CROSS-SITE REPORT

RESEARCHING THE SUSTAINABILITY OF REFORM

FACTORS THAT CONTRIBUTE TO OR INHIBIT PROGRAM ENDURANCE

Executive Summary

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PROLOGUE

Over the past decade, extraordinary resources have been committed to promoting the improvement of science education. Since 1990, a conservative estimate suggests that the National Science Foundation (NSF) has invested well over $450 million to improve K–12 science education through comprehensive reform efforts. If one also includes NSF's investments in curricula and materials, that amount would significantly increase. Additionally, many school districts have invested their own resources along with countless hours in the planning and implementation of NSF's investments in their schools. And still other districts have simply taken on the science education reform endeavor at their own expense. These seasoned educators at all levels of the education system have seen reforms come and go due to shifts in the political tide, changes in school and district leadership, or increases in the popularity of different pedagogical approaches. So, if there is one question ever-present on the minds of teachers, administrators, funders, and policy makers working to improve education for their students, it is: *How do we ensure that the programs we are implementing will last?*

The reform efforts referred to above have centered on establishing science programs that promote the use of hands-on materials through an inquiry approach. Creating such a program, or changing a districtwide science program from one that is driven by textbooks to one that is centered on using materials, is a formidable task with far reaching implications. District budgets, teacher training and professional development, articulation and alignment, testing and assessment processes, curriculum design, and science standards and frameworks are only some of the districts' policies and practices that program leaders and administrators need to address. Without sufficient planning, resources, resilience, and fortitude, initial investments are unlikely to bear fruit, no matter how dedicated the leaders. And even with a full complement of all of the above, educators ask, how long should it take for a hands-on program to become embedded in a district's culture? And what else does it take to make sure that the initial efforts will ultimately pay off in the form of an enduring, hands-on, districtwide science program?

Indeed, these questions were prominent in the minds of the practitioner colleagues of staff from the Center for Science Education (CSE) at Education Development Center, Inc., (EDC) in Newton, Mass., and the Caltech Pre-College Science Initiative (CAPSI) at the California Institute of Technology in Pasadena, Calif. CSE and CAPSI both had a strong foundation of working with school districts to plan and implement districtwide, hands-on elementary science education programs and had concerns about the sustainability of their fledgling programs. Moreover, CSE and CAPSI staff had seen the price that districts paid when their reform efforts failed. Resources were clearly lost, but so was time, effort, morale, opportunities to expand teachers' content knowledge and teaching skills, not to mention opportunities for children to experience science in ways that heretofore had been unavailable to them.

Thus, motivated by the importance and urgency of these sustainability questions, CSE and CAPSI collaborated to obtain funding from NSF for a research effort aimed at answering the question: *What contributes to or inhibits the sustainability of a districtwide, hands-on inquiry science program?* The project, which came to be known as Researching the Sustainability of Reform (REC-9805078), attempted to answer this question through a three-year study of nine districts in the United States that had districtwide, hands-on inquiry science programs in place from nearly 10 to 30 years. Findings from this research are contained in nine site-specific reports and in this cross-site analysis, which discusses the broader findings, trends, and themes gleaned from all sites.

This cross-site analysis is organized into four parts. Part I provides an overview of the study including design and methodology. Part II sets the stage for understanding the findings by presenting some of the overarching ideas that emerged from the study and providing the reader with a concrete portrayal of what these programs look like, how they develop, and the ways they are implemented. Part III is a discussion of the findings themselves including the contexts and conditions that influence sustainability, factors that pertain to the individual elements of a science program, and factors that affect the program as a whole. Finally, Part IV focuses on the implications of the findings for leaders of individual science programs and for the field.

Background of EDC's Center for Science Education (CSE)

CSE's history of working with school districts to improve their science education programs is grounded in 15 years of curriculum development, professional development, technical assistance, and research, all conducted in collaboration with practitioners in urban, suburban, and rural school districts. In 1987, CSE began its work focusing on inquiry-based science curricula by developing *Insights: A Hands-On Elementary Inquiry-Based Science Curriculum.*[1] Not long after, CSE developed *Insights* for the middle level, and then *Insights in Biology* for grades 9 and 10. CSE staff now are developing materials for the Pre–K, elementary, middle, and high school levels.

Concurrent with curriculum development work, CSE has provided technical assistance and professional development support to over 300 districts across the country, many of which have NSF-supported teacher enhancement and systemic reform projects. Much of the work has been in close collaboration with science directors/coordinators of district school systems

1 *Insights: An Elementary Hands-On Inquiry Science Curriculum.* Developed by Education Development Center, Inc., 1997. Published by Kendall/Hunt Publishing Company.

as well as superintendents, assistant superintendents, principals, and teacher leaders. CSE has conducted seminars and institutes on many issues related to science education reform, including assessment, science and literacy, science standards, and increasingly diverse student populations. In addition, CSE staff, along with leaders of several mature districtwide, hands-on science programs, provided direct technical assistance to districts beginning their work in science education reform. Part of this work included the development of materials and resources for leaders of these fledgling programs, including the first monograph in the NSF *Foundations* series[2].

Using this foundation of knowledge and experience, CSE also has developed a body of research and evaluation work grounded in a commitment to conducting rigorous studies that provide useful, practical information to educators engaged in education reform. The research work is a natural outgrowth from the Center's curriculum writing, professional development, and technical assistance efforts that regularly raise many research issues and evaluation questions—in this case, the focus is on sustaining reform. The research and evaluation work includes a range of methodologies, purposes, and approaches. It reflects the beliefs that research studies should result in findings that are directly applicable in the field; research questions should emerge from field-based experience and issues of direct importance to practitioners; and evaluations should provide information of practical and immediate use to the client.

