that made up the LTIs. Periodically during Leader Teacher sessions, there were times for participants to reflect about the pedagogy and to meet with other teachers from the same grade level or from the same school. The intent was to build teacher leaders who could support change in their own schools and districts. Four Leader Teachers attended from Highland Avenue. They found the quality of the professional development that was modeled for the Leader Teachers to be exemplary.

> *It would be good if we could recreate that feeling that everyone had the first three years [at LTI]...For me this was a wonderful experience and very broadening...The camaraderie across the district...People involved are still very close. There is a sense of cohesiveness. I don't know if it was the timing or the people we worked with...the first group just "clicked." I don't know that I have experienced that in any other teaching situation anywhere. We need more of that.*
>
> —Leader Teacher

A next phase in the professional development began in 1996, when the Peer Teacher Workshops (PTWs) were organized. These voluntary workshops provide opportunities for teachers to spend a week in the summer acquiring deep knowledge of one part of their curriculum. The summer sessions are followed up during the school year to make sure that teachers are supported in their efforts to change and improve. In 1996, kits had been recently purchased for use in schools, so the focus of the professional development became more kit-oriented. Teachers wanted to learn how to use the materials in the kits, and become familiar with the underlying content knowledge and pedagogy. Many of the summer workshops still focus on kits, but the workshops address other math and science topics as well. Within and across districts, MISE is frequently credited with modeling an approach to science reform that was replicated when it was necessary to address changes in mathematics.

For MISE, the PTWs also had an important secondary focus, which was to expand capacity across the district for teachers to lead workshops in science. However, not all Leader Teachers wanted to be workshop leaders. Those teachers interested in becoming workshop leaders were invited to participate on the instructional teams, which involved more professional development to help them plan workshops and become effective leaders. Over time, Peer Teachers accumulated so much expertise that they, too, began to be trained to serve on the instructional teams.

Ultimately, a large number of workshops were held each summer on a variety of topics in math and science, including but not limited to kit usage. By 2001, 93% of the teachers at Highland Avenue had been to some form of professional development orchestrated by MISE and the third-grade Leader Teacher had spent some 88 hours serving on instructional teams. The other Leader Teachers did not want to lead workshops, but worked within the school, modeling the new pedagogy in their classrooms, addressing other teachers at staff meetings, helping with the school's science events, and encouraging their peers to attend the PTWs.

Even after the program was underway, there were separate sessions to orient new teachers to the science program in the schools. In interviews with teachers at Highland Avenue, the value of the "Merck workshops" was frequently mentioned by teachers who came to the school well after the science program was established.

> *When I came into the district four years ago, we had mandatory new-teacher workshops and they walked us through the kits for your grade level. It was a kind of orientation, and it was very helpful. Since then, I have signed up for MISE workshops each summer for a week. This past summer, I did Mixtures and Solutions with technology.*
>
> —Teacher

Although in teachers' minds the workshops tend to be equated with MISE's professional development activities, in fact, MISE had a much broader perspective about professional development. They realized that maintaining focus, sustaining the change process, and fostering a continuing dialogue about teaching and learning would require a cohesive professional community and strong, informed leadership. To this end, MISE worked closely with the mathematics supervisor, the elementary science specialist, and the district's science supervisor. These district leaders have helped to build professional community by:

- Talking and working with principals,
- Organizing and attending various task forces (such as the curriculum committee and the assessment committee),
- Working with the Leader Teachers,
- Making frequent visits to schools and classrooms,
- Promoting the active involvement with MISE, and
- Attending to the numerous details involved with marshalling a reform effort of this magnitude.

All three leaders have been instrumental in keeping science at the forefront in Highland Avenue.

