Researching the Sustainability of Reform

BENTON

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PROJECT OVERVIEW

The *Researching the Sustainability of Reform (RSR)* project focused on the question of how to maintain the gains of an initial educational change process and support continuing reform over time. Within the broader study of sustainability, the research paid particular attention to systemwide approaches to science education reform as well as to the role that external funds can play in initiating reforms that are sustained. The research was conducted by staff of the Center for Science Education at Education Development Center, Inc. (EDC), in Newton, Mass., in collaboration with staff at the Caltech Pre-College Science Initiative (CAPSI) in Pasadena, Calif. This research was supported by a grant from the National Science Foundation and was directed by Dr. Jeanne Rose Century at EDC and Dr. Jerome Pine at CAPSI.

The goal of this study was to identify and document factors in school systems that contribute to sustained educational change in science education. The purpose was to provide districts now engaged in improving their science education programs and districts that are considering doing so in the future with information to help them more strategically and effectively build an infrastructure for long-term improvement.

Specifically, this study focused on nine communities with K–6 science education programs begun from nearly 10 to 30 years ago. These communities differed in their sources of funding as well as the longevity of their programs. This study investigated how, and the extent to which, these communities have sustained their science education programs and the factors that have contributed to this sustainability.

Through on-site interviews and observations, surveys, case studies, and document analysis, the study investigated the districts' efforts in the following areas:

- Current status of the science program compared with initial goals
- System context and external conditions that have an impact on lasting change
- Strategies for achieving program goals and building district capacity to improve
- The influence of practitioner and system capacity on sustainability
- External funds as a catalyst for widespread, lasting reform

The findings of the research include nine descriptive site summaries and a cross-site report. The site summaries were designed primarily to provide the reader with a description of the origins, implementation, and evolution of each of the nine science programs. They also offer a brief analytic section that is designed to provide the reader with a bridge to the cross-site report. The cross-site report draws from all nine sites to identify common themes and recurring issues relevant to sustainability. It is primarily analytic while offering concrete supporting examples drawn from the nine sites. The cross-site report also includes a discussion of implications of the findings for funders, reformers, and practitioners.

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SUMMARY OF RESEARCH METHODOLOGY

Research Questions

The study was guided by the global research question: What factors contribute to or inhibit the sustainability of a districtwide hands-on science program? Within this broad question, the research focused on several sub-questions: (1) What is the current status of the science education program within the system and how does that compare with the initial goals and implementation of the program? (2) What conditions and contexts surrounding a science education reform effort impact the sustainability of the reform? (3) What decisions have practitioners made and what strategies have they used to bring about enduring change and build capacity for continuous growth? (4) How has the capacity of the practitioners in the system and the capacity of the system itself affected the sustainability of the reform? and (5) What is the role of external funds as a catalyst and/or support for lasting, widespread reform?

Research Design & Analysis

To answer these questions, the study utilized a multi-site case study methodology that made full use of primary and secondary data sources and accounted for the uniqueness of each community while allowing for cross-site generalizations. The primary data was gathered using qualitative approaches including semi-structured interviews, focus group interviews, observations, and document analysis. This data was supplemented with quantitative data collected through a survey administered to all principals and a random sample of 100 teachers at each site.

Some members of the research team had previous experience working with some sites. To alleviate bias, researchers gathered data in sites with which they had no prior interactions. Throughout the process of analyzing data, researchers were careful to address the potential of bias as a result of their experience with hands-on curriculum and any interactions with sites previous to this study.

Site Selection

The study focused on nine school districts[1] that have established an elementary science program reflecting the standards developed by the National Research Council and the American Association for the Advancement of Science. The districts fall into two main groups: those that began their science education reform efforts in the 1960s and early 1970s, and those that began their efforts from the mid-1980s into the 1990s. Four of the nine communities are in the former group. Of those four, two have had enduring science education programs and the other two had programs that were strong for a number of years, waned over time, and are currently in a process of renewal. These communities were of particular importance to the study as they shed light on the long-term development of science education programs and on how the "trajectories" of reform efforts vary over many years.

The remaining five communities fall into three sub-groups: Two had funds from the National Science Foundation that had been expended before the research began; one received funds from the National Science Foundation that were expended immediately prior to the beginning of the research; and two initiated their science reform efforts without significant external funding. Together, these districts represent a range of size and geographical location as well as years of participation in reform.

1 All district and individual names are pseudonyms.

Site Visits

Teams of two researchers made several site visits to each of the nine sites over two and one half years of data collection. Each site was visited at least three times with each visit lasting two to four days. In the initial phase of the research, researchers conducted "pre-visits" and phone interviews that enabled them to obtain an overview of the history of the site, discuss data collection procedures, and identify important issues and additional data sources/key individuals to interview. These pre-visits allowed researchers to construct a timeline of the science program, identify critical events in the life of the program, and identify major players both inside and outside the district. This initial contact also included discussions of logistical issues (e.g., timing for site visits), potential schools and classrooms to visit, and tentative scheduling of individuals to interview on-site.

Following the pre-visit, site visits typically consisted of interviews with key district personnel including the superintendent, assistant superintendent, assessment specialist, director of professional development, director of curriculum and instruction, budget manager, science coordinator, Title I and Federal Grants administrators, mathematics and language arts subject matter coordinators, technology program director, and special education director. In addition, researchers conducted teacher focus groups as well as interviews with key stakeholders, such as school board members, union representatives, and community members. Researchers also conducted a minimum of 20 observations of science instruction in at least 10 schools and conducted interviews with the teachers observed and their principals. Researchers also observed professional development sessions and reviewed documents on-site.

Interview and Observation Protocols[2]

Interview protocols were designed to gain information about the goals/vision of the district science program, actual classroom practice, professional development, support for teaching science, sustainability of the district science program, and other key critical issues that had an impact on the science program or the district. Interview protocols were adapted to the individual/group being interviewed. The interviews also explored the factors an individual thought contributed to sustainability of the science program, what factors supported or jeopardized the program, and what they envisioned for the future of the district's science program. Individuals were also given the opportunity to discuss any other issues that they thought were relevant that the interview had not explored.

Researchers conducted observations of science classes to gain a clearer understanding of the current status of the district science program. The objective of an observation was to obtain a "snapshot" of instruction, to contribute to a larger understanding of the school district's practices and goals, and to document the use of hands-on investigation and/or inquiry methods of teaching science. Researchers normally observed an entire science class in grades K–6 that varied in length from approximately 30 minutes to an hour depending on the lesson. Researchers used a semi-structured observation protocol to document the structure of the lesson and capture the teacher's instructional strategies.

Principal and Teacher Surveys

Researchers administered two surveys: the first to all principals in each of eight district sites and the second to a random sample of 100 teachers in each of the eight district sites[3]. The purpose of the surveys was to supplement the qualitative findings of the study by providing additional data on the current status of the program.

2 For a list of interviews and observations conducted at this site, see Appendix A.
3 One district, Montview, chose to abstain from participation in the survey.

These data may not accurately reflect actual districtwide practice. (For a summary of the survey data, see Appendix B.) Survey development followed a three-step process: (1) Researchers conducted a review of other similar instruments; (2) surveys were piloted and interviews were conducted with pilot participants; and (3) a survey expert reviewed the surveys and provided feedback so final revisions could be made.

The surveys provided corroboration of qualitative data and helped guide future qualitative data gathering. They were designed to answer the following questions: (1) What are the respondents' understandings of the current science program? (2) What importance do respondents place upon the science program and what priority does it get within the other areas? (3) What are the respondents doing to implement/support the science program? (4) What factors are important in sustaining an effective science program? The surveys included items about teacher/principal background and experience, school instructional practice, curriculum and materials, professional development, principal practice, teacher classroom practice, influences on science, support for science, and sustainability of science.

For more detailed information about the methodology of this project, please refer to the cross-site report.

OVERVIEW OF PROJECT SITES

	GLENWOOD*	LAKEVILLE	HUDSON††	MONTVIEW‡	BAYVIEW	GARDEN CITY	SYCAMORE	BENTON	BOLTON
SIZE									
Sq. Miles	47†	76	200	800	55	800	25	15	320
# elem. students	27,000	12,000	43,151	47,087	5,849	28,000	6,400	4,300	27,000
# elem. schools	77	23	50	92	23	52	30	15	60
# elem. classroom teachers	1,300	778	1,630	1,978	600	1,300	300	200	1,144
RESOURCES									
Per pupil expenditure	5,668	4,996	5,122	4,443	5,973	5,046	6,500	13,296	6,508
Teacher starting salary	$31,172	$35,573	$27,686	$25,832	$27,467	$27,718	$29,892	$34,116	$32,600
NSF funds?	yes	yes	yes	no	no	no	no	yes	yes
DEMOGRAPHICS									
% students eligible for free and reduced price lunch	66%	70%	41%	18%	40%	32%	65%	39%	30%
% white	13	17	68	85	57	69	69	41	62
% African American	18	34	3	1	12	28	12	34	9
% Hispanic	21	45	23	11	10	0	11	14	6
% Asian/Pacific Islander	27 (Chinese)	4	2	3	18	0	8	10	9
% Native American	21	0	4	0	3	0	0	0	13
% Other	0	0	0	0	0	3	0	1	1
OTHER INFORMATION									
Year program began	1989	1986	1974	1968	1966	1989	1988	1994	1977

* District names are pseudonyms.
† Figures are for years ranging from 1998–2000. During this time demographics and expenditures shifted and were calculated in a variety of ways.
†† The Hudson site report offers the reader an additional detailed description of a classroom science lesson.
‡ The Montview site report is unique in that it emphasizes the historical development of the program and the circumstances that influenced and shaped its evolution.

BENTON
EXECUTIVE SUMMARY

INTRODUCTION

The districtwide K–6 science program in Benton[1] began in 1994 and, until recently, has followed a well-defined path of maturation. Teachers use a kit-based curriculum featuring units developed by National Science Foundation (NSF)-funded projects of the 1980s, and professional development opportunities abound. These opportunities service teachers new to the district who require basic kit training as well as experienced teachers who want to explore inquiry pedagogy, science content, and science notebook use. Consistent with the district and community culture of individuality and independence, teachers have taken advantage of these opportunities in varying degrees, and a large cohort of science enthusiasts has developed. Several science resource teachers provide important pedagogical help to both new and old teachers and support the program through regular contact with principals.