Thus, this research project was a natural fit for CSE and its practitioner colleagues. CSE staff understand that program leaders' abilities to make the case for inquiry-based or hands-on science education, guide materials selection, develop professional development programs, and provide overall leadership make progress possible. But still, it cannot completely guard against their programs' vulnerability to the shifting pressures that accompany political and community change. This research project sought to reduce that vulnerability with understandings and strategies identified by studying those places that had found a way to survive.

For more information about CSE, visit the CSE Web site at http://www.edc.org/CSE. For more information about EDC and its other areas of work, visit http://www.edc.org.

Background of CAPSI

CAPSI (Caltech Precollege Science Initiative) was founded in 1985 as a collaborative effort of Caltech scientists and the Pasadena Unified School District to initiate a K–6 program of hands-on inquiry science in the schools. Begun on a small scale with volunteers in one school, the program

2 National Science Foundation. (1997). *Foundations: The Challenge and Promise of K–8 Elementary Science Reform.*

was expanded to the entire district of over 10,000 students in 23 elementary schools. This scale-up, with NSF support, became a model for the NSF Local Systemic Change Initiative. In the 1990s, many educators from across the United States and from overseas visited the program, observed classes, and consulted with the leaders on how to implement their own programs, many of which became successful districtwide efforts. In addition, scientists and engineers in France, Estonia, and Colombia have built on the CAPSI model of collaboration with educators to begin to implement national programs in their own countries.

CAPSI expanded its activities into the development of both pre-service and in-service science content courses for elementary teachers in the late 1990s, which have been successful in a variety of school districts across the nation and in Los Angeles area colleges. At that time, CAPSI and the Pasadena Schools collaborated to apply for and win the first NSF Center grant for teacher enhancement, to work with 14 predominantly minority school districts in California in establishing inquiry-based K–6 programs. After seven years, the Center still supports the continuing growth and development of 10 districts, which have formed a unique closely-knit consortium of K–6 reformers.

CAPSI's experience helping to establish districtwide science programs and coping with the problems of sustainability matched the experience of the leaders in the Center for Science Education at EDC. Together, they proposed this study on issues related to the sustainability of K–6 inquiry science programs. This initial research effort by CAPSI has grown to encompass a variety of other studies, all closely related to the practice of inquiry science education. These include a comparative study of fifth graders' science abilities in hands-on and textbook-based programs; a study of an Internet-based interactive site that appeals particularly to middle school girls; and a study of how best to use science notebooks in K–6 classrooms and their impact on science and literacy learning. In addition to the work of the Center and the Research Group, CAPSI has embarked on a project to develop next-generation inquiry curricula for grades 7–10, with field-tests of the first units beginning in 2002–03.

CAPSI has been identified by the National Academy as an exemplar of scientist-educator collaboration, and is featured on their Web site at www.nas.edu/rise/examp81.htm, while the CAPSI Web site is at www.capsi.caltech.edu.

PROJECT DESCRIPTION

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

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

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

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

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

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

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To download site reports from this study, visit the CSE Web site at http://www.edc.org/cse

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.

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EXECUTIVE SUMMARY

INTRODUCTION

Since 1990, a conservative estimate suggests that the National Science Foundation (NSF) has invested well over $450 million to improve K–12 science education through comprehensive reform efforts. Additionally, many school districts have invested their own resources along with countless hours in the planning and implementation of NSF's investments in their schools. And still other districts have simply taken on the science education reform endeavor at their own expense. Educators at all levels of the education system have seen reforms come and go, and one question ever-present on their minds is: *How do we ensure that the programs we are implementing will last?*

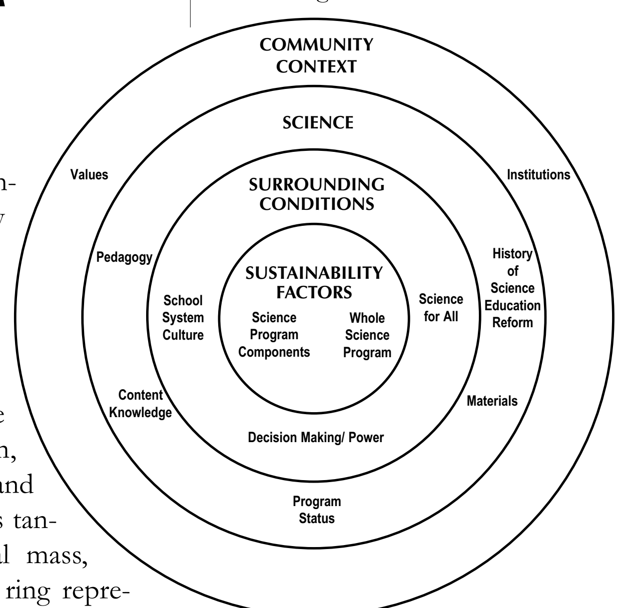
Motivated by the importance and urgency of these sustainability questions, the Center for Science Education, Newton, Mass., and California Pre-Science Initiative, Pasadena, Calif., collaborated on a research effort aimed at answering the question: What contributes to or inhibits the sustainability of a districtwide, hands-on inquiry science program? The project (REC-9805078) addressed this question through a three-year study of nine districts in the United States that had districtwide, hands-on inquiry science programs in place from nearly 10 to 30 years. Findings from this research are contained in nine site-specific reports and in this cross-site analysis, which discusses the broader findings, trends, and themes gleaned from all sites.

