Lessons from the Keystone Science Network: The Role of Networked Technology in Improving K-8 Science Education

Prepared for
The Franklin Institute

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Chapter I: The Keystone Science Network: A Testbed for Innovation in Science Education Reform

THE KEYSTONE SCIENCE NETWORK

> *Long-term observers of educational innovation and school reform have argued that reform might more productively be seen as a problem of learning than as a problem of "implementation." That is, the progress of reform appears to rest in crucial ways on the capacity of teachers, both individually and collectively.*
> *(Little, 1999. p.2)*

The improvement of K-12 classroom science instruction is a long-term undertaking and, as Judith Warren Little argues in the above quote, can best be viewed as a learning process rather than as policy implementation. In 1999, The Franklin Institute (FI) launched the Keystone Science Network (KSN), a "cogent, replicable model for science education reform, both systemic and electronic." The Keystone Science Network was designed to establish a professional learning community in the eastern half of Pennsylvania by creating an integrated network of K-8 science educators, standards-based science curriculum materials, and electronic resources. Funded by the National Science Foundation, with additional support from Unisys Corporation, KSN built upon lessons from two previous projects of FI: the Science Learning Network and the Commonwealth Excellence in Science Teaching Alliance. The hope was to refine a model of science reform that could be scaled up in Pennsylvania and nationally.

Project developers envisioned KSN as a support for district-initiated science education reforms that had as their centerpiece the implementation of standards-based science kits. The pedagogical foundation of science kits is that "students learn science by *doing* science, not by reading about science in textbooks or by watching their teachers conduct demonstrations." (Jorgenson & Vanosdall, 2002) Doing science allows and pushes students to learn the processes of science—hypothesizing, conducting experiments, recording data, presenting findings, and theorizing. As districts made kit-based curriculum materials available to K-8 teachers, Franklin Institute staff would provide professional development related to the kits to a cadre of teachers from each participating district. Additionally, a KSN website would serve teachers by providing high-quality, focused, and relevant information when they needed it and in an efficient manner—what Gordin et al. (1996) call "just-in-time curriculum." Its resources would offer teachers background information on science kit topics and equip them with a myriad of ideas for extending and deepening kit activities. Another feature of the KSN website would be online peer forums where teachers, no matter how far-flung geographically, would learn from one another as they encountered the knotty problems of practice inevitable in any challenging reform effort. Teachers would be able to "partner as a means of enhancing student learning." (Sabelli & Dede, 1998).

KSN project developers aimed not only to support teachers' adoption of science kits, but also to help them become comfortable with an inquiry-based approach to science instruction. Inquiry science engages students with problem-solving activities that incorporate authentic, real-life questions and issues in a format that encourages collaborative effort, dialogue with informed expert sources, and generalization to broader ideas and application. This was an ambitious goal, in light of research warning that teachers who used kits often focused more on procedural issues, such as time management and helping students to "finish" a lesson, rather than the more demanding aspects such as adapting science lessons to student-generated questions or discussing varying results. (Sevilla & Marsh, 1992; Olguin, 1995)

Additionally, program developers' high expectations for KSN's electronic resources came at a time when the contributions of networked technology to education remained largely hypothetical. While the vision was rich—teachers exchanging ideas with leading experts in the field, observing best practices in the classrooms of exemplary teachers through telecommunications, receiving coaching from mentors via web conferencing, and retrieving information from online virtual libraries full of instructional resources and research—the evidence base for networked technology was immature. (The National Staff Development Council, 2001)

The Keystone Science Network provided a testbed for innovation in science education reform. As a research and development project, KSN offered the potential to move the discourse about Internet use in classrooms from the abstract and prescriptive—i.e., "use the Internet because it's becoming a central part of life in the 21st Century"—to a more contextualized and detailed exploration of what networked technology has to offer teachers as they go about improving their science teaching.

The Evaluation Research

In this report we present findings from three years of evaluation research conducted by Research for Action staff that accompanied implementation of KSN. During that period, three cohorts totaling 185 teachers participated in KSN professional development activities and used the online resources developed by The Franklin Institute. These teachers were from eighty-two schools in twenty-two districts across eastern Pennsylvania.

The view of educational change as a learning process offered a conceptual framework for investigating how KSN assisted individual teachers to undertake new and challenging instructional practices and leadership roles in scaling up science education improvement in their schools and districts. Recent literature points to what helps teachers hone their craft and become more accomplished at standards-based classroom practices. Below, we highlight findings from that literature.

1. Clear and consistent messages from leaders and policies at the state, district and school levels about the vision and goals for science education. (Knapp, 1997; Blanc et al. 2001)
2. Access to high quality curricular materials. (Cohen & Ball, 1999)
3. Ongoing and intensive professional development that helps teachers acquire the knowledge and skills to use standards-based curricula in ways that match reform-encouraged pedagogy and takes into consideration where they are in their practice and the daily realities of their classrooms. (Loucks-Horsley et al. 1998)
4. Consistent opportunities to interact with experts. (Loucks-Horsley et al.)
5. Time to share ideas and struggle through problems of practice with colleagues who are engaged in similar improvement efforts. (McLaughlin and Talbert, 1999; Blanc et al, 2002)

Informed by the literature summarized above and our conversations with program developers about KSN's goals and program components, we identified the following questions for study:

1. What did teachers learn about effective and innovative science curriculum and instruction and inquiry pedagogy as a result of their participation in the Keystone Science Network? What programmatic components of the Keystone Science Network contributed to teachers' learning? How?
2. How did teachers incorporate their learning into their classroom practices? Specifically, how did they use science kits in their classrooms to strengthen their students' conceptual understanding of science topics and how did they engage their students in inquiry science?
3. How did KSN teachers provide their schools and districts with leadership in the dissemination of effective and innovative science curriculum and instruction and inquiry pedagogy? More specifically, how did they help their colleagues learn more about using science kits and adopting an inquiry pedagogy? How did they participate in and help to develop school and district level policies, structures, and activities that would support the ongoing learning of teachers? What factors in schools and districts contributed to the development of teacher leaders?

To investigate these questions, Research for Action staff attended the majority of face-to-face KSN professional development sessions—summer institutes and colloquia—and conducted focus group interviews of participants during these sessions. Researchers conducted extensive field work, observing teachers' classrooms and interviewing KSN participants and district and school administrators. We also closely monitored KSN's website and archived relevant data. Lastly, teachers twice completed an extensive survey: (1) upon entering KSN and (2) near the end of the project's third year, in April, 2002.[1]

General Conclusions

Overall, we found that KSN's web-based curriculum resources combined with the intensive professional development of the KSN summer institute and schoolyear colloquia were strong supports to

1 See Appendix V, Research Methods, for more detail on research design, data collection and analysis.

teachers at all stages of their learning about a standards-based approach to science instruction. The Kit Matrix and Curricular Companions streamlined web usage for KSN teachers who accessed them at the same frequency with which they used the Internet as a whole prior to KSN. In addition to helping KSN teachers plan for instruction in their own classrooms, online curriculum resources were important tools for KSN teachers who were inclined and able to become leaders in promoting science instructional reform in their schools and their districts. Promoting the KSN website was a comfortable entry point for teachers who were previously reluctant to assume leadership, because KSN teachers were confident that their peers would find the website valuable. In addition, fledgling teacher leaders did not have to tout their own expertise — always a risk with peers — but instead could point to the website as a pathway to increased information and knowledge. The second feature of the KSN website, online peer forums, were underutilized as sites for reflection and collaboration. This suggests that there is more work to be done in conceptualizing both how the forum is structured and how other programmatic components might work together to encourage teacher participation in an online community.

The professional development provided by KSN staff helped teachers become comfortable with engaging their students in hands-on science activities. In the institutes and school year colloquia KSN staff engaged teachers in learning science through inquiry. This approach proved successful at encouraging teachers to make inquiry science an important goal for their practice. KSN teachers became conversant in inquiry science as a pedagogical approach. Not surprisingly, teachers' ability to use an inquiry pedagogy in their classrooms varied widely.

Chapter II: Learning from the Keystone Science Network

In this chapter we offer findings about the Keystone Science Network and its accomplishments. The major research questions provide the organization for the chapter, with each section addressing one of the study's three major questions.

The Contribution of KSN to Teachers' Learning

> What did teachers learn about effective and innovative science curriculum and instruction and inquiry pedagogy as a result of their participation in the Keystone Science Network? What programmatic components of the Keystone Science Network contributed to teachers' learning? How?

Finding 1: KSN's online curricular resources proved to be powerful tools for deepening teachers' knowledge and understanding about the science topics that they taught and about standards-based curriculum and instruction. Teachers praised the online resources for their quality and relevance and routinely used them to provide important background knowledge for unit and lesson development.

KSN's web-based Kit Matrix and Curricular Companions provided resources on: background content, kit enrichment, interdisciplinary connections, assessment strategies, and standards that related to specific STC, Insights, and FOSS science activity kits. KSN staff rolled out the ten topic-area Companions three or four per year over the course of the three-year project. By the second year of KSN, an interactive Kit Matrix was developed and posted on KSN's site. The Kit Matrix facilitated easy access to information about specific kits. Also included in the Companions were ideas and experiences KSN teachers shared about working with specific kits. In addition, the email newsletter, *Keystone Weekly*, offered information on science topics, local science-related events, and resources in science education.

All teachers praised KSN's website. They reported that the website was highly relevant to what they were doing in their classrooms and they had confidence in the quality of the resources linked to at www.keystone.fi.edu. For busy teachers, the Companions streamlined web usage – a significant benefit of the Internet resources. They became the first stop for many teachers when using the Internet for information on science content or curriculum. Nearly all teachers who reported using KSN's web resources used Curricular Companions as background to unit planning. Using the Kit Matrix and Curricular Companions became an easy routine for teachers, a powerful phenomenon given research showing that when teachers can embrace and incorporate routines, many tend to continue using resources over time. In fact, teachers used the Kit Matrix and Curricular Companions and the information linked to in the *Weekly* at the same frequency with which they used the Internet as a whole prior to KSN. A significant number of teachers not only bolstered their own background knowledge, but also used KSN's web resources with students to deepen their students' understanding of science.

Finding 2: Teachers judged KSN's professional development as highly effective in giving them the experiences and tools necessary to reform their instructional practices in science.

Teachers reported that KSN professional development helped them to (a) increase their comfort with science kits; (b) gain confidence with science content; and, (c) better understand inquiry-related teaching practices. Teachers gave the professional development offered by KSN very high marks as compared to other professional development they had encountered. A comparison of teachers' experiences with KSN professional development and prior experiences found KSN to be significantly more likely (significant at the $<= .000$ level) to lead to reported changes in teaching practices than previously experienced professional development. Teachers valued the opportunity to work with KSN staff, whom many described as "excellent." Teachers appreciated KSN staff's expertise and commitment and their willingness to spend time discussing more "nitty-gritty" instructional practices like assessment strategies and ways to modify lessons to include inquiry elements.

Finding 3: All teachers recognized inquiry science as an important goal for their practice and were able to explain the broad contours of an inquiry pedagogy, clear evidence that KSN's approach to

professional development — having teachers experience inquiry science as learners —was successful as an introduction to inquiry. In addition, KSN teachers learned that shifting science instruction to inquiry and doing science requires new assessment strategies and that students need opportunities to represent their knowledge in a variety of ways.

The success of science education reform depends on teachers' ability to teach in a different way from the way most adults learned science as students. For many adults, early experiences in science and math classes included a primary focus on decontextualized work, note-taking from teachers' lectures, and a focus on memorization of facts and procedures. Teachers need the opportunity to "unlearn much of what they believe, know and know how to do, while also forming new beliefs, developing new knowledge, and mastering new skills through 'transformative learning.'" (Thompson & Zeuli, 1999) In addition, as they adopt new curricula, teachers typically face challenges in moving from the procedural challenges of using new materials and techniques to addressing their students' conceptual learning, which is at the heart of science reform. (Loucks-Horsley et al. 1998).

KSN professional development focused on how to use the kits and was designed to engage teachers in working with hands-on materials in ways that promoted minds-on science and science inquiry. The belief was that, by experiencing inquiry as learners, teachers would see firsthand the power and the complexity of the inquiry mode of learning. Further, the in-depth nature of the professional development, in particular the summer institute, allowed participants to immerse themselves in their inquiry work, gaining not only deep pedagogical knowledge of the process of inquiry, but also increased comfort with and knowledge of new science content.

As a result of their participation in KSN professional development, KSN teachers were able to clearly articulate the goals for inquiry science. In interviews KSN teachers demonstrated that they understood that shaping questions about phenomena is central to inquiry science and many regularly asked students to generate questions about what they observed. KSN teachers understood that effective science instruction calls for a broad range of pedagogical tools, from helping students develop their own investigations to connecting scientific concepts to students' known worlds.

Finding 4: Teachers did not make extensive use of KSN's online peer forums for communication and collaboration with their peers.

Online peer forums were to be the primary mechanism for creating a professional community of KSN science educators. These forums offered the opportunity for teachers to share teaching ideas as they figured out how to use new curriculum materials in their classrooms. "Conversations" and "Site Visit Journals" were both central to KSN's model for effective infrastructure in support of teachers. Conversations were separated into "Conversation Boards." Any visitor to the website could post on any board (no username or password is necessary) using an HTML-based text box. The Site Visit Journals provided both pictures and "descriptive essays" of FI staff visits to KSN teachers' classrooms, allowing teachers to virtually look inside each others' classrooms to access and share information about instructional practices.

Communication across participants via network technology, either on www.keystone.fi.edu or via email, was limited to a small percentage of teachers. Teachers did not make extensive use of the online resources to engage in more sophisticated collaborative practices such as reflecting on their students' learning, planning curriculum units, or analyzing their own teaching. However, recent strategies to address this challenge appear promising. Classroom narratives, both reflective and observational, are providing pathways for finding a place in the professional community. The Classroom Experiences are deliberately organized by grade level and content area in order to make it easy to connect common interests and potentially facilitate collaboration.