CONTEXT

Community Overview

Benton is a city of 15 square miles, which includes approximately 90,000 residents and a mix of academia, hi-tech industry, and residential housing. The school population is a mix of poor, middle income, and upper middle income students with a decreasing percentage of the most affluent evident in the last few years. The student population reflects the diversity of the community. In grades K–6, approximately 40 percent are white, 33 percent are African American, 14 percent are Hispanic, and 13 percent are Asian. Forty-seven percent of the children qualify for free or reduced lunches.

Benton has 15 elementary schools (most K–8) and 1 high school. The total student population is about 7,500, with about 4,600 of those students in K–6. There are approximately 250 elementary teachers, and district turnover is low—about 5 percent per year. However, teachers are frequently transferred from school to school as enrollment fluctuates. Principals also have a history of staying in Benton for a long time. In October 1997, the district hired a new superintendent from outside the state. She faces a challenge of acquainting herself with the local personal, and political culture as she pursues her stated goals to address programmatic and financial inequities between schools.

1 Any individual, organization, or corporation named in this report has been given a pseudonym.

Budget

The per pupil expenditure for the 2000–2001 school year was a high $17,000, but administrators still need to watch their bottom line closely because Benton has increasingly competitive teacher salaries and a relatively large staff (due in part to the need to accommodate Benton's relatively high number of special needs students). With K–6 class size at an average of 16.7 (target is 22), many in the district expect staff reductions and budget cuts in the years ahead.

PROGRAM HISTORY AND DEVELOPMENT

Hands-on science in Benton developed in "fits and starts" over the past 40 years and then greatly accelerated in the 1990s with the support of NSF funding. The origins of the program are partially rooted in the national reform efforts of the 1960s and 1970s. At that time, Benton was interested in establishing state-of-the-art curriculum programs and began using some hands-on materials for science, primarily Science Curriculum Improvement Study (SCIS) kits.

Activities in the late 1980s are the foundation for the current program. At that time, a new superintendent established a focus on curriculum in part because, as she explained, "the school committee said 'fix the high school and give us curriculum'." So, with a very strong assistant superintendent for curriculum and instruction, she proposed five-year plans for new curriculum development and implementation in every core subject.

In 1991a committee selected Constance Connor, the present K–12 Benton science coordinator. Then, 1992 brought a turning point for the science program when Connor took a trip to the National Science Resources Center Leadership Institute in Washington, DC. She had obtained corporate support to attend the institute with a team to learn about kit-based curricula. Upon returning, Connor submitted a grant to NSF's Teacher Enhancement program, which was not funded. The next year, Connor tried again, this time working with school staff as well as several external consultants. The grant, which focused on teacher professional development was funded in June 1994 for $1.8 million.

The NSF-funded project established the vision of the current K–6 program, which was to give all children the experience of doing hands-on inquiry science, using *Insights*, *FOSS*, and *STC* modules. A second goal was to improve science education in grades 7–9. The key ingredient in the K–6 program, given materials support, was teacher professional development. This was to be based on the talents and activities of District Science Resource Teachers (DSRTs)—expert science teachers out of their classrooms supporting implementation of the program in the schools. The proposal was designed, with encouragement of the external consultants, so that K–6 teachers would all teach science whereas, previously, the systemwide science specialists mentioned earlier taught K–8 science. The provision of five DSRTs, paid by the district, was a key part of the plan and was financially viable due to money saved by eliminating the previous 20 K–8 science specialists.

The goals of the program ranged from the lofty to the practical. Leaders hoped to change expectations, the culture, and the practice of science instruction. The assistant superintendent explained that the district intended to change teacher's thinking about how science was taught—transforming from a mixture of textbook and teacher-directed hands-on approaches to an exclusively hands-on enterprise that fostered close collaboration between classroom teachers and their students. The inquiry pedagogical approach was a focal point of this vision. As one teacher explained, inquiry was about having "children framing their own goals for knowledge and answering their own questions."

THE CURRENT PROGRAM

Curriculum

The present curriculum is almost entirely a mix of FOSS, Insights, and STC units, with three kits required per grade level (see Appendix for complete list). This curriculum was crafted over several years with the input of key teachers to reflect a district science framework that addresses concept development, understanding, and skills. In addition to the kits, some teachers feel free to draw from other sources for additional science materials.

Materials Center

A carefully managed and organized materials center supports the science program. The center occupies a large space where staff collect and refurbish kits and send them out to teachers on a fixed schedule. Most kits are used three times per year with a few for the lowest grades remaining in classrooms all year. A manager and a clerical assistant support this center as well as the program as a whole, and are paid for with district funds, as are materials for unit refurbishment.

Science Notebooks

In response to the district's emphasis on literacy, the science department has, since 1999, used science notebooks intended to supplement and go beyond structured worksheets, and to encourage students to record and comment upon their observations and initial hypotheses. In 1999–2000, notebooks were distributed to all Benton elementary teachers and their students for experimental use in the classroom.

Instruction

Teaching Philosophy

All teachers interviewed subscribed to philosophies that emphasized the benefits for students of inquiry, and of learning by their own experiences. They appreciate having the kits, and some even feel comfortable adapting and building on them. One teacher said, "Kids learn more when they are generally curious, when something real is happening, and when they can ask their own questions." Another remarked, "When I think of science I don't think of topics; I think of the science process."

In spite of trying conscientiously, teachers in Benton face various barriers on their way to more developed and successful instruction. These include classroom management, science content understanding, and an apparent lack of participation in professional development. Many teachers feel they do not have enough time to prepare effective science instruction. This, combined with pressures that come from consideration of state, district, and school-based emphases on literacy affects their planning process for science instruction.

DSRTs

More than any other component of the science program, the changing roles and numbers of the DSRTs reflect the adaptations that the program has had to make in the face of changing district conditions. The use of DSRTs was introduced with the NSF grant in 1994, and was related to the new approach that regular teachers—rather than science specialists—would offer science instruction in the classroom.

The 2001–2002 school year brings a major restructuring of the DSRT staff. The present positions and title of "DSRT" will be eliminated, and instead, there will be two K–6 science mentors, one 6–8 science mentor, and one 7–12 science mentor. The mentors will be required to have an undergraduate science degree and a science teaching credential for 5–9 or 9–12. They also must have experience teaching inquiry science, leading professional development, and working in an urban school.

Assessment

Beginning in 1998, the state standardized test known as STAR (State Testing and Assessment Record) has exerted a significant influence on the science program. The results are publicized in the press, and the district is very serious about achieving good performance. In 2000, the district score in elementary science was below the state average. Some feel that the STAR is a waste of time and a distraction. Others, however, feel that it is a help to the science program because it raises its visibility and credibility.

Professional Development

The professional development experiences in the first few years of the program were critical. They were highly valued by many and helped to instill loyalty to the science program and to the inquiry process. One teacher who experienced that professional development remarked that she now understands how she teaches science and that she has "done a full 180...I look forward to teaching science." Another commented that the science department is focusing "not only on student learning but also on teacher learning."

Additionally, teachers seem to recognize and appreciate the respectful, professional way the science program works with them. Connor was strategic about selecting professional development that was not only kit-based but also had personal inquiry experiences that effectively gained the participants' "buy in." Beginning in 1997, there was no districtwide "first-stage" training on kits, or an introductory overview. New teachers and those changing grades were expected to get help from the DSRTs and through optional training sessions on some individual kits. The Science Department offered a wide range of more advanced staff development opportunities for motivated teachers, often with DSRTs leading.

DECISION MAKING AND LEADERSHIP

District-Level Decisions

The central office provides verbal and financial support for the science program, but at the same time, takes actions that ultimately inhibit the program. Science is considered a core exemplary subject, but its status is declining as the district elevates its support for the other core subject areas. Other district priorities and a looming budget crunch have resulted in the "maintenance" of the science program, but there has been no allocation of additional funds since the end of the NSF grant. District leaders in a position of decision-making about money seem confident that the program will remain strong without extra funds.

Communication

Within the central office, communication about the science program appears to be thorough and regular. Connor meets with the assistant superintendent monthly, and they periodically touch base. The superintendent believes that the science program can be sustained only if they have a common vision and come to agreement on their goals for student achievement and how to accomplish them. The regular meeting is one way to achieve that.

Communication between the Science Department and the Office of Professional Development is still developing. The director of professional development envisions close interaction between the three offices of accountability, curriculum, and professional development. But she has chosen to place the Office of Professional Development in a school, making this interaction somewhat of a challenge. Still, she feels strongly about being close to the schools and believes that their discussions are regular enough and the proximity close enough that they should be able to maintain open communication.

Principals and School-Level Decisions

The Benton school culture prizes a decentralized, school-based approach, which has been reinforced in recent years by the linking of some professional development monies with school improvement plans. The science program has also tried from time to time to heighten principals' understanding of the program via briefings at the regular principals meeting, printed materials, and tips for classroom observation. Uncertain of the effectiveness of past efforts, Connor wants to launch a renewed and larger effort directed toward principals, perhaps with the science mentors. DSRTs have encouraged principals to avail themselves of the trainings offered through the Science Department—especially in the areas of science notebooks and performance assessments—in meeting literacy and assessment-oriented goals for their schools.

District Science Leadership

Connor is known throughout the district as a strong leader. Some suggest that she can be difficult to work with, but at the same time, they respect her for her abilities and drive, and for what she has accomplished with the science program. The superintendent described her as a "visionary" and others have referred to her as a "genius" and a "powerhouse." One principal believed that Connor was responsible for the durability of the program and fears that unless it is under a "watchful eye," it could easily disappear.

Connor's relationship with the classroom teachers seems very strong. They appreciate her professional manner and many have developed loyalty to the program because of that. They also comment that she listens to them when they raise concerns about the program. For example, when some of the kits didn't work well and needed improvement, Connor helped them to adapt the kits to make them a better match. The newer teachers in the district, however, did not share that experience and may not hold the same loyalty for Connor and the science program.

The DSRTs, along with a middle school lead teacher plus two other middle grade science teachers, comprise Connor's informal leadership team. They meet weekly and discuss all of the district business as it relates to the science program. Although this is a strong team, they do not have a great deal of authority, which limits their leadership abilities somewhat.