SETTING THE STAGE FOR THE FINDINGS

MAPPING THE FINDINGS

Sustainability as it relates to the findings of this study is complex and covers a spectrum of factors. Figure 1, Sustainability Factors and Surrounding Conditions, maps the factors and conditions important to sustainability and represents the complexity of their interactions with one another.

Figure 1
Sustainability Factors and Surrounding Conditions



In the center are the most concrete factors that contribute to or inhibit sustainability—those that pertain to specific science program components (accountability, implementation, instructional materials, leadership, money, partnerships, and professional development) and those that are somewhat less tangible and pertain to the whole science program (critical mass, adaptation, perception, philosophy, and quality). The next ring represents factors (district culture, decision making and power, and science for all) that influence the conditions that have some bearing on the operation of the program in the district context and on the strategies program leaders employ to support the program's stability and development. These factors are the core findings of this study.

The next ring represents science, itself, and the array of unique issues it brings, particularly when implemented at the elementary level. And finally, the broadest ring in the diagram represents the community context. This refers to the values and institutions that predominate, influencing the program and shaping program leaders' decisions. Although the community context is, perhaps, the most removed from an elementary science program's daily work, it clearly exerts pressures that can play a powerful role in a program's constancy and growth.

DEFINING SUSTAINABILITY AND THE PHASES OF CHANGE

To coherently understand this study's findings, the reader must first understand two important concepts: what we mean by sustainability and the ways in which science programs experience changes over time.

Defining Sustainability—Maintenance vs. Sustainability

> *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.*

Educators commonly view sustainability as program maintenance—embedding a program, as designed, into a standing operating system. By this definition, anything short of a replica is not sustainability.

This project found that "sustaining districtwide education reform" is a contradiction in terms, because at the same time that school districts want to maintain the innovations they put in place, they also need to continually adapt and improve them. The tension between maintenance and adaptation grew to be at the heart of this research as researchers sought the answers to two questions: (1) Was the program essentially the same one that had originally been implemented, a near or distant relative, or one that was virtually unrelated to the original? and (2) What factors had contributed to the program's endurance and adaptation(s)?

As the research progressed, it became clear that none of the programs were exact replicas of their earliest years, and the longer the time horizon, the more clearly the trends in evolution emerged. Thus, it was important to make a clear distinction between program maintenance and sustainability. A program is maintained if its basic elements are well established and commonly accepted as standard practice. Sustainability, on the other hand, stresses the importance of adapting and improving in response to the changes that inevitably occur in a school district. A program must be maintained before it can reach sustainability, but it cannot be stalled at maintenance; it must develop an ability to evolve and adapt. But adaptability alone is not enough; adaptations must be guided by the essential values and beliefs that characterize the core of the program's intent. It is the continued influence of those beliefs and values that ensures that, as programs evolve, they remain closely connected to their earlier generations.

Three Phases—Moving Toward Sustainability Over Time

The research identified three stages of program development that advance programs from maintenance to sustainability: *establishment, maturation,* and *evolution*. The lines of demarcation between phases are not exact; and programs do not always move forward smoothly. They may advance, hold, slide back, retrench, and then move ahead again. But, the longer a program's time horizon, the more clear its pattern of growth and development.

The *establishment* phase focuses on the very concrete elements of the program, making sure that they are well established, accepted, and working efficiently and predictably districtwide.

The next developmental phase is *maturation*. Here, the focus is on embedding the use of kits across the district and arriving at a point where kit use is habitual, even in the absence of the limelight that accompanies a "new" initiative.

The third phase of development is *evolution*. The hallmarks of the evolution phase are growth and improvement.

Programs never shed entirely the threats and challenges of earlier phases. Rather, leaders continue to address ongoing issues as they take on a new set of goals associated with their continuing development. Moreover, with each additional set of goals, there are important implications at all levels of a school system: the classroom, the school, and the district. To be sustained, program goals must be realized at different levels, which require multiple strategies often employed simultaneously by program leaders. Thus, at any given point in the development of a program, program leaders might direct their attention to the factors identified in this study at any of these different levels of the system. Together, the phase of development and the program leaders' level of orientation determine the factors' importance and priority.

FINDINGS

Introduction

The stories of the elementary science programs in this study are complex. Many factors have contributed to and inhibited their sustainability over time. These factors do not operate in isolation; they interact with each other, shift in importance and influence over time, and are often difficult to distinguish from one another. To discuss them, it is necessary to draw somewhat arbitrary distinctions between them, but their web-like relationships are a finding in and of itself. It explicates the range of pressures that come to bear on the sustainability of a program and the difficulty program leaders face in anticipating or controlling for them.

SECTION 1: FACTORS THAT PERTAIN TO SURROUNDING CONDITIONS

School System Culture

- *A shared culture of collaboration and respect can support the establishment, growth, and evolution of sustained programs, while a competitive culture that illuminates rivalries can inhibit them.*
- *Even when there is individual will and interest, a district culture that lacks established communication avenues can stand in the way of taking actions to support a sustained program.*
- *Tensions between centralized services and a decentralized district culture can negatively affect sustained programs.*
- *A district culture that promotes learning and outreach can benefit sustained programs.*

In this project, culture refers to the nature of the human, structural, and systemic environment in which science programs function. Specifically, the human environment refers to the number and efficiency of communication channels between individuals in the system and the extent to which individuals are encouraged or supported in their efforts to work together in a collegial manner. The structural environment refers to the organizational hierarchy and how strict or formal that hierarchy actually is. Finally, the systemic environment refers to accepted and expected practices (e.g., volunteerism, support for professional growth, and extent of support for innovation).