Finding 5: Joining the Keystone Science Network was an impetus for some districts to adopt curricula endorsed by the National Science Foundation, a critical step towards standards-based curriculum and instruction. However, not all district and school leaders followed through on their stated intention to supply classrooms with science kits and networked technology. This posed a significant impediment to their teachers in making the most of the curriculum-related supports provided by KSN.

In their applications to join the Keystone Science Network, districts committed to providing those teachers who participated in KSN with science kits and with at least one classroom computer that had Internet access. Staff from some districts told us that

KSN was a major factor in their decision to adopt science kit curricula, often their first step in moving toward standards-based curricula. However, only seventy-six percent of KSN teachers responding to our 2002 survey reported using a science kit in the third year of the project; the remaining twenty-four percent never received science kits. In addition, although teachers reported a slight increase (four percent) in the availability of computers with Internet access in their classrooms, only seventy-eight percent of teachers had Internet access on a computer in their classroom at school when surveyed in April 2002. Ninety-three percent of teachers, however, had Internet access at home, a four percent increase since beginning KSN.

While the original program model expected teacher access to both the Internet and science kits in the classroom, these inconsistent classroom circumstances became acceptable in order to avoid the appearance of exclusivity. The impact, though, was that an already ambitious project was operating, effectively, at three-quarter capacity.

The Contribution of KSN to Teachers' Classroom Practices

> How did teachers incorporate their learning into their classroom practices? Specifically, how did they use science kits in their classrooms to strengthen their students' conceptual understanding of science topics and how did they engage their students in inquiry science investigations?

Finding 6: As a result of their participation in summer institutes and school year colloquia, KSN teachers gained confidence in the use of hands-on materials and became proficient at engaging their students in the use of a range of science process skills, including predicting, categorizing, observing, recording, measuring, drawing, graphing/charting, interpreting evidence, drawing conclusions, making hypotheses, and testing those hypotheses.

In the lessons we observed, KSN teachers demonstrated comfort with involving their students in hands-on science. They had developed systems for gathering, preparing, distributing, using, and collecting materials and they established classroom climates that encouraged students to talk with one another and move around as they worked. Students routinely made predictions and recorded their observations; they categorized, measured, graphed, charted, and described. They used writing during science lessons as they recorded their work in science journals and lab books furnished by kit publishers.

Finding 7: Not surprisingly, there was variation in teachers' ability to organize hands-on activities in ways that helped students make conceptual links as they moved from activity to activity. A teacher's ability to involve students in a wide range of process skills provided a foundation for engaging students in higher-order cognitive tasks such as: planning and carrying out investigations; reviewing experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating results.

Our observational data indicated that in lessons in which students used higher order skills—interpreting evidence, drawing conclusions, hypothesizing—they also engaged in a wider range of the other science process skills—measuring, categorizing, recording, etc.—than we routinely found. In these lessons, teachers gave students the opportunity to "do science" in enriching ways, while simultaneously pushing their students to make sense of their findings. They constantly switched the classroom focus from activities such as measurement to recording observations and methods to making sense of what was happening. These teachers (approximately one third of the eighteen teachers we observed) routinely asked their students to engage in reflection on the meaning of what they noticed in the midst of conducting activities or experiments. Through routine reflective discourse, these teachers' students demonstrated the degree to which they had grasped or were grappling with both science content and process.

Finding 8: There was also considerable variation in teachers' abilities to use an inquiry approach in their classroom that involved helping students plan and carry out their own investigations.

As mentioned earlier, KSN teachers understood that developing questions is an important part of the inquiry process and many regularly asked students to generate questions about what they observed. Teachers we observed fell into three categories regarding the degree to which they encouraged and made it possible for students to seek answers to their questions. Approximately 40 percent of the teachers we observed had students generate questions at some point in their working with a science kit, but gave the students little to no opportunity to follow up or find answers to their questions. Questions may have, in theory, driven kit-work, but in practice were generated and then rarely referred to again. Another 40 percent had students generate questions and discuss ways to design investigations or access resources to find answers to those questions. Students did not, however, conduct the investigations they proposed. Twenty percent of the teachers facilitated their students in asking questions, designing investigations, and conducting those investigations. In these classrooms, teachers capitalized on their students' inquisitiveness, giving them experience with scientific processes and the time and guidance to seek answers to questions of intrinsic importance to them.

Finding 9: Many teachers incorporated new assessment strategies such as systematically observing students using kits and culminating activities to test the knowledge students gained throughout the kit-unit.

In our visits to classrooms we observed many instances of students recording observations and drawing pictures of what they had learned. Further, in about half of the classrooms we observed that teachers used additional ways to engage students in representing what they were learning. These included oral presentations to the class, reflective writing, and learning new scientific vocabulary. Teachers saw that testing students in conventional ways would ignore how students have learned to use process skills like measuring or observing. It would also gloss over how students think about their experiments—how they interpret evidence and draw conclusions. Teachers reported that the KSN website had made possible changes in the ways in which they assessed students' learning. They praised the resources related to assessment that were part of the Kit Matrix and Curricular Companions and found them to be one of the most helpful aspects of the KSN web resources.

The Contribution of KSN to Developing Teacher Leaders in Science Education

> How did KSN teachers provide their schools and districts with leadership in the dissemination of effective and innovative science curriculum and instruction and inquiry pedagogy? More specifically, how did they help their colleagues learn more about using science kits and adopting an inquiry pedagogy? How did they participate in and help to develop school and district level policies, structures, and activities that would support the ongoing learning of teachers? What factors in schools and districts contributed to the development of teacher leaders?

Finding 10: Most KSN teachers provided leadership in their grade groups and/or schools by promoting the use of hands-on curriculum materials.

KSN program developers intended to create a cadre of teacher leaders who could forward standards-based science curriculum and instruction in their home schools and districts. These teacher leaders were central to KSN's strategy for scaling up reform within schools and districts. The literature has suggested a wide range of possible roles for teachers in leading science reform: including "talking up" new curricula and instructional practices; facilitating workshops; and leading inquiry groups of teachers who conduct research about their classrooms and students. KSN teachers did indeed take up informal leadership roles in their grade groups and schools. They promoted kits and generated enthusiasm for using them; they helped colleagues with the many logistical details involved in using kits; they acted as consultants to teachers planing and trying new activities; and they led workshops for their grade groups and school faculties.

Finding 11: KSN's online curriculum resources provided important support to KSN teachers for whom leadership was a new undertaking.

The KSN website gave emergent teacher leaders the confidence they needed to undertake new responsibilities. As described earlier, KSN teachers had confidence in the quality of the website and rated it highly for its relevance to their practice. Promoting it to their colleagues was a natural entry point to leadership for teachers who had been reluctant to step forward previously. KSN teacher leaders eagerly introduced the website to their colleagues and showed them how to use it as background information on curriculum topics, for unit planning, and as resources for their students.

Finding 12: Some KSN teacher leaders played significant roles in shaping curriculum policy in their schools and districts, but local district and school contexts varied widely in their capacity to capitalize on the potential of KSN teachers to lead improvements in science education.

There was considerable variation across districts and schools, however, in the prevalence of formal opportunities for leadership. Over the three years of

KSN, school structures for supporting teachers in professional and leadership roles in science (e.g., science and technology committees) have declined significantly. This may have reflected the shifting of limited resources (e.g., teachers' time) away from science towards other high-accountability areas like language arts and math.

Finding 13: For the most part, KSN teacher leaders did not facilitate the kinds of sophisticated collaborative practices (e.g., teacher inquiry groups, systematic review of student work) recommended by the literature as necessary for helping teachers to take on the challenging alterations in their practice associated with standards-based instruction.

Only about a third reported inviting other teachers to visit their classrooms for the purpose of observing and analyzing their instruction. In some cases, KSN teachers worked as mentors to their colleagues, but even in these ongoing relationships their help was focused more on transmitting knowledge than on reflection and inquiry.

Reflections

Scaling up educational reform involves both going broad - beyond individual classrooms and pockets of success to widespread innovation - *and* going deep - beyond adoption of the easiest pieces of reform to substantive changes in overall educational approach. Outside partners, or intermediary organizations (as they have come to be known), like The Franklin Institute have important roles to play in scaling up reform. They bring needed expertise to the challenges of both going broad and deep and can be a major support in building capacity both at the individual teacher level and at the organizational level. The intention of KSN program developers was to create and support a cadre of teacher leaders who would actively promote science reform in their schools and districts. Intensive professional development, online resources that provided information and knowledge about science topics and effective instructional practices, and a networked professional community would arm KSN teachers with the knowledge, tools, and collegial support they needed to effect instructional change in their own classrooms and beyond. Teacher leaders and online resources were to be bridges to scaled-up science reform. Below we consider the Keystone Science Network's contribution to scaling up science education reform.

KSN built legitimacy and urgency for standards-based science education. KSN provided an impetus for district leaders to adopt kit-based science curricula. It is likely that, in a high-stakes environment at the state level where only language arts and math were tested subjects, some districts might not have made this decision if KSN had not made kits a prerequisite for participation. But in other districts, science has remained on the back burner, with other subject areas taking the prominent role in espoused priorities. These districts have not made a commitment to high quality curriculum resources, such as kits, or have done so in limited ways (e.g., one kit per grade or kits for some grades, but not others). In still others, there are no forums, such as science committees, where KSN teachers can exert influence and offer expertise. Where such forums exist and where there are other science reform initiatives under way, KSN teachers and staff have reached out to connect KSN to these efforts. These districts and schools are reaping the cumulative benefits of multiple and well-coordinated initiatives and partnerships.

KSN's online curricular resources and professional development clearly increased the motivation and capacity of a wide range of teachers to try kits in their classrooms and to learn how to use them effectively. The literature has demonstrated that kits have frequently been implemented in rote ways, with teachers focused on moving students through kits activities in a lockstep fashion. KSN's professional development and online resources helped teachers to go beyond superficial adoption of kits to using them to build students' conceptual understanding of science topics. Although not all participating teachers mastered minds-on science or an inquiry approach, all had embraced these practices as goals and taken important steps toward them. Additionally, teachers who had reached full adoption of standards-based instructional practices credited their involvement with KSN as pivotal in the transformation. Finally, teachers' participation in KSN professional development and their knowledge of the website encouraged teachers to play a role in promoting science reform in their schools and districts. This kind of teacher advocacy is important for spreading educational change.

Looking Forward

In order to take the next steps toward breadth and depth of change, KSN program developers will need to further their creative thinking about networks - both human and technological. They must flesh out what KSN teacher leaders - working in concert with other district and school leaders - need to know and be able to do to create strong communities of practice in which teachers can learn about, reflect upon, and refine new instructional practices. Research has established that in order for teachers to make the challenging alterations in their practice demanded by standards-based reforms they must work in contexts characterized by opportunities to struggle through problems of practice with their colleagues. KSN teacher leaders were well prepared to help their colleagues with the complicated logistics of using kits. They had many ideas to share about how to adapt kit activities and extend them. They had assessment tools that would help their colleagues become confident that students were indeed learning.

But KSN teacher leaders were less well prepared to engage their colleagues in planning together what they would teach and how they would teach it; in documenting, analyzing, and reflecting upon their instructional practices; and, in reviewing student work as part of an ongoing system of assessment of student learning and modification of instructional practice (Loucks-Horsley et al.1998) KSN Program developers will need to consider how their professional development and their online resources can work together to support KSN teacher leaders in establishing professional communities which can fulfill these essential functions and facilitate the ongoing learning of teachers. They will also need to develop strategies for working with district and school leaders to create hospitable environments for sustained learning.

While KSN's goals were far-reaching, program developers have, in professional development and online resources, kept the project's focus on teachers—on their experiencing of inquiry first-hand, on their instructional practices, and on their use of the Internet for content and collaboration. Greater potential exists for tapping into teachers' passion and sense of responsibility to improve their students' learning. Positioning students more at the center of professional development on both instruction and Internet use, or still more in Kit and Curricular Companions, would likely allow KSN to speak directly to teachers' consistent desire to improve and add new strategies to their practice for their students' benefit.

In addition, KSN program developers and staff hold a wealth of resources that KSN teachers and other KSN participants strongly and consistently reported valuing. KSN should capitalize on their staff's many strengths and work towards strengthening district- and school-level in direct ways such as providing technical assistance to districts as they (1) develop and implement plans to increase their technology capacity; (2) work to align standards, curriculum, and assessment; (3) coach district administrators on what to look for in science classrooms as they observe teachers.

We believe that Keystone is in an excellent position to take the next steps in program refinement. Teachers highly value the project and its resources, and evidence of its impact exists in every district and school that has participated.

Chapter III: Case Studies of Three KSN Teachers

In this chapter we look closely at three teachers to understand what and how they are learning about the ambitious reforms in science education espoused by the Keystone Science Network. RFA observed each of the three teachers in the midst of their everyday instructional practice and conducted interviews related specifically to the influences on the lessons we saw, and more broadly on teachers' experiences with science instruction, inquiry, leadership, and technology use. These case studies capture the dynamic interplay of factors—KSN professional development, online resources, a given teacher's knowledge and experience, school community and district context—involved as teachers learn to use new curricular materials and undertake new teaching strategies. We reiterate the point made in the introduction: individual teachers' learning is the foundation for both broad and deep educational change. For this reason, the case studies focus more on teachers' learning than on the degree to which they are implementing specific curricular content and pedagogical methods.

These case studies show three teachers—Alice Dressler, Ruben Knight, and Marsha Overby[2]—making substantial use of KSN resources to learn new ways of doing science with their students. These teachers are at different points in the journey toward undertaking standards-based educational practice and they are capitalizing on the resources and opportunities of KSN in different ways and to different degrees.