In the earlier stages of the science program, "liaisons" were part of the school leadership structure. These staff were "go-betweens" between the science department and the teachers and offered support to classroom teachers. They helped with colleagues who were very resistant to change, and they also "helped teachers find materials," distributed information, and helped manage materials. Over time, their roles lost effectiveness and support, and Connor eliminated the positions in 1998.

RESOURCES AND SUPPORT

Funding

Funding is an ongoing, serious concern. The continuation of the professional development activities, which NSF funds launched is very important. While Connor has been successful at obtaining grants, many would like to see the district secure solid local funding. Connor currently receives $30,000 annually from the assistant superintendent for professional development and materials. A next step in securing financial support would be to obtain a commitment from the Curriculum Department or the Professional Development Office, but so far this has not happened. Currently, funds for the DSRTs are in the district budget. The superintendent has publicly stated that the science program will receive the financial supports it needs to continue.

Community and Partnerships

Benton has numerous scientific, research, and cultural institutions nearby that are willing to be involved with the schools. Although the district as a whole has few formal partnerships, the Science Department, as well as individual schools and teachers, have ongoing relationships with several institutions. In some cases, these relationships have provided powerful professional development experiences for teachers and enhanced the learning experiences of students.

ACCOUNTABILITY

The goals of the science program are communicated through the district framework and materials handed out to principals and teachers. The state science frameworks, which were finalized in May 2001, appear to have resulted only in relatively minor adjustments in the curricular program. The STAR, as mentioned earlier, is predicted to have a mixed impact on the program, promoting general accountability for the teaching of science but possibly serving as a distraction that will threaten the program.

Still, no practical accountability measures exist for the science program, so teachers can choose not to teach science. In some cases, principals say they stay informed about the status of instruction through the DSRTs, but few directly observe teachers teaching science. One principal, however, did remark that she uses a form provided by the DSRTs. This form lists the important concepts in each module and clearly describes evidence of student learning. These were distributed to the principals so that they would know what to look for in their teachers' classrooms, but apparently they aren't widely used.

In 1999–2000, the superintendent also took steps toward increased accountability by establishing the Office of Achievement and Accountability. One area of targeted work for this office is supporting the creation of curriculum frameworks and assessments. It has budgeted $10,000 for Connor's staff to work on assessments, and it has given the director of professional development $20,000 for professional development around literacy. Their work is supported by the work of the director of development and assessment. She and one assistant process all the test data from STAR and SAT-9 and provide schools with results they ask for to use for diagnostics to improve instruction. She also writes an annual report to the School Committee, and provides data to the co-directors of achievement and accountability. The assessment director has begun a new initiative designed to determine through a questionnaire and some classroom observations what math and science is really taught in the classrooms.

EQUAL ACCESS TO SCIENCE

Equity is a shared, but not often articulated, concern among teachers and administrators in the system. Equity-related issues generally are either programmatic or building-based and are shaped, in part, by the fact that Benton has a school choice plan that enables students to attend any school in the district. Parents select their top three schools and then participate in a lottery based on race, location, and whether or not there is a sibling in the school. This plan is intended to stabilize the student population, but some feel that it brings instability since parents can move their children each year.

Currently, the science program appears to be an island of equity in the system. All students are intended to have the same curriculum and access to the same materials and program. All teachers are provided with the same materials and have equal access to the professional development needed to support it. The science program has obtained support and can continue to obtain support on that basis. The equal opportunity, however, does not necessarily mean an equitable program. Without an accountability system for ensuring the program is implemented, there is no guarantee that all students truly have the access they are intended to have through this program.

SUMMARY

The Benton program, while not as long-standing as many, is a beneficiary of a national science reform movement that made available standards, commercial instructional materials, and funding. NSF funding enabled the program to roll out according to a well thought-out strategy, and conveyed the program's image as smart and reliable. The program has enjoyed strong and sustained leadership since its inception.

The very strong position of the program in the minds of all the people in the district speaks well for keeping the resources needed to sustain the present program, but there is no indication that additional resources will be available. The change in staffing, intended to make the focus of the science program more explicitly K–12, presents a major challenge to the K–6 program. With only two science mentors for the elementary schools instead of four DSRTs, the K–6 program will require a new and different work plan. The important notebook and assessment projects will require ongoing work to bring them to fruition, efforts extending beyond the mentors' other school and teacher-based activities. Even with this strong foundation, the program will still need to work hard to sustain itself into the future.

BENTON

INTRODUCTION

The districtwide K–6 science program in Benton[1] began in 1994 and, until recently, has followed a well-defined path of maturation. Teachers use a kit-based curriculum featuring units developed by National Science Foundation (NSF)-funded projects of the 1980s, and professional development opportunities abound. These opportunities service teachers new to the district who require basic kit training as well as experienced teachers who want to explore inquiry pedagogy, science content, or science notebook use. Consistent with the district and community culture of individuality and independence, teachers have taken advantage of these opportunities in varying degrees, and a large cohort of science enthusiasts has developed. Several science resource teachers provide important pedagogical help to both new and old teachers and support the program through regular contact with principals.

SUSTAINABILITY: THE ABILITY OF A PROGRAM TO MAINTAIN ITS CORE BELIEFS AND VALUES AND USE THEM TO GUIDE PROGRAM ADAPTATIONS TO CHANGES AND PRESSURES OVER TIME.

The legacy of NSF financial support is a core program that is highly respected. It has matured quickly and taken root as an exemplary and uniquely centralized program within the district. Blessed with resources and leadership, the program has adapted to changing conditions as it moves toward its goal of offering quality science instruction to all children. Now, the program faces challenges and must continue to adapt to reduced financial resources and shifting curricular priorities within the district. The Benton science program is present in every school and touches every teacher in some way. Yet lingering questions persist: How much science is being taught, and how well? How will the state standardized tests affect the science program? and Will there be enough financial support to sustain the program now that NSF funding has come to an end?

CONTEXT

Community Overview

Benton is a city of 15 square miles, which includes approximately 90,000 residents and a mix of academia, hi-tech industry, and residential housing. It is the home of a major university as well as many corporations. The surrounding area is teeming with research labs, teaching hospitals, high-tech firms, educational nonprofits, and museums with strong interests in serving children. Benton is also home to many families living below the poverty level. These contrasting populations enhance Benton's eclectic environ-

1 Any individual, organization, or corporation named in this report has been given a pseudonym.

SIZE	
Sq. miles	15
# elem. students	4,600
# elem. schools	14
# elem. classroom teachers	200
RESOURCES	
Per pupil expenditure	$8,800
Teacher starting salary	$34,116
NSF funds?	yes
DEMOGRAPHICS	
% students eligible for free/reduced price lunch	39%
% white	41
% African American	34
% Hispanic	14
% Asian/Pacific Islander	10
% Native American	0
% Other	1
YEAR CURRENT PROGRAM BEGAN	**1994**

Figures are for years ranging from 1998–2000. During this time demographics and expenditures shifted and were calculated in a variety of ways.

ment but also challenge the school district to serve a student population with widely ranging socioeconomic backgrounds.

The school population is a mix of poor, middle income, and upper middle income students with a decreasing percentage of the most affluent evident in the last few years. Housing is quite expensive with a median value of approximately $250,000. Few residents live in single-family homes; most live in two- and three-family dwellings, and the poorest live in subsidized housing. Many residents rent, and with the removal of rent controls about five years ago, many middle-and low-income families have moved out of the city. The wealthier residents tend to send their children to private and parochial schools.

The student population reflects the diversity of the community. Eighty-five percent of Benton students are enrolled in public schools. Of these, in grades K–6, approximately 40 percent are white, 33 percent are African American, 14 percent are Hispanic, and 13 percent are Asian. Forty-seven percent of the children qualify for free or reduced lunches. The district has had a "controlled choice" plan in place since 1981 so the individual school populations do not necessarily reflect their surrounding neighborhoods. The aim of this plan was to align student demographics in all schools with the demographic distribution of the overall student population. In reality, school populations differ significantly demographically and economically. In 2001, the School Committee passed a new school choice plan that placed greater emphasis on socioeconomic status of students and less emphasis on race.

Benton is known for being politically liberal and highly focused on the process of how political decisions are made, sometimes at a loss of sufficient focus on what those decisions are. As the superintendent described, Benton is "a very process-driven city." Parents and other community members closely watch the workings of the school system that are tightly linked to citywide politics. Issues—such as where to place a new public library—can be hotly debated for years. And yet, many acknowledge that despite the involved process, not everyone has equal access to participation or to the decision-making power.

Benton has 15 elementary schools (most K–8) and 1 high school. The total student population in 2000 was about 7,300, with about 4,300 of those students in K–6. There are approximately 250 elementary teachers, and district turnover is low—about 5 percent per year. However, teachers are frequently transferred from school to school as enrollment fluctuates. Principals also have a history of staying in Benton for a long time. In October 1997, the district hired a new superintendent from outside the state. She faces a challenge of acquainting herself with the local personal, and political culture as she pursues her stated goals to address programmatic and financial inequities between schools.

Budget

Eighty-five percent of the $130 million school budget is locally funded. The mayor serves as a member and chair of the school committee. The result is a high degree of local control but a budget process that involves politicians.

Several changes in recent years are beginning to affect educational policy. An increased cost of living in Benton is causing many poorer families to leave, resulting in an upward shift in the average socio-economic status of residents. For the schools, this has produced an overall drop in enrollment. Two schools have recently merged, and more mergers are expected. This trend has made at least one school committee member feel that the public school system in Benton is at a "crossroads." The per pupil expenditure for the 2000–2001 school year was a high $13,296, but administrators still need to watch their bottom line closely because Benton has increasingly competitive teacher salaries and a relatively large staff (due in part to the need to accommodate Benton's relatively high number of special needs students). With K–6 class size at an average of 16.7 (target is 22), many in the district expect staff reductions and budget cuts in the years ahead.

Issues of Local Importance

Literacy and assessment issues are high priorities for the district. All schools are required to submit School Improvement Plans (SIPs), and the district administration has mandated that literacy be one of the three goals all plans must include. The district also is attempting to develop alternative assessments to meet district-based benchmarks that currently are under development in core subject areas. Low performance in a number of schools is a concern. The superintendent is attempting to rectify this situation through a battery of approaches whose main focus is to ensure equity, both encompassing and extending beyond science.

