A Report on the Evaluation of the National Science Foundation's

Statewide Systemic Initiatives Program

National Science Foundation
Directorate for Education and Human Resources

AN REC – SPONSORED REPORT ON EVALUATION

A Report on the Evaluation of the
National Science Foundation's

Statewide Systemic Initiatives (SSI) Program

by

Andrew A. Zucker, SRI International
Patrick M. Shields, SRI International
Nancy E. Adelman, SRI International
Thomas B. Corcoran, Consortium for Policy Research in Education
Margaret E. Goertz, Consortium for Policy Research in Education

Bernice T. Anderson, Evaluation Officer
Division of Research, Evaluation and Communication
Directorate for Education and Human Resources
National Science Foundation
Arlington, VA

June 1998

Prepared under NSF Contract No. SED-9255371

AN REC – SPONSORED REPORT ON EVALUATION

Prepared by SRI International, Menlo Park, CA,
for the Division of Research, Evaluation and Communication (REC),
Education and Human Resources (EHR) Directorate,
Bernice Anderson, Evaluation Officer

June 1998

The conduct of this study and preparation of this report were sponsored by the National Science Foundation, Directorate for Education and Human Resources, Division of Research, Evaluation and Communication, under Contract No. SED-9255371.

CONTENTS

EXHIBITS

Preface

This is the culminating report in a series of more than 15 that have been produced as part of the evaluation of the National Science Foundation's Statewide Systemic Initiatives (SSI) program. The evaluation has been conducted by SRI International and its partners over a period of more than 5 years. Although SRI has had experience evaluating dozens of federal and state education programs, the SSI evaluation has posed unique challenges. We believe it is important that the reader understand several of these challenges.

First, the concept of systemic reform is relatively new and not yet well understood. Therefore, the evaluation team needed to specify the concept in some detail in order to gather, analyze, and interpret appropriate data. To a far greater degree than in most program evaluations, this task required the clear specification of a conceptual framework that would represent many, if not all, of the important features of several dozen state education systems (or at least those features that were "targets" of program activities). The model that we have used (outlined in the Introduction) is one that was designed to make sense in a wide variety of state contexts and for 25 systemic initiatives, each with a distinctive character of its own. Our reflections on the impacts of the SSI program (discussed in the last section of this report) are anchored partly by using the model to view impacts across states and across all SSI-sponsored activities. One important reason for using the model in this way is to contribute not only to an understanding of the SSI program itself but also to an understanding of the very concept of systemic reform. We will be pleased if this work adds to the knowledge base about standards-based systemic reform. At the same time, we are well aware that this is neither the last word about systemic reform nor the only useful perspective on the subject.

Second, the technical problems in conducting this evaluation were substantial. The number of variables to be measured was large, and their complexity meant that it was more often than not difficult to quantify them. The fact that observations were spread across 25 states and dozens of school districts meant that it was not feasible to use statistically valid samples to represent the universe of affected teachers and students in any given state. In fact, most of the data that were used were qualitative rather than quantitative. (Interested readers can examine a substantial amount of source data by reading the case studies produced for 12 of the SSIs and published earlier this year in three volumes.)* Even in cases where quantitative data were available—for example, data about student achievement in SSI versus non-SSI classrooms—the evaluation team relied primarily on data gathered by other investigators, who were working under constraints of their own. There is a long way to go before evaluators can expect to find uniform, valid, and reliable data being collected in comparable fashion across many districts in dozens of states.

Finally, unlike controlled experiments in the hard sciences, it is rarely possible in educational evaluations to "hold all other variables constant." In particular, over the past 5 to 10 years, many states (both states that were and were not funded by the SSI program) have supported activities that can rightfully be viewed as part of the nationwide movement to implement standards-based systemic reform. As an example, almost all states have written or revised state subject-matter standards or curriculum frameworks in an effort to better define what students should know and be able to do. These and many other important system improvements have often been funded by sources other than the SSI program. Yet, to answer key evaluation questions relating to the program, it is necessary to understand which effects can be attributed to the program's investments and which cannot. We have taken a conservative stance, trying to link program investments directly and plausibly to impacts. System improvements, such as those documented by rising fourth-grade mathematics scores in many states on the National Assessment of Educational Progress, that cannot be specifically linked to the SSI program may have been due, *in part*, to NSF's investments, but as evaluators we must be able to trace those links in a causal manner before we can make such a

* See, for example, Zucker, A. A., and Shields, P. M. (Eds.) 1998. *SSI Case Studies, Cohort 1: Connecticut, Delaware, Louisiana, and Montana.* Menlo Park, CA: SRI International.

claim. "Correlation does not prove causation" is a basic maxim in our trade. This may limit our ability to draw certain important conclusions, but it is nonetheless a vital safeguard.

Readers will judge for themselves how well we have succeeded in our efforts. It may be surprising, given the caveats listed above, but we believe there will be widespread agreement about most of our conclusions. Where there are disagreements, some of them, at least, may be understood as natural in light of the preceding challenges.

In any event, the views expressed are those of the authors and are not intended to represent the views of the National Science Foundation or its staff, to whom we are grateful for the opportunity to do this work. The design and conduct of the SSI evaluation were the responsibility of SRI International, acting as an independent third party under contract to the Foundation.

Andy Zucker and Patrick Shields
April 1998

EXECUTIVE SUMMARY

Background

In 1992, SRI International was awarded a 5-year contract for the evaluation of the National Science Foundation's (NSF's) Statewide Systemic Initiatives (SSI) program. To assess the extent to which the SSIs produced the broad-scale changes NSF envisioned and to examine the efficacy of different state strategies, SRI and its partners (the Consortium for Policy Research in Education, the Council of Chief State School Officers, Policy Studies Associates, and Woodside Research Consortium) developed a conceptual framework to guide the evaluation (see Exhibit S-1) and engaged primarily in three data collection activities. First, quantitative data about the initiatives were gathered annually from the principal investigators in each SSI. Second, the evaluation team conducted repeated site visits in every SSI (and prepared detailed case studies for 12 of the SSIs). In all 25 SSI states, members of the evaluation team interviewed key stakeholders, observed SSI activities, and conducted document reviews. The third data collection strategy was secondary analysis of data sets collected from several SSIs to provide an in-depth examination of selected topics (e.g., professional development, class-room practices, and student achievement) related to system wide changes. This report is a synthesis of the evaluation data and is meant to provide useful information to policy-makers with an interest in state and federal education programs and/or systemic reform in mathematics and science education.

Key Findings

Key findings from the SSI evaluation are reported here under three headings. These focus on the strategies used by the SSIs, the accomplishments of the SSI program, and lessons from the SSIs that can inform future efforts to improve mathematics and science education.

What strategies did the SSIs use to improve mathematics and science education?

The SSI program invited states to design approaches to systemic reform and implement strategies that fit their particular needs and contexts. The result was three clusters of SSI states, as categorized by their primary focus/approach. The clusters reflect the fact that the goals of systemic reform include both changes in student outcomes and changes in the infrastructure and supporting components of the education system (see the arrows in Exhibit S-1 that show investments moving from the oval labeled SSI Activities into the education system):

- **Focus Close to the Classroom**. For 11 states, the preponderance of SSI activities over a 5-year period were directed primarily at districts, schools, classrooms, teachers, and students.
- **Focus on the State System and Infrastructure**. For 7 other states, the SSI activities were directed primarily at changing state education policies and improving the infrastructure for sustaining educational improvement by addressing organizational issues, building various kinds of partnerships, and building regional infrastructures.
- **Balanced Focus**. The remaining 7 states focused the SSI's attention fairly evenly on both state and local reform activities.

The SSIs began their reform activities by focusing energy and resources using one of these three distinct approaches. Any one of the approaches might have been a sensible choice because the approach was determined by specific state reform contexts—the preexisting situation in a state and the nature of other reform initiatives under way when the SSI award was made.

In adopting any one of these three approaches, the SSIs employed a total of eight basic strategies to reform mathematics and science education. No strategy was used in isolation; in fact, SSIs typically used four or more implementation strategies in combination.

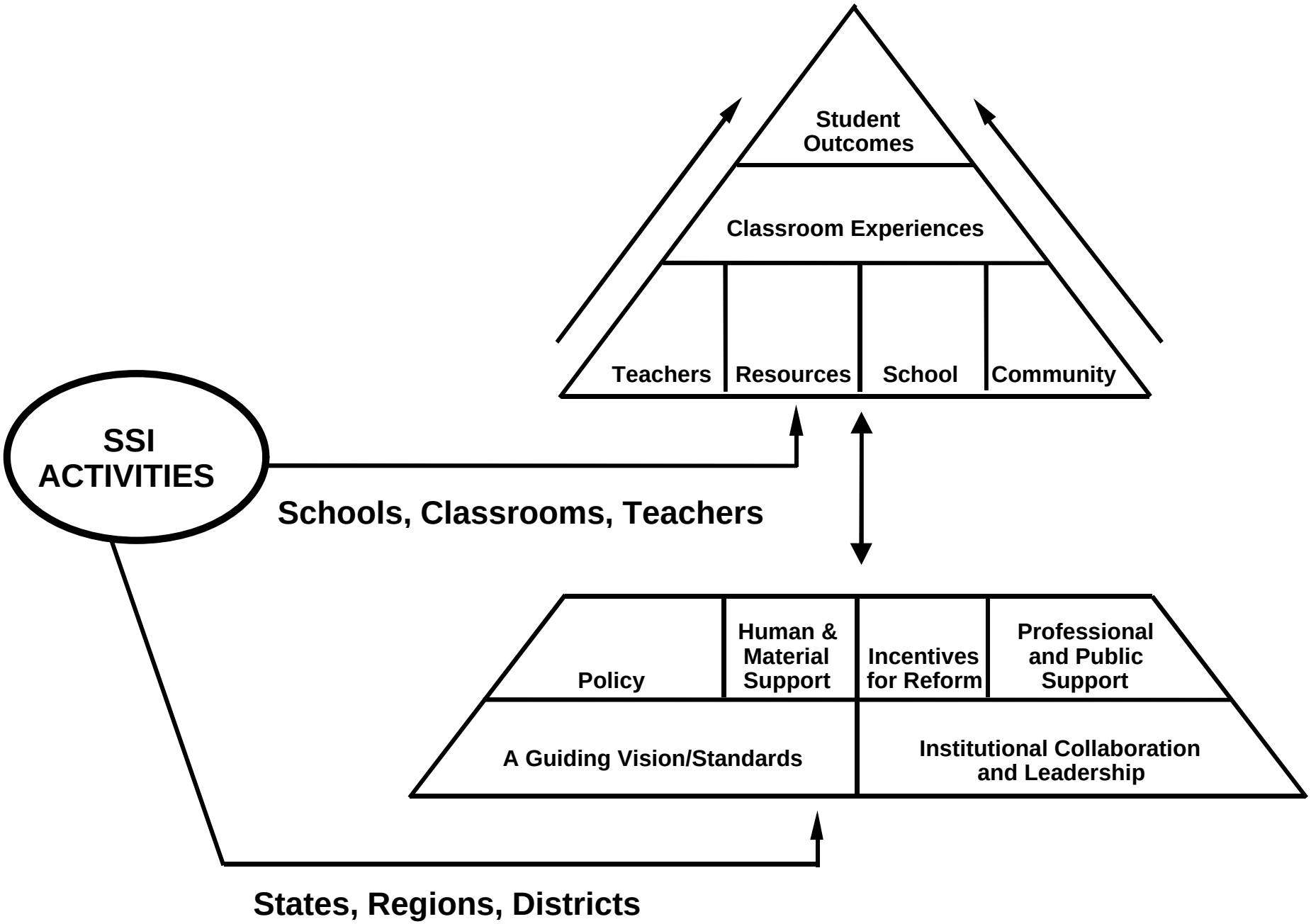


Exhibit S-1: A MODEL OF SYSTEMIC REFORM

The SSIs used three major implementation strategies for activities close to the classroom:

- Supporting teacher professional development (20 SSIs).
- Developing, disseminating, or adopting instructional materials (initially, 6 SSIs but by 1997, 13 SSIs).
- Supporting model schools (7 SSIs).

The SSIs used five implementation strategies for focusing on the state and district systems and infrastructure:

- Aligning state policy (a primary target for 3 SSIs and a secondary target for 13 other SSIs).
- Creating an infrastructure for capacity building (22 SSIs).
- Funding local systemic initiatives (9 SSIs).
- Reforming higher education and the preparation of teachers (13 SSIs).
- Mobilizing public and professional opinion (14 SSIs).

What has the SSI program accomplished?

Classroom impacts. High-quality, focused interventions by SSIs had some demonstrable, positive classroom impacts. Approximately half of those 22 SSIs completing the 5-year funding period had strong, positive impacts on classroom practice, meaning that there was credible evidence of changes in curriculum and instruction toward more inquiry-based learning, in line with state and national education standards. These changes included greater use of hands-on work (instead of just lecture and seatwork), greater attention to student inquiry as a motivating force, greater use of small-group work, changes in classroom assessment practices, and more use of certain materials, such as science kits, calculators, and computers. Generally, the SSIs with these strong impacts on classroom practices focused attention on teachers and provided them with high-quality professional development activities that were both intensive and relatively long term. Many of these SSIs also identified or provided teachers with effective instructional materials.

Instructional materials. Three SSIs produced new instructional materials of high quality. The materials produced in Montana (*SIMMS/MCTM Integrated Mathematics: A Modeling Approach with Technology*) and Nebraska (*Math Vantage*) are nationally disseminated.

Teacher professional development. As a group, the SSIs provided high-quality professional development. Generally, the professional development experiences offered by the SSIs focused on subject-matter content, were coherent and sustained, included active learning, engaged their participants, and offered some kind of incentives. The most common model of effective professional development was an intensive summer institute lasting a few weeks, with academic-year follow-up activities. In part because of the intensity of these experiences, the SSIs as a group reached at most 10% of their eligible mathematics and science teachers in any one year.

Student assessment. The SSIs contributed to assessing students' learning in science on a more routine basis. At least three SSIs (Maine, Massachusetts and Vermont) had a great influence on the alignment of the state's assessment system with its curriculum frameworks and/or national standards.

State policy. In most SSI states, the pattern has been steady forward movement toward aligned, standards-based policies for curric-ulum, instruction, and student assessment, with attention in some states to related policies such as teacher preparation, licensing, and recertification. The most common policy-related activity of the SSIs was contributing to the development of new or improved state curriculum frameworks in mathematics and/or science. Eleven SSIs invested time and money directly in the development of frameworks or content standards for K-12 mathematics and/or science. This work proved more time-consuming than expected.

Leveraging other funds. Over a period of 5 years, the SSIs were able to leverage more than $500 million in additional funds—more than twice the amount that NSF invested during the same period. In addition, in a few states (e.g., Delaware and Arkansas), the SSI resources were

central to all standards-based reform activities throughout the state.

Mobilizing stakeholders. In terms of coalition building, a significant accomplishment of the SSIs has been the strong advocacy role that nongovernmental, nonprofit institutions have played in at least four states. These institutions are likely to continue to exist after the life of the SSI award and tend to be less affected by political tides than government agencies.

Student achievement. In a careful review of seven SSIs, the four with the most credible evidence of positive impacts on student achievement were those with the interventions most intensively directed at classrooms and characterized by intensive teacher professional development as well as significant investments in instructional materials/resources. The other three SSIs invested most heavily in activities directed at the alignment of state policy or concentrated on building a state-level infra-structure to support change or building local capacity to reform instruction. Thus, these SSIs invested fewer resources in direct, intensive training of teachers, and they had difficulty producing evidence of changes in student achievement that could be attributed directly to the SSI activities.

The leadership pool. There is now a broader, deeper leadership pool in the SSI states than there was before the program began. This is an important legacy of the program since good strategic thinkers are scarce and yet their efforts are vital.

Understanding "what works." Related to the growth of a leadership cadre is the growing knowledge base about "what works" in systemic reform, such as:

- Setting clear and ambitious education standards does, in fact, seem to be an important step in improving education (as the theory of systemic reform suggested it would be).
- Local control need not be a barrier to systemic reform. However, local-control states require different approaches than others.
- Changing whole schools took significant time and resources targeted on a small subset of the system. The results were limited unless the model-school strategy was combined with well-developed strategies to ensure that the lessons from model sites could be used in additional schools .
- Mathematics and science content knowledge is a necessary part of the systemic reform of mathematics and science education. The success of state and federal efforts to improve student achievement in mathematics and science depends on the capacity of individual teachers themselves to thoroughly understand what they must teach students.
- Capacity building is a key to having world-class mathematics and science education, and nearly all SSIs used some of their resources to improve their capacity-building infrastructure. Building infrastructure took different forms in different states: for example, teacher networks, new regional assistance centers, a technology infrastructure, or improved procedures for selecting instructional materials.
- Going to scale with standards-based reform requires states, districts, and schools to work together and takes more than 5 years.

What lessons learned from the SSI program can inform future state and federal efforts to improve education?

In reviewing the experiences of the SSIs and the federal efforts to support their work, a number of lessons have become clear.

No "one best way." There is no "one best way" to reform state education systems. Systemic reform requires movement on many fronts. Nearly all the SSIs crafted a reform plan that targeted multiple components, either simultaneously or over the course of the 5-year period. SSIs typically used four or more of the eight strategies listed above and targeted multiple points in the system (as shown in Exhibit S-1).

Reform has to work in its specific context. The coordination of multiple reform efforts is important. Successful SSIs took advantage of other promising reform efforts that were under way in their states. Conversely, some SSIs that

did not fare well seemed to work at cross-purposes, or in a disjointed way, with other initiatives in the state.