We purposively selected these three teachers because they are representative of the range of classroom practice we observed during our three years of classroom visits and the range of ways we documented KSN participants engaging with the resources offered by The Franklin Institute.[3] Demographic data on the cadre of KSN participants show:[4]

1. Nearly three-fifths of the 163 participants were elementary school teachers and one-sixth were science-only—largely middle school—teachers;
2. Over three-quarters were experienced teachers, with more than six years in the profession; three-fifths had been at their school for over six years;
3. Three-quarters held a Master's degree;
4. Four-fifths were female;
5. Nine-tenths were white; slightly less than one-tenth were African-American.

Our three case study teachers also varied in their backgrounds and experience and in the ways they approach learning about science content, technology, and teaching. They hold different expectations for themselves as professionals and for their students as learners. For these reasons, we believe that these three case studies tell a realistically complex story about the Keystone Science Network. They help to provide "systemic understanding of patterns of practice in classrooms where teachers are trying to enact reform." (Thompson & Zeuli, 1999). Thumbnail sketches of the teachers follow:

1. Alice Dressler, a first grade teacher in a suburban school district who has more than a decade of teaching experience, attended her first KSN Institute in 2001 and returned to her classroom ready to embrace a new pedagogical framework in its entirety. Over the course of the school year, she made shifts in her classroom practice that, on the surface, appeared simple, but, in fact, represented a transformation in how she taught and her students learned science. Alice gave an articulate account of her learning process and the catalytic role that the KSN Summer Institute played. A leader in science and technology prior to attending the summer institute, Alice was grateful for the KSN resources she now had at her fingertips to support colleagues. She was also eager to engage her colleagues in inquiry science.
2. Ruben Knight, a fourth grade teacher in a rural school district, began teaching in Fall 1999 and attended the first KSN Summer Institute. His teacher training program had already introduced him to "hands-on"/"minds-on" science instruction and he came to KSN a facile user of technology. He attended many KSN events and relied heavily on the Curricular Companions to orient him and his students to new science topics. Students in Ruben's classroom work

2 Pseudonyms are used for all teachers, schools,and districts in this report.

3 See TABLE XVII: Research Cohort's Degree and Kind of Involvement with KSN.

4 See TABLES XXI-XXV

easily together on kit activities and talk readily about what they are doing. As a committed and confident new teacher, Ruben was immediately tapped for leadership on school and district committees where he has promoted KSN online resources as a strong boost to district priorities.

3. Marsha Overby has been teaching for twenty years in a mid-sized urban district that has recently undertaken ambitious educational reform. She attended the Summer Institute in 2001. Marsha feels the press for change and is daunted by all that is being asked of her. She views her participation in the KSN Summer Institute as very helpful in grounding her in how to use the kits mandated by her district and as an introduction to an inquiry approach. She is reluctant to undertake inquiry at this point because of the stress she feels to prepare students for standardized tests. She has availed herself of the help offered by district science leaders who were trained by KSN.

To construct case studies of these teachers, we drew from multiple data sources: observations in the teachers' classrooms, multiple interviews of the teachers, artifacts collected in their classrooms, online reflections written by the teachers and by Franklin Institute staff members who made visits to their classrooms, and interviews of other staff members in their schools and districts. Our goal was to discover the factors influencing their instructional practices. And so, before a classroom observation, we asked teachers to tell us about their planning for the lesson. In addition, we asked teachers to reflect on the lesson's success immediately afterward and probed for next steps and assessment strategies. At a later time, we conducted hour-long semi-structured interviews covering a range of topics specific to KSN's vision (use of online resources, teacher leadership, professional community, inquiry science, kit use) and to district and school context. These interviews also allowed us to listen to teachers discuss aspects of their practice that we did not see during the lesson(s) we observed.

Case Study 1 :
Learning Inquiry, Teaching Inquiry: A Case Study of Alice Dressler

Alice Dressler is a first grade teacher at Washington Elementary School in the Eastern School District. This past year was her first as a participant in the Keystone Science Network. Alice is a self-described lover of technology and science, and since beginning KSN, a passionate practitioner of and advocate for using science kits to do inquiry. Her commitment to inquiry came after a revelation during the 2001 summer institute. "Because we went through the inquiry process ourselves, I really understood how different it was from what I did in my classroom where I had started to use science kits a couple of years ago and what we did was hands-on, but not inquiry." After that institute, she significantly increased the time she and her students spend on science (five hours per week this year as compared to three last year) and she systematically shifted her instructional practice from merely asking students to "*do* science" to facilitating their undertaking authentic inquiry investigations.

Alice's operates in a generally science-friendly environment. Her district has taken numerous steps to create a network of teachers well versed in the use of science kits and moving towards inquiry. It has a science committee composed of teachers who oversaw the selection of kits and their staged dissemination. Many of the teachers on this committee are KSN teachers. The district also designates "Science Fellows" and asks these teachers to conduct workshops in schools across the district. The KSN website has become well known as KSN teachers who are also Science Fellows highlight it in the training sessions they conduct. Alice is a Science Fellow and has been on the Science Committee and the Technology Committee. In these roles she has had additional contact with other KSN teachers who are not in her school. These encounters reinforce her ideas about science instruction and her ties to KSN.

Inquiry, as Alice describes it, is a powerful "approach to learning where student discover things with some guidance, but more of their own choice." In order to incorporate inquiry into her classroom, Alice saw that her students would have to learn new ways of being in school—new assumptions and expectations for their role and their teacher's role. Alice as teacher wouldn't be completely defining the specific work that students would do. She wouldn't possess the "right answer." Though her students were just first graders, Alice decided that she would need to build up to true student-driven investigations—like the one she and her fellow KSN teachers had conducted at the summer institute—because her students would be unfamiliar with the new modes of learning she would be asking of them. She also felt that science instruction in first grade needed to emphasize learning science process skills.

Taking all of this into account, Alice decided that she would work gradually throughout the year using the three kits she teaches—FOSS's "Air and Weather" and "Solids and Liquids" and STC's "Organisms"—to move students towards authentic inquiry. She decided to end the year with "Organisms" and use the kit materials to let her students investigate aspects that interested them. She began the year with "Air and Weather," giving students guidance on the choice of activities and helping to build their skills in measuring, observing, recording, and drawing. In the second unit—"Solids and Liquids"—Alice began to give students significant decision-making power. We visited Alice's classroom twice during her use of this kit, once near the beginning and once near the end. We offer next a close look at one of the lessons we observed which illustrates how Alice's teaching was influenced by her experiences with KSN.

The Lesson: How different liquids react when water is added and when the mixture is shaken

The lesson we observed was very simple in structure:

- Step One: pour water into liquid, observe what happens, record observations, and report to the class;
- Step Two: shake up liquid and water mixture , observe what happens, and report to class.

These steps allowed students to engage in a range of science process skills. In addition, Alice asked students to make sense of their observations, develop hypotheses, and discuss and represent their learning in ways that required the use of specific, detailed language.

Since Alice wanted to give her students a chance to work with materials they found interesting; she asked students to bring in any liquids from home for their tests. Among the liquids the students brought in were fabric softener, molasses, ranch dressing, honey, dishwashing detergent, grape soda, orange juice, and mineral oil.

As students began the day's lesson, Alice instructed them to pour water into their liquid and write down what they observed. "You might see things happening as you pour the water in," she told her class. "You need to draw pictures and write down what happened—while you pour it in, after you pour it in, and then a while after you pour it in." She told partners to work together to help each other pour and observe. Stressing the skills of observation and recording, she reminded students, "some of your liquids might change and some might not, but just because nothing happens doesn't mean you failed or you have a boring liquid, it just means we know something about that liquid."

Students "ohhed" and "ahhed" as they poured water in their liquids. Students had three or four minutes to pour and then record what happened. Alice then called the class back together and asked students to report on which liquids mixed with the water and which did not. Students eagerly called out answers and observations. Many leaned across tables to show their classmates their mixtures. After a brief discussion about which liquids mixed and which did not, Alice asked students to predict which substances will change when they shake them up. "Just predict," she said, "we don't know yet. Remember we're just predicting." A few students whose liquids had mixed well with water predicted that their mixture wouldn't change much. "It might get bubbly, but that's just because I shake it hard," one student said. Another student said, "I think the water will go up the sides of the bottle and go on top and make bubbles."

As students shook their liquid/water mixtures, they again "oohed" and "ahhed." They called out, "look!" to their classmates and showed them their mixtures. "Mine mixes up and separates again really fast when you stop shaking," one said. Another told her table, "Nothing's different—it's still blue and there aren't even any bubbles really." Still another student wondered, "Maybe the honey is too thick to shake up?" A few, unprompted, opened their bottles and felt their mixtures.

Again, Alice called the class back together after about five minutes and asked them to report what they saw. A few students whose liquids were some kind of oil said that their mixture separated quickly after shaking. A lot of students focus on the bubbles—how bubbly their mixture got, where in their mixture they observed bubbles (only on top, throughout the mixture), how long the bubbles remained, how bubbles dissipated from large ones to small ones as the mixture settled. Though Alice had begun this section of the class discussion attempting to have students compare the differences in how oils and non-oils reacted when mixed with water, she embraced the excitement and focus on bubbles and asked her students, "So where did we get the bubbles? Spend a few minutes in your group talking about it."

Students immediately began discussing their theories at their tables. "I think it comes from shaking it hard," one said. "Yeah, but what are the bubbles made of and how come they go away so fast?" a student responded. Another said, "And how come I didn't get any bubbles? Maybe it's because my liquid is too thick or something." One girl hypothesized that the bubbles are air that gets underneath the liquid. She held her bottle and showed her table. "See, when you start there's room on top and then when you shake it the liquid goes up there really fast and the air goes underneath." Her tablemates nodded.

The lesson wound down with a brief session where students shared the discussions at their tables with the whole group. Time was short, but Alice asked for a couple of students to share their ideas. The girl who had explained the displacement of air to her peers enthusiastically raised her hand, "Can I say something I noticed? When I shook my molasses, the bubbles were big and then they got smaller when the big ones went away. I think it's because the air gets trapped underneath the liquid and then it moves to the top in a bubble and then escapes at the top so the bubble pops." Another student yelled out, "Air bubbles!" Alice said, "That's an excellent observation and maybe you can find out more about that the next time you use the Internet." Alice ended the lesson by telling students, "Tomorrow we'll talk about other things we noticed when we added water and shook our liquids up and we'll see if we can start figuring out how some of our liquids are alike and some are different."

Reflections on the Lesson

During the course of this one lesson, Alice's students:

Investigated materials that interested them personally;

Observed, recorded, drew pictures, predicted, reported their observations, discussed their findings with their peers, drew conclusions from their observations, and, at least some, hypothesized reasoned explanations for what they observed;

Were given time to explore aspects of the experiment that interested them.

Overall, the lesson was simple, yet rich. By accomplishing ostensibly simple tasks, primarily noticing things, some of Alice's students were able to arrive at complex interpretations of phenomena. Those that didn't reach that point were still fully engaged observers and were excited about trying to understand the phenomena they observed.

Alice's Reflections on Her Instructional Practice

Alice acknowledged that she had thought the pedagogical benefits of science kits were their "hands-on" quality and that her science teaching prior to KSN, even with kits, was not "really inquiry based." Upon realizing this due to her experience as an inquiry learner, she changed her practice: "I had to let lose of my control and had to design experiments to accommodate time for students to explore their interests." Her goal for science during her first year after KSN was "to see what students could learn from observing and spending time not just filling out a paper, but thinking on their own." She said she enjoys teaching science more because of inquiry—her students "are more into science" and their parents notice. She described her shift in teaching leading to "more 'aha' moments for students—they're not learning what they expect to learn, from the teacher, but what they learn on their own." Alice worked hard to get her students comfortable with the process of "saying anything they notice" and then "working towards figuring out what it means."

Alice asked her students to represent their knowledge by "presenting, talking, keeping a running record of what's going on; they also made charts, drew pictures." As Alice began to change the culture of her classroom towards inquiry, she asked students to keep a list of questions that arose during their work with kits. Before moving to fully student-driven investigations in her final science unit on insects, Alice's students were able to use time during indoor recess and "stations"—where they moved to different areas around the room, reading in one area, writing in another, and so on—to consult the Internet to find answers to their questions, to, as they called it, "do their 'Inquiry,' a term that became a regularly used noun in her classroom. In addition to focused searches for information, Alice has her students using the five networked computers in her classroom frequently, letting them use "sites and links for students from the [KSN] website" that relate to kit topics. She explained that because her instruction is inquiry oriented her students are eager to conduct research and this has naturally taken them to the Internet. Having the resources that are part of Curricular Companions has been a wonderful support to connecting students to good material on the Internet.

Ultimately, Alice said she considers the following three things to be indicative of how her students are learning: (1) "when students have more questions it shows they're making connections," (2) "when they can try and explain why they think something is happening," and (3) "when they can find ways to test something." She assessed students by keeping what she called a "kid-watching chart" where she "writes what students said and did," and by looking at their science journals.

Influences on Alice's Teaching

Alice availed herself of resources from KSN, her colleagues, and kit publishers. She praised effusively the summer institute and the dramatic change it caused in her teaching: "Most important, it changed the way I teach science. It helped me to teach using the inquiry method rather than just covering the material." Alice said that she starts getting ready to teach a kit or unit by reading the kit manufacturers' manuals and checking the KSN website. "One of the first things I do before teaching a kit is to look at the Kit and Curricular Companions to see if there's new information or new websites out there."

Prior to beginning KSN, she attended workshops given by her colleagues already in KSN about their experiences at the summer institutes. Alice also received training from FOSS and thought highly of the manuals from STC and FOSS, which, she said, "are great and have a lot of what you need right there if you just read them."

Alice's Influences on Others

Alice is a member of her school's science committee, which has met to discuss "how to move more teachers to use kits" and "decided to do more activities, like summer workshops." Most recently, the committee met to "match science assessments to the Pennsylvania State Standards and to make sure that what students do in science in grades one through three leads up to the state test in fourth grade." In an attempt to push teachers to become more comfortable with the Internet, Alice and her colleagues on the science committee required teachers to use a website to sign up for mandatory summer professional development. Science committee members lead professional development workshops at the school. Alice wished the workshops she leads could provide teachers with the kind of experience she had as an inquiry learner in the KSN summer institute, but because of a lack of time, she could only present "the methods of inquiry."