The district also is struggling most immediately with a variety of issues related to the statewide standardized test known as STAR (State Testing and Assessment Record). The issues include low scores in many areas, parent protests about overemphasizing the value of the test, and a high failure rate for the high stakes grade-10 test required for graduation. While science is not part of the graduation requirement, it still is a matter of concern at all grades. Many believe it is not a close match with the science program at the elementary level. The director of professional development commented, "You have a quality [science] program and you may not necessarily have test scores that indicate the depth of what is happening with that science instruction in the inquiry model."

PROGRAM HISTORY AND DEVELOPMENT

Early Years

Hands-on science in Benton developed in "fits and starts" over the past 40 years and then greatly accelerated in the 1990s with the support of NSF funding. The origins of the program are partially rooted in the national reform efforts of the 1960s and 1970s. At that time, Benton was interested in establishing state-of-the-art curriculum programs and began using some hands-on materials for science, primarily Science Curriculum Improvement Study (SCIS) kits. The science coordinator purchased them for science specialists who used them to teach most of the elementary science in the district, once a week for 45 minutes in each class. Aside from this activity, classroom science was textbook driven. Eventually, the emphasis on curriculum was eclipsed by other programmatic preoccupations such as interest in alternative schools, high school houses, a teenage parenting center, and expanded bilingual and special education.

Second Generation

Activities in the late 1980s are the foundation for the current program. Early on, Carolton, a small liberal arts college in the community, worked to involve some Benton schools in a hands-on science program. Carolton provided courses for interested teachers and the district provided some money for materials, but the program didn't expand because, according to one of the science specialist teachers at that time, "there was no one to spread it." Individual schools also sometimes used kits produced by the local museum of science. Both institutions have remained connected to the Benton science program, along with many other partners.

"Fix the high school and give us curriculum."

In the mid-1980s, a new superintendent reestablished the focus on curriculum started in the 1970s. She had been in the district in many capacities including teaching; leading the K–8 program; and working on accountability, testing, equity, and counseling. She explained that at the time, "the school committee said 'fix the high school and give us curriculum'." So, with a very strong assistant superintendent for curriculum and instruction, she proposed five-year plans for new curriculum development and implementation in every core subject.

For science, the assistant superintendent convened a broad-based science advisory committee which, in 1991, selected Constance Connor, the present K–12 Benton science coordinator. Connor came highly qualified for the job, with a powerful background in science and education, including experience as an immunology graduate student, lab technician, middle grades science teacher, professor of science education, and public schools administrator. She also has an Ed.D. with doctoral work that focused on the interaction of outside organizations with school systems. At the time Connor was hired, there had been some debate about whether to hire two coordinators (one for K–6 and one for 7–12) or none at all. Those who were against the idea of hiring a coordinator were concerned about the fiscal implications; hiring a coordinator for science would mean they would have to hire for all of the other subject areas as well. The committee compromised by deciding to hire one for K–12. Although it was clear that it might be an overwhelming job, Connor accepted the position. The high school part of her job is extremely challenging and competes with the K–8 work for time and attention.

The NSF Grant

A turning point for the science program came in 1992. That year, Connor took a trip to the National Science Resources Center Leadership Institute in Washington, DC. She had obtained corporate support to attend the institute with a team to learn about kit-based curricula. Upon returning, Connor submitted a grant to NSF's Teacher Enhancement program, which was not funded. The next year, Connor tried again, this time working with school staff as well as several external consultants. The grant, which focused on teacher professional development (this was prior to NSF's systemic programs) was funded in June 1994 for $1.8 million. The nominal end of the grant was in June 1998, but Connor husbanded funds for a gradual decrease in NSF support that lasted through fall 1999.

The NSF-funded project established the vision of the current K–6 program, which was to give all children the experience of doing hands-on inquiry science, using *Insights*[2], *FOSS*[3], and *STC*[4] modules. A second goal was to improve science education in grades 7–9. The key ingredient in the K–6 program, given materials support, was teacher professional development. This was to be based on the talents and activities of District Science Resource Teachers (DSRTs)—expert science teachers out of their classrooms supporting implementation of the program in the schools. The proposal was designed, with encouragement of the external consultants, so that K–6 teachers would all teach science whereas, previously, the systemwide science specialists mentioned earlier taught K–8 science. The provision of five DSRTs, paid by the district, was a key part of the plan and was financially viable due to money saved by eliminating the previous 20 K–8 science specialists.

The goals of the program ranged from the lofty to the practical. Leaders hoped to change expectations, the culture, and the practice of science instruction. The assistant superintendent explained that the district intended to change teacher's thinking about how science was taught—transforming from a mixture of textbook and teacher-directed

They intended to change teacher's thinking about how science was taught—transforming from a mixture of textbook and teacher-directed hands-on approaches to an exclusively hands-on enterprise.

2 *Insights*: Developed by Education Development Center, published by Kendall/Hunt Publishing.
3 *FOSS* (Full Option Science System): Developed by Lawrence Hall of Science, published by Delta.
4 *STC* (Science Technology for Children): Developed by National Science Resources Center, published by Carolina Biological.

hands-on approaches to an exclusively hands-on enterprise that fostered close collaboration between classroom teachers and their students. The inquiry pedagogical approach was a focal point of this vision. As one teacher explained, inquiry was about having "children framing their own goals for knowledge and answering their own questions."

The initial five DSRTs participated in three years of intensive professional development, working closely with Connor and external consultants. Each DSRT worked with a group of schools, with the five DSRTs distributed across a total of 15 schools. The initial ratio of DSRTs to teachers was approximately 1:50 (better than many kit-based programs where there are resource teachers). In addition to the DSRTs, the original plan also identified one or two classroom teachers as "liaisons" at each school. The program paid them a modest annual stipend and provided them with special professional development sessions. "It was wonderful. They were really excellent meetings," remembered one former liaison. The original plan also called for school-based "Science Action Teams" to enlist parental and other outside support for the program. These teams never were fully realized, partly because of the lack of principal support and also because they were intended to build on existing school teams that, themselves, were not well established. Finally, there was to be a Science Advisory Board, which never became functional. In the end, therefore, the strongest professional development aspects of the program remained the DSRTs and those teachers who served as liaisons, many of whom have remained loyal to the science program.

Soon after the project was funded, Connor convened its first summer institute. Teachers attended on a voluntary basis and were paid from the NSF grant for their two days of work. The institute attracted about one third of the K–6 teachers. The agenda included an introduction to one kit per grade level with workshops led by the external consultants. Before the institute began, Connor had selected two kits per grade level "without a lot of organized thought." Staff development continued for the next three years with summer institutes and release time during the school year. Typically it reached about one third or fewer of the 250 teachers. Kit training has always been voluntary, but paid. Since then Connor and the DSRTs have worked with teachers to get feedback and pilot many additional units so that now the program has three kits per year, taught over varying periods.

Recent Developments

Nineteen ninety-eight brought a sea change for the program. Shrinking NSF funding coincided with the arrival of a new superintendent and the implementation of statewide testing. All three districtwide changes have challenged the science program to adapt while holding fast to its core vision. First, the new superintendent established a new Office of Professional Development focused initially on school-based budgeting and control of professional development. Second, the students took the STAR test for the first time in spring 1998 resulting in highly publicized scores for language arts, math, and science. And third, in 1998–1999, the end of the NSF grant threatened the staffing of the program, reducing staff by one DSRT and a grants manager beginning in 1999–2000. Additionally, Connor was on sabbatical for the 1999–2000 school year, and an DSRT led the science program. That same year, the DSRTs instituted a revised school-based strategy, and the program moved to emphasize literacy connections to match the highest district priority. The administration attempted to reduce the staff by another DSRT in 2000–2001, but was successfully opposed.

THE CURRENT PROGRAM

Curriculum[5]

The present curriculum is almost entirely a mix of *FOSS*, *Insights*, and *STC* units, with three kits required per grade level. This curriculum was crafted over several years with the input of key teachers to reflect a district science framework that addresses concept development, understanding, and skills. In addition to the kits, some teachers feel free to draw from other sources for additional science materials. For example, one teacher described a "planting a garden on a grid" activity that came from a math curriculum, and explained she sometimes borrows textbooks from grade-7 and grade-8 colleagues for "filler time" between kits. This teacher teaches science every day, and tries to extend "the curiosity and fun and sense of exploration" to other subjects she teaches as well.

Leaders of the program hold varying points of view of what the highest priority program goals are, including "excitement for kids and developing interest in hands-on science," "introduce the inquiry process," and "using the kits."

Principals and top administrators talk about the program with generalities like "hands-on," and a few mention "inquiry" but cannot speak specifically about the "nuts and bolts" of the program. Leaders of the program hold varying points of view of what the highest priority program goals, including "excitement for kids and developing interest in hands-on science," "introduce the inquiry process," and "using the kits." Despite these mixed views, there is general clarity about the basic approach and intentions of the program.

Science is generally taught anywhere from one to three times a week, but no one closely monitors the time. School committee regulations specify the number of minutes that science should be offered to elementary students each week, but this is not enforced by principals. Interestingly, the survey administered in 2000 suggests that principals have the impression that teachers at the upper elementary level are teaching more science than they actually are. Still, for the most part, Benton teachers seem to have adhered to the kit-based program. The survey suggests that science textbooks have no presence in nearly all classrooms in the district and that Benton elementary teachers understand that they are expected to teach three science kits per year, and most are doing so.

5 For an overview of the curriculum units used at this site, see Appendix C.

Materials Center

A carefully managed and organized materials center supports the science program. The center occupies a large space where staff collect and refurbish kits and send them out to teachers on a fixed schedule. Most kits are used three times per year with a few for the lowest grades remaining in classrooms all year. A certified teacher ran the materials center very effectively in the 1998–1999 school year, and then became an DSRT. A new manager for kit refurbishment was hired and trained at the start of the 1999–2000 school year. A manager and a clerical assistant support this center as well as the program as a whole, and are paid for with district funds, as are materials for unit refurbishment. According to materials center staff, about 70 percent of the kits are returned with most of the contents used. Only about 15 percent are returned with less than half of the contents used.

