Researching the Sustainability of Reform

GLENWOOD

Staff of the Center for Science Education (CSE)
Education Development Center, Inc. (EDC)
Newton, Mass.
Jeanne Rose Century
Abigail Jurist Levy
Felisa Tibbitts
Mary Jo Lamberti

and

Staff of the Caltech Pre-College Science Initiative (CAPSI)
Pasadena, Calif.
Jerome Pine
Pamela Aschbacher
Ellen Joy Roth
Melissa Jurist
Cynthia Ferrini
Ellen Osmundson
Brian Foley

ACKNOWLEDGMENTS

Foremost, we would like to thank the site leaders in each of the study's sites for their support, hard work, and frankness throughout the data collection process. We are grateful to the teachers, principals, district administrators, and many others who spoke with us. We also would like to acknowledge the input and support of the RSR advisory members, and we would like to thank EDC staff members Judi Sandler and Karen Worth for their thoughtful attention and support throughout this work. Additionally, we would like to thank EDC staff members Keith Suranna, Daphne Northrop, and Silvia Tracanna for their assistance in revising these reports and the tireless efforts of Kerry Ouellet in the editing and layout process.

Center for Science Education
Education Development Center, Inc.
55 Chapel Street
Newton, MA 02458-1060
800-225-4276

This report and other project information can be found at http://www.edc.org/cse

This material is based upon work supported by the National Science Foundation (NSF) under Grant No. REC-9805078.

TABLE OF CONTENTS

Project Overview iii

Summary of Research Methodology v

Overview of Project Sites ix

Executive Summary..xi

Site Report..1

- Introduction..1
- Context 1
- Program History and Development..2
- The Current Program 9
- Decision Making and Leadership 19
- Resources and Support 23
- Accountability..27
- Equal Access to Science 28
- Analysis 29
- Summary 33

Appendix 35

- A. List of Interviews and Observations 37
- B. Survey Data 38
- C. Curriculum Units 48
- D. Executive Summary of Cross-Site Report 49

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.

Please direct any inquiries about this study to:
EDC Center for Science Education
55 Chapel Street
Newton, MA 02458
617-969-7100

Dr. Jeanne Rose Century	Abigail Jurist Levy
x2414	x2437
jcentury@edc.org	alevy@edc.org

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.

GLENWOOD
EXECUTIVE SUMMARY

INTRODUCTION

The Glenwood School District (GSD)[1] science program is the result of strategic leadership, negotiated partnerships, and a steady stream of external funding. The inquiry-based hands-on program, which has been in place for just over a decade, is built on a foundation that began with the convergence of two separately funded efforts in the late 1980s. Two significant partners, a local science museum that focuses on hands-on learning and a state university, had programs that meshed into one. Over the years, these partners have contributed significantly to professional development and support for teachers, but those benefits have not come without a cost. Although the collaboration has gone through many ups and downs over the years, it now seems stable and productive. Together, the partners have enjoyed the program's steady growth in spite of political and economic shifts in district, city, and state environments. Most recently, faced with new fact-oriented state science standards and an increasing emphasis on accountability and literacy, program leaders are looking at new hurdles they must overcome if the program is to survive, evolve, and be sustained.

CONTEXT

Community Overview

Glenwood is a major metropolitan area with a diverse population. It has nearly 64,000 students with 27,000 in elementary grades K–5. Like the city, the school district is very diverse with more than 60 nationalities represented among the student population. Minorities are the majority with 27 percent Chinese, 21 percent Hispanic, 18 percent African American, 13 percent white, and 21 percent Native American. Over 40 percent of the elementary students are not proficient in English, and about two-thirds are eligible for free or reduced price lunch.

The K–12 district has 67 principals for its 77 K–5 elementary schools and 6 K–8 schools (some principals serving more than a single site). There are about 1,000 classroom teachers for grades K–5, and 40 resource teachers, only 3 of whom support elementary science instruction. While less so than the student body, the elementary teaching staff also is ethnically diverse, with about 47 percent white, 19 percent Chinese, 13 percent Hispanic, 10 percent African American, and 11 percent other Asian, Native American,

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

and others. Like many urban districts, the turnover rate of teachers is fairly high (estimated at 25 percent by some), and there have been five superintendents since 1990.

Issue of Local Importance

Pressures on Teacher Recruitment and Preparation: GSD, like many other districts in the state, has been seriously impacted by 1996 state policies legislating class size reduction. The policies, together with the recent retirement of many older, experienced teachers, has necessitated the hiring of large numbers of new teachers, many on emergency credentials with very little teaching preparation. This has had the unanticipated effect of depleting the substitute teacher pool, thereby making it more difficult to release teachers from class for professional development during the academic year. Over 30 percent of the district's teachers are within their first three years of teaching, placing heavy demands on district efforts to provide training in all areas of the curriculum, including science.

Science Standards: The most recent state science standards pose a challenge for the underlying values and beliefs of the science program. The inquiry-oriented district science standards were developed in the early 1990s by a group of teachers, administrators, and scientists. Then in 1998, the state adopted new content standards that emphasize factual knowledge over inquiry processes. GSD decided to retain their own standards rather than adopt those of the state because the latter did not reflect the district's commitment to hands-on, inquiry-based science and, according to science program leadership, they were less rigorous than their local standards.

Competing Priority of Literacy: Federal Title I and state policies calling for standardized testing in grades 2–11 in reading, writing, and mathematics are having the unintended side effect of undermining the GSD elementary science program. According to the associate superintendent, about 60 percent of the students are from homes where English is not spoken, thus "...literacy is a big issue here." The district has been working for several years on a literacy initiative to build staff capacity in reading and writing. One principal noted, "The superintendent has said that literacy should be a living thread through everything." In response, the science program staff are trying to demonstrate to teachers, principals, and the public that the skills students learn in inquiry-based science instruction also can contribute to student achievement in other areas, including reading comprehension and writing.

PROGRAM HISTORY AND DEVELOPMENT

Program Origins

Glenwood School District's K–5 science program grew out of a collaborative effort led by science-oriented institutions in the mid to late 1980s. At that time, Glenwood became part of the Science Network—a network of districts that pooled resources for hiring service providers in the area to provide their elementary teachers with professional development workshops in science. The Science Network was run by a private nonprofit organization, Glenwood Improves Education (GIE), which contracted with the service providers. An advisory committee comprising teachers, scientists, and service providers determined GIE's annual teacher professional development agenda.

Around that same time, a controversial state proposition was passed that severely limited property taxes. As a result, district funds for teacher training were scarce, so GIE's resources for professional development became particularly desirable. The situation caused some of the science service providers to engage in political maneuvering in an effort to secure a bigger piece of the limited resource pie. In the midst of these conflicts, the coordinator of the district's K–8 science program left in frustration and Sondra Calder, one of the district's Mathematics Collaborative leaders, was selected to take her place.

Calder's background in science and her experience with the Mathematics Collaborative proved useful. In 1988, she conducted a survey of all elementary teachers to better understand the needs of the schools. With questions such as "How many minutes do you teach science?" "What do you teach?" and "If there were professional development, would you take it?" the survey revealed that 90 percent of the teachers taught less than one half hour of science per week, the text-based science curriculum was not being implemented, and much of the science teaching occurring in classrooms was not very rigorous.

Early Years: The First Round of Grants

Calder used the survey information to obtain a GIE grant for a three-year Science Leaders project. The goal of this project was to develop a cadre of expert teacher leaders who would help promote improved science teaching among their colleagues. From 1989 to 1992, the project focused on science content and pedagogy, the state science curriculum framework, and hands-on science kits with the task of developing a core curriculum plan aligned with the state science curriculum framework and *Science for All Americans*[2].

Concurrent with this grant, two other projects developed. A scientist at a nearby university developed a teacher enhancement proposal for the National Science Foundation (NSF). This four-year plan, separate from Calder's Science Leaders program, was to provide 100 elementary teachers with in-service education. A third grant, overlapping the same time period, involved the local science museum and the district. In 1990, science museum staff approached Calder to discuss possible collaborations.

2 Rutherford, F.J. & Ahlgren, A.(1991). New York: Oxford University Press.

The partnership of these three major science grants, though tenuous at the outset, built a strong foundation for the GSD science program. It enabled the district to train over 100 teachers in classroom implementation of hands-on science kits, to train teacher leaders for school-level support, and to raise principals' awareness about science instruction.

THE CURRENT PROGRAM

Curriculum

The core curriculum typically consists of four units or kits per grade (grade 3 has five units, and kindergarten has three). *FOSS*[3] kits were adopted in 1992 for grades 3–5, and *Insights*[4] kits were adopted for grades K–2. The district science program does not include science textbooks. All schools use the kit-based curriculum, but it is more fully implemented in some schools than in others. Individual teachers decide on the scheduling of units during the year and, while some schools have comprehensive plans for aligning kit use with the standards and benchmarks, others do not.

Instruction

The extent of implementation and consistency of kit use varies widely across schools and classrooms. Still, observed science instruction followed a fairly typical sequence. Most lessons consisted of approximately 15–20 minutes of initial direction from the teacher with questions posed to students, asking them to predict what would happen in that day's activity. Then students engaged in about 20 minutes of prescribed hands-on activities such as making observations and recording them in a notebook. The lesson wrap ups varied greatly.

In this decentralized culture, much of what happens in science depends on the principal and the dynamics of the individual school. For example, at one school, grades 4 and 5 exchange and share kits, and sometimes have science classes together. At grades K–3, they do "round robin teaching" (i.e., the three teachers at a grade level plan integrated thematic units together, and each teacher teaches one subject within the unit). One principal explained that they try to find ways to make science "come alive" for teachers, students, and parents.

3 *FOSS (Full Option Science System)*: Developed by Lawrence Hall of Science, published by Delta Education.

4 *Insights*: Developed by Education Development Center, Inc., published by Kendall/Hunt Publishing Company.

Assessment

Prior to 1995, there was no district assessment in science below the high school level. However, the district elementary science staff recognized the potential importance of having data about the impact and effectiveness of their program and believed that full implementation required science to be included in the district accountability system. GSD needed an appropriate assessment tool—a test that could monitor the kind of student learning and classroom practices supportive of inquiry-based science. District leaders, including Calder and a resource teacher, joined a collaborative group of NSF-funded districts from their own and other states to develop science performance assessments. All participating districts needed a useful tool for monitoring student performance in their systemic initiatives. Ten to 15 teacher leaders in GSD were involved in designing and piloting the new test. In 1995, the new test (named the Science Assessment Item Resource or SAIR) was used in the district for the first time and has since been used annually.

> In GSD, all students at grades 5 and 8 take the SAIR test. Results are reported for individual schools (but not for individual students, due to limitations in score reliability) and incorporated into school portfolios. This provides a formal accountability structure for science (like math and language arts), reinforcing its importance in the eyes of administrators, principals, teachers, and parents.