The professional community has grown stronger in relation to science pedagogy, just by virtue of having such sustained professional development over time. The Leader Teachers who saw each other over three summers became especially close. And teachers at each grade level look forward to meeting and working with each other each summer in the PTWs devoted to the modules being used at their grade level. In Linden, this has meant that they get to know teachers in Rahway as well as Linden, because the districts run workshops jointly. MISE has also offered financial support and encouragement for teachers to attend national and state science conferences so that they can become part of the broader science community. And within schools, they have promoted the idea of release time and common planning time for teachers to enable them to work together, plan, and share ideas. As a result of these kinds of interactions among the teachers, the sense of community at Highland Avenue in relation to science, as well as other subjects, has grown stronger.

MISE: The External Partner

Integral to these impressive changes was MISE, the external partner, pushing for change in the district's science program and keeping the conversation on a high plane. The goal of these efforts was not only to ensure that the school's science program complied with new state standards and testing, but also to foster overall improvement in teaching and learning throughout the school. At High-

land Avenue, the strategies of MISE paid off, bringing the school to a level of proficiency with science that has endured in spite of new challenges. By being an outside partner, MISE could afford to stay on course at a time when other district or school changes threatened to derail the reform efforts. Newer teachers do not know what came before, but those who were around when MISE was forging ahead into new territory have nothing but positive things to say:

> *It's been demanding, but fun. All I can say is that it has not happened in language arts or social studies. We did address some math, because we got the start with science. But I have seen no significant [instructional] changes in 20 years except in science, and somewhat in math. It's a long way for science to come in just 10 years.*
>
> —Former principal

> *What should MISE do differently? I'd suggest a few minor things, but really it was very good...All in all, involvement with Merck has had a positive impact on the district. I used to be afraid of science and now it's one of the favorite things I like to do.*
>
> —Veteran teacher

The Impact of the Reform

The biggest impact of the reform at Highland Avenue is the overall change in the norms for instructional practice. Science lessons look much different from what they were in 1993. Through the past 10 years, with the vigilant guidance of MISE, teachers have changed from a very conventional "chalk-and-talk" approach to delivering hands-on instruction to science that is "inquiry-based." The teachers with the greatest amount of experience have moved beyond learning how to use the kits in a rote way, to reflecting about best practices and figuring out how to assess student outcomes. As a result, there is now a greater district-wide emphasis on assessment practices and greater energy directed toward refining the existing program. Also, MISE has successfully established a professional community focused on sustaining and improving science instruction. In elementary schools, where science has never had the same attention that language arts or mathematics have had, there is now considerable time and effort spent on teaching science. Teachers have developed strategies that combine the teaching of science with other disciplines — reading in the content area, writing in journals, doing research on the computer, and measuring and recording data — thinking about change over time.

Teachers credit the dramatic changes they have made to their practice to the professional development planned and implemented by MISE. These teachers also credit their ongoing support from MISE and district staff, especially the elementary science specialist.

Unfortunately there have been many staff changes at the school in recent years with many new teachers coming aboard. This creates a professional development challenge: how to address the needs of the new teachers while at the same time increasing the content knowledge and skill of more veteran teachers.

New teachers say they are grateful for their science orientation sessions, the PTWs, the meetings scheduled each quarter for new teachers, and common planning periods where they talk with their grade-level partners. All of these activities have helped them in their day-to-day practice, while at the same time drawing them into the professional community of the school.

The impact on district leaders cannot be denied. District leadership continues to support science, even as the state tests have disappeared, and MISE funding has decreased. There is a commitment to providing good science instruction, and

current district policy supports that commitment. MISE has been offering Principal Institutes to make sure that principals are keeping informed about various aspects of the reform process.

Parents also seem to have been affected by the reform efforts. They are supportive of the new ways for teaching science. Perhaps this is because their children are happy doing science; perhaps it is because they have attended so many science events such as Family Science Nights, Family Tools and Technology, and Families Achieving the New Standards.

The ultimate test of the success of the reform is, of course, the students. State tests indicate that they are doing well in science, with 96% of Highland Avenue students scoring at the "proficient" or "advanced proficient" level. Parents and teachers believe that students now like science and are truly learning by doing. Parents report that students come home and talk about what they did in science, and are interested and enthusiastic about what they learn.