Quality control is essential. Without strong quality control mechanisms, leaders of statewide reform initiatives cannot be sure what will be implemented at the local level. Successful SSIs did a good job of maintaining quality during implementation.

Fundamental change takes time. Changing state education policies involves many political and technical challenges. The primary issue that emerged from states' efforts to align policies as part of their SSI activities was the time that was needed. The pace of the alignment process was often slow for reasons that ranged from the brevity or infrequency of legislative sessions in some states to the need to move ahead cautiously when a backlash of public opinion threatened standards-based reforms. Many SSIs used a collaborative, consensus-building process involving key stakeholders throughout the state to develop support for standards-based education—a time-consuming but worthwhile strategy.

Beyond volunteer teachers. Only a few SSIs attempted to change or restructure the professional development system itself to ensure that all teachers were reached with high-quality professional development. Instead, the SSIs tended to rely on volunteer teachers by enabling them to participate in sustained and coherent professional development experiences. Additionally, the states faced difficult trade-offs of working with a small number of teachers intensively or large numbers of teachers superficially. Simply finding the resources for ongoing, high-quality professional development for all the teachers who need it is a great challenge (especially in high-population states). In response, many states are building or improving different kinds of infrastructures to sustain long-term change, such as teacher networks, regional centers, and technological delivery systems. The future challenge is to explore models that include all teachers in high-quality learning experiences as part of normal operating procedures.

The struggle to engage the public. The SSI program increased the awareness of educators in many states about the importance of mobilizing public support for improving education. Many agencies and groups (ranging from state legislatures to television stations and newspapers to businesses and universities) have made significant contributions of time and other resources to support SSI-related activities. However, few of the SSIs were able to mobilize the higher education community responsible for preservice education, in part because changing teacher preparation programs is such a large and complex undertaking. Additionally, most SSIs, including some that did an excellent job with teachers, simply did not devote much attention to parents or the community at large. To change local conditions in support of high-quality mathematics and science education, community and parental support is important. Many SSIs deemphasized their public support campaigns over their 5 years. Overall, building public and professional support was one of the weaker areas for the SSI states.

The challenge of "closing the gap." NSF and the SSIs were concerned about closing the gap between groups of students usually underrepresented in mathematics and science and their peers. The most frequent strategy used by the SSIs to help close the gap was to emphasize that high standards are for all students. Another common practice was to target the SSI's funds and activities particularly in districts or schools serving many students with special needs. However, assessing the extent to which an SSI achieved the goal of closing the gap was challenging, and the capacity to do so varied greatly from one SSI to another. State tests were often unavailable or inappropriate in one way or another, and although new assessment instruments were being designed, they were typically not available at the outset to set a baseline. In three cases (Louisiana, Ohio, and Maine), SSIs were able to document modest impacts in closing achievement gaps between students traditionally underserved (such as minority and dis-advantaged students or girls) and their peers.

Tracking progress. Documenting changes in education systems is an important part of the effort to make improvements. A number of the SSI states learned a good deal about the need for improving existing data sources in order to answer many important evaluative questions.

Federal program innovations. Several program innovations contributed to the success of the SSIs. First, through cooperative agreements (rather than grants, the typical NSF award vehicle), NSF played an active role in monitoring the SSIs on a regular basis and making decisions about the course of each SSI. Second, accompanying NSF's greater-than-usual involvement in the SSI awards was a set of activities (e.g., a technical assistance contract and an evaluation contract) designed to provide these unique and challenging initiatives with special support. NSF was also insistent that the SSI states provide data to document their progress (or lack of it). NSF's insistence on making the states accountable led to a more active NSF management role and termination of four SSIs before their 5-year term was completed. At the same time, the cooperative-agreement mechanism placed significant time burdens on both federal agency staff and staff of the SSIs and the SSIs were not always supportive of the way that NSF focused on accountability.

Conclusions

The SSI program has been a valuable testbed for the concept of standards-based, systemic reform. As the theory of systemic reform suggested, each of the SSIs did, in fact, support a series of coordinated efforts affecting a number of different components of the education system. The most successful SSIs had very ambitious, comprehensive plans for systemic reform and were able to carry out those plans effectively, with significant impact. The least successful SSIs had designs that were narrowly focused and/or experienced imple-mentation, quality control, or management problems.

The impacts of individual SSIs were positive but were limited because no SSI was able to "go to scale" and intensively affect all teachers statewide. Also, the SSIs' impacts were almost always uneven, affecting some districts, schools, teachers, or students involved in an SSI much more than others.

The impacts of the program on different components of the education system (as represented in Exhibit S-1) varied. For example, taken as a group, the SSIs did an impressive job of bringing together key leaders and institutions in their states to support reform. Likewise, the professional development that the SSIs provided to teachers was generally of high quality. On the other hand, few SSIs focused on changing the organization and culture of schools or devoted substantial attention to parents or the community at large. Extra help may be needed to change certain components of education systems (such as improving preservice teacher preparation).

A weak point of the theory of systemic reform is the issue of scale. How to "scale up" so that substantial improvements in mathematics and science education are evident in tens and hundreds of thousands of classrooms across the United States is a difficult issue. The SSIs made headway but were not able to solve this problem.

Overall, the SSI program moved classroom practices in directions that are generally considered to be an improvement over past practices. After 5 years, evidence shows that the SSI program has, in fact, left behind a legacy of new or improved curriculum frameworks, changes in a variety of state policies, new institutions and partnering arrangements, and an increased number of competent state and local leaders of reform. Additionally, evidence from selected states showed that some SSIs had a modest, positive impact in changing what happens in mathematics and science classrooms, including producing increases in students' achievement. These outcomes were the results of the strategic choices of the SSIs: they focused on what was familiar, what they understood would be effective, what would have a payoff in the medium term, and what would be politically acceptable. Overall, the SSI program has provided substantial contributions to standards-based, systemic reform in K-12 mathematics and science education.

I. Introduction

Many American policy-makers, business leaders, scholars, and educators believe that the achievement of K-12 students in mathematics and science in the United States must be raised to improve the nation's economic competitiveness. Although the results of the Third International Mathematics and Science Study (TIMSS) showed U.S. 4th-graders performing well against their international peers, the 8th-grade and 12th-grade results were sobering. Moreover, most school reformers and many policy-makers also believe that the persisting gaps between the achievements of Asian-Americans and white males and those of other minorities and women in mathematics and science must be eliminated, because they result in differential access to educational and economic opportunities and thereby contribute to inequitable social outcomes and slower economic growth. The widening wage gap between college-educated and other workers is also a concern. However, it is widely agreed that eliminating or significantly reducing these international and domestic performance and wage gaps requires deep and broad-scale reforms in educational policy and practice in the nation's school systems.

One of the most significant responses so far to this serious national problem has come from the National Science Foundation (NSF), which has challenged states and school districts to undertake ambitious systemwide reforms in science, mathematics, and technology education. For three successive years, beginning in 1991, NSF negotiated 5-year cooperative agreements with competitively selected states to undertake such initiatives. In all, 25 states and the Commonwealth of Puerto Rico were provided with up to $10 million by NSF for the support of their Statewide Systemic Initiatives (SSIs).[1]

To assess the extent to which the SSIs produced the broad-scale changes NSF envisioned, and to examine the efficacy of different state strategies, the Foundation contracted with SRI International and its partners, the Consortium for Policy Research in Education, the Council of Chief State School Officers, Policy Studies Associates, and Woodside Research Consortium, to conduct a national evaluation of the program. This report examines how the SSIs have approached NSF's ambitious objectives of improving instruction in *all* classrooms and providing *all* children with high-quality instruction in mathematics and science.

This document is the summary evaluation report produced as part of a 5-year evaluation of the NSF's Statewide Systemic Initiatives Program. Other reports produced by the evaluation team focus on how the SSIs have supported professional development for teachers (the largest single expenditure of funds under the program), the impacts of the SSIs in mathematics and science classrooms, the SSIs' impacts on student achievement, a series of detailed case studies documenting activities in 12 of the SSIs, and other topics.

The focus of this report is on the SSI program as a federal strategy to improve mathematics and science education in selected states. Three primary questions are addressed:

- What strategies did the SSIs use to improve mathematics and science education?
- What has the SSI program accomplished?
- What lessons learned from the SSI program can inform future state and federal efforts to improve education?

This report is designed to synthesize information from the other evaluation reports in a way that will be particularly useful to individuals with an interest in federal education policy, including federal agency staff, members of Congress and congressional staff, and state policy-makers with an interest in federal education programs.

Following the remainder of the introduction, there are three major sections in this report, each corresponding to one of the questions above. The first focuses on what the SSIs did—the strategies they used to improve mathematics and science education. The next section discusses the program's accomplishments. Finally, the last section reflects on the SSI program as an

[1] Rhode Island's SSI was terminated at an early point. Hereafter, this report refers to 25 SSIs.

innovative federal strategy for improving education and, on the basis of the program's accomplishments, draws some lessons for federal and state policy-makers.

NSF's Vision of Reform in Science and Mathematics Education

NSF's policy-makers had an ambitious vision of mathematics and science instruction in mind when they funded the SSIs. The vision encompassed standards, curriculum, pedagogy, and assessment, and was based on the National Council of Teachers of Mathematics (NCTM) *Curriculum and Evaluation Standards for School Mathematics* and the then-emerging national science education standards, as well as on NSF's extensive experience with curriculum development and teacher enhancement programs. The most ambitious part of the vision was that all students will master mathematics and science. Equity was a central principle for the SSI program.

In the phrase "high standards for *all* students," the term "all" has been used metaphorically by NSF and most participants in the SSIs. All parties recognize that there are some children who are so ill prepared or severely handicapped that they cannot be expected to achieve at the levels envisioned by the national standards in mathematics and science. The Foundation's officials clearly understood improvement to mean that the typical or modal performance of students in mathematics and science would reach much higher levels than at present, but this did not mean that all students would reach some nationally determined level of mastery. However, the goal was not simply to boost the average performance on tests, but to achieve performance approximating international standards of achievement. The leaders of the SSI program at NSF were adamant that the gaps in performance between males and females and between white or Asian students and other minorities would be substantially eradicated. So "all" did not literally mean every student, but was a metaphor for equitable modal performance across groups of students.

The National Science Foundation announced the SSI program in 1990. At that time, only a handful of states had adopted ambitious education standards in either mathematics or science. Few states assessed student performance in science, and most state assessments in mathematics focused on the basics.

The program was open to all states that wanted to compete for funds made available to support efforts to improve mathematics and science education through systemic reform. NSF made 10 SSI awards in 1991, 11 in 1992, and 5 in 1993. (These sets of awards are referred to as Cohorts 1, 2, and 3.) The typical award was for approximately $10 million over 5 years. By the end of 1997, most of the SSIs had reached the end of their awards. A total of only 11 SSI awards remained active at that point, consisting of all the Cohort 3 awards and 6 new awards made by NSF to extend the work of selected Cohort 1 and Cohort 2 SSIs beyond their initial 5-year efforts.

The SSI solicitation also marked a departure from NSF's previous mode of supporting improvements in mathematics and science education in the public schools. In the past, NSF had supported professional development for limited groups of teachers and the development of instructional materials. Now it sought to change instructional practices in entire state education systems. This goal required a different approach. The SSI funding not only was for a longer term (5 years) and for more money (typically $10 million per state) than previous grants, but the program also was more comprehensive in scope, had a stronger policy orientation, and required the creation of broad partnerships within the states. Additionally, by making the awards cooperative agreements rather than grants, NSF showed that it intended to play a larger leadership role than it had before. The SSIs were to be held accountable to NSF for the nature and quality of their efforts.

NSF expected all the SSIs to pursue their instructional and curricular visions not just in one subject, but in both mathematics and science. For example, NSF insisted that SSIs in Florida, Montana, and Nebraska that originally wanted to pursue only one subject should pursue both. The SSIs were also expected to include not just a few grade levels, but at least K-12 and ideally K-16. SSIs that initially focused on particular grade ranges, such as those in California, Louisiana, Montana, New Jersey, New Mexico, Ohio, and

Virginia, were pushed to address the entire K-12 system. The large scope of the task and resource limitations in the larger states made these goals impractical in the short run, but NSF expected the SSIs to mobilize other resources to continue the work beyond the 5 years of funding. Scaling up reforms in curriculum and instruction to include all K-12 classrooms in a state was always NSF's goal, and it viewed the SSIs as catalysts for state reform movements that would endure beyond the period of SSI funding.

A Conceptual Model for the Evaluation Framework

The concept of systemic reform has been outlined by Smith and O'Day (1991) and elaborated numerous times since then (see Clune, 1993; Fuhrman and Massell, 1992; Fuhrman, 1993; Vinovskis, 1996). The essence of the concept is that ambitious standards for student learning should form the basis for the alignment of all policies, practices, and resources throughout the educational system. From this perspective, improvement in the achievement of all students requires coherent policies and coordinated resources designed to realize a clear vision of what students should know and be able to do. Fundamental to the concept is that ambitious goals apply to all students, not just those destined for professional careers (O'Day and Smith, 1993).

Systemic reform, as it was formulated at the inception of the SSI program by NSF and others, was not a fully specified theory of change. Rather, it represented an amalgam of much of the best thinking about improving schooling. In particular, it brought together the cognitive science research on effective learning environments (Resnick, 1987), two decades of work examining especially effective schools (Purkey and Smith, 1983), findings on the importance of teacher capacity in promoting reform (Little et al., 1987), and observations about the promise of coherent policy in the form of curriculum frameworks and aligned assessment systems (especially as these policies were formulated in California during the late 1980s). Supporters of systemic reform were saying, in effect, "We now know much about how to reform the different components of the educational system. What is needed is to put the pieces together to reform the system as a whole. And wholesale reform of the system must reach all children equitably."

To guide the evaluation of the SSI program, the evaluation team developed a conceptual model of systemic reform, shown in Exhibit 1, specifying the key components of the educational system that need to be reformed in concert. The model reflects the NSF program announcement establishing the SSI program.

Exhibit 1 shows SSI activities or investments moving in two related but distinct channels. One set of investments has been made for activities relatively close to students and teachers, including support by the SSIs for the professional development of tens of thousands of teachers through both summer and academic-year activities. A second set of activities has focused on activities more distant from classrooms, such as the development and dissemination of state curriculum frameworks in mathematics and science. Because systemic reform aims to change both student outcomes and the education system itself, both sets of activities have been important. However, different SSIs have supported widely varying combinations of strategies to effect changes at different levels of the education system (see Zucker and Shields, 1997). Other key features of the model are as follows.

The Top of the Model: Students, Teachers, Classrooms, and Schools

By placing student outcomes at the apex of the figure, the model emphasizes that the overarching goal of systemic reform is to raise student achievement in mathematics and science, increase students' interest and enrollment in challenging courses in these disciplines, and otherwise **improve education outcomes for young people**. Improvements in student learning rest on **improved classroom experiences**. Such experiences are characterized by active student engagement with real-world scientific and mathematical

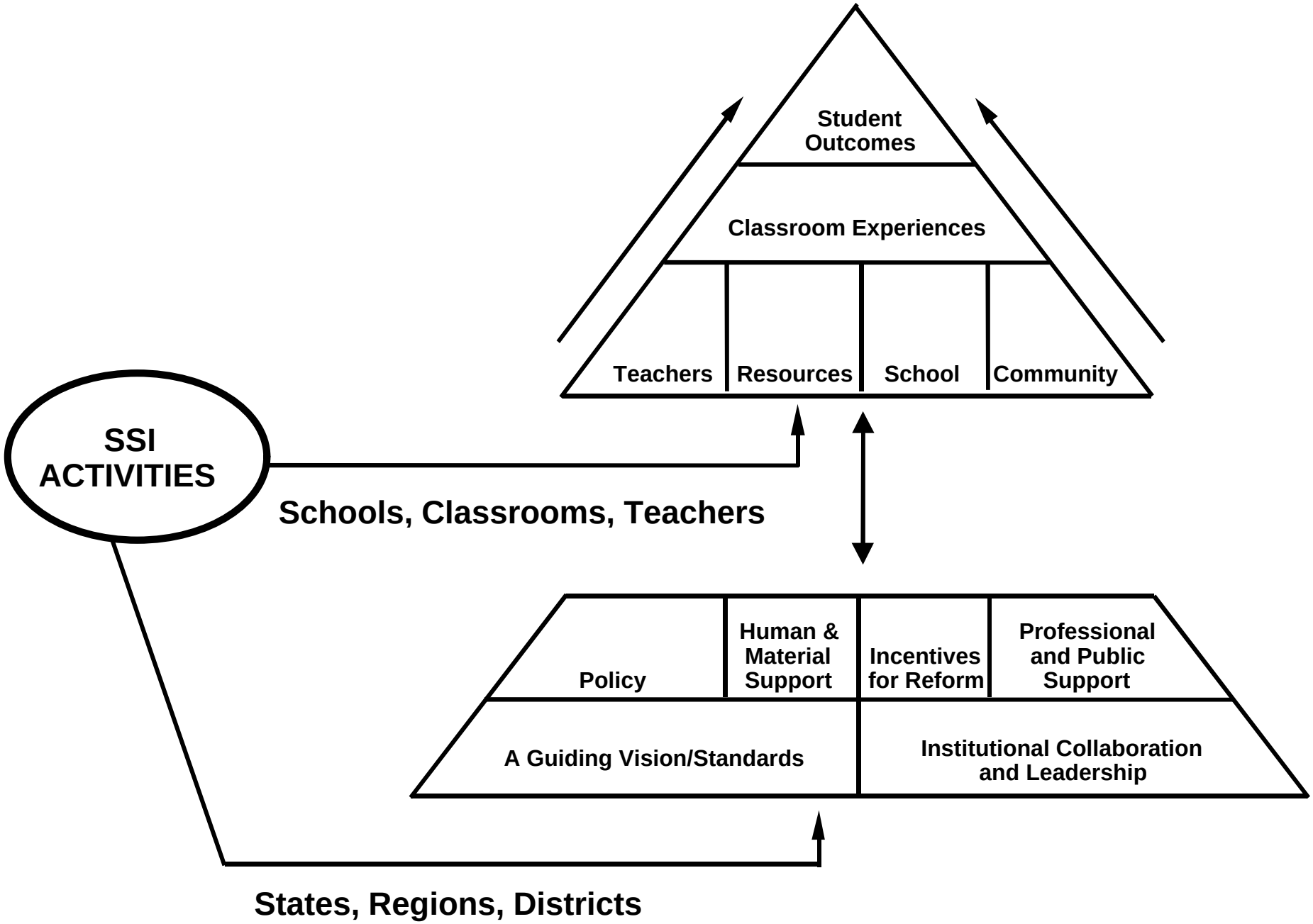


Exhibit 1: A MODEL OF SYSTEMIC REFORM

problems, critical inquiry into a limited set of topics, and opportunities for actual scientific thinking and discourse (CSMEE, 1997; Project 2061, 1993). In contrast to the typical American school, classrooms that provide such experiences are marked by less teacher-directed instruction, more student-student interaction, the flexible organization of space and time in line with the specific learning goals at hand, and regular constructive feedback to students based on their performance on actual mathematics and science tasks (Tharp and Gallimore, 1989).