Though project leaders might define culture in a far less formal way, they do not underestimate its power. They work within its confines and recognize that it affects the ways their goals, strategies, and communications are interpreted. As an influential condition, culture sets a foundation for the ways and extent to which the other factors described below contribute to and inhibit the sustained program. Thus, efforts to bring a science program to fruition must be compatible with the culture or, even though well intentioned, they are likely to fail.

Culture is a backdrop that influences program leaders actions and the interactions of the factors that support and inhibit sustainability. Readers will be able to draw links between culture and some of those factors, including decision making, leadership, implementation, money, and adaptation (to name a few) with ease. Simply put, culture is pervasive and, though at times difficult to accurately describe or interpret, a key influence on the district operations surrounding the establishment, growth, and evolution of the hands-on programs in this study.

Decision Making and Power

- *Program leaders have little formal decision-making power or authority over the elements of their science programs.*
- *Decisions are made at many levels in a district by many different stakeholders. Any single decision can advance or inhibit the status of the science program.*
- *Leaders of sustained programs must find ways to navigate the decision-making structures in their districts and gain access to those who have the power to influence the status of their programs.*
- *The support of the central office is critical to the well-being of the science programs.*

Leaders have relatively little control over the many pressures and issues that can and do influence the growth and development of districtwide hands-on science programs. In fact, there is a wide range of decision makers in a district, each with his or her own allotment of formal and informal power, who can advance or inhibit a science program's growth and development at any point in time. Given this relative lack of control, leaders of sustained programs must understand their district's power structure and be adept at negotiating it in order to exercise what influence they can over the decisions that will affect their programs.

Each of the districts in this study has its own style and process for making policy and program decisions, some more explicit than others. These different styles and allocations of power form the landscape within which science program leaders try to advance their programs. Also important in the program leader's landscape are the many different levels, district, school, and classroom, at which decisions are made about whether and how the science program will be implemented. Clearly, gaining access to those with power and decision-making authority is key.

Science For All

- *A centralized (or districtwide) program is considered an equalizer for schools and students, who may otherwise experience inequitable distributions of resources and variable classroom experiences.*
- *In the absence of accountability, equity suffers.*
- *Given the equalizing nature of a districtwide science program, when equity is expressed as a goal and value of the district, that goal isn't necessarily translated to support for the science program.*

"Science for All" often refers to the need to narrow the access and opportunity gaps between differing constituencies, such as those defined by gender, SES, or race/ethnicity. In this study, the issue of equity emerged as a factor in three main areas: access to science instruction, equitable implementation of the program, and the value of the science program for specific populations.

Teachers and administrators recognized the science program as an equalizer with regard to materials and curriculum, due in part to schools' widely varying levels of economic support and inconsistencies in curriculum in other subject areas. Moreover, all of the districts in the study have systems that ensure all schools have access to the science program; in fact, this is one of the features that defines the programs as districtwide. Yet, despite leaders' best efforts, the data show that program use within each district has been highly variable. The study found no evidence in any site of a districtwide system in place to assess whether or not teachers are actually teaching science, and there are no districtwide consequences for teachers who fail to do so. The end result, then, is that instruction is left to the discretion of the teacher, resulting in inconsistent and, by definition, inequitable instruction. Though many recognized the districtwide science program's potential, not only to provide science instruction to all students but also to contribute to making progress toward improved equity across the district, the interest in supporting this potential was never clearly articulated either verbally or in writing in any of the data collected.

Section 2: Factors that Pertain to Science Program Components

Accountability

- *There is limited accountability for student learning or for the delivery of the program. This can either contribute to or inhibit the sustainability of the science program depending on the district context.*
- *In the presence of high visibility and high stakes tests, science is often overshadowed and, therefore, time and resources devoted to its accountability are diminished.*
- *When an accountability strategy for student learning or program delivery does exist, resulting data are of little use to program leaders if they have no power or authority to make and follow through on decisions based on that data.*

Two types of accountability have played a role in the sustainability of the hands-on science programs in this study: accountability for student learning and accountability for principals' and teachers' program delivery. Accountability measures for student learning include student written and performance tests, student work, and writing in student science notebooks. Accountability measures for program delivery, on the other hand, include requirements for principal observations of science instruction, tracking of kit usage, and analysis of school improvement plans. Generally speaking, some districts have district or state tests in place that provide the only mechanism for accountability for student learning. Mechanisms supporting program delivery, however, are universally weak. The presence and absence of these mechanisms, depending on the site and its context, sometimes support the sustained program and sometimes hinder it, but always cause high levels of concern and anxiety.

In the face of demands for information on student learning, sustained programs can be vulnerable. At the same time, however, most of the programs in the study thrived for many years with no such data. This suggests that, in the absence of specific accountability measures, program leaders and others make decisions based on limited and informal data sources combined with their own observations and perceptions about the status of the program. Thus, a program can appear to be sustained—embedded in the system and accepted as standard practice—but not actually taught.

Implementation

- *Leaders of sustained programs have used a range of approaches to implementation with no single approach demonstrating more success than another.*
- *Central office support is a necessity for laying the groundwork and establishing the elements of a sustained program.*
- *Leaders of sustained programs choose implementation strategies that account for the culture of the district, district priorities, and the relative importance of the different elements of the program at a given time.*

Implementation refers to the strategies program leaders use to initiate hands-on science programs and the methods they use to bring their science programs to be accepted as districtwide practice. Though all of the district leaders in the study have shared a similar challenge—establishing a program that includes resources, curriculum, professional development, and instructional materials—their overall approaches to implementing their programs have been highly variable. It is worth noting that although each leader could have chosen to pursue any kind of science program, each chose to focus on hands-on science instruction. Whether their belief in the hands-on approach has come from exposure via a mentor or colleague, personal experience with hands-on instruction, or their own science background, all have been deeply committed to bringing the hands-on experience to their communities. Programs also were influenced to some extent by the national political climate of the 1960s and 1970s that followed Sputnik and was concurrent with NSF's emphasis on developing science curricula and increasing the number of people pursuing careers as scientists. Given the range of strategies that has worked for the districts in this study, one can conclude that no single approach to implementation necessarily leads to a sustained program.