In her role as a member of the school technology committee, Alice trained each grade level representative about the KSN website, "and then they go back and share it with their grade level." She also updated the committee about new links on the KSN site. A new Kit and Curricular Companion, Alice said, "was something I always told my committee members about. I would check which grades taught kits related to new topics on the website and stress to the teachers from those grade levels that they had all this new, organized information to use for lesson planning and background information and with their kids." Teachers at Alice's school have a lot of opportunity to access the Internet both for themselves and with their students and Alice, like all KSN participants at Washington(six in all), consistently and frequently reminded teachers of KSN online resources.

Alice has provided support and resources to her colleagues not only as a member of committees, but in non-formal ways. She and her colleagues "share at lunch, talk about what worked and what didn't." The conversations are often, she said, about specific, procedural issues like, "My beetles are floating!," and Alice willingly gives advice, often pointing teachers to the manuals. She also works actively to explain to her fellow teachers and her principal the distinction between inquiry and hands-on science, inviting visitors to observe her classroom and reflecting on which lessons best lend themselves to inquiry. Alice said she hopes she is influencing other teachers to be "more aware of the need to do the entire kit" and, more generally, to build on students' "natural inquisitiveness."

Alice is not only an advocate in non-formal settings for inquiry, but for the use of technology as well. She described herself as "always talking about the web as a resource for teaching, trying to push teachers to use it with their kids," particularly, she said, KSN's website. One of Alice's goals as an advocate for both science reform and a full embrace of the Internet was to make sure all of her colleagues knew about the wealth of resources on the KSN website. Her promotion of technology use has manifested itself through innovative practices like this one she used to expose Internet-reluctant teachers to good resources: "Sometimes I'll go to a teacher's computer, with her permission, and set it to a new homepage so I can get them on a new site." Her colleagues were grateful for Alice's facilitation of their exposure to KSN's website: "Science is sometimes overwhelming for teachers, particularly these kits, so they really appreciated the [KSN] website when I told them about it. When teachers had questions about specific kits or science content more generally, Alice told them, "Go to the KSN website I showed you and check there."

Summary and Implications

Alice's instructional practice, her use of KSN resources, and her willingness to be a leader in both formal and non-formal ways are all exemplary. In just one year of teaching she was able to bring into her classroom practice the revelation about inquiry she herself experienced first-hand during the summer institute she attended.

What, then, are the lessons to take from Alice Dressler?

Like nearly all teachers we observed whose students engaged in the higher-order process skills of interpreting evidence, drawing conclusions, and creating hypotheses, Alice's students also practiced a wide range of process skills in the course of a lesson. Alice's instructional practice makes the case strongly that the "big ideas" of doing inquiry—i.e., students designing investigations and exploring their interests so that the knowledge they build in science is meaningful to them—can co-exist seamlessly with the more "nitty-gritty" aspects of doing scientific experiments, like recording observations and categorizing.

Alice's shift in classroom practice from only a "hands-on" use of kits to authentic inquiry came about because she saw the power of grappling with an investigation. While her experience as an inquiry learner was enjoyable and significant for Alice in and of itself, it was the challenge of applying the new knowledge for her students' learning that truly excited and motivated Alice: (a) to do the hard work she did this year in changing her instructional practice, and (b) to take the risks associated with opening up her classroom to inquiry. Like many teachers we spoke with and observed at institutes and colloquia, Alice's excitement about the ideas she learned in KSN was consistently filtered through the lens of what her students would gain. In short, Alice's initial imperative for changing her practice and her continued excitement about and commitment to inquiry can both be attributed to her consideration of how her students will benefit.

Though Alice was clearly an exemplary teacher and worked diligently prior to KSN to both (a) provide her students with excellent science instruction and (b) consult Internet resources to increase her knowledge of science content and aid her instruction, KSN fundamentally changed her practice. After Alice's epiphany about inquiry at the summer institute, the Internet resources provided by KSN facilitated her in sustaining that excitement. As she worked to created an ethos of inquiry—of ongoing and constant investigation by her students—she consulted the Internet and *KSN Weekly* frequently to bolster her science knowledge and learn from other teachers' experiences. She also saw the implications of the Internet resources for her students in the climate of inquiry she was able to create in her classroom. Her students made a daily or weekly habit of using the resources linked to on KSN's website to follow up on questions that arose for them during science. Overall, KSN's web resources allowed Alice to provide more individualized support for each of her students, not only by letting them research their own questions, but by directing students who may have finished class work early to specific websites KSN linked to in the Kids Web Classroom section of the relevant Kit and Curricular Companion.

Alice's experience with KSN came during its third year, which focused on inquiry and ways in which kits and kit-lessons might be adapted to include elements of inquiry. Her approach of working gradually towards building inquiry into her classroom practice throughout the school year is a compelling model and KSN may want to consider formalizing explicit instruction to other teachers in how to go about this process.

Alice took on both formal and non-formal leadership roles in science instruction and technology use at the school and district levels, doing everything from teaching summer workshops to sitting with colleagues and showing them useful websites. KSN should consider using teachers like Alice as resources to discuss their "toolkit" of leadership resources and strategies. Though she clearly has the advantage of working in a supportive district, where teacher professionalism is validated and promoted, Alice and teacher leaders like her have a lot to teach their colleagues in all settings about the best ways to serve as a voice for science and technology reform.

Case Study II: Teaching Science Kits, Working Towards Inquiry: A Case Study of Ruben Knight

Ruben Knight is a fourth grade teacher in a rural school district in Southeastern Pennsylvania who began teaching in Fall 1999. He's a young, business-like, confident teacher experienced with technology and committed to helping his students learn science in an active, engaged manner. He sees his role as "a monitor or a guide" and inquiry as "another tool to teach kids" that "cannot be done one hundred percent of the time."

Ruben works in a district that has made improvement of science instruction and teacher and student facility with technology high priorities, even though a high stakes state environment is pressing educators to show gains in the tested areas of reading, writing, and math. The Director of Elementary Education explained why the district had "jumped on" the opportunity to be a part of KSN. When the KSN application arrived, the district was just completing an intensive, multi-year strategic planning process which resulted in decisions to 1) "throw out our science textbook series" and adopt science curricular kits as a vehicle for standards-based science reform and 2) implement a six-year technology plan that would put several computers with an Internet connection in every classroom. KSN was an ideal support for these priorities and an impetus to speed up both dissemination of kits and technology. Implementation of science kits across the district was underway when Ruben and his colleagues attended the first KSN Summer Institute.

Teacher committees are a common practice in the district. A committee of teachers piloted and then selected the kits the district ultimately adopted. And even though he was a brand new teacher, Ruben joined the science committee and within a year shared co-chair status with a high school teacher. The committee is engaged in revising the K-12 science curriculum to align it more closely with national and state standards. This process has further immersed Ruben in thinking about science reform.

As a fourth grade teacher, Ruben is required to teach STC's "Motion and Design" and "Electricity" kits, and, optionally, STC's "Land and Water," which he has chosen to do during the three years he was a part of KSN. Our two observations of Ruben took place during the first and second years of KSN; one lesson we saw came from the "Motion and Design" kit (year one) and one from the Electricity kit (year two). Unlike many of the lessons by other teachers which we saw, Ruben's lessons were centered more on building something than on doing an experiment, perhaps because of the content of the kits.

As a young teacher, Ruben's training during his certification program was much in line with the pedagogical, curricular, and technological foundations of KSN. Use of the Internet and collaboration with other teachers were part of his training. He was also exposed to inquiry, kits, and the idea of teacher-as-facilitator during his coursework and student teaching. Because of the nature of Ruben's professional training, KSN's approach lacks the kind of novelty it has for many older teachers coming to KSN with years of experience using textbooks and not much else for science teaching. KSN comes quite naturally to Ruben. In this case study we will look closely at one of Ruben's lessons and examine the ways in which KSN influenced elements of the lesson. We will also discuss Ruben's role within his school, district, and KSN, and raise questions about Ruben's practice as it relates to inquiry. Lastly, we will look at Ruben's approach to collaborating with his colleagues and discuss implications for KSN.

The Lesson: Understanding how flashlights work

Ruben Knight's classroom was neat and orderly—students quietly listened to morning announcement and cited the school pledge. Immediately afterward, Ruben explained to his students their agenda for the morning, pointing to instructions on the board and telling them, "Today you'll finish your flashlight and test it, then make a circuit diagram of the final product, and then do a switch scavenger hunt in the classroom, listing every switch you find. When everyone is finished with their flashlights, we'll present those to the class and talk about the challenges you faced." Students were engaged and enthusiastic, leaping up to gather their science materials and begin working. Students were to work with partners, from drawings—blueprints of how to make their flashlight—but few did. Many told Ruben, "I know what to do."

As the students worked diligently putting the pieces of their flashlights together, Ruben walked around the room with a clipboard, using a checklist provided by STC to observe the students' activities. As some students finished their flashlights, they moved on to helping other students construct theirs. Many of the students whose flashlights took longer spent time decorating them with magic markers. Near the end of the half hour that students were given, some flashlights were done and working perfectly, some worked more sporadically—switching on and off due to loose connections—and some were far from finished. Some students had begun to make their circuit diagrams, but none had set out on the scavenger hunt.

Ruben called the class back together after the half hour and asked that all students stop working, put all their things down, and prepare to present the status of their flashlight. Not all groups were done with the task, and Ruben decided to begin the presentations with those whose flashlights were working well. The first pair to present, two boys, told the class that they "have to find a way to have the bulb keep touching the battery. It keeps slipping." Ruben asked the pair and then the class, "Any ideas?" A classmate suggested that the boys tape on the battery and another suggested that they use a battery holder. The boys said, "We've tried both of those things and they don't help." Another students suggested that they "make another one," to which the boys said, "It works sometimes; we don't want to start over." Ruben ended the pair's presentation and said, "They gave you some ideas; you'll have to decide what to do."

The next pair—two girls with a completed battery—reported, "We have a battery clip inside to hold the batteries tight and our switch works; we used two brads with a paper clip to complete the circuit." Ruben was impressed. "So you solved the problem of the battery moving…" One other pair reported on their finished product and their use of a brass screw to complete their circuit.

The remainder of the pairs all described works in progress. One student reported, "We still need to make a switch. We tried two and then three batteries but for some reason it's not lighting. I guess one of the batteries isn't touching or a battery disconnected or something." Ruben asked him, " Why do you have those sticks at the bottom of the flashlight?" The student responded, "It's for two things; it holds the batteries in but it's also a handle for holding the flashlight." The next pair to present had success in getting their bulb to light, but had not made a switch yet. Another pair discussed their progress and reported that they thought one of their batteries was dead. Ruben asked the students, "How could we test that?" The students threw out ideas, including putting the assumed-dead battery in someone's flashlight that works to see if the problem is indeed the battery. As the discussion wound down, a student loudly slapped his desk, and said, "Look, every time I hit the desk, the light turns on for a bit." Ruben joked "like the Clapper," showing his first smile of the morning. The students ask if they'll be able to keep working on their flashlights and are pleased when Ruben says they will do so tomorrow.

Reflections on the Lesson

During the course of this lesson, Ruben's students:

- Worked hands-on with basic electrical materials to build a finished product, using whatever additional materials they desired;
- Were given the freedom to experiment with different approaches to achieving a common goal— making a flashlight light;
- Discussed their process and challenges and offered suggestions to each other, both while building the flashlights and in the whole-class discussion afterward.

The lesson built on previous lessons where students learned about circuits and drew up plans for their flashlight. Unfortunately, few used their drawings and only some student's flashlights worked, which might mean that only certain students gained an understanding of circuitry through the previous lessons. Ruben's instructional approach clearly showed that he valued students discovering things on their own and students helping other students. The discussion at the end of the lesson was perhaps indicative of a classroom culture where mistakes are valued and where science activities are given additional class time if necessary.

Ruben's Reflections on His Instructional Practice

Ruben described himself as "a professional" who "make[s] decisions about what to do based on what I think I need to do to build student knowledge." Inquiry fits into that context and may not always be the best "tool" to use in his classroom. He defined the "tool" of inquiry as "students deriving the answers by their own methods." His saw his role as "not giving [students] the answer, but guiding them to understand for themselves," trying, as he put it to "make sure I provide help, but not too much help." His explained that his students do indeed like science. "Most kids are into this kind of work (more on their own). They are always asking me about science and when they get to do it." He is required by his district to teach science kits, and did so by and large happily. He described himself as "mostly comfortable" teaching kits, and clarified that it wasn't the concepts that he had problems with so much as time management. Pressure to "achieve [district- and school-mandated]objectives," may, he said, entail "some direct teaching if I have to."

Ruben learned a lot about computers and the Internet in college and described using the Internet both to ready himself for lessons and to allow his students to find out more about the content of science lessons. He also said he looks for websites that would be "interesting for students" and "will let them follow up on these sites if they are interested."

Ruben said that "performance assessment" is the main way he assessed his students (as opposed to testing). For him, the term "performance assessment" took on two connotations: (1) assessing performance on a daily basis during science "using a checklist—keeping track of how well students stay on task, the quality of the work they're doing"; and (2) "carrying out real-life-type tasks that use what [students] have discovered or been taught." He said he tries to "teach and assess kids using different modalities."

Influences on Ruben's Instructional Practices

Ruben was one of KSN's most involved teachers, both within KSN—he was a regular and frequent participant in colloquia—and in his district and school, where he worked with other teachers in largely formal ways on science curriculum. Overall, Ruben expected to be engaged in collaboration with his colleagues, be they his grade-level peers at his school or teachers at the district level interested in science. Ruben's professionalism made him open not only to working with others, but also to learning from professional development and colleagues. "Others give me good ideas and I do the same for them." That being said, he did not describe himself as, nor did we observe him to be, a teacher who is in frequent non-formal collaboration with other teachers. He did not, for example, exchange email with colleagues in KSN and said he did not see an imperative to do so, because, as he said, "I already have people to talk to in my district about what I teach."