The creation of such classrooms, the model continues, calls for **teachers with a new set of skills, resources, and knowledge.** Teachers must have a thorough command of their subject matter—an especially challenging task in mathematics and science, particularly at the elementary level (Cohen and Hill, 1998). Teachers must understand how students learn and how to structure learning opportunities to capitalize on students' knowledge and learning styles (Darling-Hammond, 1996; National Commission on Teaching and America's Future, 1996). Perhaps most importantly, they must believe that all their students can master challenging content.

Beyond content knowledge and pedagogical skills, teachers—and their students—must have **access to appropriate tools and instructional materials**. They need classroom technology (e.g., lab equipment, graphing calculators) and high-quality instructional materials. Access to appropriate curricula is particularly important because the challenge of creating inquiry-centered classrooms is already so daunting that without good curricula, teachers are faced with the prospect of creating their own materials while simultaneously struggling to change their own practice (Adelman and Walking Eagle, 1997; Zucker, 1997).

The provision of needed material resources, as well as the time teachers need to plan and assess the teaching and learning in their classrooms, calls for associated changes in the **culture and organization of schooling**. Fullan (1996) uses the term "reculturing" to refer to fundamental shifts in a school away from traditional norms structured by bureaucratic roles to a philosophy where student attainment of high standards is the central concern of all staff. Restructuring refers to the reorganization of standard operating procedures, especially time and the use of space, to promote student and teacher learning. From this perspective, schools that are supportive of teachers creating effective classrooms are characterized as learning organizations. Teachers have time away from children to interact and reflect with their peers; resources are allocated to optimize learning; and the scheduling of class periods as well as the grouping of students is flexible and driven by learning goals (Elmore and Associates, 1990).

Such schools also reach out to others because they require **the support and buy-in of parents and the local community**. Parent and community support is especially important when fundamental shifts in classroom practice are envisioned, as promoted by systemic reform (Shields and Knapp, 1997).

The Base of the Model: Districts, Regions, and States

To support reforms at the school and classroom levels on any scale also requires coordinated and coherent reforms at the levels of states, regions, and districts. Of paramount importance is the **alignment of policies** at the state and local levels. The misalignment of traditional basic-skills-oriented, norm-referenced tests with new and ambitious goals for student learning was one of the fundamental concerns of the proponents of systemic reform (Smith and O'Day, 1991). More coherent and robust policies are needed to send consistent messages to educators and the public about what is valued. Beyond assessments and frameworks, there are a host of policies under the control of either the state or local districts, depending on political traditions, that influence who ends up in classrooms, how teachers teach, and what support teachers receive. These policies include teacher certification and recertification, school accreditation, accreditation of teacher preparation institutions, teacher induction, textbook adoption, school-based decision-making, the existence and coordination of categorical programs, and the availability and use of professional development resources.

Beyond policy, there is the need for building an infrastructure at the district, region, and state levels that will provide **human and material**

support required for school and classroom reforms. The task faced by district and state administrators is no less challenging than that confronting classroom teachers, and the "system" that holds together district and state efforts is just as disjointed as the typical school. Systemic reform calls for districts and states to jettison their traditional role as regulators of local practice and assume the new role of technical assisters to schools. They have to understand, and be willing to address, the resource allocation, professional development, and organizational issues raised by the reforms (see Spillane and Tompson, 1997). They also play key roles in building public support for reform, and in providing the focus and stability needed to make significant changes in classroom practice.

A third factor that districts and states need to address is **incentives for reform**. Changing practice requires extra time and effort by teachers—time for learning, time for redesign—and it entails some risk, including the possibility of inadequate performance; negative reactions from colleagues, students, or parents; or lower achievement. So teachers must be highly motivated to undertake changes; they must have compelling reasons for taking on the work and the possible risks. Persuading large numbers of teachers and school administrators to engage in the work of reform requires the alignment of existing incentives with reforms, the elimination of disincentives, and sometimes the creation of new or additional incentives. Guidance mechanisms such as state standards, state and local assessments, and personnel evaluation criteria are all critical parts of the incentive structure affecting classroom practice. Many reformers also call for strong accountability systems that include public release of student outcomes and clear rewards and sanctions (David, 1990).[2]

The fourth reform task at the state and district levels involves **building professional and public support for the reform agenda**. Systemic reform requires widespread public acceptance, and, if there are extra costs entailed, their active support in obtaining the necessary resources. The public may sometimes appear apathetic about instructional reforms, but changes in the classroom that depart from the public's conceptions of "real" school will quickly galvanize parents if their support has not been obtained in advance. In democratically controlled school systems with weak professional structures, classroom practice is not determined solely by professionals. Instead, teaching practice is subject to close public scrutiny by parents and community members, and changes in practice require public acceptance, as well as formal approval by local boards.

A **well-specified vision of student learning goals** forms the basic premise of all versions of systemic reform. The argument is simple: coherence and alignment in the educational system must be guided by a shared understanding of the bottom line, i.e., what we want students to learn. In the early writing on systemic reform, this vision was likely to be specified in curriculum frameworks—again based on the experience of California in the 1980s (Smith and O'Day, 1991). Throughout the mid-1990s, as states tried out many of the ideas of systemic reform, curricular frameworks were replaced by state standards as the key vehicle for communicating a vision of high-quality instruction and learning. In fact, the term *systemic reform* was often replaced in the literature by the term "standards-based reform" (David, Shields, Young, Glenn, and Humphrey, 1997).

High-level **leadership and collaboration among key institutions** at both the state and local levels are required to help assure the legitimacy of the reform vision and thus its political power to guide shifts in policy and practice, as well as to motivate the concentration of resources needed for reform. The task of fundamental reform is both technical and political. Technically, it requires collaboration among the best minds—to set standards, realign assessment systems, restructure incentive systems, and build an appropriate infrastructure to support the reform effort. Politically, it requires the will to agree on a single set of learning outcomes, to establish appropriate

[2] An alternative theory holds that past reforms have been too top-down. The argument is that a more effective way of building incentives at the local level involves decentralization, professional-ization of teaching, empowerment of teachers, and accountability to peers. This approach was not well articulated at the time the SSI program began.

accountability mechanisms, to build public support, and to garner the necessary fiscal resources. Achievement of both the technical and political tasks of reform is impossible without the buy-in and support of the top leadership. Such leadership must come not only from the governmental sector but also from the business community, scientifically rich organizations, the higher education community, and education professional organizations.

Systemic Reform: A Summary

In summary, the model of systemic reform we have outlined follows a deceptively simple logic. Based on clear standards for what students should know and be able to do, and with the support of the key leadership, states and districts must align policy, build the capacity to provide schools and teachers with needed human and material support, restructure incentive systems, and build professional and public support for the reform agenda. These actions in turn are meant to provide the support needed to help increase teachers' capacity to implement the reform vision with access to appropriate material, within schools organized to support their efforts, and with the support of parents and community. In such contexts, the argument continues, reformed classroom practice can occur and student learning will increase.

Again, this model does not represent a fully specified theory of change. Yet, the model serves several useful purposes: it provides categories for describing the reform efforts of the SSI states and subsequently for assessing the degree to which those efforts produce outcomes predicted by the model. In addition, data collection allows another test of the model in that one can judge whether the very categories identified by systemic reformers are, in fact, accurate and adequate descriptors of the activities of the SSIs. Both of these points are discussed in the last section of the report.

The Evaluation Methodology

The evaluation is based on data collected from a wide variety of sources. Three sources were most important. First, quantitative data were gathered annually from the principal investigators in each SSI. In addition, the evaluation team conducted repeated site visits in every SSI. Finally, secondary data analysis included careful study and, in some cases, reanalysis of data sets gathered by many of the SSIs as part of their ongoing efforts to assess progress toward reaching their goals.

When the evaluation began, in June 1992, there were as yet no Cohort 3 SSI awards. The data collection plan included 9 case study states, which would be studied more intensively, and 12 non-case-study states. At NSF's request, two Cohort 3 SSIs were later added as case study states, and several other adjustments were made. What resulted was a set of 12 detailed case studies, for SSIs in Arkansas, California, Connecticut, Delaware, Kentucky, Louisiana, Maine, Michigan, Montana, New York, Vermont, and Virginia. Each published case study is about 40 pages long.

The time on-site in each case study state averaged about 50 person-days. Site visiting took place both during the school year and in the summer. More than two dozen districts in the case study states were described in detail by the evaluation team (but the written descriptions were not published), as well as more than three dozen schools.

In the 13 non-case-study states, the time on-site averaged about 6 person-days per SSI, and, again, a very large amount of information was gathered and analyzed about each of them. By design, these visits were briefer, were less frequent, and typically involved only a single evaluator. Written descriptions were not published; however, they averaged about 25 pages single-spaced for each of the non-case-study SSIs.

In all the states, on-site visits were supplemented with telephone interviews, in-person interviews at periodic meetings of the SSI principal investigators and project directors, and extensive document analyses. Documents reviewed included monitoring reports about each SSI that were produced by Abt Associates, multiple documents written by each SSI (such as annual reports to NSF), and reports of a number of evaluations conducted for specific SSIs. The latter were especially useful for developing two of the evaluation reports that

focus on what selected SSIs learned about the impacts of their activities on teachers' classroom practices and on student achievement. As necessary, information about particular states was also updated via telephone or e-mail to be sure information in each report was current.

Evaluation Reports

The complexity of the education system and the enormous scope of the SSI program provided evaluators with a challenge. In response to this challenge, three different types of reports have been produced:

- **Component-focused reports** correspond to elements of the education system shown in the conceptual model, Exhibit 1. To be successful, systemic reform must focus effectively on these individual components of the system. These reports include *The SSIs and Professional Development for Teachers*; *The SSIs' Impacts on Classroom Practice*; and *Assessing the SSIs' Impacts on Student Achievement*.

- **System-focused reports** integrate information about various components, and thereby examine the education system as a whole. These reports include a first-year report; the *Second-year report: Cross-cutting Themes*; *Doing Systemic Reform: The Experiences of the SSI States;* and 12 case studies focusing on the education systems of 12 of the SSIs.

- **This final synthesis report** is designed to summarize information from all the other evaluation reports.

Citations for all the reports can be found in the references at the end of this document.

II. Activities Supported by the SSIs

In this section, we describe what the SSIs did to improve the teaching and learning of science and mathematics in their states. We begin by categorizing the states by their primary focus: directly targeting schools and classrooms versus seeking to change the state system and infrastructure supporting reforms. We then describe the eight distinct change strategies that the SSIs utilized.

Focus of the SSIs

Because the 25 Statewide Systemic Initiatives adopted multiple and evolving strategies for reforming their systems of mathematics and science education, in some respects each SSI's approach to reform was unique to its time and place. Yet, looking across the 25 SSIs, there are a number of common characteristics. First, each SSI tended to focus on either (1) activities directed primarily at districts, schools, classrooms, teachers, and students (the top of the pyramid model of systemic reform displayed in Exhibit 1); (2) activities primarily directed at changing the policy and public support environment and improving the infrastructure for sustaining educational improvement (the base of the pyramid); or (3) a combination of both the top and the base, with activities directed in a more or less balanced fashion.

Clusters of SSI states began their reform journeys by focusing energy and resources in one of these directions. Over time, as initial goals were met or certain strategies proved to be unproductive, some SSIs shifted focus. Nevertheless, it is possible to characterize the **primary target** of each SSI's activities during its first 5 years as shown in Exhibit 2.

Exhibit 2

FOCUS OF SSI REFORM STRATEGIES

Focus Close to the Classroom (11 States)	Focus on State System and Infrastructure (7 States)	Balanced Focus (7 States)
CA, FL, KY, MT, NC, NE, NM, NY, OH, SD, VA	CO, CT, GA, MI, NJ, SC, TX	AR, DE, LA, ME, MA, PR, VT

This analysis of the primary target of SSI activities is done at a gross level. It should not be interpreted to mean that any state focused solely on policy matters or solely on schools, teachers, and classrooms. In fact, all of the SSIs supported some level of activity corresponding to both the top section and the base of Exhibit 1. The test that places a state in one column or the other above concerns the preponderance of SSI activity over a 5-year period. In 11 states, the balance tips toward supporting change at the local level, while in 7 others the bulk of the SSI's work targeted state education policies, organizational issues, the building of various kinds of partnerships, building regional infrastructures, and other activities at some remove from schools and classrooms. In the third group, 7 states focused the SSI's attention fairly evenly on both state and local reform activities. Exhibits 3, 4, and 5 show the distinctions represented in this analysis for three states: California, South Carolina, and Maine.

The SSIs in these three states approached systemic reform quite differently. Their approaches were based on their specific state reform contexts (such as the nature of other reform initiatives under way when the SSI award was made), as well as on their understanding of the SSI program goals, as stated in the 1990 NSF program solicitation and its 1991 addendum. Recall that the goals of systemic reform include both changes in student outcomes (the top of the pyramid) *and* changes in the many components of the education system. Therefore, depending on the preexisting situation in a state, any of the three general approaches to systemic reform may have been a sensible choice.

Exhibit 3

A FOCUS CLOSE TO THE CLASSROOM: CALIFORNIA

At the time that California received its SSI award (1992), the state had already spent many years investing heavily in the development and implementation of a set of comprehensive, standards-driven reforms that promoted the acquisition of higher-order thinking skills by all students—the very approach to reform of mathematics and science education encouraged by the SSI program. With curriculum frameworks in place and performance standards on the way in the form of a new state assessment, leaders of the California SSI did not need to attend to major state policy issues. In addition, this set of reforms emerged from strong partnerships between state executive and legislative branches and did not, at the time, appear to have detractors among either education professionals or the public. In other words, the "top-down" part of the educational change equation appeared to be securely in place.

What California did confront was the need to familiarize large numbers of teachers with a different approach to curriculum and instruction. The SSI, therefore, made a rational decision to focus on support and expansion of two existing teacher networks—one for middle school mathematics teachers and one to enhance the teaching of science in elementary schools. Both networks provided intensive summer professional development and regular follow-up assistance during the school year. Both either provided access to or helped schools and districts adopt new curricula in line with the state's vision of high-quality mathematics and science education. Ultimately, these networks reached tens of thousands of teachers in thousands of schools. Up to 80 percent of the SSI's resources were dedicated to this purpose.

Exhibit 4

A FOCUS ON STATE SYSTEM AND INFRASTRUCTURE: SOUTH CAROLINA

In South Carolina, most SSI activities were directed toward development of standards-based education policies and the creation of a regional infrastructure for providing high-quality professional development. Policy alignment efforts were comprehensive and included mathematics and science curriculum frameworks, achievement standards, increased graduation requirements, work on a state assessment system, and an indicator system for tracking progress. The SSI was also instrumental in efforts to rethink the state teacher licensure system. Unlike California, South Carolina had not spent years carrying out such activities as these before its SSI began.

The largest SSI investment was in establishing 13 regional "Hubs"—centers where expert services and materials are collected and from which they can radiate out to schools and districts in a defined service delivery area. Creating this infrastructure was important in a state where there are many rural districts and where most districts do not have mathematics and science specialists to act as resources for classroom teachers. Over the life of the SSI, South Carolina invested in preparing cadres of "teachers of teachers" at each Hub site. During the last years of the SSI, these experts began working directly with teachers, classrooms, schools, and districts that requested their services.

Exhibit 5

A BALANCED FOCUS: MAINE

In Maine, the SSI (which was based in a nongovernmental organization with close ties to both government and the private sector) simultaneously sought to (1) influence a reform-oriented but slow-paced state policy-making environment; (2) support the development of schools and school districts within the state that would serve as demonstrations of high-quality, standards-based mathematics and science education; and (3) introduce a process to help many local districts align their curricula with state standards. The SSI staff quickly established credibility on issues related to the improvement of mathematics and science education with the executive and legislative branches of government and with local educators in the demonstration sites.