Professional Development

During the past five years, the district has moved from a centralized professional development system to a more school-based approach. District-level staff see the move as a way to make a stronger impact on classroom practice. They feel that teachers have a high awareness of the importance and need for a quality science education program for all students, but they need to focus on improving teaching and learning through a variety of professional development experiences that accommodate the range of teacher needs. For the novice, GSD offers a summer institute focused on kit training for those who are new to the profession, the district, a grade level, or who simply want a refresher course on a particular kit. More advanced professional development opportunities include case study teams consisting of small groups of teachers who meet regularly to address improving science instruction; sessions offered by the science museum focusing on inquiry; and sessions focused on assessing science.

DECISION MAKING AND LEADERSHIP

District-Level Decisions

The school board makes final budgeting decisions for the Glenwood science program, based on recommendations from the superintendent. However, from the outset, budgetary decisions about science were heavily influenced from the outset by Calder, who was the associate superintendent for curriculum and improvement until her recent departure. Over the years, Calder cultivated superintendents' and board members' support with informal discussions and formal presentations. Her efforts resulted in board adoption of *FOSS* and *Insights* kits as official elementary curricula in 1992, and she has won the active support of three out of the four most recent superintendents.

Curricular, professional development, and building-level budgeting decisions are made through the descending hierarchy of leadership structures. It is difficult to trace exactly how decisions are made because, in contrast to what one would expect in a large bureaucratic system, many of the leaders in science work in a highly participatory and mostly collaborative manner. This is a desirable feature of the district to many of its participants, but results in a cumbersome and sometimes politically charged process.

District Science Leadership

Over the years, Sondra Calder played a significant decision-making and leadership role in the program. She consistently nurtured a collaborative process of decision making and describes their work as "a constant entrepreneurial effort" that takes place through a close team effort. She saw the central office staff and teachers on special assignment (TSA) as facilitators, with individual schools as the "heart" of real reform. As she explained, "The schools need to own their plans for reform. We want people to bring these plans alive." Now, the program is led by a director of mathematics, science and technology, K–12, a director of K–12 science, and three TSAs.

RESOURCES AND SUPPORT

FUNDING

It is clear that the district views science education as a priority since it provides support for staffing, professional development, materials management, and science assessments. However, Glenwood has been fortunate in its ability to seek and receive a high level of external funding, amounting to more than $18 million over the past 12 years. According to one administrator, external funds have allowed reform efforts to progress at a more rapid rate and more intensive level than would otherwise have happened. For example, in 1999, GSD received a new $10 million, 5-year grant from NSF for districtwide reform in K–12 science, mathematics and technology, called the Urban Systemic Program (USP).

Partnerships

The State University

GSD partners with the state university through the Science and Health Education Partnership (SHEP) which was initiated in 1987 by a professor of biochemistry and biophysics. SHEP has a dozen programs, most of which are involved in professional development for teachers through building an integrated community of scientists and educators. There are approximately 350 volunteers from the university, including students in medicine, nursing, pharmacy, and dentistry; staff researchers; faculty; and post-docs who provide about 10,000 hours of service per year.

The Science Museum

For years, the science museum has been a prominent player in Glenwood's cultural and educational life. It is known as a center for inquiry-based science education whose professional development programs reach over 500 local elementary and secondary teachers. In addition, teachers throughout the country participate in the museum's summer institutes designed to focus on content and pedagogical knowledge. In 1999, according to the museum Web site, K–12 teachers in the Glenwood area ranked the museum as one of their two top science resources.

ACCOUNTABILITY

Currently, the district science staff is focusing on standards, assessment, and accountability as crucial pieces in sustaining good science education. Thus, they are working to improve and maintain science assessments at grades 5 and 8, the results of which are included in required school portfolios. The district now has both content and performance standards by grade-level ranges, whereas the state science standards are essentially content standards. The district also has a K–5 Web site with examples of student work and videos of promising practices that are aligned with the standards.

Since 2000, as a result of the USP grant, there are specific goals for improvement in science, generally a 10 percent improvement on the SAIR test scores over the five-year life of the grant. During the 2001–2002 academic year, schools used a newly revised form for filing site plans with the district that included specific language reflecting the USP science goals. While there are no specific sanctions for not meeting the science goals, it becomes part of the overall school site plan and portfolio, which is evaluated at the district level.

Still, there is no formal means of holding teachers accountable for implementing the elementary science curriculum. The district uses data from teachers' requests to the materials center for kit materials as an indicator of implementation, and provides this data to principals to be used at their discretion. There are no formal consequences other than principal feedback attached to teachers' use or non-use of kits, though the district uses some informal means (e.g., attendance at kit and leadership trainings, which include an in-depth focus on inquiry science) to gauge general levels of science interest and implementation.

EQUAL ACCESS TO SCIENCE

GSD has placed a priority on educating all of its students through a quality science program. The district has acknowledged in reports to NSF that it needs resources and tools to examine possible inequities in the delivery of instruction, access to science materials, and teacher attitudes and perceptions. They are taking some concrete steps. Beginning with the ninth grade class of 1997, as part of the high school graduation requirement, all students are to complete three years of college preparatory courses in both science and mathematics. By successfully completing these requirements, students will have met the state university eligibility criteria. These requirements, along with the science testing in grades 5 and 8, put pressure on teachers in middle and elementary schools to prepare all students to handle high school science courses. The changes in the graduation requirements illustrate how policy can help change the community's perception of who can or should engage in the study of rigorous subjects (i.e., science and math). In fact, the new graduate requirements reportedly focused the entire school community on improving science education for all students.

SUMMARY

The elementary science program in Glenwood has benefited from the coherent vision and strategic support of Sondra Calder, who helped found the district's hands-on inquiry science program over a decade ago. Over time, she made sure to obtain the support of district superintendents and negotiate collaborations with external partners. However, now that she has taken a leave from the district and there is a new superintendent, the status of the program may change. Still, Judy Larson, director of K–12 mathematics, science, and technology, remains and is a strong leader in her own right.

To date, the board and past superintendents have supported the program, but the latest superintendent has reduced the numbers of TSAs, making their job more difficult. As attention and money from the latest grant flows to technology, mathematics, and secondary science, future stability and quality of the elementary program seems less sure. Still, the past 12 years have seen the development of a strong foundation, including a core curriculum, materials refurbishment system, strong professional development, involved partners, and a widespread group of teachers committed to inquiry-based approaches to science instruction. These foundations are the key to ensuring that the program and the teachers using it will hold steadfast to their core beliefs and values in the face of the uncertainties that come with the new superintendent and his changing priorities.

GLENWOOD

INTRODUCTION

The Glenwood School District (GSD)[1] science program is the result of strategic leadership, negotiated partnerships, and a steady stream of external funding. The inquiry-based hands-on program, which has been in place for just over a decade, is built on a foundation that began with the convergence of two separately funded efforts in the late 1980s. Two significant partners, a local science museum that focuses on hands-on learning and a state university, had programs that meshed into one. Over the years, these partners have contributed significantly to professional development and support for teachers, but those benefits have not come without a cost. Although the collaboration has gone through many ups and downs over the years, it now is stable and productive. Together, the partners have enjoyed the program's steady growth in spite of political and economic shifts in district, city, and state environments. Most recently, faced with new fact-oriented state science standards and an increasing emphasis on accountability and literacy, program leaders are looking at new hurdles they must overcome if the program is to survive, evolve, and be sustained.

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.

CONTEXT

Community Overview

Glenwood is a major metropolitan area with a diverse population. It has nearly 64,000 students with 27,000 in elementary grades K–5. Like the city, the school district is very diverse with more than 60 nationalities represented among the student population. Minorities are the majority with 27 percent Chinese, 21 percent Hispanic, 18 percent African American, 13 percent white, and 21 percent Native American. Over 40 percent of the elementary students are not proficient in English, and about two-thirds are eligible for free or reduced price lunch.

The K–12 district has 71 K–5 elementary schools and 6 K–8 schools with 67 principals (some serving more than a single site). There are about 1,000 classroom teachers for grades K–5, and 40 resource teachers, only 3 of whom support elementary science instruction. While less so than the student body, the elementary teaching staff also is ethnically diverse, with about 47 percent white, 19 percent Chinese, 13 percent Hispanic, 10 percent African American, and 11 percent other Asian, Native American, and

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

others. Like many urban districts, the turnover rate of teachers is fairly high (estimated at 25 percent by some), and there have been five superintendents since 1990.

SIZE	
Sq. miles	47
# elem. students	27,000
# elem. schools	77
# elem. classroom teachers	1,300
RESOURCES	
Per pupil expenditure	5,668
Teacher starting salary	$31,172
NSF funds?	yes
DEMOGRAPHICS	
% students eligible for free/reduced price lunch	66%
% white	13
% African American	18
% Hispanic	21
% Asian/Pacific Islander	27
% Native American	21
% Other	0
YEAR CURRENT PROGRAM BEGAN	1989

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

"The superintendent has said that literacy should be a living thread through everything."

Issue of Local Importance

Pressures on Teacher Recruitment and Preparation: GSD, like many other districts in the state, has been seriously impacted by recently enacted state policies legislating class size reduction. The policies, together with the recent retirement of many older, experienced teachers, has necessitated the hiring of large numbers of new teachers, many on emergency credentials with very little teaching preparation. This has had the unanticipated effect of depleting the substitute teacher pool, thereby making it more difficult to release teachers from class for professional development during the academic year. Over 30 percent of the district's teachers are within their first three years of teaching, placing heavy demands on district efforts to provide training in all areas of the curriculum, including science.

Science Standards: The most recent state science standards pose a challenge for the underlying values and beliefs of the science program. The inquiry-oriented district science standards were developed in the early 1990s by a group of teachers, administrators, and scientists. Then in 1998, the state adopted new content standards that emphasize factual knowledge over inquiry processes. GSD decided to retain their own standards rather than adopt those of the state because the latter did not reflect the district's commitment to hands-on, inquiry-based science and, according to science program leadership, they were less rigorous than their local standards.

Competing Priority of Literacy: Federal Title I and state policies calling for standardized testing in grades 2–11 in reading, writing, and mathematics are having the unintended side effect of undermining the GSD elementary science program. According to the associate superintendent, about 60 percent of the students are from homes where English is not spoken, thus "...literacy is a big issue here." The district has been working for several years on a literacy initiative to build staff capacity in reading and writing. One principal noted, "The superintendent has said that literacy should be a living thread through everything." In response, the science program staff are trying to demonstrate to teachers, principals, and the public that the skills students learn in inquiry-based science instruction also can contribute to student achievement in other areas, including reading comprehension and writing.