KSN and other kit-specific professional development built on Ruben's recent training in his teacher certification program. His process for getting comfortable with teaching science kits, he said, was undertaken "mostly on my own—reading the manual and using the Internet." He said he went to "a brief in-service when the kit was piloted" and that KSN "in-services were good and helped me." He regularly checked the Kit and Curricular Companions when teaching kits for the first or second time to gain confidence in the science content. Beyond the science kit manuals, the Internet was the main source of Ruben's background on science content. "I don't read many journals—I get information from websites like Keystone's and the How Stuff Works site."

Ruben's Influence on Others

Ruben's overall professionalism and his interest in science and technology had already been capitalized on by his second year of teaching. He served on and co-chaired a district science committee, which he said "is the main way I collaborate with colleagues." He also worked a lot with other teachers at his school, sharing ideas and writing grant applications. He said school and district administrators "often come to me about science and technology stuff because of my passion and interest in these things." Ruben also opened his classroom to two Site Visits by KSN staff, and write-ups of both were posted on the KSN website.

Summary and Implications

In many ways, Ruben was the kind of teacher KSN had in mind when they first proposed the project. He is an elementary school teacher who loves and is comfortable with science and technology. He works with other teachers in making decisions about science curriculum and sharing ideas. His district supports and capitalizes on his interests and he willingly serves in formal leadership positions. Ruben demonstrated his belief in the relevance of KSN to his teaching, as he was a frequent participant at colloquia and a regular user of the Kit and Curricular Companions. Our observations made clear that he taught science with a commitment to science kits, to students discovering things on their own, and to going deep into hands-on science. How then might KSN push a teacher like Ruben to continue to improve his instructional practice, his use of technology, and his leadership role(s)?

1. The quality of Ruben's instructional practice could be furthered by varying the range of student work and communication during science. His students spent a lot of time discussing procedures and their experiences and issues with procedures. KSN colloquia did an excellent job, particularly during year three, of explicitly discussing ways that teachers can use well-defined, prescribed science kit lessons and adapt aspects of the lesson for greater student input, moving them towards inquiry (e.g., asking students to make decisions about how to record data rather than providing them with a handout). Concrete suggestions such as these build on Ruben's commitment to kits and good science teaching.
2. Ruben's contexts for collaboration were largely formal and almost exclusively within-district. KSN proved to Ruben and his district to be worth his making a long trip and staying overnight for five colloquia, yet Ruben did not find the online peer forums a compelling way to engage with his cross-network colleagues. Changes in the website and in the ways teachers are invited to participate in the online forums are likely necessary to engage teachers like Ruben.
3. Ruben clearly felt comfortable in leadership positions and in professional communication with his colleagues. He did not, however, appear to serve as a leader in non-formal ways like talking to colleagues during lunch or promoting KSN's web resources. If creating teacher leaders is to be a central goal of future KSN work, KSN should consider ways to train teachers in a full range of leadership roles.
4. KSN and the contexts for leadership that his district provided combined to give Ruben powerful on going development of his knowledge of science and teaching science. Because of his comfort with the Internet, Ruben frequently used KSN web resources to learn more about kits before beginning one and turned to the web resources in the midst of kit units to help him better facilitate his students' learning. Ruben also gained knowledge and confidence in teaching science through his frequent attendance at face-to-face professional development which took place at the Franklin Institute. He enthusiastically explored the museum and brought new ideas back to his classroom after each visit. Lastly, Ruben's role on the science committee—a body working on aligning science content with Standards—allowed Ruben to develop and refine his understand of the bigger, longitudinal picture of what students must learn in each grade level in science. As a science committee member he was repeatedly asked to take somewhat abstract Standards and define which kits, lessons, and student work fulfilled each Standard.

Case Study III:
Beginning Science Kits, Beginning Inquiry: A Case Study of Marsha Overby

Marsha Overby teaches third grade at Garfield Elementary School in the Western School District, a medium-sized urban school district in Pennsylvania. She is a veteran teacher who has taught in the district for twenty years. Because it is a relatively small district, Western has been able to make sweeping changes at the district level that affect all teachers. Implementing the use of science kits has been one such reform. The Western District chose to introduce its reform in science in a highly-structured manner, through promoting a few classroom teachers to district-wide positions as science curriculum specialists. These specialists then worked with teachers at the elementary schools, each of which had a designated teacher-leader in science kit use.

Marsha, unlike the other two case study teachers in our report, was not a designated leader in science curriculum nor a member of her school's technology "vanguard." We have started Marsha's story with background on her district's context because it is so central to understanding her and teachers like her. This case study asks, "How did involvement with KSN influence and change the instructional practice of, for lack of a better term, an experienced and committed teacher who felt pressed to change her practice and was uncertain about those changes.

Marsha—who had never taught science kits previously—began KSN in Year Three of the project . Prior to her participation in KSN, Marsha worried that science kits were "play-time." The time she spent at the initial summer institute convinced her that kits are a "legitimate science activity."

Overall, however, Marsha had concerns about introducing inquiry in her classroom for two reasons: (1) she saw it as in conflict with her district's mandate to teach (and test on) a six-step scientific method approach; and (2) she doubted her students' ability to get a lot out of the inquiry given that, "with no language-skills, no background in scientific vocabulary, it's hard to describe something, like the properties of an item." Marsha set forth a question many teachers new to inquiry have: "I really don't know how it practically works. I understand the theory behind it, but the practicality of it, I wonder…" As we will see, however, Marsha and her students were perhaps further along than she realized in implementing science instruction that gives her students an opportunity to make sense of science concepts by *doing* science. We examine the ways in which KSN has impacted Marsha—directly through her involvement with face-to-face professional development and more indirectly through KSN's support of and influence on her colleagues and leaders in her district. We also ask how future KSN work could help Marsha to increasingly open up her classroom to inquiry.

The Lesson: Creating Habitats for Crayfish

RFA observed Marsha twice during the Spring semester of 2002, i.e., near the end of her first year of involvement in KSN. We observed her teaching lessons with the very first and second kits she had ever used. The lesson we describe here—about the habitat of crayfish—comes from her second kit, Insights' "Living Things." This lesson built on work the class had done previously—observing crayfish and drawing pictures with text or describing what they had learned about crayfish, e.g., "I learned that crayfish can walk with their pinchers and walker legs," or, "They go through various colors as they grow." Marsha explained the habitat lesson to her students by saying, "We will experiment today and ask the right questions to figure out, 'What kind of house does a crayfish like the best?'"

Before moving to the design and creation of the habitats, Marsha began the lesson by asking her students to recall the observations they had made in previous lessons about crayfish. Students reported both general observations about crayfish—i.e., color, size, that they have pinchers—and more specific observations of the two crayfish living in their classroom: "One likes to fight a lot," "One is missing a leg." Marsha encouraged the students to think of ways to note these differences between the two and said, "If one is very different than the other, you can mark it." She then led the class in a discussion of what would be the most effective ways to mark and differentiate the crayfish. Students argued against using tape or rubber bands because, "Tape is not good because it may lose stickiness under water," and, "A rubber band might hurt or be uncomfortable for the crayfish." The class decided that small labels affixed to the crayfishes' shells would be best.

After this discussion, Marsha presented three options she has provided for the habitats: (1) small cardboard boxes with open entrances, (2) glass cylinders, and (3) mugs. She told the class, "We will choose two types of habitat and see which the crayfish like the best." The habitats were to be placed in one large glass tank. She referred to the crayfishes' current habitat, a small rectangular plastic case, and reminded the students, "Right now they're living in this, with the rocks you had the idea to put in and that you collected." The class then discussed the pros and cons of each habitat, noting things like, "Glass houses would be bad because they might break," "A glass house might be good because we could see them," "The mugs would be good because they can't be broken and they are dark in the back," "The cardboard box would be good because they can sleep and hide, except it might get soggy and fall down when it gets wet," and, "The ink from the cardboard might spread into the water and hurt the crayfish."

After this discussion, Marsha led the class in a vote. The children chose the mugs (most votes) and cardboard boxes (second most). Before they set up the habitats, Marsha asked the class to brainstorm ways to hold the mugs and boxes in place to prevent floating. Students decided to weigh down the cardboard with rocks in one corner of the tank and the mugs with erasers in the other.

Marsha asked for a few students to begin setting up the environment. The rest of the class was told to start writing a story about crayfish and draw a picture of the habitat. Marsha had the first student volunteers come to the front of the class and begin the process —moving the large glass tank to the center of the room, filling it with water, setting the habitats in, putting rocks and erasers in the tank. She had students rotate in groups of two or three, conducting one or part of one of these tasks while the others worked on their stories and drawings. Near the end of the lesson, two students moved the crayfish from their small boxes to their new home. The students finished their seat-work and the lesson ended with the two students nearest the tank reporting on the crayfish: "One is moving around and walking; the other is hiding under the mug."

Reflections on the Lesson

This lesson included some authentic aspects of students designing their own investigations:

- Students chose—from the options the teacher presented—the habitats in which to observe the crayfishes' behavior;

- Students were asked to give reasoned explanations for choosing one option over another;

- Marsha was very explicit with her students that they could make decisions about the set-up of the experiment. She frequently pointed out that she was not telling them the answers, just recording what they said.

However, students did not appear to understand the goal of creating the habitat. Was it to give the crayfish an ideal environment? Was it to allow the students to see the crayfishes' every move? The discussion mostly focused on the logistics of designing and setting up the habitat, and there was little attention given to the goals of the activities.

The lesson also had aspects of interdisciplinary and process skills, as students wrote stories and drew pictures of the crayfish habitat. Students' degree of engagement in these activities varied, with many students writing very little and focusing more on the tasks of the habitat creation.

Marsha ran a tight ship and, while each and every student got to work hands-on with crayfish habitats, they did so in brief and isolated ways, i.e., working for a few minutes with one aspect of the habitat design and set-up. Whether the limited role students had in actually *doing* science was due to lack of materials (two of the original six crayfish had died, two were "missing") or Marsha's sense that too many students with their "hands-on" building habitats at once would be chaotic, it might have been more effective both pedagogically and in terms of classroom management to have all students engaged during this lesson solely in building habitats and reflecting on their work.

Marsha's Reflections on her Instructional Practice

We observed Marsha—brand-new to teaching science kits—in an overall context of significant and wide-reaching district-imposed changes in her instructional practices. Though it has clearly been stressful for her to approach all aspects of her curriculum in new ways and in a higher-stakes environment, she does see science kits as a significant improvement in curricular materials. After finishing one kit and beginning her second, she described herself as "getting comfortable with kits." While Marsha felt like she needed and received a lot of support in implementing a new science curriculum, when it came to teaching the individual kits themselves, she described herself as comfortable on her own: "Kits are pretty much self-explanatory, and we have materials that come with kits and you can read that."

Though she sees a focus on inquiry as "giving kids a lot more science than we did before," Marsha didn't think her classroom was yet a promising context for inquiry because, "Kids have no prior knowledge to build on and we don't have endless time for science because of the district focus on literacy and math, so you can't be completely open." In our observations, we also noted Marsha's apparent ambivalence about opening her classroom up to less orderly or less rigidly structured time for students.

Since the school year started, she said she had not had much opportunity or time to learn about inquiry methods or to use KSN resources. Marsha called the work her students did with kits "guided discovery," in that they were not truly on their own to discover whatever they wanted but were instead to discover things that she (and the kits) set as goals for their learning. That being said, Marsha did see her ability to teach inquiry effectively as a work-in-progress: "In terms of inquiry methods, it's been a great start for me. I would say it'll take a couple of years to build experience in these methods." At the point we observed her, Marsha felt that her students' new-found excitement about science was a central reason for her to commit to developing greater skill as an effective facilitator of inquiry.

Influences on Marsha's Teaching

The demands placed upon Marsha by her district dominated her discussions of all aspects of her job, in particular her instructional practices in science. The following statement was illustrative of the ways she consistently characterized her situation: "We are working on such a structural program [in science]—worse than ever. Everything has to be reported. We have to teach the six steps of the scientific method and there's an assessment on it in January and February."

For all of the difficulty and stress that Marsha articulated about district mandates and her school context—she wonders how much her principal focuses on science, given the importance placed on literacy and math assessments—she felt very positively about the district-level leadership in science instruction. She named a science lead teacher and a district-level curriculum specialist as instructional leaders in science and said they provide "one-hundred percent support for inquiry method—they do workshops all the time."

In addition to formal leaders in science, Marsha also felt the influence of teacher colleagues from previous cohorts of KSN. She appreciated the work that they did in "dealing with the logistics of kits, organizing them, and making them ready to be used." She said, "I am thankful that they are taking that role, because I certainly don't have time for that."

Marsha said that her experience at KSN's professional development (her initial summer institute being the only such event she attended) was, "great—we did really great work. They allowed us to inquire about inquiry." She praised the institute because it, as she said, "took the intimidation away from me." In addition to making inquiry more tangible and possible in her eyes, KSN gave her something that "never happens in a typical workshop": time to work with concepts and ideas and to prepare for the upcoming school year. Marsha said, "I find that [with most professional development] you never have time to explore, and [in KSN] we could constantly ask questions and we did. That part I liked the best. Now we don't have time to sit down with a computer and explore these things. We have too many other pressing things. So just having time to explore during the summer institute was great." The in-depth work at the institute also gave Marsha an accurate sense of the pace of *doing* science: "It made me realize how much time it really, legitimately takes. Going through the actual steps, it made me realize how much it would take." Lastly, Marsha enjoyed the connections she made with her colleagues at the institute.