Instructional Materials

- *The curricula of sustained programs typically are composed of a combination of materials—ranging from homemade lessons to commercial units—and often have supplemental components which, in some cases, include textbooks.*
- *Instructional materials in sustained programs evolve and are adapted over time.*
- *A district materials management center provides symbolic and practical evidence that a hands-on science program has been sustained.*
- *Instructional materials for hands-on elementary science programs require processes and systems for development and selection; management, distribution, and storage; and acquisition and refurbishment that consume a great deal of human and financial resources.*

Instructional materials are an essential component of any science education program. All of the science programs in this study were primarily kit-based, meaning they were based on boxes that included a teacher's guide and the necessary manipulatives for teaching the lessons outlined in that guide. From the very start, program leaders in every site had a shared challenge—what materials to use; how to get those materials to the teachers; and subsequently, how to retrieve them and prepare them for the next teacher. While sharing similar concerns, they each devised a sensible, customized strategy given the financial resources, climates, and cultures of their districts.

Not only are materials centers necessary, practical supports for the science programs, but they also make an important symbolic contribution to the programs' sustainability. In some districts, the centers are viewed as a point of pride and perceived, to some extent, as evidence that the district is giving attention and support to elementary science instruction. Thus, eliminating the materials center would be tantamount to cutting the program. As a result, one can speculate that other areas of the program that are equally important but less visible and concrete (e.g., professional development) are targets instead.

Leadership

- *The requirements of a sustained program's leadership vary at different stages of the program and with shifting district conditions.*
- *The style of leadership needs to coincide with the culture of the community and the needs of the program.*
- *Attempts to develop the engagement of school-level leaders have largely been unsuccessful.*
- *Superintendents have three tools they can choose to exercise or not: authority, political influence, and budgetary influence.*
- *Program leaders and their leadership teams are ambivalent about the more supervisory and coaching roles they might play.*

Leadership in sustained programs is wide ranging and evident at all levels of the system. It extends from formally identified leaders to informal or "behind the scenes" leaders. Leaders of the programs in this study have had widely varied strengths and weaknesses, but their ultimate success has been dependent on their abilities to be flexible, respond to shifting district conditions, and interact appropriately with the local culture. Their experiences have offered insights into how leaders at all levels in a district can contribute to sustained programs.

Program leaders all have been intelligent and passionate about their work, with the management skills to enable them to realize their visions, albeit with different styles and approaches. Different leadership skills are required for the various stages of program development—establishment, maturation, and evolution—and although, generally speaking, the tasks remain consistent from place to place, each district's culture and operating systems require different strategies to accomplish them.

Another key leadership influence rests with the superintendent, who can exercise power over the budget, accountability measures, and political relationships. In addition to reaching out to the central office, program leaders also have built "mid-level" leadership structures to increase the capacity of their programs. Moreover, they recognize the importance of engaging principals and school-level leaders in the science program to provide instructional support to teachers and/or leadership support for the program leader.

Money

- *Supporting a science program with district funds requires vigilance and creativity on the part of program leaders, and commitment from the district's administration.*
- *External funds can boost a program while, at the same time, accentuating existing or establishing new potential inhibitors to that program's sustainability.*
- *Uses of external funds often reflect the interests of the funder and, thus, can influence the shape of the program.*
- *District funds and external sources of support each are associated with particular advantages and challenges that need to be accounted for within the context of the district's culture.*

Many equate program sustainability with a district financial commitment. While there is no question that money is a critical player in a sustained program, its role is far more complex than the simple presence or absence of financial resources. The source of the money, the amount needed, the way it is used at different points in the developing life of the program, and finally, the nature of district culture and interactions with regard to money all are significant issues.

Funding for each of the science programs in this study has been a complex amalgam of resources, including Eisenhower funds, donations from partners, money earmarked for textbooks, external grants, and general district fund line items. Identifying and tracking the varying sources of funds was a challenge, even for some of the program leaders, indicating that the business of securing funds for a program, even when restricted to within-district resources, is a complex job that requires attention and creativity.

There are advantages and obstacles associated with a reliance on internal funds alone as well as with the acquisition of external grants. Regardless of the developmental phase in which a large grant is secured, the influx of money can enable districts to accomplish large tasks in a relatively short amount of time. In addition to the financial benefits of grants, external funds also bring additional independence, stature, and influence to the program leaders. Even as the grants bring opportunities to the programs, the program leaders have to address some challenges associated with the changing ebb and flow of funds. In accessing external funds, leaders have to accommodate funders' guidelines, which may or may not be consistent with their program's needs. Large grants also create the dynamic of "haves" and "have nots" within a district, and the end of those resources can be perceived as being a loss for the program.

Districts in this study that avoided the problems of seeking and receiving external funds have taken pride in their self reliance. Although funds have certainly fluctuated in all of these places, the science programs are accepted practice and, thus, receive consistent support. What leaders gain in avoiding the pitfalls of external funding, however, they lose in the ability to make large-scale impacts on their programs in short periods of time.

These sites suggest that there is no single way or best way to fund a hands-on science program that will ensure its sustainability. Rather, it is the leaders' abilities to understand and address the complex nature of securing financial support that is key.