Over the 5 years of NSF funding, the SSI was instrumental in the development of curriculum frameworks, the adoption of Maine's first explicit set of statewide student performance standards, and alignment of the state assessment system with the new standards. The demonstration sites flourished, creating locally and regionally based expertise that became the basis for new regional infrastructures and teacher networks. Hundreds of teachers and many districts and schools continue to receive help in implementing the new state policies from a now substantial group of within-state technical assisters, many of them classroom teachers from the demonstration sites.

One key implication of the choice of approach to systemic reform made by a state was how soon the work of the SSI reached the classroom level and therefore how quickly it could be expected to have impacts on teaching and learning. The California SSI targeted nearly *all* of its resources to the classroom level for a full 5 years. Maine targeted *some* of its resources at this level for 5 years as well. Both states were able to document changes in classroom practice by participating teachers. Maine was also able to document the elimination of a gender gap in mathematics and science achievement at demonstration sites.

In contrast, South Carolina (and other SSI states, as well) focused intensively on targets several steps removed from the classroom for most of the period of SSI funding. In South Carolina, it took 4 years to establish policies that reflected the SSI's vision for mathematics and science and to build the infrastructure that would support work at the school and classroom levels. Assisting teachers to implement the vision and the new policies began in earnest only during the last years of SSI funding. Therefore, information on the effectiveness of the infrastructure in supporting changes in curriculum and instruction and, ultimately, student learning, was just beginning to emerge as this report was written.

SSI Strategies for Reforming Mathematics and Science Education

Within these different overall approaches, SSIs also used a wide variety of strategies to accomplish their goals. In an earlier report,[3] the evaluation identified eight strategies that the SSIs used to carry out reform. Below, in Exhibit 6, those strategies are grouped under headings that correspond to the categories in the preceding discussion, namely: strategies that focus close to the classroom (on teachers, classrooms, and schools), and strategies that focus on the state system and infrastructure (i.e., on districts, regions, and states). Note that categorizing the strategies under these two headings is similar to what other analysts have done in referring to "bottom-up" and "top-down" approaches to reform.

Typically, each SSI relied on one or more primary strategies and several secondary strategies as its participants undertook systemic reform in mathematics and science education. In other words, as the theory of systemic reform suggested, each of the SSIs did, in fact, support a *series* of coordinated efforts affecting a number of different components of the education system. In some cases, SSI strategies evolved or even changed dramatically over time. Exhibit 7 shows the strategies that were used by each SSI, as identified by members of the evaluation team. (In addition, the appendix includes summary descriptions of the 12 SSIs selected for the case studies, as well as an appraisal of their impacts.)

It is important to note that Exhibit 7 reflects *only* strategies that were directly part of the SSI. In other words, they represent part of the "value added" by the SSI. For example, although the state of California has clearly invested heavily in policy alignment, that investment occurred largely prior to the SSI and was not supported by SSI funds, and so "Aligning State Policy" is not shown as an SSI strategy in California. However, the case studies of 12 SSIs prepared as part of this evaluation discuss the *entire* context in which an SSI operated, including any other key strategies for education reform supported in the state in addition to the SSI. Brief synopses of these cases are found in the appendix to this report.

Brief examples are provided below to illustrate how an SSI employed each of these eight strategies. The examples have been chosen to show a relatively strong or effective implementation of each strategy. The discussion focuses first on strategies focused on the top part of the model of systemic reform and then on strategies focused on the base.

[3] Zucker, A., Shields, P., Adelman, N., and Powell, J. (1995). *Evaluation of NSF's Statewide Systemic Initiatives (SSI) Program, Second Year Report: Cross-Cutting Themes.*

Strategies Focused on Teachers, Classrooms, and Schools

The SSIs used three major strategies focusing on teachers, classrooms, and schools.

Supporting teacher professional development. Sustained professional development for teachers is important if reform is to succeed in classrooms. Professional development was the most common SSI strategy (a high priority in 20 SSIs).

- **Project Discovery: An example of a strong professional development strategy**. Ohio's SSI established a high-quality and intensive professional development program. Participating teachers attended a 6-week residential summer program conducted by a team consisting of a Ph.D.-level scientist, engineer, or mathematician and two lead teachers. During the school year, the teachers attended six seminars and received visits and on-site assistance. With its strong focus on content, modeling of appropriate pedagogy, and intensive follow-up, Project Discovery was able to demonstrate positive outcomes in teacher practice and student learning.

Exhibit 6

EIGHT STRATEGIES USED BY THE SSIs*

Strategies focused on teachers, classrooms, and schools:

1. Supporting teacher professional development
2. Developing, disseminating, or adopting instructional materials
3. Supporting model schools

Strategies focused on districts, regions, and states:

4. Aligning state policy
5. Creating an infrastructure for capacity building
6. Funding local systemic initiatives
7. Reforming higher education and the preparation of teachers
8. Mobilizing public and professional opinion

* Note that no strategy was used in isolation; SSIs typically used four or more strategies in combination.

Exhibit 7

THE SSIs' STRATEGIES FOR PROMOTING SYSTEMIC REFORM

States	Supporting Teacher Professional Development	Developing, Disseminating, or Adopting Instructional Materials	Supporting Model Schools	Aligning State Policy	Creating an Infrastructure for Capacity Building	Funding Local Systemic Initiatives	Reforming Higher Education & the Preparation of Teachers	Mobilizing Public & Professional Opinion
AR	✓	✓		✓	✓		✓	✓
CA	✓				✓			
CO					✓	✓	✓	
CT		✓		✓	✓	✓	✓	✓
DE	✓	✓	✓	✓	✓			
FL	✓		✓	✓			✓	✓
GA	✓		✓	✓	✓		✓	
KY	✓	✓	✓		✓		✓	✓
LA	✓			✓	✓	✓	✓	✓
MA	✓			✓	✓	✓	✓	
ME	✓	✓		✓	✓	✓		✓
MI				✓	✓	✓	✓	✓
MT	✓	✓		✓	✓			✓
NC	✓	✓			✓			✓
NE	✓	✓			✓			
NJ	✓				✓	✓		
NM	✓	✓	✓	✓	✓		✓	
NY	✓		✓	✓				✓
OH	✓	✓			✓			
PR	✓	✓	✓	✓	✓		✓	✓
SC	✓	✓		✓	✓			✓
SD					✓	✓		
TX				✓	✓		✓	
VA	✓						✓	✓
VT	✓	✓		✓	✓	✓		✓

Developing, disseminating or adopting instructional materials. Instructional materials, especially textbooks, are basic to what happens in schools. Only six SSIs focused on the instructional materials used in mathematics and science classrooms as a major part of their initial approach to systemic reform. By the end of 1997, the number paying attention to this strategy had more than doubled, to 13. However, in many of the SSI states, instructional materials are still a "weak link," especially in certain domains where there are few alternatives to traditional textbooks (e.g., high school science). High-quality, standards-based materials need to be identified or developed, and decision-makers need to be well informed about them.

- **The SIMMS Project: High-quality materials development.** Montana's SIMMS project produced six year-long, integrated mathematics courses for grades 9-12. The materials are innovative (e.g., they use computers and graphing calculators throughout), they were highly rated by at least two sets of external reviewers, and both the utility and sustainability of the effort are reflected in the fact that the materials are distributed nationwide by a commercial publisher.

Supporting model schools. Just seven SSIs used a model schools strategy. This is a high-risk strategy. It requires a careful plan for dissemination and scaling up; if such a plan is not well designed and well implemented, the result is, at best, improvement in a handful of schools statewide. In the two states that had the strongest model schools strategies (Delaware and Puerto Rico), that effort served as part of a much broader systemic reform strategy.

- **Puerto Rico: Successful model schools.** The Puerto Rico SSI established model sites in each of the seven education regions of the island. The sites were testbeds for curriculum development and for site-based management ("school empowerment"). In addition, they became dissemination centers in the successful process of scaling up to more schools.

Strategies Focused on Districts, Regions and States

The SSIs used five major strategies focusing on districts, regions, and states:

Aligning state policy. State policy is difficult to change because it is driven by myriad political and resource issues beyond the control of an SSI. Only 3 SSIs targeted state policy as a primary strategy, although 13 others made it a secondary strategy to align the policy system with SSI goals, and in still other SSI states (e.g., California, as noted above) policy alignment was carried out under auspices other than the SSI.

- **Project 21 in Delaware: An example of a very strong strategy to change state policy.** The state of Delaware used a classic "Smith & O'Day" approach to systemic reform: aligning curriculum, instruction, assessment, professional development, and other components of the system. Over several years, the Delaware SSI continuously increased its direct support to the state task forces charged with developing mathematics and science education standards, assisted with reform of the state's system for assessing students' learning, and supported the reform of other state policies as well.

Creating an infrastructure for capacity building. Success for the SSIs is defined in part by what is left behind after the NSF funds disappear, and a new or improved infrastructure (e.g., new nonprofit advocacy institutions or better regional education centers) is one tangible legacy. Most of the SSIs (22) emphasized this strategy.

- **The Michigan Statewide Systemic Initiative: An effective strategy for creating an infrastructure for capacity building**. Michigan's SSI focused on improving the system through which high-quality professional development was available to all local school districts. The MSSI conducted professional development for providers of professional development, developed guidelines and took action to restructure the state's system of professional development, and

helped to revise the state professional development standards.

Funding local systemic initiatives. Nine SSIs, mostly in local-control states, chose to support local systemic initiatives. Key factors in building strong local initiatives were sufficient support for participants at the local level and instituting some kind of quality control mechanism.

- **PALMS sites in Massachusetts: Strong local initiatives**. Massachusetts chose a small set of local districts through a competitive RFP process to serve as testbeds for the SSI's vision of high-quality mathematics and science. The districts were required to team with a local institution of higher education, business partners, and a museum. Local teachers willing to make a full 5-year commitment were recruited, hired by the SSI, and trained to serve as PALMS specialists. The specialists worked with local leadership teams to design and implement a reform plan consistent with the SSI vision and state reform efforts.

Reforming higher education and the preparation of teachers. Although many (13) of the SSIs adopted this strategy, it proved to be a difficult one for them. Changing teacher preparation was a challenge in part because of the intrinsic difficulty of changing institutions of higher education, and in part because of the fact that relatively few of the SSI resources were used for this purpose.

- **The Arkansas "Crusades": Some tangible successes.** All of Arkansas' 14 institutions of higher education were involved in the math and science "Crusades," the centerpiece of its SSI. Although progress was not uniform in all 14, there were some changes in liberal arts (mathematics and science) courses in both public and private colleges and universities.

Mobilizing public and professional opinion. Many surveys and studies provide evidence that public and professional opinion is critically important for education reform. Fourteen SSIs placed a significant emphasis on mobilizing opinion. Nonetheless, the SSIs had a difficult time developing powerful strategies for mobilizing opinion. One reason may be that it is difficult to find appropriate measures of success for public relations initiatives, so it can be hard to know whether one is being successful or not.

- **Louisiana: Working with local communities.** One member of the Louisiana SSI (LaSIP) staff devoted all his time to helping local districts inform their communities about LaSIP reforms. On the basis of a strong theory of change that involved altering the generally low opinion of education held by the public in Louisiana, the SSI responded to local media requests for information and provided custom audio, video, and written information about how LaSIP was improving education in the state. The SSI helped local entities to develop high-quality presentations that were reported to have had a positive impact in their communities.

The SSI program invited states to design and implement approaches to systemic reform that fit their particular needs and contexts. The result was a set of SSIs that shared many common strategies, illustrated by the exhibits and vignettes above. Yet, when one considers the innumerable variations and combinations of strategies that were implemented, it is clear that each of the SSIs was, in important respects, unique. What the SSIs were able to accomplish by using these strategies is the subject of the next section.

III. Accomplishments of the SSI Program

Beginning in 1995, NSF asked the SSIs to report annually on progress with respect to each of six areas that NSF calls "drivers" of systemic reform, which are identified below. This section is organized around the drivers, which represent nearly all of the possible outcomes of the program that might be important. A few program accomplishments that do not correspond to any driver are identified and discussed separately, at the end of the section.

The drivers of systemic reform were described by NSF as follows:

- Driver 1: Rigorous, standards-based instruction for all students, and the curriculum, professional development, and assessment systems to support that instruction.
- Driver 2: A unified set of policies that facilitate and enable driver 1.
- Driver 3: A unified application of all resources to facilitate and enable driver 1.
- Driver 4: Mobilization of the full community of stakeholders.
- Driver 5: Increased student attainment in science, mathematics, and technology.
- Driver 6: Reduction in attainment differences between those traditionally underserved and their peers. (National Science Foundation, n.d.)

To facilitate the discussion of driver 1, the SSI program's accomplishments are discussed for curriculum and instruction first, then for professional development, and finally for assessment systems.

Driver 1: Curriculum and Instruction

Curriculum and instruction are aspects of the education system that are relatively close to the student; that is, they belong in the upper portion of Exhibit 1 (in the cell called classroom experiences). Loosely speaking, curriculum can be conceived of as what is taught to students, while instruction focuses on how course content is taught. In practice, the two concepts are intertwined.[4]

Across the SSIs, there was general agreement on what the problems in mathematics and science classrooms were and about desirable reforms in curriculum and instruction. In terms of content, the SSIs argued for the need for new kinds of curriculum materials that place increased emphasis on all students' conceptual understanding of fundamental mathematical and scientific concepts, their applications in real-life situations, and their interrelatedness across disciplines. In terms of instructional strategies, the SSIs sought to diversify the ways in which students engage with the curriculum—away from passive, isolated absorption of information and toward active or interactive approaches.

Many SSIs were able to document changes in classroom practice due to the activities supported by the SSI (Shields, Marsh, and Adelman, 1997). Approximately 11 of the 25 SSIs had strong, positive impacts on classroom practice, meaning that there was reasonable evidence of changes in curriculum and instruction toward more inquiry-based learning, in line with state and national education standards. These changes included greater use of hands-on work (instead of just lecture or seatwork), greater attention to student inquiry as a motivating force, and more use of certain materials, such as science kits, calculators, and computers. Some SSIs also documented greater use of small-group work, instead of whole-class activities, and changes in classroom assessment practices.

[4] For example, curriculum frameworks often discuss instructional methodologies, such as the use of calculators, computers, or cooperative work by groups of students.

The SSIs that were able to document these types of changes generally focused attention on teachers early in the history of the initiative and tended to provide teachers with high-quality professional development activities that were both intensive and relatively long term. Many of these SSIs also identified or provided teachers with effective instructional materials—a practice that increased over the life of the program. (See Exhibit 8 for a discussion of SSI strategies for changing curriculum and instruction.)

In a few cases, the SSIs produced new instructional materials of high quality. For example, both Montana and Puerto Rico developed mathematics or science materials for several full grades, and the Nebraska SSI developed a number of mathematics units. The materials produced in Montana and Nebraska are nationally disseminated.

There are, however, caveats about the impacts of the SSIs on classroom practices. Even in the best cases, the impacts were limited in terms of the numbers of teachers and classrooms reached. No SSI was able to "go to scale" and affect whole cohorts of teachers statewide (e.g., all the state's middle school science teachers). The impacts were also moderate, in the sense that the changes for teachers were rarely wholesale transformations of practice; rather, the changes were tentative and modest in size or degree. Finally, the impacts were almost always uneven, affecting some teachers involved in an SSI much more than others.

It is not surprising to find that the SSIs' impacts on classrooms were limited, because SSIs typically focused on a subset of all classrooms in the state and because so many components of the education system must change in order to produce widespread improvement in typical classroom practices. The more important fact is that high-quality, focused interventions had some demonstrable, positive classroom impacts. The SSIs moved classroom practices in directions that are generally considered to be an improvement over past practices.[5]

Driver 1 (continued): Professional Development

The largest single portion of the SSI funds (approximately one-third) was used by the SSIs to support professional development activities for teachers (Corcoran, Shields, and Zucker, 1997). Among the 25 SSIs active during 1995 and 1996, 20 of them used professional development as one of their strategies for effecting improvement in classroom practices (see Exhibit 7, in Section II).

A number of factors contributed to the decision of the SSIs to invest heavily in professional development. For example, elementary teachers, who are generalists, often have an inadequate preparation in science and mathematics, and the same problem occurs for many middle school teachers, as well. Also, many existing professional development opportunities for teachers are of short duration, are poorly aligned with the reform goals of the SSIs, or otherwise are less than satisfactory.

The primary approaches to improving and expanding professional development employed by the SSIs fell into three general categories:

- **Local Human Resource Development:** Provides training to the maximum number of teachers possible or preparation of teacher cadres to do local training.
- **Local System Capacity Building:** Attempts to alter school and/or district policies, priorities, incentives, practices, resources, and relationships with regard to professional development.
- **State System Capacity Building:** Attempts to alter state policies, priorities, incentives, practices, resources, relationships, etc., with regard to professional development.

[5] For recommendations on desirable changes in classroom practice, see, for example: National Council of Teachers of Mathematics (1989, 1991, 1995) National Research Council (1995); Project 2061, American Association for the Advancement of Science (1993).

Exhibit 8

REFORMING CURRICULUM AND INSTRUCTION

The SSIs used a variety of strategies to improve curriculum and instruction, seeking to balance immediate impacts with longer-term infrastructure improvements. In fact, most of the components in the conceptual model of systemic reform (Exhibit 1) in some sense contributed to the reform of core classroom practices, although the results might not be seen for a number of years. Strategies that were most directly and immediately targeted at curriculum and instruction included providing professional development to teachers; developing, disseminating or adopting instructional materials; and supporting demonstration sites through strategies such as model schools and local systemic initiatives. Activities in these areas could reasonably be expected to result in relatively quick improvements in classrooms (within a year or two, at most).