> *I've been a parent at this school for the last seven years. Science is great here. I like the hands-on. They do a lot of ramps, and guppies, and mealy bugs. Kids talk about science at home.*
>
> —Parent

> *Science is such a hands-on program. That is the best condition for our special ed. students...They really see the relationship between the book or video or whatever with the hands-on materials. It's a good condition for special ed. students because it pulls in more of their talents. They can participate successfully.*
>
> —Special education teacher

Student comments are especially revealing, as they explain the kinds of science they have been doing the past few years. All of the students that researchers from the Consortium for Policy Research in Education (CPRE) talked to have experienced no other way of learning science. They came to school after the new curriculum was in place, and have never learned science any other way except through hands-on experimentation and inquiry. Fifth-grade students share memories of their science classes over the past few years:

> *We mixed colors in fourth grade, did tie dyes on coffee filters...We made designs with markers, and sprayed them with water. It was called chromatography... Yeah and we had sand and gravel and clay and had to feel it and put water in it and feel it and say what it felt like...And in third grade we did electricity to make light bulbs go on and make the engine work...And we had a box with dirt and made a river to find out how rivers are formed...And we dissected owl pellets. We used a toothpick and got the bones and then we got to see what the rat really looked like...I remember mock rocks in fourth grade and we took 'em apart to learn what was inside. We were learning about how rocks are made...And I remember when we did the water cycle and we drew pictures and colored them in and then we put it on the window sill and let it evaporate, but it couldn't because the moisture was in the bag.*

Lessons Learned

Lesson One: Sustained external support is crucial.

It seems natural that during the early years of MISE almost all participants in the Partnership talked about science being a high priority in their district. While it had not been such a high priority before MISE began, it rapidly became the focus of attention. In Linden, Highland Avenue was especially enthusiastic because they had an early start in focusing on science — thanks to the science specialist, the parent volunteer, the commitment of the principal, the energies

of several especially dedicated teachers, and the resulting high level of involvement by parents. The initial enthusiasm grew even stronger as the Leader Teachers received professional development of a quality and intensity that few of them had previously experienced.

The challenge facing MISE was to build commitment and capacity in the districts that would ensure the continuation of high-quality science instruction without the need for constant and direct support. By providing a respected model that could be emulated, and by providing sustained external support, MISE met the challenge. In addition, the Peer Teacher Workshops built a cadre of teachers who knew how to design and deliver better professional development than most teachers ever experience. With this capacity and with MISE's support, the district gave financial and supervisory support to continue delivering meaningful professional development in science. This external support enabled Highland Avenue to sustain its reforms in science and to do it in the face of challenges that might have undone the reforms.

Lesson Two: Sustained attention and success can change priorities.

Once the process of rethinking science pedagogy was underway, it was inevitable that districts would begin to reexamine how other subjects were taught. Linden, for example, adopted a new language arts series that emphasized improving children's writing skills and their ability to use the computer to do Internet searches and to produce word-processed documents. With the help of MISE, and using many of the same procedures used in science for selecting new curricula and attending to standards, Linden also introduced a new mathematics curriculum in the fall of 1999. When CPRE researchers visited the school during that time, several teachers commented that math was the district priority that year, and that science continued to receive more attention than it had before MISE. Language arts and mathematics are still the important target areas, but teachers are finding ways to do more science, and to relate language arts and mathematics to their science teaching. People at Highland Avenue take their science teaching seriously.

Despite changes in administration and staffing, and a shift to a more balanced emphasis on other subject areas over time, science has maintained a position of importance in Linden and at Highland Avenue. Everyone expects this way of teaching science to continue. While there is always room for improvement and there are new challenges to face, MISE has helped to build a professional community in the district that is willing and able to address the issues. For Highland Avenue, many of the current challenges are a result of having a relatively new staff and constant changes at the top. For the time being, at least, improved instruction has taken hold and science remains a very high priority.

Reference

Highland Avenue School #10. (n.d.). *Highland Avenue School #10 history*. Retrieved February 19, 2003, from http://linden.k12.nj.us/schools_2002/ten.htm

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