PROGRAM HISTORY AND DEVELOPMENT

Program Origins

Glenwood School District's K–5 science program grew out of a "primordial soup" of collaborative efforts led by science-oriented institutions in the mid to late 1980s. At that time, Glenwood became part of the Science Network

—a network of districts that pooled resources to hire service providers in the area to provide their elementary teachers with professional development workshops in science. The workshops, which varied in format, introduced teachers to a variety of instructional materials and resources for supplementing their textbook-based curriculum. Providers' interests determined the substance of these sessions more than district needs, so the resulting activities were somewhat inconsistent and uncoordinated. The Science Network was run by a private nonprofit organization, Glenwood Improves Education (GIE), which contracted with the service providers. An advisory committee comprised of teachers, scientists and service providers determined GIE's annual teacher professional development agenda.

Around that same time, a controversial state proposition was passed that severely limited property taxes. As a result, district funds for teacher training were scarce, so GIE's resources for professional development became particularly desirable. The situation caused some of the science service providers to engage in political maneuvering in an effort to secure a bigger piece of the limited resource pie. Tensions grew as the district and the GIE leadership sorted out disagreements about who should decide the focus and content of GIE's work in Glenwood. In the midst of these conflicts, the coordinator of the district's K–8 science program left in frustration. Sondra Calder, one of the district's Mathematics Collaborative leaders was selected over Lynn Marks, who was a teacher on special assignment (TSA). The implications of this hiring decision would be felt as the science program began to develop and take root.

Calder's background in science and her experience with the Mathematics Collaborative proved useful. She felt the players at GIE had a lot to offer but that the effort lacked focus, leadership, and a long-range plan. In 1988, she conducted a survey of all elementary teachers to better understand the needs of the schools. With questions such as "How many minutes do you teach science?," "What do you teach?" and "If there were professional development, would you take it?," the survey revealed that 90 percent of the teachers taught less than one half hour of science per week, the text-based science curriculum was not being implemented, and much of the science teaching that was occurring in classrooms was not very rigorous. At the same time, however, Calder learned that those teachers who had had professional development in science enjoyed teaching it and, in fact, were eager to learn more.

The effort lacked focus, leadership, and a long-range plan.

Early Years: The First Round of Grants

Calder used the survey information to obtain a GIE grant for a three-year Science Leaders project. The goal of this project was to develop a cadre of 27 expert teacher leaders (one for each of 27 "focus schools") who would help promote improved science teaching among their colleagues. From 1989 to 1992, teacher leaders attended month-long summer institutes coor-

The goal of this project was to develop a cadre of 27 expert teacher leaders.

dinated by the local science museum and the local state university campus. They focused on science content and pedagogy, the state science curriculum framework, and hands-on science kits with the task of developing a core curriculum plan aligned with the state science curriculum framework and *Science for All Americans*.[2] They also reviewed instructional materials in anticipation of the science curriculum adoption, scheduled for 1992.

During the academic year, the teachers taught in their own classrooms, received follow-up training on leadership and presentation skills, and worked in small groups to foster better science teaching in an assigned cluster of elementary schools. Their principals also came together two to three times during the year to learn about the science program and how they could promote better science teaching. Many of these principals are still in the district and continue to be active supporters of the science program.

Meanwhile, a new superintendent came to the district in 1989. According to Calder, he brought with him a limited vision for elementary science education, but he was willing to listen to advice and offer support:

> His idea was that in every elementary school we should have a teacher who puts on a lab coat and has a little cart and walks into the classroom and does science. He actually dramatized this with lots of flair and drama. I just sat there. Here I am with my plan for the future and the guy is talking about "science a la carte." I said, "Sounds great, but you know what? Kids aren't doing any science in that model. We want the kids to do the science. That is why we want these kits." He basically told me to do whatever I wanted, that I was the expert. He said he'd support me with anything except money. But the verbal support was very important because there was no discretionary money in our district.

THIS WAS THE BEGINNING OF GLENWOOD'S LONG HISTORY OF GRANT-FUNDED REFORM.

"And that," according to Judy Larson, the current director of science, math, and technology, "is when Sondra became very proficient at writing grants." This was the beginning of Glenwood's long history of grant-funded reform. During this period, Calder submitted several proposals to local businesses and foundations to pay for science kits and other materials and by 1989, the district opened a science and math center. This period of development laid the groundwork for the adoption of kits as the core district science curriculum in 1992.

Concurrent with the district's Science Leaders grant, another project developed, which had a turbulent beginning, but ultimately created a foundation for the partnerships that support the science program today. A scientist at a nearby university worked with TSA Lynn Marks to develop a teacher

2 Rutherford, F.J. & Ahlgren, A.(1991). New York: Oxford University Press.

enhancement proposal for the National Science Foundation (NSF). This four-year plan, separate from Calder's Science Leaders program, was to provide 100 elementary teachers with in-service education. The program would use kit-based materials to focus on content and pedagogical skills, thereby improving the quality and quantity of science instruction.

The university scientist and Lynn Marks did not discuss their efforts with key district staff, and the proposal was submitted with the university scientist as principal investigator (PI) without formal district approval. Not surprisingly, when it was funded in 1990, problems arose. According to Calder:

> It created quite a little commotion in the district office. The grant proposal was submitted without district involvement....There was this whole political football going on here.... There was supposedly all of this district commitment and nobody had talked to the district about it.

The new grant reinforced the growing rivalry between Calder and Marks that began when Calder was chosen over Marks to be the K–8 science coordinator. Marks became the director of the new grant and controlled millions of dollars for working with many more teachers than Calder's 27. Glenwood's political culture became increasingly evident as these and events following unfolded; it became clear that potential partners, when uncoordinated, became potential rivals.

Glenwood's political culture became increasingly evident as these and events following unfolded.

Further tension between the district and the university partners emerged from their assumptions about the goals of the programs. The district's vision was to develop a cadre of 27 teacher leaders who would educate others and foster improved instruction. The university partners, on the other hand, were focused on providing professional development to 100 teachers with the goal of improving their own classroom instruction. There was no expectation the 100 teachers would take on functions to improve science teaching in other classrooms. In the end, both approaches had an important impact on the district.

A third grant, overlapping the same time period, involved the local science museum and the district. In 1990, science museum staff approached Calder to discuss possible collaborations. They agreed that additional professional development for the cadre of 27 teacher leaders over a 3-year period would be appropriate. According to Calder, there was less tension with this partnership because the museum staff had a better understanding of how to work with a school district, and they worked collaboratively with the district to design the grant for professional development.

Negotiating and Managing the Partnerships

The partnership of these three major science grants, as tenuous as it was at the outset, built a strong foundation for the GSD science program. It enabled the district to train over 100 teachers in classroom implementation of hands-on science kits, to train teacher leaders for school-level support, and to raise principals' awareness about science instruction. Still, coordination of grant activities and working with external institutions presented some serious difficulties.

The superintendent asked Calder to be the point person to coordinate all three science grants. From 1991–1993, she facilitated regular meetings of the key players from the district, the university, and the science museum. They became known as the Science Council and had the goal of creating a formal vision for how the three programs could link to and build on each other. As a supplement to their efforts, the evaluator for all three grants occasionally conducted retreats to try to facilitate communication and coordination.

Each group came to the partnership from a different work culture with its own program goals and agenda. Over time, however, the group began to build trust.

The Council experienced significant tension in the beginning, and the collaboration did not evolve without strife and conflict. Each group came to the partnership from a different work culture with its own program goals and agenda. Over time, however, the group began to build trust and was able to focus on their shared goal of improving science education. Despite their disagreements, they acknowledged the others' strengths and capabilities, and persevered in seeking ways to contribute toward a coherent and cohesive professional development program.

Addressing Changes

In 1992, yet another new superintendent came to the district. Calder felt it was crucial that he understand the reform vision, the district's commitments under the various grants, and what was required to sustain the program. She also wanted him to provide district support for some permanent staff positions that would give the program some stability. She took the initiative and made an appointment:

> I laid out the whole math and science plan for him. I laid out the different revenue streams that came in, the district allocations that we were using, and what we needed him to secure for us. I said I wanted to see a four-year high school requirement for math, four-year requirement for science, and college prep in high school. This plan was to build the capacity for us to get there. Basically I told him, if kids can pass the hard subjects and do well in them, then their sense of empowerment grows. Then you are not dealing with an equity issue; you are dealing with accomplishment, you are dealing with empowering kids to take on the tough stuff, and that whole perception of "kids can't do it" goes by the wayside.

Not long after her meeting with the superintendent, Calder had to put her leadership abilities to work again as she prepared for the curriculum adoption. The process was complex, involving a team of 25–50 people—parents, teachers, and administrators. To begin, Calder organized a group of scientists and elementary teachers to present to the board the following strategy:

> Some of the teachers brought their science kits and did science in front of the board and talked about what they were learning and what they knew. The board bought the presentation and the whole program. They loved it. That was an important turnaround for the community because now the board knew about it, the principals knew, and so did the parents.

That year, the district took the science program to a new level, from the limited audiences touched by the three grants to classes throughout the whole district, K–5. They formally adopted *FOSS*[3] kits for grades 3–5 and *Insights*[4] kits for grades K–2, purchasing enough for all elementary schools. The district offered more comprehensive, consistent professional development and, for the first time, required all elementary teachers and their principals to participate.

That year, the district took the science program to a new level.

With districtwide implementation underway, GSD could now take advantage of the leadership investments made during the three earlier grants. The task of introducing new curriculum materials to 1,000 elementary teachers fell to the group of 127 teachers and teacher leaders who had participated in the earlier professional development. Fortunately, many teachers in the district already were aware of the new hands-on curriculum and instructional strategies. Further support came when the superintendent, encouraged by Calder, mandated that for elementary teachers, three of the state's eight annual professional development days would focus on science. By 1995, nearly all of the district's elementary teachers had received professional development in science to prepare them for districtwide implementation.

Continuing Funding and Developing the Partnership

In 1994, a revised and enlarged version of the university-based grant was proposed to NSF's Teacher Enhancement division with the PI at the university's Science, Health, and Education Program (SHEP). NSF asked them to redirect the proposal to its new Local Systemic Change Initiative (LSC) program and it was funded. Soon after, the PI left the university. Her replacement felt that given the extensive field work with many schools the grant required, it would be more appropriate for the district to take the lead on grant administration. Thus, during the 1995–96 academic year SHEP entered into complex negotiations with NSF to change both the location and PI on the grant. Calder became PI on what was now an LSC grant for approximately $2.5 million, and SHEP became a subcontractor. Although it was financially hard on SHEP, this significant change was not only appro-

3 *FOSS (Full Option Science System)*: Developed by Lawrence Hall of Science, published by Delta Education.

4 *Insights:* Developed by Education Development Center, Inc., published by Kendall/Hunt Publishing Company.

priate, but it also bought the university a lot of goodwill at the district, which has benefited both institutions ever since. The partnership was finally becoming a true collaboration.

The focus of the LSC grant was on systemic change with an emphasis on standards-based assessment, materials management, and professional development for new teachers. Since the beginning, according to Judy Larson, the district tried to take steps to ensure the program would be sustained. One strategy, for example, was a shift away from centralized support for teacher improvement, towards a site-oriented approach fostering local capacity for self-management and improvement. The intent has been to establish a "community of learners" at each school to support and improve classroom practice. This approach requires that teachers take on new demanding roles, not only changing their own teaching, but also training or coaching peers. The staff also worked hard to educate principals about why science is important and engage them as active supporters of programmatic goals.