Marsha left the institute with some questions about implementing kits and inquiry. She said that her "biggest question" remaining when she left the institute was, "When is the jumping-off point? When is the teacher ready to start using inquiry methods?" Marsha clearly understood KSN's focus on inquiry and "got" the pedagogical power and implications of inquiry, but did leave the institute wishing she had learned more about using kits themselves: "A lot of time was spent on developing a machinery rather than using kits. I'd wished for more time to actually use kits, because I had never done it."

The potential for KSN to exert continued influence on Marsha's instructional practice was limited by the fact that, as she put it, she "does not have the habit of using resources on-line." Though she had yet to develop this "habit," she did see the power of the Internet and very much appreciated KSN's instruction in web use: "The tech professional development was excellent because we spent time in computer lab with four or five excellent staff members circulating all the time—it was one of the best computer trainings I've ever attended." Her praise for the Internet ran high, both in terms of content resources and as a way for teachers to collaborate: "I know I have to use Internet resources to keep up on everything and it's the best way to link to other teachers and I hope to use it more."

Marsha's Influences on Others

Given the district's formal structures for leadership in science instruction, it was not surprising that Marsha did not regard herself as a leader per se. However, she did serve as a leader in non-formal ways: "I believe that sharing my experiences of using kits makes other teachers feel 'we can do this.'" She also saw herself as "leading by example" by, as she said, "impacting my students, getting them excited about science, which I think influences other teachers. My students excitedly talk about their science class; I'm pretty sure that encourages other teachers to use kits." Again, perhaps because of the entrenched hierarchy of leadership in the district, Marsha consistently downplayed herself as a leader while at the same time sharing her sense that she has helped other teachers to embrace and become comfortable with kits: "I think as people learn about what I am doing in my class, using crayfish and experimenting with them, they feel more at ease and it makes them more enthusiastic about science." Marsha attributed her self-perceived non-leadership role to her newness in using kits and the time it takes to deal with district demands for documenting student progress and preparing students for assessments.

Summary and Implications

Marsha presents a compelling and perhaps common case: an experienced teacher, new to science kits, an infrequent user of the Internet, and struggling with district-imposed pressures. She was clear in her understanding of the definition and scope of inquiry and clear that she had a ways to go in her own classroom in implementing inquiry. She felt it was too soon for her to introduce inquiry successfully, because of (a) her lack of experience with teaching it, (b) district demands for expanded literacy and math instruction, and (c) her students' language and, perhaps, behavioral issues.

1. Despite this sense of limitations, KSN had indeed helped Marsha—through minimal direct exposure to KSN resources—to:
    a. Understand inquiry and its power;
    b. Begin teaching science kits;
    c. Create a subsequent excitement about and interest in science in her students;
    d. Help other teachers to see new science curriculum as manageable and highly worthwhile;
    e. Gather some content and curricular resources from the Internet and see the power of—though not yet habitually use—the medium.
2. Marsha's case may provide some valuable reflections not only on KSN's influence on her directly, but also in relation to KSN's scaling up during its first three years. In the

context of Marsha Overby's work, KSN has clearly succeeded in supporting the seeding of her district with instructional leaders in science. The district-level leaders of whom Marsha frequently spoke so highly were all KSN participants in Cohorts I and II of the project. These instructional leaders—as Marsha attested—have served KSN's goals admirably and effectively. Armed with KSN resources, they have gone back to their districts and made themselves highly available to teachers, offering what Marsha recalled were thirty or forty workshops on science instruction and KSN's web resources throughout the school year. The work of many of the Cohort I and II KSN participants from Western not only yielded high-quality leadership resources at the district-level, but also resulted in the sharing of new practices in areas like performance assessment and use of rubrics. Though Marsha did not see herself as a part of the leadership cadre at either the district or school level, she clearly had picked up some of the ethos of influencing her colleagues.

3. Marsha's case raises several questions about how KSN can best help teachers like her to make the fullest use of the ideas and resources that KSN has to offer.

    a. How can KSN help Marsha and teachers like her to avail themselves more of the Internet and face-to-face professional development resources which they say that they find valuable? Marsha felt that she did not have the time either to go to the Internet or to attend school-year colloquia. Perhaps the strength of her district's science instruction leadership contributed to Marsha's inclination to make minimal use of these other resources. When in need of resources to help her teach kits, Marsha turned to others at the district and at her school or the manuals provided by the kits. Marsha did, however, express willingness and excitement about talking with her peers about science--both at her school and at the KSN summer institute. Marsha may be the very kind of teacher who would benefit greatly from an easy to use and compelling online teacher community, given her preference for sharing her knowledge in non-formal ways at the peer level. KSN could consider devoting resources to creating a user-friendly message board/web community and helping teachers to get in the "habit" of using the site, using the immersion-type of experience exemplified in the inquiry aspects of the summer institutes.

    b. Marsha's case also points to the need for KSN to continue its focus on discussing explicitly with teachers ways for them to move consistently towards inquiry. Marsha understood inquiry and that she had yet to do it her classroom; could KSN find ways to directly support teachers like Alice who are interested in inquiry but are resisting it for whatever reasons?

    c. Lastly, Marsha's frustration with district mandates, i.e., limited science time and, even within that, pressure to teach a specific set of concepts, raises the issue of how KSN could work with districts to help align science instruction and assessments. KSN has wisely and, to the great appreciation of participants, discussed assessment in detail, but might ultimately be best able to facilitate deep and wide reform and scaling-up through work with district administrators and instructional leaders to create contexts in which teachers would feel supported through the processes of (a) beginning to teach science kits; (b) gaining comfort with kits; (c) introducing elements of inquiry into kit lessons, and (d) doing authentic inquiry.

Discussion

These three case studies offer compelling evidence that the KSN summer institute and school year colloquia combined with the web-based Curriculum Companions were strong supports to teachers at all stages of their learning about a standards-based approach to science instruction. Further, all three teachers were well positioned to continue their learning about science teaching and to become increasingly skilled practitioners of hands-on/minds-on science as well as facilitators of student investigations. All three were able to articulate clearly what is entailed in an inquiry approach to science instruction and to offer analysis of how his/her practice stood in relationship to the vision and goal of KSN: inquiry pedagogy.

Although the intensity of their participation in professional development varied, Alice, Ruben, and Marsha all benefited greatly from the training. For Alice, the summer institute was indeed transformative. She experienced the power of learning through investigation and wanted this experience for her students. The summer institute catapulted her practice from hands-on science to inquiry. In her classroom, students made sense of natural phenomena by testing reasoned hypotheses about what they observed. In his three years as a KSN teacher, Ruben availed himself of almost every opportunity to attend colloquia, clear evidence that he valued what he learned from and with the Franklin Institute staff and his KSN peers. He became a skilled practitioner of teaching science kits; in the lessons observed, his students reflected on what they were doing in science. After attending her first summer institute, Marsha elected to participate in district-based training as she gained confidence in kit activities, but professional development she attended was led by district staff who were also KSN participants.

Online curriculum resources were key supports to all three teachers—whether they had opened their classrooms to student-generated inquiries or were closely following the kit activities. They used KSN web resources in planning the kit-based units and the Kit and Curriculum Companions were the first stop for Alice and Ruben any time they had a question about content, process, or materials. Significantly, the Director of Curriculum in Ruben's district cited the KSN website as perhaps the only way many teachers in his district were involved in upgrading their content knowledge in science. Our research supports his claim. As teachers explore the web-based resources they make connections between ideas they're developing in their curricula, they gather new information relevant to topics under study in their classrooms, and they find new ways to investigate questions that their students are asking. Teachers wanted help in mediating the vastness of the Internet and in addressing their immediate concerns—What am I doing tomorrow?—as well as longer term needs. Alice, Ruben, and Marsha had confidence in the curriculum links on the KSN website. They found them appealing and easy to use. They mirror their KSN colleagues in this regard. A finding of the teacher survey was that KSN teachers used the KSN website more than they used the whole rest of the Internet.

In addition to accessing KSN web resources, Ruben and Alice also began the practice of sharing experiences with kits and resources they had discovered with other teachers in KSN. Ruben invited KSN staff into his classroom and allowed them to observe and document their visit and place a narrative with photos on the website's Site Visit Journals page. Because of this, other KSN teachers, and, significantly, anyone accessing the KSN website, could look inside Ruben's classroom and see how he approached using kits. Both were also active participants at their summer institutes and the colloquia they attended, not only setting a tone of serious engagement with and immersion in inquiry activities, but also serving as resources for other teachers during professional development in technology use.

Two of the three teachers, Alice and Ruben, assumed important leadership roles in their schools and districts—although each brought his/her own style and experience to working with their colleagues. Alice was a hands-on leader who sat with teachers at their computers to explore the KSN website, helped them prepare materials for lessons, and asked them questions about how things were going. Additionally, she led workshops in her school and across the district about hands-on science. Her great frustration as a workshop leader was that she did not have the time to engage her colleagues in the kind of experience with inquiry that had transformed her practice. Real inquiry was impossible in the limited blocks of time available. In contrast to Alice, Ruben's non-formal leadership was limited to occasional sharing of ideas with his grade group. But he played an important formal role in his district as co-chair of the science committee where he led an effort to align the district's K-12 curriculum with state and district standards. Marsha kept a low profile in her school and district. One reason may be the district's aggressive stance toward science reform and its positioning of KSN-trained district instructional leaders. The KSN website gained wide visibility in all three districts as KSN participants spread word of its value to colleagues in their grade groups, their schools, and their districts.

Appendix I: Material Resources

TABLE I: Science Materials: Quality and Accessibility

Percentage of teachers who "strongly agree" or "agree" with the following statements:	**Pre-KSN**[1]	April 2002[2]	% **Increase**
Science equipment is adequate………………………………………………	46%	64%	18%
Sufficient supplies are available for my classes…………………………	53%	71%	18%
Textbooks are up-to-date………………………………………………..	38%	45%	7%
Textbooks are compatible with available kit materials……………….	34%	38%	4%
Kits are available to all teachers in my school………………………….	No Data	68%	N/A
Kits are available to all teachers in my district………………………….	No Data	55%	N/A

[1]N=163; 2N=91

TABLE I shows that most KSN teachers, when surveyed in April of 2002, reported having access to kits and science supplies more generally. Further, the percentages who agree or strongly agree that the science materials they had access to were (a) adequate and (b) available for all their classes have increased in both cases by 18 percent since teachers began KSN. All of that being said, a significant amount of teachers—36 percent—did not work in schools they felt had adequate science materials.

TABLE II: Access to and Use of Technology

Percentage of teachers who:	**Pre-KSN**	April 2002	% **Increase**
Have a computer at school for personal use	88%	92%	3%
Have Internet access on computer at school for personal use	74%	78%	4%
Have computers in their classroom for student use	83%	81%	-2%
Have access to a school computer lab for student use	92%	91%	-1%
Have Internet access in a school computer lab for student use	69%	77%	8%

[1]N=163; [2]N=91

TABLE II shows that the vast majority of teachers had access to computers, and most—78 percent—had an Internet-capable computer in their classroom with Internet capability. While this was true, the presence of these resources was not near universal. Further, very little in the way of technology resources changed in the one to three years teachers have been in KSN. There has been a slight increase in the percentage of teachers who had Internet access in their rooms and a slightly greater increase in the percentage whose schools had Internet-capable computer labs.

Appendix II a.: Teacher Learning: Instructional Practices

TABLE III: Teachers' Beliefs About Important Instructional Practices

Percentage of teachers who consider the following instructional practices **"very important" or "important":**	**April 2002**
Helping students develop their own investigations……………………………	100%
Eliciting students' questions about natural phenomena………………………	99%
Using a variety of assessment strategies………………………………………	97%
Using cooperative learning techniques………………………………………	94%
Presenting applications of science concepts………………………………….	93%
Integrating science with other subject areas…………………………………	93%
Considering student preconceptions about natural phenomena when planning	91%
Using performance-based assessment………………………………………	89%
Using the textbook as a resource rather than as the primary instruction tool…	87%
Using technology as an integral part of science instruction…………………	76%
Involving parents in the science education of their children…………………	70%

Data from teachers' Year Three survey; N=91

In rating a list of instructional practices from "very important" to "not important," all or nearly all of KSN teachers find practices central to inquiry science—helping students plan their own investigations and eliciting student questions—important or very important. Our findings are in line with Sevilla and Marsh, (1992) who found that teachers—regardless of their ability or willingness to open up their classrooms to authentic scientific inquiry—"get" that inquiry is a powerful pedagogical approach. Implementing inquiry may be a challenge for a variety of reasons, ranging from time constraints from other subject area mandates to difficulty managing students simultaneously engaged in different activities. However, the fact that teachers clearly understand the worthwhile and empowering implications of inquiry for their students' learning can serve as a foundation for science reform efforts such as KSN that aim to broaden and deepen the use of inquiry in the classroom.

TABLE IV: Distribution of Science Process Skills Observed in Lessons

										Higher Order Process Skills		
Teachers by District (Number of observations, if more than one)	Unsupported Predicting	Observing	Categorizing	Measuring	Recording	Drawing	Graphing/ Charting	Describing	Reflecting (on processes)	Interpreting Evidence	Drawing Conclusions	Hypothesizing
M. Sanders	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓
I. Rhoads	✓	✓	✓	✓	✓		✓	✓		✓	✓	✓
Alice Dressler (CS I)	✓	✓	✓		✓	✓	✓	✓		✓	✓	✓
R. Shultz	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓
A. McDonnell	✓	✓		✓	✓		✓		✓	✓	✓	✓
C. Denardo				✓	✓				✓	✓	✓	✓
L. Kenny		✓		✓	✓	✓		✓		✓	✓	
P. Burrell		✓			✓			✓		✓	✓	
C. Stevens	✓	✓		✓	✓	✓		✓	✓		✓	
J. Lee	✓	✓	✓	✓	✓							✓
H. Smith						✓						✓
Marsha Overby (CS III)		✓	✓	✓	✓	✓		✓				
Ruben Knight (CS II)		✓			✓	✓			✓			
E. Coleman		✓		✓	✓	✓						
A. Gallagher	✓			✓	✓		✓					
J. Mass					✓							
D. Katz									✓			
M. Copeland							✓					

TABLE IV presents a distribution of these skills observed in our visits to teachers' classrooms. Recalling Olquin's caution that doing science experiments does not necessarily lead students to learning and understanding science, we place emphasis on the "higher-order" processes—interpreting evidence, drawing conclusions, and hypothesizing. These three processes ask students to make sense of what they learn. Further, these skills are necessary ones for students to have experience with and facility in if they are to do inquiry.