Partnerships

- *Typical partnerships are somewhat superficial and supplemental but still serve to enrich the science program.*
- *Deep partnerships are rare, require investments of resources and political currency, and can have both positive and negative impacts on the sustained science program.*

Districts in this study have had partnerships that fall into two broad categories. Most common have been the "limited" partnerships forged between a local business or organization and a single school or district area. The other category of partnerships encompasses those that have been deep and comprehensive. Such partnerships are rare, occurring mostly at the district level and requiring investments of resources and political currency, as well as shared planning and leadership. As with many of the other factors found to be significant to sustainability, partnerships are a component that can have positive and negative effects, depending on the context and conditions in a district.

Professional Development

- *The roles of specific approaches to professional development in sustained programs vary, depending on where the programs are in their evolution.*
- *Professional development needs perceived by program leaders are not necessarily congruent with the needs perceived by teachers, nor are they necessarily the activities that will support the sustainability of the program most effectively.*
- *Professional development contributes to sustained programs independent of its impact on classroom practice.*
- *Teachers trained to provide professional development support at either the school or district level often represent unrealized potential.*

Professional development in the context of hands-on elementary science programs refers to activities focused on increasing teacher, principal, and administrator capacity to understand and implement hands-on, inquiry-based science in classrooms or schools, grasp the scientific content of particular units or lessons, and manage materials and student interactions with those materials. Such activities might include mandatory or voluntary trainings on kit use, summer academies focusing on inquiry teaching methods and/or science content, study groups entailing individual exploration of science questions or student learning, and follow-up debriefings on kit use in the classroom. In the absence of clear data on the impact of specific professional development activities on classroom practice or student outcomes, this study explored several other avenues for understanding the role of professional development in sustained hands-on elementary science education programs.

The role that professional development plays in sustainability is somewhat unexpected due, in large part, to the fact that its intended impact on actual classroom practice is unknown. Still, it appears to have an unintended but no less significant relationship to the sustainability of the programs in this study. This is primarily due to its ability to foster deeper understandings of and commitment to the programs' underlying purpose. This was particularly true for teachers who had anticipated in "higher-level" professional development because they immensely appreciated the messages of respect and professionalism that were implied through their participation in those events.

SECTION 3: FACTORS THAT PERTAIN TO THE WHOLE SCIENCE PROGRAM

Adaptation

- *No district is static. Thus, science programs must adapt if they are to endure.*
- *Sustained programs are altered in a wide variety of ways for a variety of reasons.*
- *Adaptations can be proactive or reactive.*

The definition of sustainability presented in this study suggests that sustained programs use their core beliefs and values to guide adaptations to change. The earlier discussion of what sustainability is and the phases that programs move through asserts that programs must move beyond establishment and maturation of a particular design to a state of evolution in which elements of the program can vary greatly from the program as originally conceived. It is in this movement—from maturation to evolution and beyond—that programs demonstrate the flexibility and resilience essential to their survival in the ever-changing and, sometimes, volatile district environment. Indeed, every program in this study underwent adaptation.

Some of the most visible adaptations are evident in changes to the instructional materials themselves and in their distribution systems. Other less obvious but still concrete adaptations to curricula focus on the instructional sequence. Another common area of program adaptation is the design and focus of program professional development support, which occurs for a range of reasons (including changing district priorities, leaders' changing views of high-quality professional development, and most often, the arrival of external funds). This illustrates the point that adaptations can be proactive or reactive.

Less tangible adaptations also guided the evolution of the sustained programs in this study. Program leaders make adaptations to the program goals, expected outcomes, and their own personal understandings about the extent to which the programs could and should purely reflect inquiry-based instruction. Adaptation in program goals and intent are sometimes subtle and evident only in retrospect, even to the leaders themselves. They sometimes emerged only when looking at a collection of program elements over the long-term time horizon of those places that had operated for 20 years or more. Leaders of younger programs can benefit from the recognition that program goals naturally will evolve and adapt to shifting district conditions and contexts, turnover of leaders, and trends in funding sources. However, recognizing that the core beliefs and values do not waver throughout all of the adaptations is key.

Critical Mass

- *Considering critical mass through the long-term time horizon of sustained programs sheds light on alternative views of what critical mass is and how to achieve it.*
- *In the relative short term, attention to critical mass is highlighted by the challenge of reaching sufficient numbers of teachers.*
- *In the relative long term, attention to critical mass is expanded to include the challenge of obtaining widespread and deep commitment to the core values of the program.*

Discussions of critical mass in reform programs often focus on numbers: numbers of teachers participating, numbers of students reached, and the resource-to-teacher ratio. This is consistent with a view that one prerequisite for a sustained hands-on science program is that a minimum number of teachers teach hands-on science, thus making it, in practice, the standard for the district. The definition of sustainability generated by this study expands this view to suggest that a program reaches critical mass only when there is a culture of program self-generation. Thus, "critical mass" can encompass other considerations more complex than the simple act of targeting a "magic number" of teachers to implement the program. The data of this study suggest that it also is meaningful to consider critical mass as numbers of teachers and principals who understand and believe in the program's core beliefs and values.

This is not to suggest that breadth of training is irrelevant to sustainability when compared with depth of belief in a program's core values and beliefs. Rather, these two aspects of critical mass are intertwined, with one requiring more emphasis than the other, depending on where the program is in development. Clearly, breadth contributes to the culture of program self-generation in an ongoing fashion, particularly in the relatively short-term time horizon. However, when programs have experienced shocks, depth of understanding has played an important part in their sustainability.