Since the beginning, according to Judy Larson, the district tried to take steps to ensure the program would be sustained.

The grant also called for the creation of school site teacher study groups that focused on encouraging reflective practice. Starting in 1998–99, teachers worked in groups, facilitated by TSAs, to look at student work and reflect on strategies to improve student learning. About 29 schools were involved in this effort, with at least two to three teachers at each school. Principals were required to provide time for the teachers to meet together during the work day while the grant provided stipends. While perceived as valuable (and by some as the most important feature of the LSC grant), the resources required to support this aspect of the professional development were not sustained beyond the life of the grant. When the money was gone, the stipends for the teachers ended, as did the principals' responsibility.

In 1999, on the heels of the departure of the LSC, GSD received a new $10 million, five-year grant from NSF for districtwide reform in K–12 science, mathematics, and technology, called the Urban Systemic Program (USP). The interim superintendent for 1999–2000 was "very supportive of science," according to Judy Larson (who was co-PI of the grant). This newest initiative has had several components related to the elementary science program, including increasing teachers' science content knowledge through new courses with partner universities, improving classroom practice throughout the district, aligning assessment with the district's science standards, and developing comprehensive K–12 articulation of the curriculum. A major focus of the grant is to "bridge the achievement gap" between minority and low SES students and mostly white/high SES students for science, mathematics and technology. District leaders introduced the USP grant to all district principals by outlining program goals and components at a two-day "kick-off" institute in fall 1999.

The USP has brought a shift in the district's focus. The LSC grant concentrated on the elementary science and math program, but the USP targets all grade levels K–12 and is divided among three subject areas (mathematics, science and technology). To best target the resources of the grant, the assistant superintendents for instructional support and operations divided all schools into three groups, roughly equal in size, based on economic, test score, and demographic profiles. The groupings determine the level of direct USP support. According to Judy Larson, resources may be allocated to the groups a little differently to support the long-term goals:

> Group 1 schools are the neediest. We can carry them through five years of the grant if we need to. Group 2 are intermediate. Threes are more or less on their own. If we don't get to them on an intense level, they could carry on.

In 1999–2000, 25 elementary schools were in Group 1, serving 14 percent of Glenwood's 64,000 students. Ninety-three percent of the students in these schools were minority students. These schools received special attention in several ways. Leadership teams comprising the principal and teacher leaders in math, science, and technology participated in a Summer Leadership Institute, and TSAs visited each Group 1 school one day per week for direct mentoring, coaching, and support of classroom teachers. Much of this support is directed to middle and secondary schools.

In 2000, a new superintendent was selected who initiated significant restructuring of the central office. All administrators at district and building levels were renewed only for one year, which resulted in some resentment. Specific to the elementary science program, TSAs were reduced from five to three (despite grant specifications for five) and funding for the program's clerical support was questioned. The locus of decision making about the science program is shifting and the long-term effects on the elementary science program are unclear. Judy Larson remains to oversee the science and math programs. But Sondra Calder, who had initiated the science program and, in her later position as associate superintendent for curriculum and improvement, had the final authority over all instructional and professional development decisions in the district, has taken a leave from the district.

The locus of decision making about the science program is shifting and the long-term effects on the elementary science program are unclear.

THE CURRENT PROGRAM

Judy Larson, the director of science, mathematics and technology for grades K–12 is responsible for overseeing the GSD elementary science program. A former high school resource teacher (Ed Morris) has become the director of K–12 science under the new USP grant and works under Larson. Working with Larson and Morris are three TSAs, also known as resource teachers. These staff members, along with an administrative assistant (supported by grant money through the university) and the materials refurbishment center, are headquartered in the district office.

These leaders have explicitly stated the core beliefs and values of the science program. For example, in a district progress report on its LSC grant, they wrote:

> All elementary students in GSD will receive a quality science education program that is content rich, is inquiry-based, and engages students in hands-on science experiences.

Program goals described in the same report include the following:

1. All elementary students will receive quality instruction in science for at least 90 minutes a week in kindergarten, 120 minutes a week in grades 1–3, and 200 minutes a week in grades 4–5.
2. All students will receive instruction in science that engages students in hands-on science learning experiences that promotes inquiry and critical-thinking skills, and uses the content and processes of science. The GSD Science Content and Performance Standards are the benchmark for evidence of learning at each grade level.
3. Teachers will participate in at least 100 hours of differentiated professional growth opportunities over a five-year period in science content and processes, and in math topics related to science. The professional development opportunities will be directed toward improving teaching and learning strategies that provide access for all students to the district's science curriculum, with attention to the access of African American and Hispanic students, and English Language Learners.

ALL STUDENTS WILL RECEIVE INSTRUCTION IN SCIENCE THAT ENGAGES STUDENTS IN HANDS-ON SCIENCE LEARNING EXPERIENCES THAT PROMOTES INQUIRY AND CRITICAL-THINKING SKILLS, AND USES THE CONTENT AND PROCESSES OF SCIENCE.

These and other beliefs and values underlying the GSD science program are communicated to all teachers (and any other interested audiences) throughout this and other district documents. A typical passage, emphasizing scientific inquiry and taken from the district Science Content and Performance Standards, follows. The same passage appears in materials used at a district summer institute for teacher leaders at the local science museum:

> In the GSD, we believe that the best way for our students to learn to think scientifically is through a process called "inquiry." This method emphasizes questioning as a strategy that guides students in their learning process. Recall of facts, although useful, is not what we define as "thinking scientifically." The foundation of solid scientific understanding should be based on a rigorous exchange of student- and teacher-generated questions and responses, supported by experiential classroom activities under the guidance of a knowledgeable instructor. Inquiry should infuse the science standards and be the primary strategy we utilize to deliver the content, skills, and processes we identify as important. For that purpose, inquiry, in this document, will be identified as a standard that should be held for students and teachers alike.

Curriculum[5]

The core curriculum typically consists of four units or kits per grade (grade 3 has five units, and kindergarten has three). (See the Appendix for a list of kits by grade level.) As noted earlier, *FOSS* kits were adopted in 1992 for grades 3–5, and *Insights* kits were adopted for grades K–2. The district science program does not include science textbooks. All schools use the kit-based curriculum, but it is more fully implemented in some schools than in others. Individual teachers decide on the scheduling of units during the year and, while some schools have comprehensive plans for aligning kit use with the standards and benchmarks, others do not.

In 1998–1999, the science program staff matched the kits to the new district standards. They discovered a few gaps and worked to identify additional kits to fill them. But with a decentralized approach to kit management (see below), kits reside at individual schools, making it difficult to make wholesale changes or revisions to the kits. Because the standards came later than the kit adoption, it is largely up to the teachers to adapt the kits as necessary to the current standards.

WITH A DECENTRALIZED APPROACH TO KIT MANAGEMENT, KITS RESIDE AT INDIVIDUAL SCHOOLS, MAKING IT DIFFICULT TO MAKE WHOLESALE CHANGES OR REVISIONS.

Distribution, Refurbishment, and Management of Material

The district has a relatively decentralized materials management system. Before the district adopted the kit-based curriculum, the university grant leaders established a science materials resource center to refurbish the consumable materials in the kits used by the grant's participating teachers. When the district adopted kits as the core curriculum in 1992, they decided that they could not afford the space or the staff to store and circulate all the kits. Instead, they decided to keep the kits at each school, but provide refurbishment of most consumable items from a central materials center.

At adoption, they bought enough kits for each to be shared by two teachers with enough supplies for both classes before needing to be refurbished. The schools are responsible for storing and using the kits and replacing them if lost or destroyed, as they would have been for textbooks. Each kit has a materials list and an order form, with a list of the items that are to be recycled and those that are considered consumables and may be ordered from the district. The district covers the cost of most of the consumables, but the schools take on the costs of live animals (e.g., brine shrimp, meal worms, etc.), since they are difficult to ship and store in bulk.

Ideally, teachers get together in grade-level groups at the beginning of the school year and plan the schedule of kit use. Principals sometime play an important role in keeping the process orderly. Some principals treat the kits as they do textbooks, having teachers check them out at the beginning of the year and return them at the end of the year. While seemingly simple,

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

teachers point out the possibilities for numerous problems. For example, some teachers fail to restock the kits or may borrow from other kits without replacing the items. New teachers sometimes can't find the stored kits; some do not learn their school's process for accessing or ordering materials; some keep the kits longer than planned; and some do not plan ahead to incorporate the kits into their school year.

The science program staff has tried to remedy these problems in a variety of ways. At first, they asked each school's teacher leader to take responsibility for kit management, but without sufficient time and resources, this strategy did not work. They then offered grant money for two years to pay a parent at each school to work as a "science associate" to manage the kits and order supplies. But not all the schools in the district took advantage of the district's offer. Then in 1999, schools were asked to share some of the costs for the science associate. About 50 of the 77 elementary schools were doing this in 2001. The materials center director noted that most science associates functioned well, but "some have found it difficult to assume a leadership position with teachers since most are parents or paraprofessionals and view themselves as having less status."

The fact that the materials center director also serves as a resource teacher facilitates sharing useful information about the state of kit implementation.

The materials center director is also a TSA who oversees one part-time employee who packs and mails all consumables to schools. She believes the employee is more consistently busy now since the advent of science associates, partly due to increased implementation and partly to orders being spread more systematically over the year rather than all at the end of the academic year. The fact that the materials center director also serves as a resource teacher facilitates sharing useful information about the state of kit implementation with the other resource teachers and science program leaders.

Individual schools also have sought solutions. One principal noted that he has asked two teachers to order supplies, but finding time to inventory the kits is difficult and becomes "just one more thing on their plate." Another principal said her school currently has no one to order the materials. Last year they had a parent science associate, but the person did not do the job adequately. This year the principal will have to do the ordering of science supplies herself since her school has no available "extra" money.

Instruction

The research team visited 20 classrooms ranging from kindergarten through fifth grade in 14 schools (a fifth of the district's elementary schools). Classrooms were selected from those with science instruction at a level that represented a realistic goal for what could be accomplished and sustained across the district. Class size attendance ranged from 10–30.

Science instruction followed a fairly typical sequence. Most lessons consisted of approximately 15–20 minutes of initial direction from the teacher with questions posed to students, asking them to predict what would happen in that day's activity. Then students engaged in about 20 minutes of prescribed hands-on activities, such as making observations and recording them in a notebook. In only a few classes were students asked to pose their own questions. The wrap-up also varied greatly. Teachers frequently ran out of time, making it difficult for students to share findings or for teachers to summarize the day's lesson.

In the survey administered in winter 2000 by the research project, the K–3 teachers who responded reported that they taught science an average of about 90 minutes per week, and the grade 4–5 teachers reported teaching science an average of about 140 minutes per week. This amount of teaching is nearly as much as directed by the district and far more than Calder had found in her survey before the program was established.