A quick glance at TABLE IV shows that students used two process skills—observing and recording—in most of the lessons we saw. The higher order skills were present in just about half of the classrooms we visited. Significantly, almost all of the teachers who asked their students to engage in one of these skills asked their students to engage in all. For only one of the teachers whose lesson included all higher order skills was the distribution across the other nine, more procedural skills limited. This suggests that teachers who pushed their students to make sense of science also gave them the opportunity to do science in rich ways.

TABLE V: Distribution of Student Discourse Exemplifying “Minds-On” and/or Inquiry Science

	Inquiry			**Higher Order**			**Scaffolding for Conceptual Understanding**	
Teachers by District	**Generating Questions**	**Generating Authentic Questions**	**Designing Authentic Investig-ations**	**Interpreting Evidence**	**Drawing Conclusions**	**Hypothe-sizing**	Students Referencing Prior Knowledge	Students Presenting Findings
Alice Dressler (CS I)	✓	✓	✓	✓	✓	✓	✓	✓
A. McDonnell	✓	✓	✓	✓	✓	✓	✓	✓
R. Shultz	✓		✓	✓	✓	✓	✓	✓
M. Sanders	✓	✓		✓	✓	✓		✓
I. Rhoads	✓	✓		✓	✓	✓		
P. Burrell	✓		✓	✓	✓			✓
C. Denardo	✓			✓	✓	✓		✓
L. Kenny	✓		✓	✓	✓		✓	
C. Stevens	✓				✓		✓	✓
D. Katz	✓						✓	✓
H. Smith	✓		✓			✓		
Ruben Knight (CS II)	✓						✓	✓
M. Copeland	✓		✓				✓	
J. Lee	✓					✓		✓
Marsha Overby (CS III)	✓		✓					
E. Coleman	✓						✓	
J. Mass	✓						✓	
A. Gallagher	✓							

TABLE V shows that all teachers are asking their students to generate questions; however, in only a small number of classrooms—4 of 18—did we observe students asking the kinds of authentic questions that exhibit a desire for gaining new knowledge, an expressed intrinsic motivation to discover new information. In just under half the classrooms we observed—8 of 18—students were encouraged to design authentic investigations where they could choose at least some of the following aspects (only in one case—Alice Dressler—could students design all stages/aspects of investigation):

1. the phenomena or materials under study

2. the experimental design and methods to—in their assessment—best test phenomena and/or discover new knowledge
3. the best ways to record, represent, and present data and findings

TABLE V also shows that students interpreted evidence and drew conclusions only in the classrooms of highly skilled teachers. In addition, TABLE V illustrates that students in over half of classrooms were engaged in other modes of discourse as they made sense of their work in science, such as referencing prior knowledge and orally presenting their findings to their peers.

TABLE VI: Distribution of the Ways Students Represent Their Knowledge about Science

Teachers by District (Number of observations, if more than one)	Recording Observations	**Drawing Pictures**	Using Science Vocabulary	Presenting to Class	**Writing Descriptions of Process/ Findings**
A. McDonnell	✓	✓	✓	✓	✓
R. Shultz	✓	✓	✓	✓	✓
E. Coleman	✓	✓	✓	✓	✓
J. Mass	✓	✓	✓	✓	
J. Lee	✓		✓	✓	✓
Ruben Knight (CS II)	✓	✓	✓	✓	
M. Sanders	✓	✓		✓	
L. Kenny	✓	✓	✓		
Alice Dressler (CS I)	✓	✓	✓		
I. Rhoads	✓		✓		
Marsha Overby(CS III)	✓	✓			
D. Katz	✓				✓(essays)
H. Smith		✓		✓	
C. Stevens	✓	✓			
P. Burrell	✓				
C. Denardo	✓				
A. Gallagher	✓				
M. Copeland					

Table VI shows that teachers we observed did a good job, as a whole, of having their students record observations and draw pictures to represent what they were learning. One teacher described the power of using workbooks/journals as making "the biggest difference" in her classroom because students "were responsible for keeping track of everything, they could see they were in charge of their own learning." Also of note in TABLE VI is the importance that teachers placed on vocabulary, on students using scientific terminology. Teachers who value this kind of knowledge said that *doing* science allowed their students to use technical and descriptive words in authentic ways. In other words, science terms began to take on real meaning for students as they used them to describe, for example, chemical reactions or plant growth. About half the teachers we observed asked students to present their work to the class. In this mode, we saw a range of the kind of classroom discussion that emerged, from a focus primarily on results and getting the “right answer” to a focus on reflection and looking towards future investigation. We saw and heard of fewer examples of teachers giving their students assignments that involved writing up results of their experiment or reflecting on their process.

TABLE VII: Distribution of Assessment Strategies

Teachers by District (Number of observations, if more than one)	**Observing Students**	**Review Student Science Workbook**	**Kit/Unit-Culminating** Performance Assessment	Non-Performance Quizzes/ Tests	Rubric Use
I. Rhoads	✓	✓	✓		✓
C. Stevens	✓	✓	✓	✓	
Ruben Knight (CS II)	✓	✓	✓	✓	
E. Coleman	✓	✓	✓		✓
L. Kenny	✓	✓	✓		✓
J. Lee	✓	✓		✓	✓
A. McDonnell	✓	✓	✓		✓
M. Sanders	✓		✓		✓
Marsha Overby(CS III)	✓	✓		✓	
R. Shultz	✓	✓		✓ (essay)	
H. Smith	✓			✓	✓
J. Mass	✓	✓	✓		
P. Burrell					
M. Copeland	✓			✓	
C. Denardo	✓	✓			
Alice Dressler **(CS I)**	✓	✓			
D. Katz		✓		✓ (essay)	
A. Gallagher	✓				

TABLE VII shows that, by far, the most prevalent assessment tools teachers used were observing their students work with materials and classroom discussions and reviewing their science workbook or journal. Teachers who observed their students frequently did so in systematic ways, moving about the room during a lesson and noting their observations using a chart. Some teachers made a point of formally observing and recording their observations on a set schedule—once or twice a week. Further, teachers often used some method to systematically assess students' presentations of their findings and procedures to the class[5]. Teachers who graded science workbooks or journals did so usually at the end of a unit and looked for (a) attention to processes, i.e., clear descriptions of observations and measurements; (b) students reflecting on their work and looking towards future work by predicting or hypothesizing; (c) use of scientific terminology; and (d) understanding of content, often judged by accuracy of findings. TABLE VII shows that about half of our sample used end-of-kit performance assessments, asking student to conduct an experiment that represented a culmination of their work, e.g., testing an unknown chemical or drawing a description of the process of pollination. This assessment strategy frequently correlated with using rubrics. Less than half of the sample used traditional quizzes and tests, though two of these teachers' tests often involved having their students describe in detail their processes and findings.

[5] We did not explicitly ask teachers if they documented their observations; our data in this area is thus inclusive.

Appendix II b.: Teacher Learning: Leadership

TABLE VIII: Teacher Leadership Activities at School Level
Percentage of teachers who report, since beginning participation in KSN: [1]

Sharing resources/information learned at KSN PD with other teachers in their school……	86%
Sharing resources from the KSN website with other teachers in their school…………	82%
Answering colleagues' questions about using kits………………………………………..	73%
Answering colleagues' questions about using other materials related to science………	69%
Helping other teachers plan science lessons……………………………………………….	59%
Inviting other teachers to visit your classroom to observe a science lesson……………	34%
Conducting a joint science project with another class……………………………………	32%
Leading in-service workshops or courses in science or science teaching at their school	32%
Receiving local, state, or national grants or awards for teaching………….…………....	13%

[1]Data from teachers' Year Three survey; N=91

TABLE IX: Teacher Leadership Activities at District Level
Percentage of teachers who report, since beginning participation in KSN: [1]

Sharing resources from the KSN website with other teachers in their district…………	57%
Sharing resources/information learned at KSN PD with other teachers in their district	53%

[1]Data from teachers' Year Three survey; N=91

TABLE X: School Professional Community[1]

Number of times teachers report:	Eight or more times	**Three to Seven Times**	**Once or Twice**	Never
Receiving useful suggestions for curriculum materials from colleagues	19%	41%	31%	9%
Visiting other teachers' classrooms……………………………………	15%	20%	28%	37%
Receiving meaningful feedback on performance from colleagues…….	14%	31%	35%	20%
Having conversations with principal about instructional practices……	12%	28%	32%	28%
Colleagues observing their teaching……………………………………	11%	16%	27%	46%
Inviting someone to help teach class(es)………………………………	6%	16%	33%	45%
Having conversations with principal about science curriculum………	6%	23%	37%	34%
Received constructive feedback on lessons from principal……………	2%	22%	50%	26%

[1]Data from teachers' Year Three survey; N=91

TABLE XI: Teacher Leadership on School Science and Technology Committees
Percentage[1] of teachers who:

Serve on school science committee	54%
Serve on school technology committee	22%

[1]Not all schools have science and/or technology committees. Because of this, the percentage reported in this table is for teachers who work in schools that afford them the opportunity to serve on such committees. Data from teachers' Year Three survey; N=91

TABLE XII: Teacher Leadership on District Science and Technology Committees
Percentage[1] of teachers who:

Serve on district science committee	49%
Serve on district technology committee	15%

[1]Not all districts have science and/or technology committees. Because of this, the percentage reported in this table is for teachers who work in schools that afford them the opportunity to serve on such committees. Data from teachers' Year Three survey; N=91

TABLE XIII: Science and Technology Focus in School

Percentage of teachers who report their:	**Pre-KSN**[1]	April 2002[2]	% **Increase**
School has science committee…………………………………………	56%	40%	-16%
School has technology committee………………………………………	59%	55%	-4%
School or district has adopted content/performance standards…….	70%	69%	-1%
School involved in (non-KSN) science reform projects or networks..	35%	30%	-5%

[1]N=163; [2]N=91

TABLE XVI: Science and Technology Focus in District

Percentage of teachers who report their:	**Pre-KSN**[1]	April 2002[2]	% **Increase**
District has science committee………………………………………….	No Data	80%	N/A
District has technology committee……………………………………	No Data	76%	N/A
School or district has adopted content/performance standards…….	70%	69%	-1%
School involved in (non-KSN) science reform projects or networks..	35%	30%	-5%

[1]N=163; [2]N=91

Appendix III: KSN's Value-Add: Web Resources and Professional Development

TABLE XV: Value-Add of Professional Development in Science Content and Teaching Methods to Instructional Practices[1]

Degree to which teachers agree or disagree with the following statements about ***KSN professional development in science content and teaching methods:***	**Strongly Agree/ Agree**	Neutral	**Disagree/ Strongly Disagree**
Deepened my understanding of how students learn science	96%	4%	0%
Deepened my understanding of science	92%	7%	1%
Helped me to help my students ask their own questions…………………………	91%	7%	2%
Led me to make changes in my teaching…………………………………………	89%	8%	3%
Helped me to help students develop and carry out their own investigations…….	88%	10%	2%
Helped me become comfortable with science kits…….…………………………….	80%	16%	4%
Helped me to better implement performance-based assessment in my classroom	74%	21%	5%

[1]Data from teachers' Year Three survey; N=91

Without question, KSN teachers praised KSN's face-to-face professional development. They were impressed by the summer institutes and colloquia, particularly the on going commitment to engaging in authentic inquiry experiences. Teachers valued the opportunity to work with KSN staff, whom many described as "excellent." They also benefited from meeting and working with their colleagues. TABLE XV shows that teachers very favorably viewed KSN professional development as it helped them to (a) increase their comfort with science kits; (b) better implement inquiry-related teaching practices; and (c) gain confidence in science content. A comparison of teachers' experiences with professional development prior to KSN to KSN, found KSN to be significantly more likely (significant at the <=.000 level) to lead to reported changes in teaching practice(s) than the previously experienced professional development.

TABLE XVI: Value-Add of Professional Development in Technology to Instructional Practices[2]

Degree to which teachers agree or disagree with the following statements about ***KSN professional development in technology:***	**Strongly Agree/ Agree**	Neutral	**Disagree**
Helped to increase my confidence in my knowledge of science content………...	84%	13%	3%
Had relevance to my classroom practice………………………….	84%	11%	5%
Led me to make changes in my lesson planning…………………	63%	25%	12%

[2]Data from teachers' Year Three survey; N=91

Historically the presence of technology in education—both hardware and software and the professional development around it—has been disconnected from classroom practice. As KSN faced this challenge, program developers decided to offer hands-on, face-to-face professional development in technology use in separate sessions during institutes and colloquia (separate from its professional development in inquiry pedagogy and science content). TABLE XVI shows that the professional development in technology use KSN offered had relevance and helped teachers to gain confidence with science content.