Science Notebooks

In response to the district's emphasis on literacy, the science department has, since 1999, used science notebooks. These notebooks are intended to supplement and go beyond structured worksheets, and to encourage students to record and comment upon their observations and initial hypotheses. In 1999–2000, notebooks were distributed to all Benton elementary teachers and their students for experimental use in the classroom. Science department staff offered Saturday professional development sessions for teachers interested to learn more about how notebooks could be used in their science classrooms. They also offered informal support to, and received feedback from, teachers over the year.

In 2000–2001, science staff published a detailed 42-page Science Notebook Guide and supported it by including notebooks with all kits and offering accompanying professional sessions. The guide aims to boost the use and quality of notebooks. This has been a major goal in the process of supporting science as an aid to literacy to raise it in the consciousness of principals and teachers. It offers guidance in using the notebooks as an assessment tool and as a tool for science learning. To guide and maximize notebook use, the Science Notebook Guide has an appendix that lists the key science concepts in each unit.

Alignment with State Frameworks and Testing

Science program leaders have had to give attention to ensuring that the science program is aligned with the state frameworks and tests. This has resulted in some adaptations (such as changing the sequence of some units and replacing others) but none that have drawn the program away from its core hands-on orientation. The program also is accommodating the state's decision to move the standardized science test from fourth to fifth grade in 2002.

Moving the test to fifth grade means that teachers in the earlier grades will have less feedback on their science program, and science program staff now wonder if an additional science test should be added in grade 3. No one knows if the standardized test will improve the science program, but it has reinforced the position of science as a core subject in the elementary schools. According to an DSRT, none of these changes are likely to result in dramatic changes in the kits and may actually result in some desired adjustments. She explains:

> There are a couple of units in grade 5, which we have targeted for major revisions, to put content in. For example, in the variables unit, they teach variables but they are not specific about the conceptual development at all…We want to throw out one of those FOSS activities and introduce…one or two things on sounds and look at variables....bring out some science concepts.

Connor is hoping that their future realignment work will deepen the content of the units and allow for more work on science concepts, supporting her view that the teachers need more content knowledge.

Performance-Based Assessment

In the 2000–2001 school year, staff worked to create assessments for every unit. The assessments are about 45 minutes long and are multiple choice and open response, somewhat similar in design to the STAR questions. The project is an important work in progress that the staff hopes to finish during the coming year. The assessments were developed under deadline, and given and collected once in January 2001. The task of grading several thousand is daunting and requires the use of rubrics that don't yet exist. These assessments are more closely matched to the science curriculum than the current state test, and will provide important data for educational decision makers.

Instruction

The research team observed 19 elementary classrooms (K–6 with some multi-grade classrooms) in 12 of the district's 15 schools. The teachers were described as "good" or "excellent" by the DSRTs but were not necessarily notable for their science instruction. All classes were small, averaging less than 20 students. The range of non-white students was 21–100 percent, with an average of 55 percent. In most classrooms, non-white students were the majority. In many of the classrooms, there were multiple adults present, including teaching aides, parents, teachers-in-training, and volunteers from a local university. Overall, science materials and study was evident in all the rooms, including aquariums, charts, and graphs, but little individual student work was on display. Instruction included a range of hands-on and inquiry-based activities. Some of the lessons built on students' prior knowledge, while others were more teacher-directed.

Observing Ecosystems

Curiosity and problem seeking pervade the classroom as the sixth-grade students work in their small groups. They observe many details in their ecosystems, not only naming and discussing what they see, but also forming hypotheses, disputing them, and sharing ideas about how to describe them. One student, discussing pH level remarks, "I think it's a '6' because it changes when all the stuff [pollution] goes to the bottom." Another, discussing plant height comments, "I think the reason these are the biggest is because these were the first ones." Another student adds, "And they got a lot of sunlight." The effusive enthusiasm of the children is visible for the entire lesson.

Even some who had little or no kit training felt confident about their instruction through experiences using the guides, advice from their colleagues, and help from their DSRT.

Teaching Philosophy

All teachers interviewed subscribed to philosophies that emphasized the benefits for students of inquiry, and of learning by their own experiences. They appreciate having the kits, and some even feel comfortable adapting and building on them. One teacher said, "Kids learn more when they are generally curious, when something real is happening, and when they can ask their own questions." Another remarked, "When I think of science I don't think of topics; I think of the science process."

While all of the teachers were enthusiastic about the science program, their participation in professional development activities was variable. Nearly half of the teachers have not participated in training for all of their grade-level kits. Still, even some who had little or no kit training felt confident about their instruction through experiences using the guides, advice from their colleagues, and help from their DSRT. They were uniformly pleased with the DSRTs, sometimes just by their presence and availability, if needed. One teacher characterized her DSRT by saying, "She's not pushy; she's supportive and she's knowledgeable."

In spite of trying conscientiously, teachers in Benton face various barriers on their way to more developed and successful instruction. These include classroom management, science content understanding, and an apparent lack of participation in professional development. The survey indicated that many teachers feel they do not have enough time to prepare effective science instruction. This, combined with pressures that come from consideration of state, district, and school-based emphases on literacy affects their planning process for science instruction.

DSRTs

More than any other component of the science program, the changing roles and numbers of the DSRTs reflect the adaptations that the program has had to make in the face of changing district conditions. The use of DSRTs was introduced with the NSF grant in 1994, and was related to the new approach that regular teachers—rather than science specialists—would offer science instruction in the classroom.

Four DSRTs worked in the elementary schools in 1999–2000. One DSRT position was temporarily dropped from the budget for the 2000–2001 school year, but was then reinstated by the School Committee. Compared with the five strong DSRTs who had extensive professional development during the early years of the program, the staff is smaller and weaker. One original DSRT was reassigned to the new district Office of Professional Development in 1998–1999. One DSRT remained on staff and another returned to the classroom in 2000–2001.

Teachers appreciate the efforts of the DSRTs a great deal. They deliver materials, check in with teachers on recent lessons, co-teach or lead lessons, help teachers prepare for upcoming lessons, advertise upcoming districtwide professional development, and get information about needs of the program. One teacher mentioned that her DSRT was a key part of successful science education because she and her students can e-mail the DSRT directly with their questions.

The 2001–2002 school year brings a major restructuring of the DSRT staff. In Connor's words, "The redesign will expand the scope and depth of science technical assistance and support from K–6 to K–12." The present positions and title of "DSRT" will be eliminated, and instead, there will be two K–6 science mentors, one 6–8 science mentor, and one 7–12 science mentor. The mentors will be required to have an undergraduate science degree and a science teaching credential for 5–9 or 9–12. They also must have experience teaching inquiry science, leading professional development, and working in an urban school. Only one of the DSRTs from 2000–2001 was expected to remain.

The mentor job descriptions reflect emerging needs in the district, including developing and administering authentic assessments, teaching reading and writing within the curriculum, and analyzing STAR data and developing a systemic response. The mentors will do curriculum work as well as mentor new and old teachers, and they will design and deliver professional development. The high school mentor will provide in-class demonstration teaching and instructional coaching. The requirement of a science degree and credential responds to Connor's belief that teachers need more content support.

Assessment

Beginning in 1998, the STAR has exerted a significant influence on the science program. The results are publicized in the press, and the district is very serious about achieving good performance. In 2000, the district score in elementary science was below the state average. Scores in grades 8 and 10 also were very low in all subjects, causing alarm due to the fact that passing the grade 10 test is required for graduation. Leaders of the science program are now looking at the latest STAR science test and the current curriculum and working to adjust and better align them. One DSRT has made an item-by-item analysis of the STAR science results and the Benton curriculum, and she feels that "it brings to the core whether the science curriculum is being delivered or not." She explains,

> There were two questions; they were both rocks and minerals. One was a written question and one was a multiple-choice question. Our students did not do particularly well….So what you have to do is to disaggregate the schools because often you have two third-grade teachers—one teacher who won't really teach it or teaches it poorly, and one who does. So you have already mixed your stuff up. But it does say that it could be that the curriculum is there and it is not being implemented—one possibility—or that your kids are exposed to the

Beginning in 1998, the STAR has exerted a significant influence on the science program.

> curriculum but by the end of fourth grade they don't remember the test that they did in the third grade rocks and minerals [unit]…At least the test has given us the data to think about and even raise these questions.

Some feel that the STAR is a waste of time and a distraction. Others, however, feel that it is a help to the science program because it raises its visibility and credibility. Some of the questions are, in fact, aligned with the goals of the science program, and one DSRT commented that some teachers are now "teaching to the test...but not necessarily in a bad way." Connor also has used the STAR to push some of her ideas at the 7–12 grade levels. It is providing a leverage point that she wouldn't otherwise have. It has caused some controversy in the community with some students (with their parents' support) refusing to take it. The state counts "refusenicks" as zeros in calculating average scores, making their published Benton averages difficult to interpret, but there are adjusted Benton results computed by the district. At grade 4, only five percent refused to take the test.

Professional Development

The Science Department must increasingly compete with other departments—including those that are placed high on the district reform agenda—to obtain support for professional development. In addition to $30,000 that Connor receives from the district, the Science Department has been able to obtain the additional external funds necessary to provide teachers with training and other professional development. At the same time, the Science Department has had to adapt to sweeping changes in professional development that the district began to make in 1997 when the new superintendent arrived.

Office of Professional Development

Upon her arrival, the superintendent hired a director of professional development, a new position for the district. The new Office of Professional Development has a small budget and staff in part because decision making for professional development has been placed at the school level. Funding has been distributed to the schools at a rate of $20 per student per year beginning in fall 1999, with the poorer performing schools (as determined by test scores) getting some additional money. This approach conforms with the site-based culture of Benton. As the assistant superintendent says, "The key to the future is school-based leadership." Professional development money for science, then, comes from three primary sources: school-based budgets, the Curriculum and Instruction Division, and the Office of Student Achievement and Accountability. No coordination exists among these sources and the Science Department must piece together funding in order to carry out its program goals.

The professional development director has a staff of three, each overseeing the development of professional development plans for four or five schools.