The extent of implementation and consistency of kit use varies widely across schools and classrooms.

However, the extent of implementation and consistency of kit use varies widely across schools and classrooms. In one focus group, participants estimated that science is taught for 20 minutes per week on average. These teachers attributed the low level of implementation to time constraints (or low priority compared with literacy and math), insufficient training, and lack of interest among some teachers and principals. In addition, they said that implementation of true "inquiry science" is further limited due to teacher turnover and the recent influx of inexperienced, emergency-credentialed teachers. "We are at the stage where we want teachers to just open the kit," lamented one veteran teacher. To complicate the situation, fewer teachers are attending summer training in science since training in other content areas often takes priority.

The district elementary science staff recognized the potential importance of having data about the impact and effectiveness of their program.

The results of the survey revealed further evidence of inconsistent kit usage. While just over half of the respondents reported they were expected to use four kits per year (the standard district curriculum requirement), less than 10 percent reported they actually used that number. Further, only slightly more than 10 percent reported they were trained to use the four kits they were expected to use.

In this decentralized culture, much of what happens in science depends on the principal and the dynamics of the individual school.

Another factor influencing instruction is the increasing priority of literacy in the district and the resulting reduction of time to direct to other subjects ,such as science. More than three-quarters of respondents to the survey reported using science-related literature or nonfiction books "often" or "very often" in their classrooms. And many reported that they integrate their science instruction into other subjects due to the emphasis on literacy in the district and the resulting lack of time. Time may, in fact, be the biggest factor in teachers' perception of their ability to implement science instruction. Nearly three-quarters of respondents to the survey felt they did not have enough time to prepare for effective science instruction, and their principals concurred.

Rocks, Sand, and Soil

Mr. Landford's first grade classroom is pleasantly cluttered with chart paper, with students' observations of sand dominating one bulletin board. A sample entry reads, "Brian's sand—black, soft, some gray, softer than Jordan's. Drops fast when there is a hole in your hand." A new chart is prepared to display the data from today's lesson, comparing the characteristics of salt and sand. Mr. Landford distributes film canisters of salt and sand, and the students work in pairs to observe the sand and salt with hand lenses, shake the canisters, and make comparisons any other way they can think of. Mr. Landford encourages them to use all their senses to compare the materials. "It looks like snow. It's white and soft," remarks one student, and another responds, "No, it looks like a rock". Mr. Landford responds, "Good, so you're using your sense of sight. What other senses?" and a student responds, "Sounds like music [shaking the cans]. Mr. Landford directs them

In this decentralized culture, much of what happens in science depends on the principal and the dynamics of the individual school. For example, at one school, grades 4 and 5 exchange and share kits, and sometimes have science classes together. At grades K–3, they do "round robin teaching" (i.e., the three teachers at a grade level plan integrated thematic units together, and each teacher teaches one subject within the unit). Another principal explained that they try to find ways to make science "come alive" for teachers, students, and parents. For example, parents wanted a competitive science fair, but the school staff wanted to de-emphasize competition and encourage students, rather than parents, to do science. They created a Science Night, during which students "talk science" to their parents, explaining what they have done in various experiments and, according to the principal, "The parents really want it."

Assessment

Prior to 1995, there was no district assessment in science below high school. However, the district elementary science staff recognized the potential importance of having data about the impact and effectiveness of their program and believed that full implementation required science to be included in the district accountability system. GSD needed an appropriate assessment tool—a test that could monitor the kind of student learning and classroom practices supportive of inquiry-based science. District leaders, including Calder and a resource teacher, joined a collaborative group of NSF-funded districts from their own and other states to develop science performance assessments. All participating districts needed a useful tool for monitoring student performance in their systemic initiatives. Ten to 15 teacher leaders in GSD were involved in designing and piloting the new test. In 1995, the new test (named the Science Assessment Item Resource or SAIR) was used in the district for the first time and has since been used annually.

The SAIR assessment has three types of items: multiple choice, open-ended response, and a set of performance tasks. The multiple-choice items were added primarily to improve the reliability of score results. The other components model for teachers the type of learning activities and classroom assessments promoted by the district. Efforts to improve the technical quality and utility of the SAIR test have continued over several years. For example, the district is designing a system of identifying appropriate clusters of items that will provide an indicator of student growth matched to each of the district's content standards.

These science assessments are fairly expensive due to the use of performance tasks, which require labor-intensive scoring by specially trained teachers. Ed Morris estimates that performance assessments cost about 10 times as much per pupil as the standardized multiple choice tests used in math and language arts. But, he and others also see value in the test. First, part of the cost might well be considered an expense of professional development for the teachers involved in scoring. Furthermore, they believe the incorporation of performance tasks in the test helps to reinforce the district message about the importance of students actually doing inquiry science, not just reading about concepts and facts. Nonetheless, the district has been challenged to find the resources for this testing, but so far it continues to administer it.

In GSD, all students at grades 5 and 8 take the SAIR test. Results are reported for individual schools (but not for individual students, due to limitations in score reliability) and incorporated into school portfolios. This provides a formal accountability structure for science (like math and language arts), reinforcing its importance in the eyes of administrators, principals, teachers, and parents. Still, some principals and teachers commented about the poor timing of the science assessments, suggesting that information from the test is delivered "too late" to have any significant impact on students or teachers. As one principal remarked:

> What happens is that students move on to middle school (after taking the fifth grade science assessment), and we don't have a chance to do anything with the results. We don't really use it as a way to look at our effectiveness teaching science. But the data do provide important information about the way or ways in which we are meeting the state standards for science instruction.

toward their notebooks saying, "Good, write it down." As the lesson proceeds, he guides the students enough to keep them on task but, otherwise, they are free to pursue their own line of investigation. Near the end of the lesson, Mr. Landford comments, "Keep your papers so you can refer to them. We need to organize the data from your notes."

Professional Development

According to a 1995 district LSC report, after the first two years of project-supported, districtwide professional development, program leaders were disappointed to find that the professional development had been insufficient to cause significant improvement in classroom practice. Results from an evaluation survey of teachers and a statewide science assessment of students indicated that there was a significant improvement in the amount of time teachers spent teaching science and in their students' interest in science, but there was a disappointing lack of results in student performance. Although teachers had learned to teach the units, they evidently did not know how to engage students in analyzing and making inferences about data required by the performance tasks. As a result, the LSC grant shifted its focus to provide teachers with continuing and deep professional development on best practices, looking at student work for evidence of learning and meeting standards, and increasing their content knowledge in science. The newest NSF grant continues this focus on the professional development of teachers including their science content knowledge and improved classroom practice.

The district elementary science staff recognized the potential importance of having data about the impact and effectiveness of their program.

Calder explains that, in general, teachers each have a professional growth plan that is related to their school's site plan. As a part of this effort, the district encourages elementary teachers to take 90 in-service hours in sci-

Fifth Grade: Mixture and Solutions

The 28 students in Ms. Remson's fifth grade class are, according to their teacher, united by their interest in science and love of learning. As this lesson begins, Ms. Remson invites the students to talk to a partner about how they could figure out the concentration of salt in a solution. After students respond by recalling past classroom experiences and investigation techniques, they set to work. A group leader distributes vials of salt, beakers, and small containers, and students begin the process of measuring salt and water, making solutions, and testing their salinity. Ms. Remson circulates throughout the room, offering procedural suggestions ("Make sure that you're down at eye level to get the exact amount of water" and "Don't let the meniscus fool you!") and probing students' ideas ("What do you mean, you think the salinity is bigger? How do you know?). After creating solutions and

ence, mathematics, and technology as part of their professional credential renewal process. To aid teachers in reaching this goal, the district has established its own database of professional development opportunities offered throughout the district and at local universities. In an effort to control quality, the district monitors these courses and determines which ones provide sufficient "development of content knowledge" to count toward the district-required hours. Calder also feels that state teacher certification requirements are substandard and that the district needs to require more rigorous preparation. The district wants teachers to have at least two science courses before being hired, so they are designing two science content courses in conjunction with local universities. Still, according to a group of experienced teachers, professional development opportunities are focused far more often on literacy than on science.

Despite these professional development opportunities, many teachers still feel ill prepared to teach science. Of the teachers responding to the survey administered by the research project, only about one-quarter felt "very well prepared" to teach science for their grade, while the remaining three-quarters felt only "moderately prepared." Principals tended to agree with the teachers, and one in particular noted that teachers also need help in learning to integrate science with other subjects and how to access available resources.

Experienced teachers noted that numerous resources are available to help teachers teach science, but that new teachers tend not to know about them. "The university has some great science stuff you can borrow (e.g., skeletons), but obtaining and returning it is a pain—there's terrible traffic and no parking." Some teachers seemed to feel strongly that science education is important, but they wished science were "easier for teachers to teach." One explained, "Lots of teachers think science isn't as important as reading and writing, but we think science is not 'separate.'" Another commented, "Science should be taught daily, if only for a few minutes," while still another remarked, "Many teachers think science is 'too messy,' but they could go do it in the cafeteria where they don't have a carpet to worry about and can wipe up spills."

Teacher Turnover

Despite the fact that the district trained all teachers on the core curriculum within two years of its adoption, teacher turnover requires ongoing attention to introductory professional development. Normal teacher attrition and class size reduction requirements have kept the percentage of new classroom teachers (those within their first three years of teaching) at more than 30 percent. A principal at one of the academically strongest elementary schools in the district laments that only about half of the teachers there are "clearly strong" science teachers. In addition, fully 20 percent of his teachers were new during the 1999–2000 school year. Another principal pointed out that, on average, most of her teachers had only four years of experience.

Complicating teacher turnover is the fact that many affluent districts nearby attract Glenwood teachers with up to a $10,000 increase in annual salary. According to former Associate Superintendent Calder, GSD tries to attract and retain new teachers with various professional and financial enticements. These include a mentoring program, stipends for extra duties as a lead teacher, and opportunities at some schools to participate on a team of teachers who meet regularly to discuss classroom practice and student work.

recording their observations and findings, students sit with their research partners to present their findings to the rest of the class. Then together as a group, they analyze the science work of the day. Later in the day, students will write in their journals and record additional thoughts and ideas generated during the whole-class discussion.

Professional Growth Goals

During the past five years, the district has moved from a centralized professional development system to a more school-based approach. District level staff see the move as a way to make a stronger impact on classroom practice. They feel that teachers have a high awareness of the importance and need for a quality science education program for all students, but they need to focus on improving teaching and learning through a variety of professional development experiences that accommodate the range of teacher needs.

In the past, professional development was focused on teacher learning without explicit links to student outcomes. The next wave of training focused almost exclusively on students. Now, according to program staff, they are trying to focus on both student and teacher learning. One goal of the newest grant is to build teachers' science content knowledge so they can teach the subject better. However, there is significant tension between the district and the university that would provide the courses. According to Judy Larson, the university has a tendency to treat teacher learners as passive recipients of knowledge, which does not match the district's philosophy of active learning for adults as well as for children.