Perception

- *The perception of a science program can differ greatly from the actual status of that program in a district. "Misperceptions" can both contribute to or inhibit the sustainability of a program.*
- *In the absence of firsthand knowledge of the status of the program, program leaders and other decision makers take action based on their perceptions.*
- *There is a disconnect in perceptions of the status and importance of the program held by stakeholders at different levels. This confounds efforts to accurately diagnose and address needs.*

Perceptions—whether held by program leaders, program participants, or outsiders to the district—have the potential to significantly support and/or inhibit sustained programs. In some cases, perceptions of the programs differ greatly from the apparent actual status of the program. This is significant because, in the absence of enforced accountability measures, perception becomes a key driver of decision making for program adaptation and implementation. For example, the program leader may perceive that the program is at a particular level of implementation when, in fact, it is not. Or, the superintendent and other district administrators may perceive the program as strong and exemplary, fostering a kind of complacency. While this impression is positive, it also opens the door for potential neglect in allocations of future district dollars and attention.

Given the lack of authentic data on the status of a program, perceptions of it are often all that decision makers have to guide their actions. The fact that there are disconnects and misperceptions at every turn make the challenging job of growing a districtwide science program even more difficult. It also suggests that perception has been sufficient to sustain these nine programs up until now. In an environment of increased scrutiny, however, it is impossible to say whether perception alone will continue to be adequate.

Philosophy

- *In sustained programs, there is a widespread, shared philosophy that science should be taught using a hands-on approach.*
- *Science programs become vulnerable in the presence of inconsistent philosophies about the importance of teaching science.*
- *The growth of the hands-on philosophy is supported when there are pre-existing or newly emerging complementary approaches elsewhere in the district.*

This study demonstrates that philosophy, a set of beliefs about the role of and appropriate pedagogy for science in elementary education, as it was expressed by teachers, principals, and administrators in the sustained programs, falls into two categories: (1) beliefs about the importance of teaching science, and (2) beliefs about how science should be taught. These two philosophical strands evolve, sometimes together, sometimes independently. In sustained programs, the second strand, relating to how science should be taught, is consistently strong—educators in these districts articulate beliefs that the hands-on approach to science instruction is the best way to teach science. However, the first strand, representing belief in the importance of teaching science at the elementary level, fluctuates depending on the changing district conditions. Thus, even though the programs demonstrate widespread common beliefs about science instruction, they remain vulnerable when lacking support for making science a core part of the elementary student instructional experience.

Although the two strands of philosophy are related, they are not mutually dependent. It was not uncommon to find districts where the commitment to teaching science had varied greatly over time, while the belief in teaching science with kits remained strong. In the face of a focus on other subjects, the science programs in this study sometimes adapted, adjusted, held their ground, or even retreated somewhat, while still holding fast to this second strand, the importance of teaching science using a hands-on approach. The belief in the importance of teaching science must be extremely strong to withstand the pressures that come from accountability for other issues. Generally, that belief has been strong enough to sustain programs through challenges, but not necessarily strong enough to give the sustained programs a sense of security. Only when both strands are strong does program vulnerability fade.

Quality

- *There are no effective mechanisms in place for assessing the quality of science instruction and/or the impact of professional development.*
- *In the absence of accountability measures, actual student learning of science concepts and processes becomes irrelevant to a program's sustainability.*
- *In the presence of accountability measures, program quality is defined by evidence of student performance on those accountability measures. Thus, the degree of alignment between the program and the district's accountability system becomes the primary indicator of program quality.*

This study defines the quality of a program as the extent to which its instruction and curriculum facilitate positive attitudes toward and student learning of the elements of the scientific process and the basic concepts of the earth, physical, and life sciences. If the quality of curricula and instruction is to have an impact on a program's sustainability, there must be mechanisms in place that allow program leaders and others to gain and maintain an understanding of their status. What is most striking, is that none of the districts in this study have any such systems in place. It is impossible for any of the program leaders to have a sound understanding of the quality of instruction or the impact of professional development on classroom instruction.

Over the course of their programs' history, several leaders have made attempts to understand the status of their programs, and their findings corroborated the findings of this study: Implementation of kits within each district is uneven, and, when teachers do use kits, their practice is highly variable. Leaders are also ill equipped to assess the impact of the professional development they provide.

These findings imply that the quality of instruction and professional development is irrelevant to a program's sustainability. Until the recent past, central office administrators and the general public placed relatively little emphasis on assessing programs' quality, as long as the program was seen to function smoothly with no complaints. Since the importance of student achievement on standardized tests has taken hold, the definition of quality has come to mean student scores on science tests. In this environment, the possibility of bypassing hands-on curriculum in favor of textbooks becomes more attractive to teachers and principals. The implications for future sustainability are worrisome.

CONCLUSION

Throughout this research, program leaders expressed the hope that a consistent pattern would emerge from the data collected across these nine programs and offer a formula for sustainability that would guide their efforts. They dearly wanted more knowledge about how to maintain their programs, strategically concentrate their efforts, and build capacity for continuous growth and improvement. However, as evident in the preceding discussion of the findings, no such formula emerged. Rather, this study identified a set of factors that affect the sustainability of hands-on science programs in fluid and interrelated ways. The roles these factors play in reform efforts are greatly varied and change over time and from place to place as they reflect the complex district environments around them. Within this complexity, while there is no formula for sustainability, the factors presented here illustrate trends that offer new insights into sustainability for program leaders, district administrators, and funders as they invest in new and ongoing reform efforts.

The Factors

The factors that support and/or inhibit sustainability of districtwide hands on science programs fall into three categories: those that pertain to conditions surrounding the district and its program, those that pertain to individual components of the science program, and those that pertain to the program as a whole. See Table 1.