These plans are intended to be linked with and "lift out" the priorities of School Improvement Plans (SIPs). Across all schools, only one had an item in its 1999–2000 SIP linked with science; and the same was true in 2000–2001. Literacy is the mandated and overwhelming priority. Furthermore, only a small number of schools submitted associated Staff Development Plans the first year. One principal reported that the paperwork was not worth the extra $5,000–$7,000 that the plans would bring in.

The Curriculum and Instruction Division has in the past made some money available to the Science Department specifically for training, but the great majority of the funding has come from external sources (including NSF) and Eisenhower funds. Grants from Bayer and Hewlett-Packard also supported the program, but ran out in 2001. In this environment, the Science Program must continuously work to secure funding for future professional development activities.

Professional Development Program in Science

The professional development experiences in the first few years of the program were critical. They were highly valued by many and helped to instill loyalty to the science program and to the inquiry process. One teacher who experienced that professional development remarked that she now understands how she teaches science and that she has "done a full 180...I look forward to teaching science." Another commented that the science department is focusing "not only on student learning but also on teacher learning."

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Additionally, teachers seem to recognize and appreciate the respectful, professional way the science program works with them. Connor was strategic about selecting professional development that was not only kit-based but also had personal inquiry experiences that effectively gained the participants' "buy in." For example, some of the teachers who were "liaisons" in the schools said they were "allowed to be learners" during that early professional development and that they "reflected on science ourselves." As one explained, "…we were getting fair compensation and knew what we were getting into." Now, new teachers depend on the DSRTs for periodic support and don't have the same kind of in-depth, meaningful experience.

Throughout the life of the program, the Science Department has continued to offer a variety of professional development experiences, ranging from introductory to more advanced. While the number of participants is often low, the department is dedicated to keeping these opportunities available for Benton educators, financing them through outside money, if necessary.

Beginning in 1997, there was no districtwide "first-stage" training on kits, or an introductory overview. New teachers and those changing grades were expected to get help from the DSRTs. The Science Department offered a wide range of more advanced staff development opportunities for motivated teachers, often with DSRTs leading. Optional kit trainings and an introductory overview took place in fall 1999, using the last of NSF funds for after-school stipends. There were 2.5-hour sessions for each kit, led by experienced teachers (who had taught the kit at least twice), who first attended a 3.5-hour workshop on how to lead. The DSRTs identified these teachers through an "invitation to apply" approach. The kit workshops were not as well attended as had been hoped—perhaps because of scheduling at the start of the school year and poor communication—but were judged to be worthwhile by those who attended.

The more advanced professional development activities included an "Introduction to Inquiry" institute, consisting of five two-hour sessions, and Project FIRST, a school-based program that focuses on looking at student work to gauge the needs and the effectiveness of instruction. Other professional development activities included five professional development sessions over the summer, varying in length from three to five days, covering content (a Steven J. Gould Book), process (Introduction to Inquiry), and curriculum (Linking Science and Literacy) issues. A significant-sized core group of science enthusiasts, as much as 25–30 percent of the K–6 teachers, sign up for something each summer in order to continue to grow in science. Another form of advanced professional development comes in an effort to have teachers work on curriculum or assessments. However, a recent attempt to form assessment groups failed for lack of volunteers.

In 1999–2000, teachers had opportunities to attend more than 20 workshops, each one to five days long, for 2–20 teachers. Two hundred fifty K-6 teachers participated in a total of 4,000 teacher-hours offered, resulting in an average of 16 hours of professional development per teacher. Not every teacher participated, and many attended many more hours. About 40 teachers attended the Saturday notebook workshops. A 2.5-day supplemental training on the kits was also offered at the local university supported by a grant. All teachers who participated in these sessions received either professional development credit or pay. The 2000–2001 year had an eclectic mix of professional development opportunities for interested teachers.

What the New Teachers Say

When a group of new teachers—most in their first year of teaching—spoke about the science program, they were uniformly enthusiastic about it. They expressed goals for their science instruction that ranged from teaching the process of science to developing a love of exploration and learning. As with more experienced teachers, they did not mention science content but rather clearly articulated that the approach of the science program was hands-on.

The new teachers also were especially pleased with the support from the DSRTs, and four reported that their DSRT had taught a demonstration lesson for them. Many had missed the kit trainings and the overview session, which were scheduled in early fall, and most felt the need for more training, especially more modeling. One commented, "I would be teaching science more next week if I had more training." For many, simply having the kits available was viewed as a considerable support. "It's been refreshing to me that this is in place, set up, and researched already." They felt that teaching the science program was demanding, but worth the effort. Some commented favorably on the potential value of notebooks and had attended a notebook workshop. In general, the program appears to have been successful in bringing new teachers on board.

New teachers "transition" into science through use of kits, but this cannot in and of itself substitute for a real understanding of curriculum and instructional method.

One principal felt that new teachers "transition" into science through use of the kits, but that this cannot in and of itself substitute for a real understanding of curriculum and instructional method. "They should be the invitation to go further." In many ways, this principal's comments touch upon a hidden competition within the Benton school system—the traditional, school-based impulse to change teaching through an emphasis on teaching and learning versus a state-mandated pressure to change teaching through the accountability of STAR. New Benton teachers somehow negotiate both rationales.

DECISION MAKING AND LEADERSHIP

District-Level Decisions

The central office provides verbal and financial support for the science program, but at the same time, takes actions that ultimately inhibit the program. Science is considered a core academic subject, but its status is declining as the district elevates its support for the other core subject areas. Other district priorities and a looming budget crunch have resulted in the "maintenance" of the science program, but there has been no allocation of additional funds since the end of the NSF grant. District leaders in a position of decision making about money seem confident that the program will remain strong without extra funds.

Science is considered a core academic subject, but its status is declining as the district elevates its support for the other core subject areas.

Interviews with three of the seven School Committee members revealed that all had an understanding of the basic philosophy of the science program: to give all students a chance to do hands-on inquiry science. There is relatively strong confidence in the K–6 science program, but also some concern about poor test results for the grade-10 STAR science exam. School Committee members confirmed that science is not a priority in school committee discussions; it has been strong in the past and is not a pressing issue now. One of the senior members characterized himself as a "champion of science" on the School Committee, and was very interested in finding out that the end of NSF support made district support critical. He later spoke in support of the Science Department's appeal to restore the DSRT position to the budget.

Within the central office, communication about the science program appears to be thorough and regular. Connor meets with the assistant superintendent monthly, and they periodically touch base. The superintendent believes that the science program can be sustained only if they have a common vision and come to agreement on their goals for student achievement and how to accomplish them. The regular meeting is one way to achieve that.

Connor also is part of the instructional council that meets monthly. She is hoping to bring content area people and people in other areas together. Connor also meets with her own staff on a regular basis. Beyond that, there are few formal structures or mechanisms for communication. Connor makes a point to visit the schools, meet people, and talk about the science program. As the assistant superintendent explained, "not a soul would say 'Constance who?'"

Communication between the Science Department and the Office of Professional Development is still developing. The director of professional development envisions close interaction between the three offices of accountability, curriculum, and professional development. But she has chosen to place the Office of Professional Development in a school, making this interaction somewhat of a challenge. Still, she feels strongly about being close to the schools and believes that their discussions are regular enough and the proximity close enough that they should be able to maintain open communication.

Principals and School-Level Decisions

The Benton school culture prizes a decentralized, school-based approach, which has been reinforced in recent years by the linking of some professional development monies with school improvement plans. The science program has also tried from time to time to heighten principals' understanding of the program via briefings at the regular principals meeting, printed materials, and tips for classroom observation. Uncertain of the effectiveness of past efforts, Connor wants to launch a renewed and larger effort directed toward principals, perhaps with the science mentors. A need to direct attention to the principals is evident in the fact that none of the 2000–2001 SIPs included science as an overall priority for the school. DSRTs have encouraged principals to avail themselves of the trainings offered through the Science Department—especially in the areas of science notebooks and performance assessments—in meeting literacy and assessment-oriented goals for their schools.

"My plan does not touch on science, except in the way it would support literacy."

In the survey, a large majority of Benton principals reported that they actively supported the teaching of science. This support, however, is evident in a variety of strategies, some of which are not sufficiently focused on science. For example, many schools have a science night when parents come and look at displays of the lessons and student work in science. One principal who supports the science night explains that while it is an opportunity to raise awareness of science, he primarily views it as a chance to communicate with parents and establish improved public relations with them. Another principal, commenting on the mandated SIP said, "My plan does not touch on science, except in the way it would support literacy."

Another principal was quite knowledgeable about the program and a fan of Connor. The principal felt the program was "at the cutting edge," but noted she wanted to see certain areas strengthened, such as data analysis and more "modern" content. She also felt that her reduced DSRT support this past year was unfortunate, and that Connor should lobby for more resources to support the program. Another commented that "There is a danger in withdrawing staff development support."

Connor, recognizing the critical role of principals' support, is making them a high priority as she develops her strategy for the future. Some of the principals aren't involved at all; some turn to their grade 7 and 8 science teachers to handle any questions regarding science. Connor hopes to develop their understanding of the program and enlist them to ensure the science program is being taught, and taught well.

For 2001–2002, Connor has considered working with a small number of schools as K–6 "focus schools," building on an effort in 2000–2001. In that year, four schools became "focus schools" because principals allowed the DSRTs to link their work with school-based interests in literacy or assessment. One DSRT explained:

> The Franklin [school] has been great because we just finished a five-week series on looking at student work in science that I facilitated with 10 people, so those teachers are getting paid out of the professional development money. We are going to continue to do some of that work on writing rubrics.

District Science Leadership

Connor is known throughout the district as a strong leader. Some suggest that she can be difficult to work with, but at the same time, they respect her for her abilities and drive, and for what she has accomplished with the science program. The superintendent described her as a "visionary" and others have referred to her as a "genius" and a "powerhouse." One principal believed that Connor was responsible for the durability of the program and fears that unless it is under a "watchful eye," it could easily disappear.

Several enhancements in the non-science core subject areas can be expected to contribute to competition with science for funding in the years to come. The district has recently appointed an acting mathematics coordinator (an acting language arts coordinator left the position and has yet to be replaced). Some on the mathematics staff anticipate building a districtwide program in mathematics that is similar to the science program. They acknowledge that this may increase competition for resources within the district. Another immediate priority is the development of district K–12 benchmarks based on state standards. Language arts benchmarks are the first priority for the 2000–2001 school year, according to a School Committee member. The assistant superintendent emphasized that positive communications have been established among coordinators, no doubt because of these anticipated resource struggles.