TABLE XVII: Research Cohort's Degree and Kind of Involvement with KSN

	Cohort/ S.I.	**KSN Colloquium Attendance**	**Online Participation in KSN**	**Use of KSN Online Resources**	**Number of Higher-Order Process Skills**
M. Sanders	2	High	High	High	✓✓✓
I. Rhoads	2	High	High	High	✓✓✓
R. Shultz*	1	High	High	High	✓✓✓
A. McDonnell	2	Medium	High	High	✓✓✓
Ruben Knight (CS II)	1	High	Low	High	
Alice Dressler (CS I)	3	Medium	Medium	High	✓✓✓
C. Denardo	1	High	None	Medium	✓✓✓
M. Copeland	1	High	Low	N/A	
A. Gallagher	1	High	Low	Low	
E. Coleman	2	Low	Low	High	
D. Katz*	1	High	None	N/A	
J. Lee	2	Low	Low	Medium	✓
J. Mass	2	Low	Low	Medium	
C. Stevens	3	Low	None	Medium	✓
L. Kenny	3	Medium	None	Low	✓✓
H. Smith	2	Low	Low	Low	✓
Marsha Overby(CS III)	3	None	None	Low	
P. Burrell	1	Low	None	N/A	✓✓

*Teacher leader at Summer Institutes 2 & 3

Table XVII shows that some teachers had a high degree of use of and involvement with KSN resources. These teachers attended colloquia, used the KSN website when getting ready to teach, had their students access Internet resources, and used the network infrastructure to share ideas with their colleagues. These teachers valued KSN's resources such that they both used them and contributed to them. In addition, these teachers incorporated higher order science process-skills in their classrooms. Other teachers used KSN resources in one direction—accessing information. The remainder of teachers did not avail themselves of KSN resources much beyond attending the initial summer institute.

TABLE XIX: Use of KSN Online Resources Impacting Instructional Practices[1]

	Frequency of Use[2]		
How frequently teachers report:	**Monthly or greater**	**Several times a year**	**Never or Almost Never**
Using the Kit and Curricular Companions ……………………………	50%	30%	12%
Using information referred/linked to in *KSN Weekly* received via email	48%	33%	16%
Using the Tips & Connections…………….……………………………	36%	40%	20%
Using the Standards…………………………………………………	28%	25%	39%
Using The Weekly archives……………….……………………………	25%	33%	37%

[1]Data from teachers' Year Three survey; N=91

[2]Percentages do not necessarily add up to 100 percent because respondents were given the opportunity to mark "N/A" for each item.

TABLE XIX shows how frequently teachers accessed the KSN online resources that directly impact their instructional practice. The vast majority of teachers—80 percent or more—used the Kit and Curricular Companions and *KSN Weekly* at least several times a year, and just slightly fewer used the Tips and Connections on the website. Most significantly, the Kit and Curricular Companions became the first stop for many teachers when using the Internet for information on science content or curriculum. Comparing survey data from when teachers began KSN to the end of the third year of the project shows that teachers use the Kit and Curricular Companions and the information linked to in the *Weekly* at the same frequency with which they used the Internet *as a whole* prior to KSN.

TABLE XX: Teachers' Use of Network Technology to Reflect on Instructional Practices

	Frequency[2]		
How frequently teachers report:	**Monthly or greater**	**Several times a year**	**Never or Almost Never**
Using on-line resources/email to reflect on instructional strategies with other teachers	31%	26%	39%
Using on-line resources/email to reflect on how students learn science concepts	18%	17%	52%
Collaborating on-line for lesson planning or curriculum development	14%	15%	59%
Writing KSN journal entry…….……………………………………	2%	10%	76%

[1]Data from teachers' Year Three survey; N=91

[2]Percentages do not necessarily add up to 100 percent because respondents were given the opportunity to mark "N/A" for each item.

By creating ways for teachers step to outside their classroom doors, ways for them to open their classrooms up to colleagues, and ways to reflect, involvement in KSN can have a significant impact on science instruction. TABLE XX shows that the power of network technology to facilitate reflection on instructional practices was not yet fully capitalized on by KSN teachers.

Appendix IV: Profile of KSN Teachers

TABLE XXI: Subjects Taught[1]

Elementary, all subjects	58%
Science only……….…….….	16%
Other*…………………….	16%
Math only…………….…..….	5%
Science and Math only.…	5%

[1]Data from teachers' initial, baseline survey.

*E.g., specialty teachers—technology/media center, non-classroom teacher curriculum specialists, resource teachers, principals.

TABLE XXII: Years of Experience and Years at Present School[2]

	Experience	**At Present School**
Two or fewer……………………	1%	12%
Three to five……………………...	21%	29%
Six to fifteen……………….………..	33%	42%
Sixteen or greater………………..	45%	17%

[2]Data taken from teachers' Year Three survey

TABLE XXIII: Highest Level of Formal Education [3]

Doctorate…………………	3%
Master's degree +45…….	14%
Master's degree +30…….	11%
Master's degree +15……	11%
Master's degree………….	36%
Bachelor's degree……….	25%

[3]Data from teachers' Year Three survey.

TABLE XXIV: Gender[4]	
Female……………………	80%
Male………………………	20%

[4]Data from teachers' initial, baseline survey.

TABLE XXV: Race/Ethnicity[5]	
African-American…….	7%
Asian-American………	1%
Hispanic……………….	1%
Native American……...	1%
White, non-Hispanic….	89%
Other…………………...	1%

[5]Data from teachers' initial, baseline survey.

Demographic data on the cadre of KSN participants—TABLES XXI-XXV—show:

1. Nearly three-fifths of the 163 participants were elementary school teachers and one-sixth were science-only—largely middle school—teachers;
2. Over three-quarters were experienced teachers, with more than six years in the profession; three-fifths had been at their school for over six years;
3. Three-quarters held a Master's degree;
4. Four-fifths were female;
5. Nine-tenths were white; slightly less than one-tenth were African-American.

Appendix V: Research Methods

The evaluation of the Keystone Science Network (KSN) combines qualitative and quantitative data to examine both program implementation and impact. The evaluation examines classroom curriculum and pedagogy, the influence of network technology in advancing teachers' science content knowledge, assessment and reflection, KSN's contribution to changing teachers' understanding of inquiry-based science and classroom practice, and teachers' evolving roles as a professional community of science educators.

Teacher Survey

All 163 participants in KSN completed an extensive survey upon beginning the program (during the first day of their initial summer institute) to establish baseline data on such measures as: technology use; experience with and knowledge of science inquiry; current classroom practices; resources; supports; and assessment. Near the end of the third year of KSN, follow-up surveys were distributed to all participants. Participants were asked to fill out the survey on their own time and were paid twenty dollars for completing and sending it back. RFA received 91, for a response rate of 56 percent (of the initial 163, some teachers and districts dropped their affiliation with KSN). Survey analyses were conducted on all surveys, i.e., no sampling was done.

Interviews and Classroom Observations

In each year of the three-year evaluation, RFA worked collaboratively with KSN program developers and staff to define a qualitative research focus that matched where the program was in terms of implementation.

In year one, RFA focused its research on developing (1) baseline data on teachers' use of technology as a support in planning and implementing science curricula and (2) a preliminary analyses of the nine participating KSN school districts in terms of how they were positioned to support KSN teachers back in their classrooms. Findings from the first-year evaluation highlight the supports and challenges that Franklin Institute (FI) staff and KSN teachers encounter as they work collaboratively to strengthen K-8 science education. The data pushed RFA into deepening their understanding of how teachers use KSN's web resources to enhance teaching and instruction.

In year two, RFA focused on taking an in-depth, qualitative look at how teachers make sense of and use their professional development experiences surrounding inquiry-based learning and the accompanying technological resources to enhance classroom practice. In consultation with the Franklin Institute, RFA selected eight teachers in four districts. RFA conducted intensive qualitative research about these teachers to understand how KSN is supporting them to

1. Enrich their science content knowledge
2. Deepen their understanding of inquiry-based pedagogy
3. Develop strategies for performance-based assessment
4. Participate in professional learning communities and provide leadership to local districts and schools
5. Use grade-appropriate supplemental science materials for lessons and guide students' independent exploration
6. Utilize web-based resources

Year three research built on many of the themes of year two, and added a more explicit focus on school and district context. RFA chose a sample of eight teachers, visiting two from previous years and six others—two from one urban school district we had visited all three years of the evaluation, and four from one school in a suburban district new to the evaluation sample, but with a high number of teachers in KSN.

RFA visited the classrooms of and interviewed eighteen teachers, gathering descriptive data about their perspectives and use of technological resources to enhance science teaching and instruction. During the Spring of 2000, 2001, and 2002, RFA conducted site visits in districts, examining the range of teachers' practice of inquiry-based science. Using a detailed observation protocol adapted from a Horizon Research protocol, we interviewed teachers immediately before teaching a lesson regarding their preparation and goals for the lesson, as well as salient classroom context issues. We:

1. Observed an inquiry science lesson;
2. Interviewed teachers immediately after the observed lesson, probing their evaluation of the

day's lesson as well as next steps in the unit and assessment strategies;

3. Conducted an in-depth interview with teachers regarding their use of network technology and their experiences with inquiry and collaboration.

In conjunction with KSN principal investigators and staff, we chose a sample of teachers taking into consideration several dimensions: (A) a range of rural, suburban, and urban districts; (B) a range of grades taught; (C) use of kits (for year three of the evaluation, we only observed kit-users); and (D) involvement in and use of KSN resources. TABLE XXVI shows the distribution of district-type, grade level, and kit use during our observations.

TABLE XXVI: Sample of teachers observed

Teachers by District	**Grade Level**	Cohort	**Taught Kit During Observation(s)?**	**District Type**	**# of Visits Year 1**	**# of Visits Year 2**	**# of Visits Year 3**
M. Sanders	5th	II	Yes	Suburban		✓	✓
I. Rhoads	3rd	II	Yes	Suburban		✓	
Marsha Overby	3rd	III	Yes	Urban			✓✓
A. Gallagher	4th-5th	I	No	Urban		✓	
J. Mass	3rd	II	No	Urban		✓	
C. Stevens	2nd	III	Yes	Urban			✓✓
P. Burrell	3rd	I	No	Rural	✓		
Ruben Knight	4th	I	Yes	Rural	✓	✓	
M. Copeland	4th	I	Yes	Rural	✓		
C. Denardo	2nd	I	Yes	Rural	✓	✓	
E. Coleman	3rd	II	Yes	Suburban			✓✓
L. Kenny	3rd	III	Yes	Suburban			✓✓
Alice Dressler	1st	III	Yes	Suburban			✓✓
A. McDonnell	3rd	II	Yes	Suburban			✓✓
R. Shultz	4th	I	Yes	Suburban/Urban	✓	✓	✓
D. Katz	6th	I	No	Suburban/Urban	✓		
H. Smith	5th	II	Yes	Suburban/Urban		✓	
J. Lee	5th	II	Yes	Suburban/Urban		✓	

In addition to teachers, RFA interviewed the KSN Site Liaison in each district we visited, gathering data on issues such as district-level curriculum and technology support and district opportunities for teacher leadership.

Observations of KSN Professional Development

RFA staff were participant observers at the teacher professional development activities offered by the Franklin Institute. Observations of these activities provide RFA data about the particular experiences of teachers from Cohorts I, II, and III engaging in inquiry science. During the Summer Institutes, RFA conducted focus groups with teachers to examine early perceptions of KSN goals and expectations, anticipated challenges, and their hopes for informing classroom practice. RFA also observed seven of the eleven colloquia, talking with teachers largely informally, but also formal focus groups about technology use.

In addition to observing face-to-face professional development, RFA regularly monitored KSN's website for changes, archived data from KSN online resources, including the website and Keystone Weekly, and checked the message boards for participants.

Appendix VI: Works Cited

Blanc, S., Passantio, C., & Mordecai-Phillips, R. (2001). Urban Systemic Program Year One Report: Opportunities and Challenges of Professional Development in a Period of District-wide Transition. Philadelphia: Research for Action.

Blanc, S., Mordecai-Philips, R., & Pickron-Davis, M. (2002, forthcoming). Urban Systemic Program Year Two Report. Philadelphia: Research for Action.

Cohen, D., & Ball, D. L. (1999). Instruction, Capacity, and Improvement. Research Report. Consortium for Policy Research in Education. Philadelphia, PA.

Gordin, D. N. , Gomez, L. M., Pea, R. D., & Fishman, B. J. (1996). Using the worldwide web to build learning communities in K-12 . Journal of Computer-Mediated Communication, 2 (3). [http://www.ascusc.org/jcmc/vol2/issue3/gordin.html].

Jorgenson, O. & Vanosdall, R. (2002). The Death of Science? What We Risk in Our Rush Toward Standardized Testing and the Three R's. Phi Delta Kappan. V.83 No.8 Pages 601-605/April 2002. [URL: http://www.pdkintl.org/kappan/k0204jor.htm].

Knapp, M. S. (1997). Between Systemic Reforms and the Mathematics and Science Classroom: The Dynamics of Innovation, Implementation and Professional Learning. Review of Educational Research, 67(2), 227-266.

Little, J.W. (1999) Teachers' professional development in the context of high school reform: Findings from a three-year study of restructuring schools. Paper presented at the annual meeting of the American Educational Research Association, Montreal.

Loucks-Horsley, S., P.W. Hewson, N. Love, & K.E. Stiles (1998). Designing Professional Development for Teachers of Science and Mathematics. Thousand Oaks, CA: Corwin Press Inc.

McLaughlin, M., & Talbert, J. (1999). Communities of Practice and the Work of High School Teaching. Stanford University: Center for Research on the Context of Teaching.

The National Staff Development Council (2001). E-Learning for Educators: Implementing the Standards for Staff Development. Oxford, OH.

Olguin, S. (1995). Science Kits as Instruction Tools. On Common Ground. No.4 p. 8 Spring, 1995. New Haven, CT.: Yale-New Haven Teachers Institute.

Sabelli, N., & Dede, C. (1998). Integrating Educational Research and Practice: Reconceptualizing the Goals and Process of Research to Improve Educational Practice. Education and Human Resources, National Science Foundation.

Sevilla, J., & Marsh, D.D. (1992). Inquiry-Oriented Science Programs: New Perspectives on the Implementation Process. Paper presented at the Annual Meeting of the American Educational Research Association. San Francisco, CA, April 1992.

Thompson, C. L. & Zeuli, J. S. (1999). Teaching as the Learning Profession: Handbook of Policy and Practice. The Frame and the Tapestry: Standards-Based Reform and Professional Development. Jossey Bass Publishers. San Francisco, CA. 341-375.

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