The adoption of any specific strategy—teacher professional development, or developing and disseminating instructional materials, for example—did not in itself guarantee positive impacts on classroom practice across all states that used that strategy. The impact of SSIs on classroom practice had less to do with the selection of an overall strategy—even one intended to produce relatively quick results—than with the design and implementation characteristics of that strategy.

SSIs had more success in changing teachers' attitudes, beliefs, and intentions than in changing classroom practice itself. Translating new beliefs into practice was much more difficult than changing attitudes. Most teachers participating in the SSIs articulated an understanding of and commitment to the new paradigm of teaching—hands-on activities, students working cooperatively, teacher probing for students' prior knowledge and encouraging the students to demonstrate understanding of concepts. Many teachers experienced difficulty in fully implementing this vision in their classrooms, but some were able to do so.

Overall, SSIs were more likely to affect classrooms positively when they:

- targeted classroom teachers early in the initiative through a comprehensive reform effort including access to high-quality professional development and effective instructional materials,
- provided long-term support for teachers, not just one-shot workshops, and
- included effective quality control mechanisms for all the SSI activities.

Few states fit neatly into a single category; indeed, at least nine of the SSIs employed all three approaches to improving professional development for teachers. And, of course, the particular mix, as well as the strategies employed, varied from state to state, depending in large part on political traditions and the policy environment, the locus and influence of the SSI leadership, state resources, the status and strength of other state reform efforts, and the alignment of the SSI with these other state reform initiatives.

A common model of effective professional development was intensive summer institutes lasting at least a few weeks, with academic-year follow-up activities. Many of the SSIs supported high-quality summer institutes for teachers. Some of these institutes, such as those sponsored by the California SSI, were part of "teacher networks" that involve a growing number of schools statewide and that, by design, are carefully aligned with other changes in the state's education system, such as revisions in a state's curriculum frameworks or textbook adoption policies (Shields, Marsh, Marder, and Wilson, 1997).

There is general agreement in the profession that high-quality professional development should embody the 10 dimensions discussed in Exhibit 9. The professional development experiences offered by the SSIs, for the most part, focused on subject-matter content, were coherent and sustained, included active learning, engaged their participants, and offered some kind of incentives**.** However, the duration of the experiences was not always adequate, and teacher input into design and delivery was often limited**.** Although all the SSIs claimed their content was research based, there have been few reported or observed instances where that research was discussed and critiqued.

Despite the high quality of most professional development supported by the SSIs, there are several important, unresolved issues. Scale is still a problem, with the SSIs reaching at most 10 percent of the eligible mathematics and science teachers in any one year, including some at lower levels of time intensity than ideal. (See Exhibit 10 for information about the numbers of teachers served.) The SSIs depended heavily on volunteer teachers, and many of the SSIs (e.g., those in Montana and Louisiana) found that the demand for lengthy summer institutes was limited to some fraction of eligible teachers. Relying on volunteers is a reasonable part of an overall strategy for systemic reform, but too few SSIs found ways to make professional development a normal part of the work life of all teachers. As long as the professional development "system" in states remains unchanged, SSIs and the states themselves will face difficult trade-offs between working with small numbers of teachers intensively or large numbers of teachers superficially. Only a few SSIs (including South Carolina and Michigan) attempted to change or restructure the professional development system itself.

Many people understand that traditional inservice training activities—short, one-time workshops, with little or no follow-up—are inadequate to support the kinds of reform in classrooms that states want (Corcoran, 1995; Little et al., 1987. An increasing volume of high-quality teacher professional development is being supported, by the SSIs and through other means. However, there are few, if any, places that are models of "systemic" professional development, i.e. including all teachers in high-quality learning experiences on a routine basis, as part of normal operating procedures.

Driver 1 (continued): Assessment Systems

The last component of the education system identified by NSF as part of driver 1 is the set of systems for assessing students' learning and determining whether learning goals are being met. Most SSI states are struggling to build or improve their assessment systems, many of which are not well aligned with new state and national education standards (Laguarda, Breckenridge, and Hightower, 1994; Breckenridge, Goldstein, and Zucker, 1996; Blank et al., 1997). This is true at several levels, including large-scale state assessment systems (see Exhibit 11), the routine assessment practices of classroom teachers, and the SSIs' use of data about students to guide the SSI and provide evidence about "what works."

Exhibit 9

THE QUALITY OF SSI PROFESSIONAL DEVELOPMENT

There is general agreement in the profession that high-quality professional development should embody the 10 dimensions discussed below.

1. Emphasis on Teacher Knowledge of Subject Matter

Most SSI professional development activities were strongly rooted in state and national standards for science and mathematics education and emphasized subject matter**.**

2. Drawing on the Knowledge Base about Teaching

The pedagogy emphasized in SSI professional development programs has been generally consistent with knowledge about teaching**.** However, there has been a strong commitment to constructivist instruction, and the value of direct instruction has often been neglected.

3. Sustained, Coherent Effort

More than half of the SSI states have provided or supported coherent professional development sequences that included follow-up during the school year**.** Some were less successful because the professional development was low in intensity or of limited reach.

4. Sufficient Time and Intensity

The SSIs typically provided teachers with less than 1 week a year of professional development, although some SSIs provided more extensive experiences, ranging from 3 to 6 weeks for a limited number of teachers**.**

5. Opportunities for Teachers to Be Active Learners

Almost all the SSI states have effectively addressed this dimension of professional development quality**.** Most SSI summer institutes have treated teachers as adult learners and professionals.

6. Meaningful Intellectual, Social, and Emotional Engagement with Ideas, Materials, and Colleagues

All the SSI sites provided teachers opportunities to engage with ideas and materials in intellectually stimulating ways**.**

7. Engaging Teachers in Planning, Design, and Delivery

The design of most SSI professional development activities involved input from higher education faculty, master teachers, and other outside experts**.** Some SSIs, however, used participating teachers as instructors, as follow-up consultants, or in other roles.

8. Recognizing Teachers' Varying Expertise, Experience, and Beliefs

With the exception of some variations for different grade-level groupings, most of the SSI sites simply ignored teachers' differences**.** Doing so was possible in part because the SSIs have worked primarily with volunteers who may be less diverse in their backgrounds.

9. Accessibility and Inclusion

Most SSIs relied on volunteers, thereby attracting highly motivated teachers**.** However, this strategy is less than systemic, and teachers needing the most help are not necessarily reached.

10. Incentives for Teacher Participation

The incentives for teacher participation in the SSI states included, among others: the quality of the training, interest in a new curriculum, the materials provided, credits, and stipends.

State assessment systems are often the last large component of a state's education system that changes (after state curriculum frameworks, teacher certification requirements, textbook adoptions, and the like). (Vermont, which began implementing a portfolio assessment system in the late 1980s, is one of the exceptions.) Few SSIs had a great influence on state assessment systems. However, there are examples of positive changes to assessment systems among the SSIs, such as changes that have taken place in Maine and Massachusetts, with assistance from the SSI staff. (For example, staff of the Massachusetts SSI helped to align the state's new assessments with its curriculum frameworks, and used pilot assessment data to investigate progress of school districts involved in the SSI.) At the same time, there are also SSI states in which reforms to state assessment systems have been stalled, abandoned, or called into question. For example, California's highly publicized assessment system (CLAS) was abandoned. Even Kentucky's relatively new (1992) assessment system, KIRIS, which is radically different from what is in place in other states, has come under strong criticism. There is no doubt that improving large-scale assessment systems poses technical and political problems.

However, the SSIs have contributed to a growing perception that science is, after all, a "new basic" (in the phrase of the National Commission on Excellence in Education) that should be assessed as routinely as mathematics or reading. For many years, assessment of students' learning in mathematics (via standardized tests, state assessments, or other means) has been routine, whereas assessment in science has been less common (see, for example, Laguarda, Breckenridge, and Hightower, 1994). This situation is changing. Assessment in science is becoming more common, increasing from only 14 states in 1984 to 31 states in 1995 (Blank et al., 1995).

The slow pace of change in state assessment systems means that data from these systems have not been particularly useful to the SSIs in tracking students' progress (Laguarda, 1998). Louisiana's SSI, LaSIP, is one of only a handful that were able to use state assessment data for their own purposes; even so, the state tests in Louisiana were not well aligned with LaSIP's goals. A number of SSIs (e.g., Montana and Ohio) developed and administered their own tests in order to assess the impacts of the SSI, but many SSIs made little use of student-level achievement data from any source to track the impacts of their efforts, or used data of limited quality and quantity (Laguarda, 1998).

Some SSIs promoted changes in teachers' routine classroom assessment practices (e.g., by encouraging the use of journals, portfolios, or interviews with students). An example is the publication by the Montana SSI of an *Assessment Handbook* designed for high school mathematics teachers. Also, some SSIs supported the training of teachers to use mathematics and science performance assessments (such as those developed by the New Standards project) as a supplement to traditional multiple-choice tests.

Driver 2: A Unified Set of Policies

NSF's driver 2 is "*a unified set of policies that facilitate and enable driver 1*." As noted in the introduction to this report, developing and aligning state policies involves a very wide range of activity.

Aligning state policies (e.g., state requirements with regard to curriculum content, student assessment, teacher preparation and certification, etc.) is a cornerstone of systemic reform theory (Smith and O'Day, 1991). In the context of NSF's SSI program, policy alignment is broadly understood to mean moving toward a standards-based education system where all state policies and programs send a consistent and coherent message to practitioners by reflecting a single set of ambitious standards for student learning. Throughout the 1990s, policy alignment in the states has been a moving target. Generally speaking, the policy arena was very dynamic. Some states that exerted strong, state- level policy control of education at the outset of the SSI program (e.g., California, Florida) had

Exhibit 10

SCALE OF SSI PROFESSIONAL DEVELOPMENT ACTIVITIES THROUGH JUNE 1995

State	Year of SSI	Major Grade Focus Math	Major Grade Focus Science	Number of Elem. M/S Teachers Served	Number of Middle Grade M/S Teachers Served	Number of HS M/S Teachers Served
AR	3	K-16	K-16	5,031	802	992
CA	4	6-8	K-6	36,540	1,700	60
CO	3	K-16	K-16	1,885	475	305
CT	5	K-16	K-16	3,037	774	476
DE	5	K-12	K-12	673	214	150
FL	5			3,356	704	513
GA	4	K-16	K-16	2,916	3,083	1,170
KY	4	K-16	K-16	2,672	1,287	606
LA		4-8	4-8	710	1,769	548
MA	4	K-16	K-16	1,778	1,467	1,075
ME	4	K-16	K-16	1,280	682	275
MI	4	K-12	K-12	10,646	3,367	3,568
MT	5	9-12		30	98	543
NC	5	K-16	K-15	29,840	14,559	11,116
NE	5	K-16	K-16	1,588	423	742
NJ	3	K-8	K-8	357	403	135
NM	4	K-8	K-8	2,271	861	45
NY	3	K-12	K-12	470	245	50
OH	5	6-8	6-8	2,061	2,683	905
PR	4	K-12	K-12	3,816	1,137	231
SC	5	K-16	K-16	4,266	1,724	1,354
SD	5	K-12	K-12	1,419	393	474
TX	4	K-16	K-16	1,690	420	290
VA	4	K-8	K-8	559	251	200
VT	4	K-12	K-12	820	576	466
Totals				119,711 15%*	40,097 37%*	26,289 20%*

Notes: M/S = math/science. No comparable data on teachers involved in professional development exist for the 1995-96, 1996-97, or 1997-98 school year.

* Percentages indicate estimated fraction of all M/S teachers in these states, combined.

Source: Marder (1996).

Exhibit 11

SUMMARY OF STATE ASSESSMENT PROGRAM CHARACTERISTICS
SEPTEMBER 1997

States	State Assessment Program in Mathematics	Mathematics Content Aligned with Goals of the SSI	State Assessment Program in Science	Science Content Aligned with Goals of the SSI
AR	✓		✓	
CA	Developing		Developing	
CO	Developing		Developing	
CT	✓	✓	✓	✓
DE	Developing		Developing	
FL*	✓			
GA	Revising		Revising	
KY	✓	✓	✓	✓
LA	✓		✓	
MA	✓	✓	✓	✓
ME	✓	✓	✓	✓
MI	✓	✓	✓	✓
MT				
NC*	✓		✓	
NE				
NJ	✓(Grade 4 pilot)		Piloting	
NM	✓		✓	
NY	Developing		Developing	✓
OH	✓		✓	
PR	Revising		Developing	
SC	Developing		Developing	
SD*	✓		✓	
TX	✓		✓	
VA*	✓	✓	✓	✓
VT	✓	✓	✓†	✓

* States in which SSI funding was discontinued earlier than planned.

† Vermont administers a science assessment every other year, alternating with social studies.

Sources: SSI site visitors; Blank et al. (1997); AFT (1997).

"devolved" decision-making to the local level by 1997. Conversely, some states with strong local-control traditions (e.g., Massachusetts, Kentucky) passed reform legislation placing greater policy-making authority at the state level than ever before. In most SSI states, however, the pattern has been steady forward movement toward aligned, standards-based policies for curriculum, instruction, and student assessment, with attention in some states to related policies such as teacher preparation, licensing, and recertification. Importantly, policy development is inherently a political process, and many SSIs faced an often-shifting political context that made their job more difficult.

Policy alignment was a focus of activity for 16 of the SSIs. One reason that this number is not even higher is that in some states, such as California and Arkansas, a great deal of effort had already been spent on formulating or revising state policies of various kinds; therefore, the SSIs in those states focused their energies and resources on other activities.

In the majority of the SSI states, the SSI contributed to this evolution of policy toward greater coherence and clearer relationships to higher standards. Rarely, however, was policy alignment a primary objective or investment of the SSI per se, nor was the SSI typically leading the policy charge. In 1996, policy alignment was a primary systemic reform strategy in only three states (New Mexico, South Carolina, and Texas). Still, all of the SSI states developed or are in the process of finalizing curriculum frameworks or content standards, and many are also now concerning themselves with the relationship between frameworks, content standards, student assessment policies, and performance standards.[6]

One of the most common policy-related activities conducted by the SSIs was to contribute to the development of new or improved state curriculum frameworks in mathematics and/or science. In 11 states, the SSI directly invested time and money in the development of frameworks or content standards for K-12 mathematics (Exhibit 12). Since these documents typically set out ambitious goals for what students should learn and be able to do, they are logical starting points for systemic reform (Smith and O'Day, 1991). In the model of systemic reform (Exhibit 1), the curriculum frameworks are one of the key documents used to provide a "guiding vision" for the other components that make up the education system. Among the many SSIs that were active in developing frameworks were:

- Georgia, where the *Georgia Framework for Learning Mathematics and Science* was adopted as policy by the state board of education after the SSI led its development.

- Colorado, where the SSI leadership participated in writing the state curriculum frameworks for both mathematics and science education.

In a number of states, the SSIs were also involved with the reform or revision of student testing policies. Artifacts of this process sometimes include establishing student performance standards (e.g., Maine's legislatively approved Learning Results) and new assessment instruments or items that are aligned to the content standards. Many of the SSIs were also involved in formulating other types of policy documents. These were related to teacher certification and recertification requirements, materials adoption policies (e.g., for textbooks), and state technology initiatives to support education, to name only a few.

The primary issue that emerged from states' efforts to align policies as part of their SSI activities was time. The pace of the alignment process was often slow for reasons that ranged from the brevity or infrequency of legislative sessions in some states to the need to move ahead cautiously when a backlash of public opinion threatened standards-based reforms. Leaders of the Maine SSI reported that politicians directly told them that they were "too

[6] Clearly, the SSI states were not alone in developing frameworks and standards. Indeed, a recent report from the Council of Chief State School Officers indicates that 46 of the 50 states have completed mathematics and science standards (Blank et al., 1997).

Exhibit 12

STATUS OF MATHEMATICS AND SCIENCE CURRICULUM FRAMEWORKS IN SSI STATES, SEPTEMBER 1997

State	Mathematics Framework	Science Framework	SSI Funds Used for Framework Development
AR	In place (1993)	In place	N
CA	In place (being revised, 1997)	In place (reconfirmed, 1996; revision likely in 2004)	N
CO	In place (1995)	In place (1995)	N
CT	In place (revisions under review, 1997)	In place (revisions under review, 1997)	N
DE	In place (1995)	In place (1995)	Y
FL	In place (1996)	In place (1994)	Y
GA	In place (revising for the first time since the mid-80s)	In place (revising for the first time since the mid-80s)	Y
KY	In place (1993)	In place (1993)	N
LA	In place (1996)	In place (1997)	Y
MA	In place (1994)	In place (1994)	Y
ME	In place (1996)	In place (1996)	N
MI	In place (revised, 1995)	In place (revised, 1995)	N
MT	In place (1996)	In place (1996)	Y
NC	In place (1989)	In place (1994)	N
NE	In place (1994)	In place (1994)	N
NJ	In place	In place (draft under review)	N
NM	In place (newly adopted)	In place (newly adopted)	Y
NY	In place (1994)	In place (1994)	N
OH	In place (being revised)	In place (being revised)	N
PR	In place	Developing	N
SC	In place (1993)	Developing	Y
SD	In place (not visible)	In place (not visible)	N
TX	In place (1997)	In place (1997)	Y
VA	In place (revised 1995)	In place (revised 1995)	N
VT	In place (1996)	In place (1996)	Y

Note: In this exhibit, the term “framework” is used as a general category—the list includes documents titled state “frameworks,” “content standards,” and “curriculum guides.”
Sources: SSI evaluation site visitors; Blank et al. (1997); Humphrey, et al. (1997).

far out in front" of the state's populace in terms of ideas about improving mathematics and science education. Another full year of discussion and debate about performance standards produced the desired policy outcome in terms of the state's Learning Results. However, further debates lie ahead to bring teacher preparation and certification policies into alignment with content and performance standards for K-12 education. Alignment activities have been under way in Maine for at least 5 years. It may take another 5 to complete the process.