THEY NEED TO FOCUS ON IMPROVING TEACHING AND LEARNING THROUGH A VARIETY OF PROFESSIONAL DEVELOPMENT EXPERIENCES THAT ACCOMMODATE THE RANGE OF TEACHER NEEDS.

Major Professional Development Efforts

Kit Training: GSD's program of professional development and support includes a range of opportunities for teachers at all levels of experience. For the novice, the district offers a summer institute to be attended by those who are new to the profession, new to the district, new to a grade level and its curriculum, or who simply want a refresher course on a particular kit. Teachers receive a stipend to attend. The science program leaders have found training is most effective when aimed at teachers in the second and third year of teaching instead of during the first year, when they are often overwhelmed with other concerns.

A summer institute in 1999 was designed by the TSAs and consisted of two weeks devoted to in-depth understanding and implementation of one kit for each grade level. The science leaders recognize that there are pros and cons to long training on a single kit. As one new teacher noted with frustration, it will take four years for her to be trained to implement the full science curriculum for the grade she now teaches. Others, however, pointed out the value of learning about a science topic in depth and having the opportunity to discuss many aspects of its implementation with colleagues.

THERE ARE PROS AND CONS TO LONG TRAINING ON A SINGLE KIT.

At the institute, each kit was taught by a teacher leader, with assistance from a fellow teacher and a scientist from the university. The institute began with a discussion of "inquiry," which was incorporated into each subsequent day's work. By the end of two weeks teachers had worked through every lesson in the kit. Three Saturday follow-up sessions to the institute were planned during the school year with the lead teacher and scientist.

Case Study Teams: Case study teams were a site-based, teacher-centered approach to professional development that GSD supported as part of the LSC grant from 1999–2001. The teams were small groups of six to eight teachers in a school, although they could have as few as two members, typically across all grades K–5. Teachers applied to participate and were selected by the TSAs based on their interest and motivation. Teams met once or twice a month, before or after school, to focus on improving the effectiveness of inquiry-based science instruction. Teachers received a stipend of $300 per meeting for 10 meetings. Group leaders receive $2,000 per year, funded through the LSC grant. One experienced teacher who participated described the teams as "so eye-opening." Another explained that they "make you feel motivated to teach science."

The purpose of the case study sessions was to address how to teach science better: how to look at student work to understand what students are learning and to determine what to do next instructionally. They called on teachers to pool their knowledge, experience, and expertise in child development and learning, instruction, motivation, assessment, and science content. Participants kept a journal of what they were learning and what help they would like with their own teaching. Discussion topics ranged from teaching to the district science standards to handling the hands-on materials to putting students in charge of their own learning. According to some, the case study teams have encouraged some reluctant teachers to teach more science and have helped teachers to determine their own teaching strengths and how to capitalize on them to improve science instruction. With the departure of the LSC funds, the future of formal support for the case study model is uncertain.

Science Museum Professional Development: During the summer of 1999, the science museum provided two five-day sessions for teacher leaders on implementing inquiry science in the classroom. It should be noted that while some lead teachers are quite experienced science teachers, others are novices. Some teachers expected that the training would consist merely of sitting and talking for five days, but instead, they discovered that for the first three days they would do lots of "messing about" with materials, implement inquiry methods, and explore many questions about how the world works. This opportunity helped teachers deepen their content knowledge in this area of science as well as experience firsthand how learners build conceptual understanding through an inquiry learning process. The final two days addressed how teachers become facilitators of students' inquiry processes and learning.

While some lead teachers are quite experienced science teachers, others are novices.

District Professional Development on Assessment: The district also offers direct services to teachers. Namely, it convenes an annual week-long Scoring Institute in which teachers are trained and then score student work on the SAIR science assessments. Teachers blind-score students' work from their district as well as work by students in other districts. Eventually, teachers score approximately 140 tests per day. Schools are encouraged to send at least one teacher to the Scoring Institute, each year but they are not meeting this goal. According to the program leaders who organize the institute, teachers who participate in this scoring experience enjoy it and gain significant insights into what students can do and how they think when learning science. Participants typically go back to their schools and help their colleagues create classroom assessments that are similar to the SAIR test to help prepare students to do well in the future.

Principals are crucial to good instruction in the classroom.

Principal Involvement in Professional Development: The leaders of the science program believe that principals are crucial to good instruction in the classroom. Hence, they have involved principals in professional development efforts in science for several years. Principals have participated in introductory in-service sessions for teachers on science kits and have met in cluster groups with their colleagues to address implementation issues at their schools. They also have additional opportunities to engage in leadership groups during the year.

Principals praised the district's professional development efforts, calling them "well organized, accessible, and well evolved." They noted that teachers still have to take the initiative to profit from them and that some choose to do something else. One principal commented that science wasn't her area of expertise, but she learned through these teachers and the district professional development for principals about how principals could be a part of this reform and what to expect teachers to do in their classrooms.

DECISION MAKING AND LEADERSHIP

District-Level Decisions

The school board makes final budgeting decisions for the Glenwood science program, based on recommendations from the superintendent. However, until her recent departure, budgetary decisions about science were heavily influenced from the outset by associate superintendent for curriculum and improvement Calder. Over the years, she has cultivated superintendents' and board members' support with informal discussions and formal presentations. Her efforts resulted in board adoption of *FOSS* and *Insights* kits as official elementary curricula in 1992, and she has won the active support of three out of the four most recent superintendents.

Curricular, professional development, and building-level budgeting decisions are made through the descending hierarchy of leadership structures.

It is difficult to trace how decisions are made because, in contrast to what one would expect in a large bureaucratic system, many of the leaders in science work in a highly participatory and mostly collaborative manner.

It is difficult to trace exactly how decisions are made because, in contrast to what one would expect in a large bureaucratic system, many of the leaders in science (such as the TSAs) work in a highly participatory and mostly collaborative manner. This is a desirable feature of the district to many of its participants, but results in a cumbersome and sometimes politically charged process.

District Science Leadership

The GSD has strong leadership in Judy Larson and Ed Morris, along with three TSAs. Sondra Calder played a significant decision-making and leadership role in the program early on and then, in her position as associate superintendent, ensured that the program had strong central office support.

Calder has consistently nurtured a collaborative process of decision making. For example, when it came time to write the recent USP grant, she collaborated with five to six key writers and took suggestions from many sources. As she pointed out, "This way everyone owns the process and the results." According to Calder, they began work on the goals of the grant even before they knew whether their proposal would be funded because she felt these efforts would propel the participants toward accomplishing their goals anyway. She called it "a constant entrepreneurial effort." Calder felt that having several teams working simultaneously on mutual concerns develops group support for the goals of the larger educational community. She saw the central office staff and TSAs as facilitators, with individual schools as the "heart" of real reform. As she explained, "The schools need to own their plans for reform. We want people to bring these plans alive."

"This way everyone owns the process and the results."

Adjusting and Adapting the Program to Address the Priority of Literacy: In recent years, an increased emphasis on literacy has had an impact on the science program. While this could lead to competition for time and resources between elementary science and literacy instruction, TSAs spoke about discouraging an "us versus them" mentality. Instead, they are constantly looking for ways to connect science with the literacy curriculum. One TSA noted, "One piece often missing in the classroom is the lack of students talking deeply about ideas. That's a key piece of literacy. And science provides these opportunities for students." Another TSA commented that, "in scoring science assessments, the teachers can't help but notice the importance of working on student writing and discussion skills."

Ed Morris also commented that science can be a vehicle for reading comprehension across the curriculum. He pointed out that there is a lot of reading involved in many science tasks and assessments, implying that it is important to be able to comprehend science-related materials, and that such reading is good practice. Similarly, Judy Larson felt that science tends to be motivating for students, and those with low literacy scores tend to need the motivation the most.

Nonetheless, Larson said she still sees some conflict between science and the recent strong emphasis on literacy. Principals are held accountable for reading scores and are evaluated by their school portfolios, which include standardized test scores in language arts, math, science, and other indicators linked to the school site improvement plan. According to Ed Morris, improving reading scores is the first priority for site administrators. "Principals are not 'against' science," said Larson. "They are just 'overwhelmed,' and literacy does take time away from science, especially for those schools who must improve their test scores." A new principal said succinctly, "The district priority is literacy." When asked if science played a role in her teacher evaluations, she said that the school focus is on literacy and math, and that is her focus when evaluating teachers. However, she claimed that science is taught every day, albeit "… integrated so it may not look like science. That is, the students might not be utilizing the kit materials every day." In contrast, the principal at one of the highest scoring schools asserted that science instruction is not threatened by a literacy focus:

> Literacy doesn't whiplash science here. We have high test scores, but we also have students who score below grade level. Being a K–8 school, we inherit our own problems [from the elementary grades]; we can evaluate our own kids. Since we can't get a bigger plate, we discuss how to manage our plate better—how to integrate subjects.

"Principals are not 'against' science, They are just 'overwhelmed.'"

TSAs or Resource Teachers

Until the 2000–2001 academic year, there were five elementary science resource teachers in GSD. Now there are three. All have been classroom teachers and have been in the TSA position between four to six years. As a team, they help design and implement reform strategies, and coordinate major components of the science program, such as materials refurbishment, focus schools, case study teams, professional development efforts for new teachers as well as the teacher leaders, and student assessment.

As a team, the TSAs in GSD have a unique role compared with TSAs in other districts. There has not been an elementary science director for several years. After wanting to fill the position for some time, the district decided to stop the search and let the strong team of five TSAs take on the role through a collaborative leadership model. According to the TSAs, that decision made a very significant impact on their personal growth. They met often to reflect, design, and discuss their work and challenge one another's thinking. The current team is very interested in bringing the latest research to bear on their plans to improve instruction and assessment, and their connections to the national arena of science reform have given them information to shape their program. As one of them said, "Someone needs to have the big picture." There still are struggles with how much autonomy the team has, but as one program partner put it, "The design they developed for a collaborative approach to leading the elementary science program knocked the socks off the advisory committee, and we are all excited about it."

The district decided to let the strong team of five TSAs take on the role through a collaborative leadership model.

Teacher Leaders

A district LSC report reveals the importance the science program staff accords teachers who provide leadership at the building level:

> A strong core of teacher leaders is essential to building the capacity for change in a system. Utilizing the expertise of teachers increases their sense of professionalism. Teacher leaders need support in content knowledge, teaching strategies, communication, facilitation, and mentoring. Building the change process from within and empowering teachers to take responsibility for each other's learning is a powerful tool towards change.

Many teachers are not aware that Leads exist as a source of science instructional support.