Table 1

Factors that Pertain to Surrounding Conditions	Factors that Pertain to Science Program Components	Factors that Pertain to the Science Program as a Whole
Culture	Accountability	Adaptation
Decision Making and Power	Implementation	Critical Mass
Science for All	Instructional Materials	Perception
	Leadership	Philosophy
	Money	Quality
	Partnerships	
	Professional Development	

Implications

These findings offer many implications for program leaders, district administrators, and funders with regard to their investments in their science programs. Some are described below:

- *Leaders and supporters of districtwide programs can gain from giving attention to the wide range of factors that affect sustainability and account for them in all strategic and financial decisions.*

The leaders of the sustained programs in this study emphasized the factors related to program elements throughout the lives of their programs—even as they moved out of the establishment phase and into maturation and evolution. Thus, their investments in and accounting for the other factors have been a fortunate by-product. This study serves current and future program leaders by making the factors that pertain to surrounding conditions and the whole program more explicit, allowing leaders to be more purposeful about how, and in what ways they allocate their resources.

Thus, this study offers readers an illustration of the importance of attending to factors that are not often addressed or even recognized as important to sustainability of a program. It highlights the concrete ways that the programs in this study have done so, albeit most often unintentionally, and offers a starting point for systematically assessing the importance of each, given the particular time and circumstance, and developing strategies to accommodate them.

- *Leaders and supporters of districtwide programs can benefit from defining and considering sustainability through the lens of a long-term time horizon.*

The RSR project's definition of sustainability, discussed in detail earlier in this report, while acknowledging the factors that pertain to program elements, highlights the important contributions of the factors that pertain to surrounding conditions and the program as a whole. In particular, it refers to the significance of core beliefs and values (philosophy) and adaptation, and acknowledges the importance of culture and decision making and power as sources of change and pressure:

> *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.*

This definition of sustainability stresses a shift in understanding from sustainability as program maintenance, in which the elements of the program are preserved over time, to one of adaptation, in which the program elements evolve and adjust. Thus, a look at reform through the lens of this definition of sustainability suggests that it is appropriate to reconsider expectations for the outcomes of program investments. Educators need to recognize that change can be subtle and it can be latent. And simply because there is no evidence of a "revolution" does not mean that there isn't important evolution. Educators are well-served to reserve judgment about the failure or success of reform until considering all of the ways it may have affected educational practice and interpreting evidence of those changes in light of a long-term definition of sustainability.

- *Leaders and supporters of districtwide programs must increase attention to the quality of their programs with explicit, focused strategies.*

Hand in hand with discussions about how to sustain programs, educators also should engage in a careful and critical look at what is being sustained. The programs in this study were unevenly implemented and, as such, did not represent the districts' articulated goals for their districtwide programs. Even programs at the height of their renown were not as thoroughly implemented as their reputations would have suggested.

The issue of program quality is of obvious critical importance to all stakeholders but faces obstacles that prevent leaders from both assessing its value as well as improving it over time. These obstacles principally grow out of the lack of leaders' authority, limited access to classrooms, and lack of capacity to collect data and make use of it.

Evidence is essential and beyond the reach of program leaders: Sustaining a program of high quality requires evidence of its impact and its status. The inability of leaders to gather such data is stunning in its absence and chilling in its implications. Lack of evidence of student outcomes, as well as evidence that is not aligned with the goals and intent of the program, leave it vulnerable to being misunderstood and undervalued. In the same vein, without knowing how students are progressing, it is impossible for leaders to know how to direct program improvement efforts.

High teacher and principal turnover locks leaders into the cycle of continuous re-establishment and limits their ability to attend to quality issues in the long-term: Districts that were characterized by a high degree of stability were far more able to advance from the establishment phase into maturation and evolution than districts where teachers and administrators came and went through a revolving door. While they, too, struggled with questions about the quality of that professional development and its impact on classroom instruction and students, they were better equipped to develop strategies for addressing quality concerns.

If educators accept the premise that professional development is linked to quality of instruction and program implementation, they must recognize the challenge of teacher turnover and account for it if sustained programs are to offer high quality instruction that promotes student learning. Regardless of the approach, district and program leaders can not avoid the need to address the threat to stability and lost investments posed by high teacher and principal turnover rates.

Implications for the Future

This study makes the evolutionary nature of reform programs, as well as the patterns of disturbances that they endure, explicit. The shocks and pressures that influence programs' sustainability, such as a change in a district's financial status, a shift in public demand for accountability, or decentralization, are standard fare and, in response, all districts experienced ebbs and flows in the strengths and capacities of their programs over time. Some programs waxed and waned dramatically, but history clearly showed that all programs, regardless of their age or apparent stability, were vulnerable to shocks and pressures, the majority of which were beyond the control of the program leaders. And yet, given society's propensity to debate the value of and need for reform efforts and even specific approaches to instruction, any expectation that a sustained program would become immune from these challenges is misguided. Sustained programs are noteworthy not because they have eliminated threats, but because they survive in the face of them.

This study finds that sustained programs withstand these potential threats with resilience that lay in strengths not easily seen. They were in places where no one had looked—meaning in the more subtle factors of adaptation, perception, philosophy, and critical mass—and were apparent only after the passing of time. Understanding sustainability from the perspective of history and these more subtle factors does not guarantee better outcomes for hands-on programs. But, it does argue that, if leaders attend explicitly to what were previously unrecognized program supports, as debates arise about the way science should be taught and the worth of hands-on programs, their value will be explicitly and thoroughly presented. Likewise, when more hospitable times return, programs will be better equipped to advance further, with greater confidence in their awareness of the gains they have made.