To address the issue of being too far ahead of general public and professional sentiment, many SSIs used a collaborative, consensus-building process. In Delaware, for example, every school district was represented on the committees that developed the mathematics and the science frameworks, respectively, as were the state's higher education institutions, business and industry, and state government. The review process for the frameworks involved many more educators and the public. This strategy, which was also followed in other states, such as Vermont, developed support for standards-based education. The involvement of the business community has been very important in some states where attacks on "outcome-based education" have threatened forward movement on standards-based reform.

Involving many people in the development of policy documents is important, but states also had to pay attention to involving the right people, given the policies in question. In Montana, where the primary SSI activity has been development of an integrated secondary school mathematics curriculum, SSI leaders have also participated in efforts to revamp teacher preparation and certification policies for mathematics teachers. To accomplish this, the SSI was instrumental in bringing together key stakeholders, including higher education faculty, the State Higher Education Executive Officer, representatives of the admissions offices at universities that prepare teachers, and staff from the state education agency, among others.

Overall, this area was one in which the SSIs had solid accomplishments. Yet, progress was slower and less uniform than NSF expected it would be. There are several reasons for the slow pace. First, as the evaluation reported some years ago, there are many political and technical challenges involved in changing policy; a notable example is state assessment systems (Zucker et al., 1995). Second, many key state policies (such as those related to equity in school finance) extend far beyond the disciplines of mathematics and science and involve a number of powerful stakeholders; SSIs cannot be expected to tackle such policy issues directly.[7] Third, some of the SSIs were poorly connected with state policy-makers, and, in a few cases (such as Virginia, where the SSI was ultimately terminated early by NSF), the policy-makers and the SSI staff had very different visions of education reform. Finally, as noted above, some states intentionally moved at a relatively slow pace in order to involve large numbers of people in deliberations about what would be appropriate curriculum frameworks, performance standards, or other key policies.

Driver 3: Coordinated Resources

NSF's driver 3 is "*a unified application of all resources to facilitate and enable driver 1*." In other words, because the NSF investment in the SSIs is such a small portion of the states' total education spending (well under 1%), it is critical that the SSIs be able to make use of other resources (Shields, Corcoran, and Zucker, 1994).

Over a period of 5 years, the SSIs were able to leverage more than $500 million in additional funds—considerably more than twice the amount that NSF invested during that same period. The largest single source of these other funds was from state budgets. Exhibit 13 shows the sources of "matching" funds during 1993, 1994, and 1995.

[7] For example, New Jersey (an SSI state since 1993) has been beset with lawsuits brought by dozens of school districts that want to change the state's school finance system, and other SSI states have also been in litigation on this issue. The SSIs are not likely to change this situation.

Exhibit 13

FUNDS LEVERAGED BY SSI FROM OTHER SOURCES *

Funding Sources	1993 Dollar Amount (N = 21)	1994 Dollar Amount (N = 24)	1995 Dollar Amount (N = 25)
Eisenhower/elementary funds	$14,168,646	$11,812,034	$22,787,925
Other district/school funds	N/A†	N/A†	14,990,550
Eisenhower/higher ed funds	6,712,256	11,945,968	13,445,500
U.S. Department of Education Curriculum Frameworks Grants	556,710	2,828,190	1,933,525
Other U.S. Dept. of Ed. funds	3,313,839	2,732,238	3,473,325
Other NSF funds	5,067,616	11,864,052	13,505,600
Other federal funds	62,842	872,792	1,316,600
State funds	19,424,829	31,706,963	44,460,075
Corporate funds	N/A†	N/A†	6,669,700
Other foundation grants	794,080	883,817	1,221,800
Other	7,307,531	8,895,739	19,514,925
Total	**$57,408,349**	**$83,541,793**	**$143,319,525**

* Through another data source, the SSIs reported nearly $400 million in "matching" funds for 1997. However, this figure seems high. Data are not available for other years.

† N/A: Data are not available because these categories were not included in data collection instruments in 1993 or 1994.

Source: Compilation of SSIs' annual reports of data to NSF, 1993, 1994, and 1995.

- For example, the Louisiana SSI was able to leverage $5 million in contributions from both the Louisiana Board of Regents (the agency that governs higher education) and the state's Board of Elementary and Secondary Education.

The second-largest source of other, non-NSF funds for the SSIs was the Eisenhower Professional Development Program administered by the U.S. Department of Education. Some of the Eisenhower program's funds were used to support teacher professional development at the school, district, and state levels in support of SSI goals, often in conjunction with SSI funds.

- In California, the SSI had a particularly effective strategy for leveraging Eisenhower funds, requiring that schools and districts pay to send teams of teachers for professional development; districts often used local Eisenhower monies for that purpose.

As a general rule, the portion of Eisenhower higher education funds earmarked for institutions of higher education was more closely coordinated with the SSIs' activities than the portion of funds earmarked for school districts. For example:

- In Maine, Delaware, and some of the other SSI states, the SSI staff helped to write the state's annual requests for proposals from institutions of higher education. In this way, they made sure that every higher education grant awarded in the state was aligned with the SSI.

In a few states, the SSI resources were central to *all* standards-based reform activities throughout the state. Examples include Arkansas and Delaware, where each state's political leaders were committed to the same vision of reform as the SSI. This was a desirable state of affairs, because it meant that the state's resources for systemic reform were unusually well coordinated. (See Exhibit 14 for an example.)

Nonetheless, there were certain important programs, such as the $7 billion federal Title I program, which provides compensatory education in mathematics and language arts for disadvantaged students, that were almost never closely coordinated with the SSIs.[8] The glass can thus be viewed either as half full (the SSIs leveraged much more money than NSF itself invested), or as half empty (coordination was limited to certain programs, and the total amount of leveraged funds was still small in comparison with total education spending on mathematics and science education in the SSI states).

Driver 4: Mobilizing Stakeholders

The fourth of NSF's drivers is "*mobilization of the full community of stakeholders*" to reach the goals of systemic reform. Apart from groups with obvious education missions, such as school boards, these stakeholders may also include parents, taxpayers, state legislatures, businesses, universities, nonprofit institutions of all kinds (e.g., professional associations, museums), or others with an interest in improving education in mathematics, science, and technology. In the model of systemic reform (Exhibit 1), this driver is represented by three cells: institutional collaboration and leadership, professional and public support, and the school community.

Several of the SSIs recognized the importance of building broad-based public and professional support for new state policies and new approaches to teaching and learning mathematics and science, but relatively few targeted significant resources or energy to this strategy. Fourteen SSIs had initiatives in this area. Although no state adopted communication with the public about mathematics and science reform issues as a primary strategy, the SSI program increased the awareness of educators in many states about the importance of mobilizing public support for improving education. (See Exhibit 15.)

[8] The Texas SSI was the only one that made strong efforts to influence the way Title I dollars were spent.

Exhibit 14

LEVERAGING RESOURCES IN THE ARKANSAS SSI

The Arkansas SSI pulled together the various communities committed to improving mathematics and science education for Arkansas' students and improved the capabilities of thousands of teachers in a state that has historically performed poorly in education. The SSI worked not only with the state department of education and state-supported regional educational cooperatives but also made significant inroads into the higher education community by bringing together university and K-12 faculty for staff development.

Funds from the U.S. Department of Education's Eisenhower program were often used by districts to support teachers' participation in the SSI and were also used by institutions of higher education to support SSI professional development projects. Individual districts were able to use some Department of Education Title I (compensatory education) funds to support SSI initiatives, but that was not done systematically across the state. Altogether, the SSI reported leveraging about $8 million in support of systemic reform from state, federal, and private funds. Private donors included Southwestern Bell, Arkansas Power and Light Company, Exxon, Wal-Mart, and Tyson's Foods.

Connecticut arguably mounted the most ambitious public awareness strategy undertaken by any of the SSIs. Using the expertise of the state's public television office and a public relations firm, the SSI mounted a comprehensive public awareness campaign delivered in many ways: television, radio, newspapers, events, speakers, take-home materials, ads on buses, and so on. This statewide campaign ran for 2 years but it soon became clear to the SSI leadership that it was very difficult to estimate how effective the strategy was and whether the investment in public relations paid off. The SSI then chose to put less effort into this area.

Most of the SSI states that included a public awareness component focused their efforts on the local level rather than undertaking a statewide campaign. Thus, for example, Louisiana's SSI, LaSIP, made dissemination of information about the SSI and its mission a priority but targeted media coverage at the grassroots level and at education professionals. A full-time communication coordinator prepared materials such as information packets, presentation materials, and broadcast quality videotapes for use by individuals and groups active in education at the local and regional levels. LaSIP was strategic in its approach, preferring not to draw too much public attention until it had positive results to promote.

A number of SSI states specifically worked to increase the awareness of parents concerning the new vision for mathematics and science education. Particularly popular vehicles for these efforts were Family Math and Science Nights at the elementary school level, designed to involve parents more actively in their children's education. In some states, many teachers and parents became expert in planning and implementing these events. Parents at one local systemic initiative site in Maine prepared a handbook of instructions on organizing Family Nights, which was distributed statewide. In other states, the SSIs worked with local PTAs.

Although many of the SSIs believed that informing the public and educational professionals about the new vision for mathematics and science education was important, they were frustrated by their own lack of expertise in public relations campaigns and by the difficulty of engaging the interest of the general public in education issues beyond taxes and test scores. "Gimmicks" that some states adopted, such as tray liners at fast food restaurants with math and science puzzles and facts about the systemic reform initiative, were an inexpensive dissemination medium, but there is no way to determine whether they were read with interest by parents and grandparents, whether children tried to solve the puzzles and

problems, or whether the liners simply slid into the trash can with the hamburger wrappers.

Evaluating the impact of a public relations strategy is extremely challenging when the "product" to be sold is a vision or an idea or a philosophy of education, especially if the purveyors of the message have their own vocabulary that is difficult for the uninitiated to understand. Even a simple word such as "standards," a term that holds an important meaning for systemic reform, defies precise definition, and, for some Americans, "standards" has become synonymous with other educational philosophies that they eschew, such as "outcome-based" education. There is a chance that a high-profile public relations campaign supporting standards-based reform of mathematics and science education might backfire. States like Louisiana that shared the SSI vision in low-key, local formats may have found a safer approach, but again, there is little or no information on which to judge the success of the strategy.

Rather than using direct public relations campaigns, a more promising strategy for building public support for standards-based reform may be sustained coalition building through independent groups that are supportive but constructively critical of comprehensive reform efforts. The Pritchard Committee in Kentucky acts in this capacity for the state's legislated systemic reforms (which are far broader than the SSI). The Board of Directors of the Maine Mathematics and Science Alliance, a 501c(3) organization that led the SSI, serves in a similar capacity. The representatives of stakeholder groups that serve on these independent councils can strategically reach out to larger constituencies, thus gradually building a consensus around the vision for reform. At both national and state levels, for example, this strategy has been successfully used to establish a strong commitment from business and industry to the need for a high-quality, standards-based system of education that prepares a well-educated work force. This commitment has helped standards-based reform survive opposition more than once.

In terms of coalition building, a significant accomplishment of the SSIs with respect to driver 4 has been the strong advocacy role that nongovernmental, nonprofit institutions have played in many states. Because these institutions are likely to continue to exist beyond the life of the SSI award and may be less affected by political tides than government agencies, they can become a powerful, lasting force pushing for systemic reform. In several states, whole new institutions have been created to help govern and advocate systemic reform activities. Examples include the Connecticut Academy for Mathematics, Science, and Technology; the Vermont Institute for Science, Mathematics, and Technology; and the Montana Mathematics and Science Society. In other cases, the role of preexisting nonprofits has been strengthened, such as in Kentucky, where the Kentucky Science and Technology Council has played a strong role in the SSI.

Many other agencies and groups have also been mobilized by the SSIs, ranging from state legislatures (many of which have contributed funds to support SSI-related activities), to television stations and newspapers, to businesses and universities. Typically, each SSI has been able to involve a large number of different groups and institutions and garner significant contributions of time and other resources from them. However, few of the SSIs were able to mobilize the higher education community responsible for preservice teacher preparation, in part because changing teacher preparation programs is such a large and complex undertaking. Exhibit 16 provides two specific examples of SSIs' efforts to mobilize support for reform.

Exhibit 15

SSIs MOBILIZING SUPPORT FOR RESTRUCTURING MATHEMATICS AND SCIENCE EDUCATION

Almost all the SSI states sought to legitimate reforms by building strong political coalitions, but there was a wide variation in how they did so. Examples include:

Vermont: The central role of a new nonprofit agency. There is a close working relationship between the SSI, the Vermont Institute for Science, Mathematics, and Technology (VISMT, a nonprofit), and the Vermont Department of Education. VISMT's activities are well integrated with the state's reform initiative. The former can be viewed as the R&D laboratory for the latter, providing new tools and documentation of needs and impacts. VISMT led the development of the state's science and mathematics framework and undertook the development of new assessments for the state. In both instances, it sought broad professional and public input, which helped legitimate the reforms. VISMT has effectively used local media to publicize its work and increase public awareness of the need for reform.

Georgia: Involving institutions of higher education. A few of the SSIs developed strong collaborations with colleges and universities, engaged them in K-12 reforms, and had some impact on their programs. In Georgia, the SSI brought together 32 of the 34 colleges and universities across the state that prepare teachers, in 4 regional groups. These groups became engaged with Georgia's P-16 initiative, which promotes collaboration across institutional boundaries. There was evidence of impacts on mathematics and science teacher preparation in some of these institutions. The SSI also produced a document, *Principles of Educating Teachers* (POET), which was widely disseminated throughout the state.

Driver 5: Student Achievement

NSF's drivers 5 and 6 are outcome oriented, focusing attention on the apex of the model shown in Exhibit 1. Driver 5 addresses "*increased student attainment in science, mathematics, and technology*," the ultimate goal of systemic reform.

Some SSIs did gather evidence demonstrating modest, positive impacts of their SSI activities on students' achievement in mathematics or science (see Laguarda et al., 1997). Not all of the SSIs expected to demonstrate short-term impacts on student achievement, however. In Michigan, for example, the focus of the SSI was on the base of the systemic reform model shown in Exhibit 1, that is, the education infrastructure.

Measuring the impacts of the SSIs on student outcomes was challenging, for a number of reasons: treatments varied greatly from one SSI to another; state tests were often unavailable or inappropriate in one way or another; and new assessment instruments were being designed (such as the New Standards reference exams), but were typically not available at the outset to set a baseline. Also, selecting, maintaining, and testing both experimental and comparison groups is expensive. Finally, many SSIs lacked other needed resources, such as sufficient expertise in tests and measurement.

NSF recognized these difficulties and addressed them in several ways. For example, NSF awarded a grant to the RAND Corporation for an independent assessment of student achievement in selected systemic initiatives (including several Urban Systemic Initiatives, as

well as some SSIs) and recommendations about how best to collect such data. A grant was also made to the leaders of the Ohio SSI to extend their data collection and analysis beyond the end of the SSI award. Also, the national evaluation team worked closely with seven of the SSIs to understand their student achievement data and draw conclusions from the data across a number of states (Laguarda, 1998).

It requires considerable effort to analyze and present data so that the size of any "gain" is clear (e.g., by reporting an "effect size") and so that the reasons for attributing impacts to the SSIs are understandable and credible.

Overall, on the basis of the nature of the SSI "treatments" of students and of the data that were collected in some of the SSIs, it seems likely that the SSI program's impacts on student achievement were limited both in terms of the numbers of students affected and the size of any gain. In addition, the impacts were uneven, affecting some students more than others, both within states and across them.

The national evaluation examined evidence that selected SSIs produced gains in student achievement. For practical reasons, the review was limited to those SSIs that were likely to have generated the most credible evidence that student achievement had risen. In many SSIs, there was simply little, if any, credible data available to answer questions about the impacts of SSI activities on student achievement. (This lack of evidence was due to factors such as those noted above, including the absence of several years of data for a consistent set of grade levels, very small sample sizes, and difficulties in selecting and maintaining valid experimental and comparison groups.) More specifically, the SSIs included in the review of student outcomes had: (1) adopted an intervention strategy that was likely to produce some student-level effects, (2) carried out their own analysis of student achievement data, and (3) reportedly designed a rigorous evaluation that would allow any gains in student achievement to be linked back to the SSI.

The review focused on findings from seven quite varied SSIs: Kentucky, Louisiana, Montana, New Mexico, Ohio, Puerto Rico, and Vermont. Exhibits 16 and 17 summarize evaluation activities and findings in these 7 SSIs.

Although the evidence is limited, the SSIs in Louisiana, Montana, Ohio, and Puerto Rico have been able to attribute small, statistically significant increases in student achievement, with some confidence, to the effects of their interventions with teachers and schools (see Exhibit 18). In each of these states, students in classrooms taught by SSI-trained teachers outperformed their counterparts in non-SSI classrooms by a margin of one to eight percentage points. This result is encouraging because it suggests that systemic reform can increase student achievement. However, there are also serious limitations to the data that underlie these findings, even in the best cases: (1) the quantity of the data is extremely limited, both within and across states; (2) the data within states are contradictory in some cases; and (3) effect sizes are small.