The district has had teacher leaders since the "primordial soup" days preceding the current program, but its commitment to them has grown over time. There is typically one teacher leader (Lead) per school, although some schools have more than one and a few schools have none. Leads are classroom teachers who get four release days per year to facilitate science teaching teams on-site. They present units to their teacher colleagues with the help of a partner scientist, and explain the district assessment program in science to fellow teachers, the principal, and parents. Some of the Leads teach the summer kit training accompanied by a scientist partner. There used to be a requirement of at least five years of teaching experience to be a Lead, but now teachers may become Leads simply if they are interested and competent. Despite this history, many Leads said they are not sure what their title is and claim that many teachers are not aware that Leads exist as a source of science instructional support.

Principals

According to Larson, principals provide leadership for the science program in a variety of ways. They may show interest in what students are learning in science class, fund case study teams, foster scheduling of kit use at their schools so all teachers can teach all kits, and hire effective science associates to refurbish the kits. Glenwood principals are required by the district to pick three priorities for their improvement plans and are required to formulate a discrete number of measurable objectives and action plans for each. For example, one principal said that one of his school's goals was "comprehension," which included comprehension in science as well as other subjects. Others may choose to include science test scores, samples of student science work, and photos from science classes to illustrate how students are meeting district science standards.

Principals vary in their interpretation of their role as leaders of science education. For example, one principal remarked that the key role of the principal is "to be a barrier for imposed accountability." She wanted her teachers to be relaxed and not feel stressed, watched, or hovered over. Otherwise, she feared, they would go back to "covering the book." Another principal described her role as "making sure science is an integral part of the curriculum."

Scientists

Scientists, primarily from the local university, have been involved with the district's science program since the beginning, and their role has evolved. Some scientists worked "in residence" at the 27 focus schools during the first grant, but the goals and intent of the district were not always clear at the time, resulting in under utilization of the scientists' expertise. As the district began to emphasize working with teachers in their schools, the science program staff began to develop new ways for scientists to work with teachers and created a program involving "scientist-teacher action teams," comprising two scientists and two teachers. Each team works across two schools. Through this program, district science staff have found that regardless of what standards or units teachers and scientists work on, the same issues come up over and over: habits of science, what is the nature of the discipline compared with other disciplines, and what skills are needed to teach science well. Thus, they have tried to incorporate these issues in the various types of professional development offered.

Regardless of what standards or units teachers and scientists work on, the same issues come up over and over.

RESOURCES AND SUPPORT

Funding

It is clear that the district views science education as a priority since it provides support for staffing, professional development, materials management, and science assessments. However, Glenwood has been fortunate in its ability to seek and receive a high level of external funding, amounting to more than $18 million over the past 12 years. According to one administrator, external funds have allowed reform efforts to progress at a more rapid rate and more intensive level than would otherwise have happened. Table 1 provides an overview of the major grants supporting the elementary science program.

Table 1

Title	Source	Dates	$ Million	Primary Purpose
Science Leaders	Glenwood Education Foundation	1989–1992	< 1	Twenty-seven K–5 science teachers funded for professional development.
University Grant	NSF	1991–1996	2.8	Professional development in science for 100 K–5 teachers.
Science Museum Grant	NSF	1990–1994	1.4	Intensive training for a cadre of 100 elementary teachers over four years.
LSC Grant	NSF	1996–2000	3.8	Focus on professional development for all teachers to support inquiry-based science. Expanded professional development for 100 teachers in science museum grant.
USP Grant	NSF	1999–2004	10	K–5 science, math, and technology over five years.

Community and Partnerships

Over the past decade, GSD has had multiple partnerships and relationships with a variety of institutions that support its elementary science program. The two main partners, the state university and the science museum, both of whom played key roles in the early years in particular, are described below. The district highly values such partnerships. One of its reports on the LSC grant describes a particular "lesson learned" about the value of partnerships:

> A district needs the expertise and resources of scientists, university faculty, and members of other educational institutions to enrich the content program for students. This is especially true for science. Partnerships can help a district strengthen its science program and offer avenues of access to students and teachers who may not be intrinsically motivated by science.

Regarding the partnerships, "It takes a lot of work, but they are worth it."

As associate superintendent, Calder spent about 20 percent of her time on building and maintaining relationships with the state universities, local businesses, and other institutions. She feels they each have their own work culture, and the two do not always understand each other. Part of her job was to make sure that all partners and school sites followed through on their mutual commitments. As she stated regarding the partnerships, "It takes a lot of work, but they are worth it."

The State University

The Science and Health Education Partnership (SHEP) was initiated at the state university in 1987 by a professor of biochemistry and biophysics. According to the executive director of SHEP, who has held the position since 1994, there is an interesting anecdote frequently told about how SHEP began:

> A professor was bored at a cocktail party and complained he was paying too much money to have his outdated scientific equipment stored in university warehouses. Could we send some of these materials out into the schools, he wondered. Well, lo and behold, once that discussion started happening, the teachers actually wanted to talk with scientists, and it went from there.

The well-established volunteer scientist program has the mission of improving the quality of science instruction for all students in Glenwood's public schools. SHEP's program utilizes its intellectual and material resources to support systemic reform in a manner that aligns with the *National Science Education Standards*[6] and the district's own science standards and curriculum.

6 National Research Council. (1996). Washington, DC: National Academy Press.

SHEP has a dozen programs, most of which are involved in professional development for teachers through building an integrated community of scientists and educators. There are approximately 350 volunteers (some receive stipends, depending on the program and time commitment) from the university, including students in medicine, nursing, pharmacy, and dentistry; staff researchers; faculty; and post-docs who provide about 10,000 hours of service per year. SHEP programs are active in about 75 percent of the elementary schools and in 92 of the 117 schools overall. Some university staff and students are initially involved in one program, then another, as their school or work schedule and interests change. SHEP encourages this serial participation since participants tend to gain an understanding of science education issues over time, and the quality of the partnership is sustained. The executive director has anecdotal evidence that scientists participating in SHEP programs have benefited from the experience as well. For example, they have been able to use their experience to secure academic positions, to negotiate higher salaries, to establish outreach programs, and to revamp lab programs in high schools.

SHEP provides about six hours of training for its volunteers that prepare them to work effectively with and learn from teachers. This training includes pedagogy (e.g., learning styles, hands-on and other teaching strategies, cognitive development, lesson planning, etc.) and discussions of the language and professional cultures of scientists compared with educators. Scientists also are expected to spend several hours planning with the teachers they will partner with and observing their classrooms prior to working with them.

The director of SHEP expressed a need to develop training for teachers in how to work effectively with scientists, since there is a significant "culture clash." She said they try to encourage teachers to articulate how they do what they do (e.g., how they manage the students in small work groups), and they try to encourage the scientists to explain how they formulate good inquiry questions. The goal is to foster mutual respect among participants and help them understand what issues are important in their respective worlds. One scientist commented that it is difficult to "get teachers to realize that scientists do not know everything in their area, and that wrong answers are okay and valuable."

The goal is to foster mutual respect among participants and help them understand what issues are important in their respective worlds.

SHEP is currently staffed by two post-docs, four program coordinators, and three other administrative staff. Of these, a subcontract from the district grant pays for part of the director's time, one full-time resource teacher, and a full-time administrative assistant who works at the district office.

The Science Museum

The science museum has, for years, been a prominent player in Glenwood's cultural and educational life. It is known as a center for inquiry-based science education whose professional development programs reach over 500 local elementary and secondary teachers. In addition, teachers throughout the country participate in the museum's summer institutes designed to focus on content and pedagogical knowledge. In 1999, according to the museum Web site, K–12 teachers in the Glenwood area ranked the museum as one of their two top science resources.

The stated mission of the science museum is:

> To create a culture of learning through innovative environments, programs, and tools that help people nurture their curiosity about the world around them.

The science museum first became involved with GSD in 1987 through federally funded summer institutes it offered to teachers in Glenwood and a neighboring county. Then came the three-year effort to provide intensive training to the 27 teacher leaders in the GIE directed by Calder. A critical juncture in the museum's relationship with the district came in 1995, when both institutions planned to submit major proposals to NSF. They recognized they needed to create a common vision. Thus, they decided they would both submit independent proposals, but they would structure them so that the two would be integrated and provide a holistic approach. A museum program leader described this effort: "I think it was a hallmark that after all of this tension, we could sit in this room and craft two proposals that were fairly strategic and intertwined."

"It was a hallmark that after all of this tension, we could sit in this room and craft two proposals that were fairly strategic and intertwined."

NSF, however, did not fund the proposals as written and, instead, directed both institutions to two different programs. The revised proposals of both institutions were funded, but unfortunately, the new grants made it more difficult for the museum and the district to work together.

Other District Relationships

In addition to formal partnerships, the district also benefits from participating in studies conducted by researchers from two universities in the state. For example, the district has been able to improve their professional development strategies based on research findings (e.g., How can teachers provide effective feedback to students in their science journals?) Other support has come from a university-based scholar who has helped to refine the technical quality of the science assessments used by the district.

GSD also has engaged with many science educators across the country in a variety of ways. They have been involved in work in the Center for Science Education at Education Development Center, Inc. (EDC), in Massachusetts as well as the National Institute for Science Education at the University of Wisconsin—Madison, the other NSF-funded Urban Systemic Programs, and the American Association for the Advancement of Science. Calder feels that such activities help inform the district's work and keep it current on research literature. These experiences have provided new ideas for and validation of their reform efforts.

ACCOUNTABILITY

Over the years, the science program has benefited from increases in accountability for instruction and program effectiveness. For example, around the same time that kits were first adopted by the district, the superintendent realized that a lot of money was coming into the district through a variety of programs (in other areas as well as science), and he wanted to understand the results. He, thus, required programs to add an evaluation piece after the first few years and, since then, any program that does not show student results will not get funded by the district the following year. According to Calder, this approach realigned district resources, releasing money from ineffective programs for use in the more successful ones.

Currently, the district science staff is focusing on standards, assessment, and accountability as crucial pieces in sustaining good science education. Thus, they are working to improve and maintain science assessments at grades 5 and 8, the results of which are included in required school portfolios. The district now has both content and performance standards by grade-level ranges, whereas the state science standards are essentially content standards. The district also has a K–5 Web site with examples of student work and videos of promising practices that are aligned with the standards.

Most of the district emphasis on accountability to date has been on literacy skills and mathematics. Even though there has been a district science test in place for the past several years, this test is "low-stakes," and has not been linked to any consequences for students, teachers, or principals. More recently, however, science leaders have pushed to include science more formally in the accountability system, and they saw some progress in the 2001–2002 school year.

Principals are held accountable for general school performance, and are evaluated each year. The evaluation is based on two broad criteria: (1) student academic achievement, which includes raising test scores and closing the "achievement gap for African American, Hispanic, and English-Language Learners," and (2) school leadership, which includes 15 components ranging from implementing site plans and monitoring teachers' professional growth to maintaining a clean school environment. During each school year every principal prepares and files site improvement plans with the central office, setting goals for the coming year that are aligned with the standards used for evaluation.