Connor's relationship with the classroom teachers seems very strong. They appreciate her professional manner and many have developed loyalty to the program because of that. They also comment that she listens to them when they raise concerns about the program. For example, when some of the kits didn't work well and needed improvement, Connor helped them to adapt the kits to make them a better match. The newer teachers in the district, however, did not share that experience and may not hold the same loyalty for Connor and the science program.

The DSRTs, along with a middle school lead teacher plus two other middle grade science teachers, comprise Connor's informal leadership team. They meet weekly and discuss all of the district business as it relates to the science program. Although this is a strong team, they do not have a great deal of authority, which limits their leadership abilities somewhat.

In the earlier stages of the science program, "liaisons" were part of the school leadership structure. These staff were "go-betweens" between the science department and the teachers and offered support to classroom teachers. They helped with colleagues who were very resistant to change, and they also "helped teachers find materials," distributed information, and helped manage materials. Over time, their roles lost effectiveness and support, and Connor eliminated the positions in 1998.

RESOURCES AND SUPPORT

Funding

A major change in the 1999–2000 school year was the end of the large NSF grant that supported the initial implementation of the program. At the beginning of the year, the financial manager of the program (paid by the school district) moved to a newly created position in the District Office of Professional Development. The last carryover money was used in the fall for science unit training. However, Eisenhower money and a number of small grants were used to continue a strong and varied staff development program.

> The superintendent has publicly stated that the science program will receive the financial supports it needs to continue.

Funding is an ongoing, serious concern. The continuation of the professional development activities, which NSF funds launched is very important. While Connor has been successful at obtaining grants, many would like to see the district secure solid local funding. Connor currently receives $30,000 annually from the assistant superintendent for professional development and materials. A next step in securing financial support would be to obtain a commitment from the Curriculum Department or the Professional Development Office, but so far this has not happened. Currently, funds for the DSRTs are in the district budget. The superintendent has publicly stated that the science program will receive the financial supports it needs to continue. However, one administrator described the budget process in Benton as being "a free for all," so even a superintendent's commitment is not a guarantee of financial support.

Community and Partnerships

Benton has numerous scientific, research, and cultural institutions nearby that are willing to be involved with the schools. Although the district as a whole has few formal partnerships, the Science Department, as well as individual schools and teachers, have ongoing relationships with several institutions. In some cases, these relationships have provided powerful professional development experiences for teachers and enhanced the learning experiences of students.

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For example, Connor has established connections with the local university. About 10 initiatives involving university faculty are ongoing. One program has provided undergraduate student volunteers to work in classrooms and to help classroom teachers. These student volunteers provide assistance and science expertise in the classroom. In addition, a university lab provides upper elementary classes full and half-day science activities that are coordinated with the curriculum units. The lab is staffed by a full-time outreach coordinator and university undergraduate volunteers. Six total lab activities have been developed and are linked with four kit units for fourth-, fifth-, and sixth-grade students. Teachers at these grades take their classes a few times a year to the university lab to extend their learning in an environment that supports learning by doing science. Some teachers interviewed spoke very highly of this opportunity and took advantage of it regularly. During her sabbatical, Connor worked closely with the university to generate more collaborative activities.

Some schools have partnerships with local businesses (sometimes as a result of connections to parents), and participate in research, curricular, and training programs associated with one of the many research and cultural institutions in the area. Several of the teachers observed had been associated with outside projects that had provided them with some training, teaching materials, and supports that they still employed. In fact, at least a full half have been involved in science-related supplemental projects. The teachers were very skilled in leading the discussions, and student thinking was very much in evidence. In three of the classrooms observed, either a university undergraduate was present or there was experimental teaching technology provided by the university in use in the classroom. Other science-related supplements include visits to local Audubon Society parks and the use of SkyLabs (donated by a local corporation).

Of the 10 principals who were interviewed, one had attended an Inquiry Institute at the Exploratorium in San Francisco, which he said helped give him a better grounding on the work the teachers are doing. The principal mentioned that teachers and parents, sparked by the university volunteers, had organized an after-school girls' science club, which had received external support successfully for three years. This program, which attracts over 100 elementary-level girls and even pairs them with female leaders from the middle and high schools, demonstrates how school-based initiatives can thrive in Benton schools where there is high parent involvement.

Other significant partners for the science department are the external consultants who, supported through the grant, helped conceptualize the program and train the DSRTs for several years.

ACCOUNTABILITY

The goals of the science program are communicated through the district framework and materials handed out to principals and teachers. The state science frameworks, which were finalized in May 2001, appear to have resulted only in relatively minor adjustments in the curricular program. The STAR, as mentioned earlier, is predicted to have a mixed impact on the program, promoting general accountability for the teaching of science but possibly serving as a distraction that will threaten the program.

Still, no practical accountability measures exist for the science program, so teachers can choose not to teach science. In some cases, principals say they stay informed about the status of instruction through the DSRTs, but few directly observe teachers teaching science. One principal, however, did remark that she uses a form provided by the DSRTs. This form lists the important concepts in each module and clearly describes evidence of student learning. These were distributed to the principals so that they would know what to look for in their teachers' classrooms, but apparently they aren't widely used.

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Because of the lack of formal accountability for science teaching at the school level, perception plays an important role. The survey administered by this project suggested that principals value science teaching more highly than their teachers perceive, and vice versa. Just as principals are not persuaded by teacher's actions that they place a high value on science teaching, teachers in turn are not convinced that principals value science teaching in the schools. The relevance for the Benton science program is clear: without principal monitoring or formalized accountability, teachers generally make their own decisions about how much science to teach, leaving the science program vulnerable to other curricular priorities and individual teacher preferences.

The arrival of the new superintendent has brought a heightened sense of professionalism and accountability to the system. She already has established new evaluations for the principals and has conducted three-hour "pre-visits" to each school at the beginning of the year, followed up with post-visits at the end. She is hoping to build trust with the principals so that they can work together and with the instructional coordinators. Similarly, the superintendent explains that she works closely with the school committee to put changes in place. They have two meetings and two workshops every month.

In 1999–2000, the superintendent also took steps toward increased accountability by establishing the Office of Achievement and Accountability. One area of targeted work for this office is supporting the creation of curriculum frameworks and assessments. It has budgeted $10,000 for Connor's staff to work on assessments, and it has given the director of professional development $20,000 for professional development around literacy. Their work is supported by the work of the director of development and assessment. She and one assistant process all the test data from STAR and SAT-9 and provide schools with results they ask for to use for diagnostics to improve instruction. She also writes an annual report to the School Committee, and provides data to the co-directors of achievement and accountability. The assessment director has begun a new initiative designed to determine through a questionnaire and some classroom observations what math and science is really taught in the classrooms.

EQUAL ACCESS TO SCIENCE

Equity is a shared, but not often articulated, concern among teachers and administrators in the system. Equity-related issues generally are either programmatic or building-based and are shaped, in part, by the fact that Benton has a school choice plan that enables students to attend any school in the district. Parents select their top three schools and then participate in a lottery based on race, location, and whether or not there is a sibling in the school. This plan is intended to stabilize the student population, but some feel that it brings instability since parents can move their children each year. The school enrollments demonstrate that the racial balances within the schools do not all mirror the demographics of the overall student population, and some racial enrollments vary greatly. For example, the Clive Experimental School is physically within the Franklin school. According to the principal of the Franklin, the Franklin is 65 percent free and reduced lunch whereas the Clive Experimental is 18 percent free and reduced lunch. Another principal referred to "bimodal issues" in the district and believes that, "controlled choice allows segregation of a certain extent to occur." The superintendent proposed a revised choice plan that de-emphasizes race and emphasizes SES. This groundbreaking initiative was passed by the School Committee in 2001.

Still, the schools compete with each other for enrollment and, in particular, seem to note the importance of "marketing" themselves better to white middle class parents. For example, one DSRT commented that she felt that money was spent on programs designed to attract students to the school (e.g., Chinese language program) when the resources for basic programs (like science) were insufficient. Some believe that the science program has helped to level the differences between the schools, at least in part because all schools have access to the same program with the same materials. As a result, the program has helped to de-emphasize competition and open up a dialogue across the district.

In addition to revising the school choice plan, the superintendent's Office of Achievement and Accountability also demonstrates her interest in addressing "access to learning" inequities. Their activities have included a "Closing the Achievement Gap" tutoring plan, the development of

Language Arts Standards, the creation of performance assessments, and STAR item analysis. They are particularly interested in supporting the Project FIRST work described earlier that looks at student work in all subjects—though science originally took the lead. The co-directors appear knowledgeable but may still need to develop specific strategies to meet their goals. Their work has a clear connection to the science program through the assessment, FIRST, and STAR projects.

Currently, the science program appears to be an island of equity in the system. All students are intended to have the same curriculum and access to the same materials and program. All teachers are provided with the same materials and have equal access to the professional development needed to support it. The science program has obtained support and can continue to obtain support on that basis. The equal opportunity, however, does not necessarily mean an equitable program. Without an accountability system for ensuring the program is implemented, there is no guarantee that all students truly have the access they are intended to have through this program.

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It appears that the district is taking steps to address this issue. In 2000–2001, the Office of Achievement and Accountability led a team from the district and the community to create a District Improvement Plan, a two-year blueprint for achieving the district's vision of good instruction for all. This plan reflects that the office is rightfully concerned about monitoring—particularly the quality of classroom instruction—and that administrators feel principals need professional development to judge math and science teaching. In response to the question of who would provide this training for principals, accountability office staff commented that five people would have to come together to make it happen: the superintendent, the assistant superintendent, the Office of Staff Development, and the math and science curriculum leaders. They were not encouraged at the possibility of effective action.

ANALYSIS

The story of elementary science in Benton is, like any district program, complex. Many factors have contributed to and inhibited its sustainability over time. These factors fall into three general categories:

1) factors that pertain to the surrounding conditions-these describe the influences of the context in which the program operates;

2) factors that pertain to the science program components-these describe the role that concrete elements of the science programs (e.g., curriculum, professional development, leadership) have in contributing to or inhibiting sustainability; and

3) factors that pertain to the whole science program-these describe overarching contributors to and inhibitors of sustainability that affect the program in less tangible but still powerful ways.