Among the SSIs included in the review, the four with the most credible evidence of changes in student achievement—Louisiana, Montana, Ohio, and Puerto Rico—are those with the most intensive interventions aimed directly at classrooms: (1) intensive professional development for teachers, totaling 6 weeks or more in the cases of Louisiana, Montana, and Ohio; and (2) significant investments in developing new curriculum materials and training teachers to use them in the cases of Montana and Puerto Rico. For example, Ohio's Project Discovery offered a 6-week, content-rich summer institute, followed by a full year of support on introducing inquiry teaching and performance assessments in classrooms. Montana's SSI produced six year-long, integrated math courses for grades 9-12. The materials are innovative (e.g., they use computers and graphing calculators), and they have been highly rated by at least two sets of external reviewers. Both of these interventions are intensive enough that one would expect them to produce substantial changes in students' classroom experiences.

Exhibit 16

SUMMARY OF STUDENT OUTCOMES IN MATHEMATICS FOR SEVEN SSIs

State	Test Instrument(s)	Grades Tested	Sample Size (SSI Only)	SSI vs. Non-SSI [a]
KY	Kentucky Instructional Results Information System	4 8 12	All SSI schools (223 schools)	0 + ++ [b]
LA	Louisiana Educational Assessment Program	5 7	All SSI students (varies by year)	+ (4-year average) +
MT	SIMMS open-ended tasks (10 items, 3 items per student)	9 10 11	10 classrooms 10 classrooms 9 classrooms	++ ++ 0
	PSAT	9 10 11	10 classrooms 10 classrooms 9 classrooms	0 [c] 0 0
NM	Iowa Test of Basic Skills (ITBS)	3 5 8	All SSI students (varies by year)	+ (3-cycle average) 0 +
OH	Project Discovery NAEP-based assessment (14 items)	7/8 7/8	12 classrooms 46 classrooms	++ (African-American students only) 0
PR	Puerto Rico Assessment of Educational Progress (PREAP)	8	17 schools	++
	APRENDA	7	7 schools 17 schools	++ ++
	SENDA	7	78 schools	+
VT	New Standards Reference Exam	4 8 10	No SSI sample	Baseline data only No analysis by SSI participation
	Mathematics portfolios	4 8	No school-level scores or SSI sample	No analysis by SSI participation

[a] "0" signifies that there were no significant differences between students enrolled in SSI classrooms and students in non-SSI classrooms; "+" signifies differences of 3 or fewer percentage points or raw score points; and "++" signifies differences of 4 or more percentage points or raw score points.

[b] High school teachers in Kentucky received little in the way of direct training from the SSI. The difference in performance between these schools and other Kentucky high schools is probably due to self-selection bias, not the efforts of the SSI. See the appendix to *Assessing the SSIs' Impacts on Student Achievement: An Imperfect Science* for a fuller discussion of this finding.

[c] SIMMS evaluators argue that these results, taken with the results of the SIMMS assessment, are positive; they show that SIMMS students do not fall behind students in traditional mathematics classrooms on more traditional assessment measures.

Exhibit 17

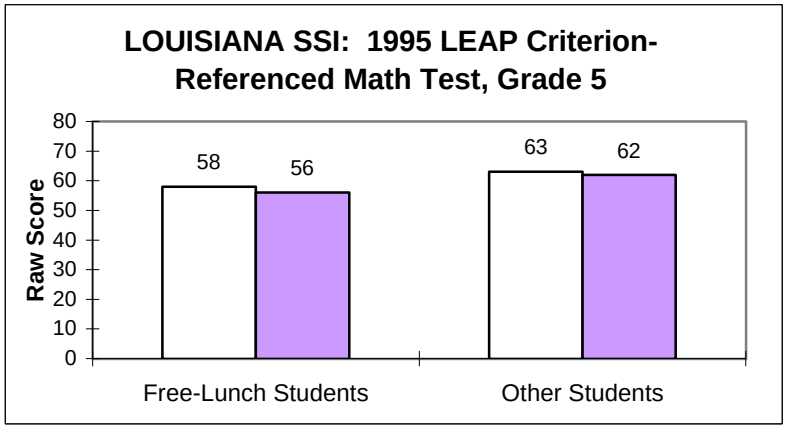
SUMMARY OF STUDENT OUTCOMES IN SCIENCE FOR SEVEN SSIs

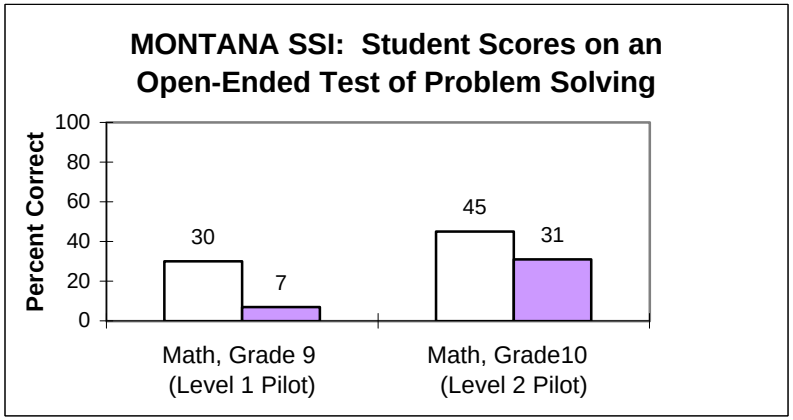
State	Test Instrument(s)	Grades Tested	Sample Size (SSI Only)	SSI vs. Non-SSI [a]
KY	Kentucky Instructional Results Information System	4 8 12	All SSI schools	0 + ++ [b]
LA	No instrument			No data
MT	No intervention			No data
NM	Iowa Test of Basic Skills (ITBS)	3 5 8	All SSI students	0 (3-cycle average) 0 +
OH	Project Discovery NAEP-based assessment (29 items)	7/8 7/8	12 classrooms 46 classrooms	++ +
PR	Puerto Rico Assessment of Educational Progress (PREAP)	8	17 schools	++
VT	Vermont Science Assessment	6 11	No SSI sample	Baseline data only No analysis by SSI participation

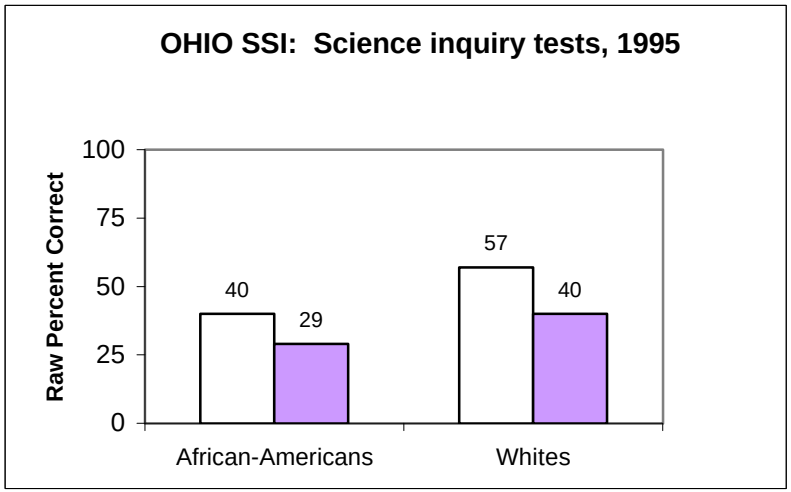
[a] "0" signifies that there were no significant differences between students enrolled in SSI classrooms and students in non-SSI classrooms; "+" signifies differences of 3 or fewer percentage points or raw score points; and "++" signifies differences of 4 or more percentage points or raw score points.

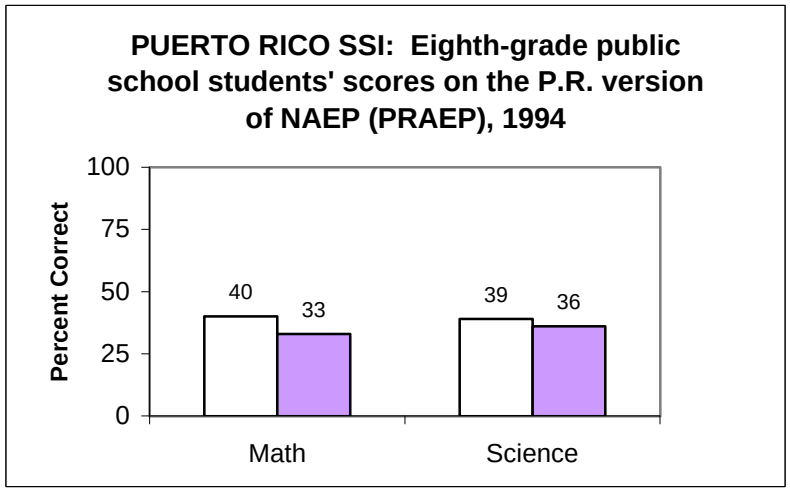
[b] High school teachers in Kentucky received little in the way of direct training from the SSI. The difference in performance between these schools and other Kentucky high schools is probably due to self-selection bias, not the efforts of the SSI. See the appendix to *Assessing the SSIs' Impacts on Student Achievement: An Imperfect Science* for a fuller discussion of this finding.

Exhibit 18
SAMPLE FINDINGS ABOUT STUDENT ACHIEVEMENT IN FOUR SSIs









These findings confirm what might be expected—those SSIs that worked most directly and most intensively at the classroom level were able to generate the most credible evidence of gains in student achievement. Among the seven that were carefully reviewed, those SSIs that invested most heavily in activities directed at state-level policy alignment, such as New Mexico and Vermont, or concentrated on building a state-level infrastructure to support change or on building local capacity to reform instruction, such as Kentucky or Vermont, necessarily invested fewer resources in direct, intensive training for teachers. The effect of these efforts on student learning was indirect, by design. As a result, these SSIs found it much more difficult to produce evidence of changes in student achievement that could be attributed directly to the SSI.

Putting this in terms of the conceptual model shown in Exhibit 1, there appears to be a trade-off, at least in the short term, between investing heavily in the base portion of the model (e.g., changing state policies and developing the education infrastructure) versus making investments that produce gains in the student outcomes shown at the top.

Driver 6: Closing the Gap

Driver 6 is the "*reduction in attainment differences between those traditionally underserved and their peers*." To accomplish this goal, SSIs focused on a number of groups of students underrepresented in mathematics and science, including those attending high-poverty schools, racial and ethnic minority groups, and women (Zucker et al., 1995). (See Exhibit 19.)

The most common strategy used by the SSIs to help "close the gap" was to emphasize that high standards are for *all* students. Moving many opinion leaders away from the idea that the academic curriculum for lower-achieving students should focus exclusively on "basic skills" has been a very important event during the past decade, and the SSIs have supported this trend.[9] For example, state standards and curriculum frameworks developed in recent years typically make it clear that the higher standards they advocate are for *all* students.

A variety of other strategies were also used by SSIs. Among these, a common strategy was to target the SSI's funds and activities particularly in districts or schools serving many students with special needs:

- Connecticut provides a good example of an SSI that focused resources on high-poverty districts, working intensively with the poorest urban areas in the state.

- New York's SSI targeted for special attention a small set of high-poverty schools in poor, urban districts.

Documenting such changes requires that the data be disaggregated—by race, gender, poverty level, or other student characteristics. The effort to disaggregate scores is important, and evidence from a few states suggests that systemic reform can help to close the gap in performance for historically underserved populations. However, the data need to be interpreted with caution. For example, when sample sizes are small to begin with, further dividing the sample by subgroup makes the development of reliable, stable measures of student performance even more difficult.

In a few cases, SSIs were able to document modest impacts in closing achievement gaps. Louisiana and Ohio, for example, collected data to show small reductions in the achievement gaps for African-American students and girls, compared with others involved in the SSI. Maine's gender gap disappeared on both the Maine Educational Assessment and the state-by-state NAEP.

[9] Changes in the Title I program, for example, have focused states' attention on the need to raise standards for low-achieving students. (For a careful study of the outcomes of different types of instruction on students in high-poverty elementary schools, see Knapp and Associates, 1995.)

Exhibit 19

EQUITY GROUPS FOCUSED ON BY SSIs

State	Racial/ Ethnic Minorities	Females	Rural Students	Low-Income Students (Urban or Rural)	Students with Disabilities	Appala-chian Students
AR	✓	✓	✓			
CA	✓	✓		✓		
CO	✓	✓				
CT	✓		✓	✓		
DE	✓					
FL						
GA	✓	✓				
KY	✓	✓		✓		✓
LA	✓	✓	✓			
MA	✓					
ME	✓	✓		✓	✓	
MI	✓	✓	✓	✓	✓	
MT	✓	✓				
NC	✓	✓				
NE	✓	✓	✓			
NJ	✓	✓				
NM	✓					
NY	✓	✓				
OH	✓	✓				✓
PR			✓	✓		
SC	✓	✓	✓			
SD	✓	✓	✓			
TX	✓	✓				
VA	✓	✓				
VT		✓	✓			

Source: Analysis of SSI documents.

* "Other" includes a number of less common equity activities, such as special efforts to recruit underrepresented students into science and mathematics classes.

Despite the positive data, the fact remains that it is hard work to raise the achievement of underserved student groups. This agenda is very large and difficult. It is interesting to note that by the mid-1990s, NSF itself was investing considerably more money in the Urban and the Rural Systemic Initiatives programs than in the SSIs, which was a tacit recognition of the difficulty of affecting change in high-poverty areas. In fact, individual Urban Systemic Initiatives have generally received more money—up to $15 million—than the SSI states in which the cities are located. The SSIs alone have certainly not been able to turn the situation around. However, as a group, they have tried to address this issue responsibly and in many different ways.

Other Accomplishments

Some accomplishments of the SSI program do not fit neatly into the categories described by NSF's six drivers. Two of these accomplishments are of particular importance: an improvement in the capacity of education leaders to think strategically about improving education systems, and, related to the first, a growing knowledge base about what is needed to change state systems.

The opportunity to take a leadership role in trying to change many key components of a state's education system is not given to many people. The opportunity to do so at a time when the nation is focused on raising education standards, and is therefore unusually open to change, is given to even fewer people. Importantly, as our many state case studies show, effective systemic improvement is highly context dependent. What works well in one state may not work as well in another. For example, this was the case in terms of selecting which major change strategies to use in the state, and in what combination (Zucker and Shields, 1997; Adelman et al., forthcoming). As a result of all these factors, many leaders of the SSIs had a great deal of learning to do "on the job," because there was no road map available to them to learn how to change education systems on such a large scale.

Consequently, the SSIs provided a rich opportunity for growing education leaders. In some cases, these leaders were the principal investigators and the other managers of the SSIs. A number of these individuals grew in stature within their states and in the wider education community nationwide. Furthermore, in many SSIs (e.g., California, Maine, New York, and Vermont, among others), dozens of individual teachers took on new roles in statewide reform efforts and proved to be very able leaders. As a result, there is now a broader, deeper leadership pool in many SSI states than there was before the program began. This is an important legacy of the program.

Related to the growth of a leadership cadre is the growing knowledge base about "what works" in systemic reform. For example, the important role of nonprofit, nongovernment institutions in many SSIs is a lesson that can be transferred to other states. The success of teacher networks in a number of SSIs is a lesson that has spread to other SSIs and is likely to spread beyond the SSI program altogether. The fact that the development of state standards and curriculum frameworks has been slow work is now widely known, but at least a number of agencies and institutions have kept public attention focused not only on whether these documents have been produced, but on their quality. (For example, independent, ongoing efforts to scrutinize state curriculum frameworks are managed by the American Federation of Teachers; the Council of Chief State School Officers, in cooperation with SRI International; the Council for Basic Education; and a new organization called Achieve.) Our earlier reports about the SSI evaluation identify a number of additional lessons learned from the program, as do publications from other sources (e.g., Fuhrman, 1997; Knapp, 1996). A number of the most important lessons are highlighted in the next section.

IV. The SSI Program as a Strategy for Improving Education

In this section, reflections about the program and its accomplishments are organized around three main questions:

1. What have we learned about the theory of systemic reform and the extent to which the impacts of the SSIs were consistent with the theory?

2. What features of the operation of this federal program were unusual and significant?

3. What lessons can be learned from the experience of the program, particularly lessons for state and federal policy-makers?

Each question corresponds to one of the three major headings below.

The SSI Program as a Strategy for Improving Education

In the first section of this report, the theory of systemic reform, which led NSF to begin the SSI program in 1990, was described in some detail. Eight years after the program was initiated, and looking across all the SSIs and the 5 (or more) years that each operated, one can ask questions about the theory, in terms of what the SSIs did and what they accomplished:

- To what extent were the SSIs as a group able to reform the components of the system? Which components of the education system (as depicted in the model) were successfully addressed and which were not?

- Did the SSIs' systemic reforms lead to improvements in education outcomes for students?

- In light of answers to the preceding questions, how systemic were the SSIs, taken as a group?

System Change

After 5 years, evidence shows that the SSI program has, in fact, left behind a legacy of new or improved curriculum frameworks, changes in a variety of state policies, new institutions and partnering arrangements, an increased number of competent state and local leaders of reform, and other tangible improvements in many different components of more than two dozen state education systems. The breadth of the impacts is striking and significant. However, not every component of the state education systems was influenced to the same degree as every other.