Since 2000, as a result of the USP grant, there are specific goals for improvement in science, generally a 10 percent improvement on the SAIR test scores over the five-year life of the grant. During the 2001–2002 academic year, schools used a newly revised form for filing site plans with the district that included specific language reflecting the USP science goals. While there are no specific sanctions for not meeting the science goals, it becomes part of the overall school site plan and portfolio, which is evaluated at the district level. The possible sanctions against a principal for

While there are no specific sanctions for not meeting the science goals, it becomes part of the overall school site plan and portfolio, which is evaluated at the district level.

consistently poor performance on overall goals, including science, include probation, renewal of a one-year contract instead of a three-year contract, and/or non-renewal of contract.

There is still no formal means of holding teachers accountable for implementing the elementary science curriculum.

With this said, there is still no formal means of holding teachers accountable for implementing the elementary science curriculum. The district uses data from teachers' requests to the materials center for kit materials as an indicator of implementation, and provides this data to principals to be used at their discretion. However, no principals reported using this to guide their planning for science or as part of teacher evaluation. In fact, no principals reported ever having observed a science lesson to evaluate a teacher. There are no formal consequences other than principal feedback attached to teachers' use or non-use of kits, though the district uses some informal means (e.g., attendance at kit training and leadership training, which include an in-depth focus on inquiry science) to gauge general levels of science interest and implementation.

EQUAL ACCESS TO SCIENCE

GSD has placed a priority on educating *all* of its students and has acknowledged that it needs resources and tools to examine possible inequities in the delivery of instruction, access to science materials, and teacher attitudes and perceptions.

GSD has placed a priority on educating *all* of its students through a quality science program. As a district, the GSD is aware that for a variety of reasons, its African American, Hispanic, and English Language Learner students are less successful at mathematics and language arts than their peers. Unfortunately, SAIR data is reported only at school level, and is not disaggregated for those subgroups. Also, the lack of solid data on who is implementing the curriculum and to what extent makes it impossible to know if all students have equal access to opportunities to learn science. The district has acknowledged in reports to NSF that it needs resources and tools to examine possible inequities in the delivery of instruction, access to science materials, and teacher attitudes and perceptions.

They are taking some concrete steps. Beginning with the ninth grade class of 1997, as part of the high school graduation requirement, all students are to complete three years of college preparatory courses in both science and mathematics. By successfully completing these requirements, students will have met the state university eligibility criteria. These requirements, along with the science testing in grades 5 and 8, put pressure on teachers in middle and elementary schools to prepare all students to handle high school science courses. The changes in the graduation requirements illustrate how policy can help change the community's perception of who can or should engage in the study of rigorous subjects (i.e., science and math). In fact, the new graduate requirements reportedly focused the entire school community on improving science education for all students.

ANALYSIS

The story of elementary science in Glenwood 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 Glenwood are discussed below. For an in-depth discussion of all of the factors, see the cross-site report of this study[7].

Factors that Pertain to Surrounding Conditions

Culture: Collaboration and Competition

The story of the GSD elementary science program illustrates an aspect of the Glenwood culture that has a strong impact on sustainability—the tension between collaboration and competition. One contributing factor to this tension is the simple issue of "turf" that is so often embedded in the day to day operations of school districts—particularly large ones. There often are conflicts over who will oversee whom and who will have authority over which programs. In such an environment, even when there is interest in collaboration among leaders, the effort can prove to be an uphill climb because there are no formally established avenues for open communication.

Even when there is interest in collaboration among leaders, the effort can prove to be an uphill climb because there are no formally established avenues for open communication.

Another factor contributing to Glenwood's competitive culture is the entrepreneurial nature of the district. Glenwood's leaders nurture and even encourage competitiveness through their focus on obtaining external funding. Efforts to secure external funding (and the status that comes from those who are successful) illuminate the rivalries that exist between and within departments and between the school district and external entities. These rivalries can undermine the sustainability of a program by diluting efforts to develop widespread shared beliefs among program participants and by exasperating coordination issues.

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

Within this larger competitive arena, however, GSD program leaders seem to have recognized and addressed the importance of collaboration. Within the program, decisions are made by a team of TSAs who work with one another in a thoughtful, collegial manner. The district also has developed and nurtured its relationships with its external partners so that all parties involved have an opportunity to provide feedback and input, and express concerns. Even though the development of the first university proposal without consultation with the district set the stage for potentially complementary programs to operate independently of one another, the leaders were able to overcome their differences and operate in a coordinated manner. This was a critical move toward the ability of the program to be sustained. The result of years of work is a more aware, committed group of leaders that support the program with deeper conviction and shared commitment.

Science for All: Benefiting from Accountability

One of the primary motivations behind the initiation of the large science grants was the commitment to providing all students with a sound science education. This commitment has been echoed in GSD's grants, its reports ,and its processes for documenting improvements in schools. But program leaders are facing a challenge because no formal accountability system for the science program exists; and without sufficient accountability systems, equity can suffer. If there is no formal means for understanding how the program is being used, it is likely that many students will not be given the opportunity to participate in and grow from the program.

Without sufficient accountability systems, equity can suffer.

GSD program leaders have taken steps to remedy the situation. They have engaged their teachers in the meticulous process of developing and administering a district science assessment. This assessment can provide some information about the status of the program and its implementation, but without the capability to disaggregate the data by student group, their analysis of the information is limited. Further, the fact that the test carries with it no consequences undermines their efforts to use the test to bring legitimacy and importance to the science program.

Factors that Pertain to Science Program Components

Leadership: Moving with the Changes

The elementary science program in Glenwood has benefited from the coherent vision and strategic support of the past associate superintendent for curriculum and improvement, Sondra Calder, who was one of the founders of the district's hands-on inquiry science program over a decade ago. "As long as she's here, science will be around," said one principal, explaining that Calder's vision and power have been crucial. Now that she has taken a leave from the district and there is a new superintendent, the current leaders of the program find themselves somewhat afloat, seeking out the stability that they have enjoyed for the last several years.

With Calder's departure, the TSAs have stepped in as a shared leadership team. Early worries about losing valuable institutional knowledge with the reduction of TSAs now have come to pass as their number has been cut from five to three. The team is still developing their understanding of an appropriate role for themselves. Unable to predict what kind of support they will receive from the central office, the TSAs have focused primarily on building leadership structures at each school. The intent is that these school-based efforts will sustain the science program—both for teachers and principals. However, although they may put structures in place at individual schools, the reality is that faculties constantly turn over, so the TSAs will never be "out of business"—they will always be needed for teacher professional development.

Unable to predict what kind of support they will receive from the central office, the TSAs have focused primarily on building leadership structures at each school.

Money: The Challenge of Sustaining with External Funding

The GSD program has long been supported by financial and human resources external to the district. While the central office always has provided verbal support for the program, it provided little money at the beginning and encouraged the program leaders to seek funding elsewhere. The program leaders have been very successful at fundraising, and this has served the development of the program well.

However, because the program has had a steady stream of funding from outside the district, the question of how the program will react when that money is gone remains unanswered. As one administrator bluntly remarked, "When money to support the resource teachers goes, science will go." Yet with the departure of the LSC grant and the reduction in the number of TSAs, the program still may be able to continue unencumbered, depending on how the remaining TSAs are used.

Because the program has had a steady stream of funding from outside the district, the question of how the program will react when that money is gone remains unanswered.

A further challenge that has emerged from the steady stream of external funding has been the strategic and design constraints of the funding sources. Glenwood has had to accommodate the requirements of the funder's programs, and in doing so, has adapted particular leadership and professional development structures. While Glenwood leaders may have made the same choices without the funder's guidance, one can speculate that had they been unencumbered by some of the funding requirements, their choices would have been different and, perhaps, more effective. Still, in the end, the leaders' decisions did indeed support the growth and evolution of Glenwood's sustained program.

Partnerships: Good Times and Bad Times

Glenwood's science program has benefited from the attention of many science educators. Leaders at the district, the science museum, and the university all have invested resources, personnel, and themselves into the development and growth of the program. And yet, while this widespread attention has benefited the program, it also has been the root of serious tensions and conflicts in leadership and management. The fact that the program leaders were, in the end, able to overcome the many potential communication breakdowns speaks to their patience and diplomacy.

The strong partnership that exists in Glenwood is a rarity. Most often, partnerships between businesses or organizations and schools are superficial and somewhat supplemental to the core program. Such partnerships enrich the program but are limited in their support. The partnerships in Glenwood, on the other hand, require investments of resources and political currency and focus on shared planning and management. The cost/benefit of this partnership is hard to predict for the long term, though it seems likely that, having gone through the pains of growth together, the partners will remain together to support their shared interest: the science program.

Factors that Pertain to the Whole Science Program

Philosophy: Building Shared Belief Systems

Glenwood program leaders always have clearly articulated the program's philosophy—its core beliefs and values about the goals and purposes of the science program. Leaders have expressed these goals verbally through teaching guidelines written directly for teachers and in their grant project reports. From the outset, Calder and others close to her in the development of the program held shared views of how science should be taught and why it should be taught that way.

The early projects targeting the 127 teachers focused on disseminating this philosophy and building shared beliefs among the participating teachers. These teachers became a cadre of supporters that dispersed among the schools, generating enthusiasm and sharing ideas with their teacher colleagues. The commitment to inquiry in Glenwood has not wavered, even in the face of fact-oriented state science standards. Glenwood's leaders believe that this approach to science teaching is the most appropriate for science learning in general, and in particular for the GSD's diverse population.

The commitment to inquiry in Glenwood has not wavered.

However, even though the GSD remains committed to inquiry science, the district's commitment to the importance of science instruction is uncertain. The district leadership has, without a doubt, stood squarely behind the program from the beginning. But they, like other district leaders across the country, are faced with increasing pressures to focus on literacy and mathematics at the elementary levels. There is, in fact, no clear accountability system in place, so the extent to which science instruction is present or absent is unmonitored. If the program is to endure, district leaders must make it clear that they not only are committed to inquiry-based, hands-on science, but that they also place great importance on ensuring that science is taught.

SUMMARY

The elementary science program in Glenwood has benefited from the coherent vision and strategic support of Sondra Calder, who helped found the district's hand's-on inquiry science program over a decade ago. Over time, she made sure to obtain the support of district superintendents and negotiate collaborations with external partners. However, now that she has taken a leave from the district and there is a new superintendent, the status of the program may change. Still, Judy Larson, director of K–12 mathematics, science, and technology, remains and is a strong leader in her own right.

To date, the board and past superintendents have supported the program, but the latest superintendent has reduced the numbers of TSAs, making their job more difficult. As attention and money from the latest grant flows to technology, mathematics, and secondary science, future stability and quality of the elementary program seems less sure. Still, the past 12 years have seen the development of a strong foundation, including a core curriculum, materials refurbishment system, strong professional development, involved partners, and a widespread group of teachers committed to inquiry-based approaches to science instruction. These foundations are the key to ensuring that the program and the teachers using it will hold steadfast to their core beliefs and values in the face of the uncertainties that come with the new superintendent and his changing priorities.