These factors do not operate in isolation. They interact with each other, and shift in importance and influence over time. Factors that were particularly striking and pertinent in Benton are discussed below. For an in-depth discussion of all of the factors, see the cross-site report of this study[6].

Factors that Pertain to Surrounding Conditions

Culture: Survival in a Decentralized System

Benton's culture of school-centered decision making and teacher autonomy has created both benefits and disadvantages to a centralized science program. Administrative directives do exist in the district, but they are less likely to be in the curricular reform area. Rather, teachers are invited to try new programs (such as hands-on science) and participate in related professional development. Subject matter departments are, thus, challenged to guide rather than direct teachers, and must develop strategies and approaches that reflect this collaborative approach. The positive result of such an approach is grassroots support, such as that which exists for the science program.

A decentralized system that depends upon teacher initiative is vulnerable.

A decentralized system that depends upon teacher initiative is also vulnerable in certain ways. Teachers are not required to attend kit trainings nor to work with an DSRT when they first come to the district or receive a new grade-level assignment. DSRTs work collaboratively with teachers who invite them into their classroom, but their authority rests on their expertise alone. In the absence of a districtwide monitoring system, teachers are essentially accountable only to themselves. Since the science program enjoys a positive reputation in Benton and teachers embrace the kits, this does not present a problem. But as other curricular priorities continue to crowd out the science, teachers may teach less and less science with no clear system for ensuring that what is taught is taught well.

Science for All: Providing Access with a Centralized Program

Achievement scores confirm what has been known for some time: Some Benton students are learning less than their peers in other schools in the city. In the past few years, Benton administrators have taken concrete steps to address long-standing areas of inequity. They have targeted some schools for renovation or merger and re-examined the school choice plan. Equity

6 The Executive Summary of the Cross-Site Report can be found in Appendix D.

was on the list of 13 key goals for the district developed by the School Committee, and many related ones were also included, such as achievement goals for literacy in the early grades.

Desire for equity, a high concern for district leaders, has not translated directly into increased political support for the science program—one of the uniquely centralized program delivery systems operating in the district. This may be because the science program is seen as strong on its own terms, or because the centralized nature of the program is viewed as inevitable due to the materials-centered characteristic of the kit-based program. Regardless, the science program exists as a prime exemplar of how a curricular program can use a combined centralized/decentralized approach to provide teachers with access to training and materials to help ensure program delivery. The DSRTs—also initiated through the science department—help to support classroom delivery of the science program, and could potentially be an even more powerful tool for equity if low-performing schools were specifically targeted.

Factors that Pertain to Science Program Components

Leadership: The Untapped Potential of DSRTs

Constance Connor has been a strong and persuasive leader since the inception of the hands-on program. She has helped the program to maintain itself under new district conditions—such as a new superintendent, and STAR—and also to take constructive advantage of opportunities, for example, by relocating the Materials Center out of the high school into a larger and more accessible space.

Connor acknowledges that her strengths lie more with political relationships and administrative responsibilities rather than close work with principals and teachers. During her sabbatical year, she promoted a key DSRT to work part-time in a leadership capacity. This person, quieter and less authoritative in demeanor than Connor, strengthened relationships with principals and enhanced the school-level strategies of the DSRT support work.

Stronger leadership from a stable group of DSRTs has the potential to strengthen the program and contribute to its longevity.

Stronger leadership from a stable group of DSRTs has the potential to strengthen the program and contribute to its longevity. Connor has relied upon the DSRTs, a group whose composition has changed year to year. This volatility presents a challenge, as schools are increasingly expected to take professional development into their own hands. Connor's leadership needs to be complemented by a stable and qualified DSRT staff, who can find effective strategies for lobbying both principals and teachers and can keep science visible at the school level.

DSRTs may need to become more assertive in their leadership roles. They often operate as peer coaches with their colleagues, which responds to the interests and needs expressed by individual teachers, but doesn't allow for much pro-active leadership. In order to increase the numbers of teachers attending professional development trainings and improve the quality of science teaching, DSRT support may need to be more strategic and proactive.

Professional Development: Building Capacity Through Professional Development

Professional development and training has always been a strength of the Benton program. Teachers, DSRTs, and liaisons across the board praise the support they receive. Training was "exciting" and participants were "allowed to be learners." The program has cultivated a group of teachers loyal to the program. Although systematic impact information was not collected for these professional development programs, teacher interviews showed that their participation had contributed to their loyalty to the program and their commitment to the hands-on philosophy of science teaching.

Even though the program is perceived as being well established and strong, it is actually fragile.

The DSRTs and other science staff also are recognized in the district as having a great ability to organize and implement high quality professional development. According to the director of professional development, in other subject areas they have brokered professional development from the outside, not built internal capacity to deliver that professional development. The science department is one area where that is not the case.

Even though the program is perceived as being well established and strong, it is actually fragile. Liaisons interviewed questioned the assumption that there was any sustainability for this program. They recognize that it will take a lot of effort to ensure that it endures and maintains the intended quality and breadth. With the reduction in professional development when NSF funding ended, questions arise about the ability of this program to endure at the level it currently exists, let alone grow and develop.

Accountability: Mixed Role of High-Stakes Testing

The low scores on the science section of the STAR test have been an embarrassment to the program. The development of new, authentic assessments by the district may help to offset the disappointing scores, although the absence of such district tests makes the program vulnerable in the meantime. Still, the fact that science is tested on the STAR gives it much needed stature, especially in light of the priority on literacy. The science department's analysis of STAR has provided the district with useful diagnostic information about student learning. The Benton science department appears to be strategizing well for dealing with a test whose impact on the program will be mixed at best.

While the STAR increases the priority on science, it could also become a distraction from the goals and vision of the program.

While the STAR increases the priority on science, it could also become a distraction from the goals and vision of the program. Connor and others will need to protect the program from "teaching to the test" (when it is inappropriate) and from the competition with STAR literacy and math. One principal commented that the DSRT in his school would need to get mileage out of the priorities on literacy and the STAR; science was not a priority in his SIP.

Factors that Pertain to the Whole Science Program

Critical Mass: How Much Resource Teacher Support Is Enough?

The Benton science program is operating within a close-knit and decentralized district with a history of science specialists. With the focus on classroom teachers teaching science, the Science Department has relied heavily on its DSRTs to serve as emissaries for the hands-on program. As documented in other parts of the report, the DSRTs have served flexibly in a variety of capacities. Over the history of the program, they have totaled four or five, working within 15 schools. In terms of typical science resource teacher to teacher ratios, this is a generous amount of support.

Yet, having established this standard—both through NSF and district support—it is difficult to part with it. The Science Department feels that the resource teachers are indispensable, and even a staff of four from five has been a necessary, but regrettable, accommodation. This suggests that there may be no absolute standard in terms of the ratio of resource teachers to educators; rather, the rule of thumb is simply "the more the better."

Adaptation: Sustainability Through Adaptability

The structural and organizational capacities of the Benton science program appear to be strong. The superintendent and the assistant superintendent are strong supporters, the DSRTs are paid for, and the Materials Center is fully funded. Connor's task will be to maintain this support in the face of personnel changes and competition from other subject areas. The district has hired two new acting K–12 subject coordinators who will generate more competition for resources and attention.

The strong Materials Center is essential for providing and maintaining sufficient kits for all of the teachers. The kits, in turn, have served multiple valuable purposes, including providing the teachers with science information and providing the confidence they didn't have before. However, having the kits is not enough. One principal, for example, expressed fear that the slow reduction of professional development support for the program will lead to its demise. How the science program negotiates these new terms of engagement within the district will add further evidence to the adaptability of the program and its ability to be sustained.

The program has successfully begun an adaptation to non-NSF support. An attempt by the district to cut the DSRT staff was successfully fought at the School Committee level, and four DSRTs are supported by the district. Important program changes have been made with plans for further adaptations to help the program become stronger and to better mesh with changing district priorities. Key strategies include a focus on the introduction of science notebooks (to link with districtwide priorities in literacy and alternative assessment), outreach to principals, and attempts to link with school improvement and professional development plans at the school level. These positive developments in the program were initiated despite the absence of Connor during a sabbatical year. Even with these positive developments, it seems clear that the science program will need to recruit additional external resources to maintain its staff development program.

SUMMARY

The Benton program, while not as long-standing as many, is a beneficiary of a national science reform movement that made available standards, commercial instructional materials, and funding. NSF funding enabled the program to roll out according to a well thought-out strategy, and conveyed the program's image as smart and reliable. The program has enjoyed strong and sustained leadership since its inception.

The program enters the new millennium with an excellent reputation and a professional development design that is the envy of other departments. It appears to be active and sustained: the kits are visible in classrooms, and classroom-based supports are available. Less visible is the precarious financial situation the program now faces. NSF funding has ended, but central district leaders seem not to be overly concerned that the ending of the NSF grant will deleteriously affect the program. Poor STAR scores might seriously threaten the reputation of the program, but at the same time, until there is general recognition that the science program is vulnerable, it is unlikely that anyone will take notice of the program's need for secure funding.

Connor, with enormous energy and a unique combination of abilities in education, district politics, and interpersonal relationships, has built a strong reputation for the science program; it is highly respected and recognized throughout the system from the teachers to the top administrators as a model for the other subjects. One teacher remarked, "Whatever the science program does, I wish the other departments would do it. Science is the best..." According to the director of professional development, "Constance has created one of the strongest models for what public education should look like" and the superintendent concurs, stating that she is "not so worried about science" because it is "under control." One teacher explained that there is a perception that this was the first time there was a longstanding commitment to a program beyond when the "glitz" wore off.

The very strong position of the program in the minds of all the people in the district speaks well for keeping the resources needed to sustain the present program, but there is no indication that additional resources will be available. The change in staffing, intended to make the focus of the science program more explicitly K–12, presents a major challenge to the K–6 program. With only two science mentors for the elementary schools instead of four DSRTs, the K–6 program will require a new and different work plan. The important notebook and assessment projects will require ongoing work to bring them to fruition, efforts extending beyond the mentors' other school and teacher-based activities. Even with this strong foundation, the program will still need to work hard to sustain itself into the future.