A discussion follows of each of the major components of the education system depicted in the conceptual model (Exhibit 1), beginning with the base of the model. Exhibit 20 illustrates this discussion.

A guiding vision: well-specified learning goals for students. The program provided energy and resources in many states to help policy-makers set ambitious goals for what students should know and be able to do in mathematics and science. All the SSIs developed clear vision statements consistent with national standards in mathematics and science education. Eleven states used SSI funds to help create or revise state curriculum frameworks for mathematics or science education. Although these documents varied in their quality and the degree to which they could be usefully employed to guide changes in practice, there is now widespread agreement across virtually all the states that specifying learning goals is an extremely important step in improving education systems (Humphrey et al., 1996).

Leadership and institutional collaboration. Nearly all the SSIs viewed leadership and collaboration as vital parts of their work. In general, the SSIs succeeded in bringing together the key leaders and institutions in their states to support the reform vision. Where the SSIs failed to bring key leaders on board, their efforts were typically severely limited and, in some cases, NSF phased out an SSI before the end of 5 years. Notably, the SSIs demonstrated the efficacy of using nonprofit, nongovernmental organizations to lead reform efforts. The SSIs also created significant opportunities for participating professionals—including hundreds

Exhibit 20

THE SSIs' IMPACTS ON THE COMPONENT TASKS OF SYSTEMIC REFORM

Classroom experiences. SSIs that targeted classrooms early, provided access to high-quality professional development and curricular materials, and maintained strong quality control were able to demonstrate positive impacts. Yet, at best, the impact on classrooms were limited in scope, moderate in terms of breadth, and uneven among participating teachers.

Improving teachers' knowledge and skills. The SSIs provided high-quality services to many thousands of teachers. There was far less focus on improving preservice teacher education.	**Access to appropriate materials and resources.** Attention to this component increased over time as more high-quality materials became available. A few states developed exemplary materials on their own.	**Supportive school organization and culture.** Few SSIs focused on changing the organization and culture of schools.	**Community and parental support.** Most SSIs, including some that did an excellent job with teachers, simply did not devote much attention to parents or the community at large.

Aligned and supportive policy. The majority of states sought to align at least a portion of their policy systems, typically frameworks (or standards) and assessments. Other policy areas—teacher certification and recertification, for example—were targeted less often.	**Infrastructure: Providing human and material support for reform.** Within the time frame of the SSI program, states did a reasonably good job of creating ways to deliver high-quality support to large numbers of teachers and schools.	**Creating incentives for reform.** Most SSIs appealed to volunteers and hoped that state assessments would be an incentive for the rest. Incentives included stipends, other financial supports, technical assistance, and appeals to professionalism.	**Building public and professional support.** Although most of the SSIs targeted some resources on public and professional engagement, they struggled to have any impact in this area. Overall, this was one of the weaker areas for the SSI states.

A guiding vision: well-specified learning goals for students. All the SSIs developed clear vision statements consistent with national standards in mathematics and science education.	**Leadership and institutional collaboration.** The SSIs succeeded in bringing together key leaders and institutions in their states to support reform. They also demonstrated the efficacy of using nonprofit organizations to lead reform efforts.

Key to cell shading:

	An effective effort by the SSIs
	A moderately effective effort by the SSIs
	Not addressed, or not effectively addressed, by the SSIs

or even thousands of teachers who were given new roles by the SSIs—to grow in their capacity as leaders. This "side effect" of systemic reform was more important than was probably anticipated by advocates of systemic reform.

Building public and professional support. From the outset, NSF emphasized the importance of building public and professional support for reform, making it one of the six "drivers." Fourteen of the SSIs targeted some resources on public and professional engagement, but no SSI used this as a primary reform strategy. The targets of these efforts were parents, the public at large, the state legislature, teachers and administrators, or other groups. Yet, given their limited success, many SSIs dropped or deemphasized their public support campaigns over their 5 years. In a few cases (e.g., California), public opinion seemed to move in the opposite direction from what the SSI wanted. This was one of the weaker areas for the SSI states as a whole.

Creating incentives for reform. Making the kinds of changes envisioned by NSF and the SSIs requires much of teachers and administrators, yet neither NSF nor the SSIs focused on structural incentives for professionals to reform their practice. Nearly all of the 20 SSIs that focused on professional development appealed to volunteer teachers to participate and hoped that state assessments would be an incentive for the rest. Only one or two SSIs addressed issues of teachers' supervision or evaluation, and none addressed compensation. For teachers, schools, and districts, the most common incentives to be part of an SSI were stipends or other forms of financial support, technical assistance, and appeals to professionalism. At the same time, some states (such as Kentucky) have begun to change incentive structures for teachers and schools but not through the SSIs.

Infrastructure: Providing human and material support for reform. Twenty-two of the SSIs built or improved some kind of infrastructure as part of their overall reform strategy—a clear recognition that infrastructure is an important contributor to the success of reform efforts. The particular forms of the infrastructure varied, and included new nonprofit agencies, new regional centers, strengthening of existing delivery systems for professional development, distance learning networks, and others. The ultimate efficacy of these efforts is still in question, since they generally have not been in place long enough to be tested by time, resource constraints, and politics. But within the time frame of the SSI program, states did a reasonably good job of creating ways to deliver high-quality support to schools and teachers.

Aligned and supportive policy. The alignment of policies to support the realization of the ambitious learning goals for all students is a cornerstone of systemic reform. Sixteen SSIs sought to align at least a portion of their state policy systems. However, only three SSIs targeted policy alignment as a primary reform strategy. The most common policy target was the development of curriculum frameworks or standards documents. A number of states also targeted reform of the state assessment system, but progress here was very uneven for both technical and political reasons. Other policy areas—teacher certification and recertification, for example—were targeted less often. Overall, the SSIs recognized the importance of policy alignment, and focused most often on the core areas of standards and assessments. Yet the SSIs also recognized the limits of their potential impacts in the political environment surrounding policy changes.

Improving teachers' knowledge and skills. Twenty of the SSIs succeeded in providing high-quality professional development to tens of thousands of volunteer teachers—an impressive number, but nonetheless a limited percentage of all mathematics and science teachers. The support the SSIs provided teachers was generally of high quality, including intensive initial "treatments" and long-term follow-up. There was, however, far less focus on the reform or improvement of preservice teacher education (although 13 made some efforts in this area). Half of the SSIs (or more, if we ignore a low level of effort by some) simply made the choice that wholesale change in institutions of higher education were beyond the scope of what they could accomplish in 5 years.

Access to appropriate materials and resources. There was a very wide variation among the SSIs in the extent to which they focused on this component. In 3 or 4 cases, SSIs created entire new curricula for mathematics

and/or science. More typically, SSIs sponsored development and/or dissemination of shorter units or modules, including promoting the adoption of existing high-quality instructional materials. Sometimes, SSIs literally provided schools or teachers with necessary materials, including equipment. Overall, attention to this component of the education system increased in the SSIs over time—in part because of the increasing availability of high-quality materials. By the end of 1997, more than half of the SSIs were identifying, developing, or disseminating high-quality instructional materials. It would make sense for more states to adopt and/or disseminate *existing* high-quality instructional curriculum materials.[10]

Supportive school organization and culture. Changing whole schools, although considered important in the literature on systemic reform, takes significant time and resources targeted on a small subset of the system. Consequently, only a handful of SSIs focused on changing the organization and culture of schools. Although seven SSIs used a "model schools" strategy, as it was conceived the impacts were usually limited and weak, except when combined with other strategies, such as in Puerto Rico, which emphasized site-based management as well as curriculum, instruction, and dissemination to other school sites. Other strategies, such as the training of lead teachers or groups of teachers from the same school, had the advantage of reaching larger numbers of schools, but were typically less effective in changing the entire school culture and organization to support reform.

Community and parental support. Community and parental support is important, but changing local conditions was simply beyond the reach and expertise of most SSIs. Efforts in this area included sponsorship of Family Math and Family Science programs or providing teachers with packets of information designed to help them communicate with parents and the community. The majority of the SSIs—including some that did an excellent job with teachers—simply did not devote much attention to parents or the community at large.

Classroom experiences. Eleven of the SSIs were able to demonstrate strong impacts on classroom practice. These were SSIs that targeted classrooms early in the initiative, provided access to high-quality professional development and curricular materials, and maintained strong quality control mechanisms. Most other SSIs chose strategies designed to impact classrooms later and with less intensity. These latter SSIs focused more on building infrastructure. Yet even under the best of circumstances, the impacts on classrooms were limited in scope, moderate in terms of breadth, and uneven among participating teachers.

Improving Outcomes for Students

The model of systemic reform (Exhibit 1), shows that changing outcomes for students is the ultimate goal of systemic reform. Because outcomes for students depend on the behavior of the whole education system (in theory, at least), by their nature NSF's efforts to improve student achievement through the SSI program should be viewed as a long-term goal. From the outset, leaders in many SSIs expected that demonstrating changes in state test scores would take more than 5 years.

Evidence from selected states showed that some SSIs had a modest, positive impact in changing what happens in mathematics and science classrooms, including producing increases in students' achievement. For example, Montana was able to demonstrate increases in the problem-solving performance of students completing the first 2 years of its integrated high school mathematics courses, compared with students enrolled in traditional courses.

Some staff at NSF had higher expectations for what the program could accomplish, in terms of raising students' test scores. However, as long as substantial fractions of the SSIs' resources were invested in system change (the base of the model), rather than aiming for immediate classroom change (the top portion), and in light of the relatively small size of the funding

[10] However, in some curriculum areas, commercially available textbooks are still not well aligned with national mathematics and science education standards. For example, developing a new "vision" of high school science, and the instructional materials to implement that vision, appears to be a particular problem, and few of the SSIs even began to tackle it.

involved (much less than 1% of annual education expenditures in the SSI states), only the modest impacts on student achievement that were observed could reasonably be expected.

Does It Add Up to Systemic Reform?

This discussion of the various components of the education system makes a number of points clear. First, some components were addressed much more effectively through the SSI program than others (see Exhibit 20). Looking across the 25 SSIs, they did a remarkably strong job of creating a vision of good mathematics and science education, coalescing the right leaders and institutions behind that vision, and building the capacity to provide material and human resources to schools and teachers. They also provided strong professional development for teachers, increased teachers' access to good instructional materials, and provided moderate support for aligning state policies. In contrast, the SSIs did a fairly poor job of creating incentives for reform, building public and professional support at either the state or the local level, or supporting whole-school change. The net result, as noted, was positive yet limited, moderate, and uneven impacts on classroom practices.

The reason for these strategic choices across the SSIs can be traced to a number of factors. First, the SSIs drew their leadership primarily from the ranks of professional mathematics and science education reformers. These were individuals who understood mathematics and science well, understood what good classroom practice looked like, and had experience helping teachers to implement the kinds of practices envisioned by the SSIs. Although there were exceptions, they were typically less astute at manipulating the political system or working with issues of public relations. Second, the SSIs generally focused on components of the system where there were reasonably well established strategies for achieving success. By the early 1990s, the field of education knew how to provide good professional development, for example. Policy-makers in the U.S. also knew how to develop coherent visions of good practice—given the existence of the NCTM *Standards*, *Benchmarks for Science Literacy*, and the draft *National Science Education Standards*. In contrast, there was a much less well-established empirical basis for improving other components, such as designing effective incentive systems. Third, there was increasing pressure to justify the large NSF expenditures—pressures to demonstrate impacts on classrooms and on student achievement. Finally, the SSIs' leadership recognized the political quagmire represented by efforts to reform certain pieces of the system, such as incentive structures for teachers or teacher certification and recertification policies.

In summary, then, the strategic choices of the SSIs made reasonable sense. They focused on what was familiar, what they understood would be effective, what would have a payoff in the medium term, and what would be politically acceptable.

Variation across the SSIs. These conclusions are based on an analysis of the SSIs as a whole. However, the second point to be drawn from the analysis is that when one looks at the states individually, there was substantial variation across SSIs in the degree to which they focused on specific components of the system—even considering the almost universal attention paid to issues such as standards development and professional development for teachers. No SSI focused on only one of the system components, although a few were fairly narrowly focused in a few areas. Nearly all the SSIs crafted a reform plan that targeted multiple components (typically four or more), either simultaneously or over the course of the 5-year period covered by the national evaluation.[11] The number of strategies used by the SSIs demonstrates that most SSI leaders understood that systemic reform required movement on many fronts.

As noted in Section II, any SSI's individual strategies need to be examined in light of the state reform context in which the SSI was planned and implemented. Some SSIs were comprehensive and played the lead role for the reform of mathematics and science in a state.[12] Others

[11] Note that some SSIs, such as Connecticut, established time frames early in their history that extended far beyond 5 years.

[12] For purposes of this discussion, comprehensiveness is defined by the number of strategies the SSI employed, the extent to which it

were comprehensive within the area of mathematics and science education reform and were, in addition, integrated into an even more embracing state reform effort. A third group supplemented broader state reforms through a fairly narrow range of SSI strategies. Finally, some SSIs were both narrowly focused and fairly isolated from other reform agendas in a state. Exhibit 21 below shows the distribution of the states by degree of comprehensiveness of the effort and their relationship to broader reforms.

An SSI's placement in any one of these cells does not in and of itself signify anything about the success of the initiative. For example, both Montana's and Ohio's SSIs did an excellent job of carrying out their relatively narrowly focused strategies, and both were able to demonstrate positive impacts on classroom practice and student learning.

Identifying successful SSIs. In other words, both Montana and Ohio accomplished a great many of the goals they established for their SSIs. From this perspective, they were successful initiatives, characterized by clear visions, strong and realistic strategies for implementing that vision in classrooms, a high degree of quality control, and clear evidence of impacts. However, as shown in Exhibit 21, both SSIs had a relatively narrow focus.

This thinking leads to one reasonable definition of "success" for the SSIs, based on two criteria: (1) establishing ambitious, comprehensive plans for systemic reform and (2) carrying out those plans effectively, with significant impact. The most successful SSIs were those that earned high marks on both criteria. The least successful were those that did poorly on both criteria or very poorly on either one. Those SSIs shown in Exhibit 21 in the row labeled "comprehensive" were attempting to meet criterion 1, but not all of them made significant progress toward meeting their goals.

At the high end of the success continuum were states that had a comprehensive, multi-faceted approach, were able to use and leverage the NSF dollars especially well, and thus were, in fact, able to affect many components of their education systems in important ways. Puerto Rico stands as the best example of this type of SSI. A university-based initiative, the PR-SSI carefully attended to all aspects of the theory of systemic reform. It developed and implemented curriculum, supported model schools in whole-school change efforts, provided intensive professional development for teachers, and engaged parental interest in school change. In contrast to most other SSIs, Puerto Rico also allocated substantial resources to evaluation, including student assessment, in order to document the outcomes of the initiative.

Although the PR-SSI focused on demonstrating standards-based reform in a small number of schools from the outset, it simultaneously sought to make an impression on the larger education system. Through its model school sites, the PR-SSI took the lead in establishing a new vision for mathematics and science education that it hoped would influence the leaders of the larger system. Over time, the Commonwealth Department of Education has become a partner in the systemic reform effort, and the governor has also become a supporter. The SSI has thus built, by example, a receptiveness to educational change and improvement in the professional community.

One of the greatest strengths of the PR-SSI may be its carefully designed, coordinated approach to scaling up its vision. Schools that participated early in intensive professional development and piloting of the new curriculum have been designated Regional Dissemination Centers (RDCs). The RDC training teams, in conjunction with staff of the SSI and the Department of Education, provide sustained professional development and other kinds of support for up to 10 schools in their regions with less experience in implementing the reforms. This is a model that presumably could continue to expand until most schools on the island have been reached.

---

focused on both science and mathematics, and its reach across many grade levels.

Exhibit 21

THE COMPREHENSIVENESS AND CONNECTEDNESS OF THE SSIs

Focus	Lead Role	Integrated into a Broader State Initiative	Stand-alone Initiatives
Comprehensive	LA, NM, PR	AR, CO, CT, DE, KY, MA, ME, MI, SC, VT	
Narrow		CA, FL, NJ, TX, VA	GA, MT, NE, NY, NC, OH, SD

In contrast, the least successful SSIs, from this perspective, included a group with poor implementation strategies, little quality control, and weak management. This group is made up of the states defunded by NSF (Rhode Island, Florida, Virginia, and North Carolina). SSIs with designs that were narrowly focused (as shown in Exhibit 21) and that, in addition, experienced implementation, quality control, or management problems also fall into the category of the least successful of the SSIs. New York provides an example. The focus of New York's SSI on a very small group of "R&D" schools (fewer than a dozen over most of the life of the SSI) made it difficult to fit the initiative within any definition of systemic reform. Yet, in spite of the narrow focus, the R&D schools did not receive adequate resources (nearly every one lacked modern computers, for example), and over 5 years most experienced modest progress, at best.

On the success continuum, about half of the SSIs fell somewhere in the middle. These were the states with more narrow foci than the most ambitious SSIs, but which accomplished most of their goals, plus those SSIs that had comprehensive goals and significant, but less than complete, success in implementing their plans.

California provides an example of an SSI that accomplished many of its goals but did not have a comprehensive focus. Both of the SSI's teacher networks (the California Science Implementation Network and Mathematics Renaissance) reached thousands of teachers, had demonstrable impacts on classroom practice, and were able to sustain themselves after the SSI ended, leaving an infrastructure in place to support continued change in practice. At the same time, California's SSI fell far short of its goals in other areas, such as efforts to mobilize public opinion. The initiative was also undermined by political shifts within the state that it was unable to influence and that resulted in changes in policy very different from what the SSI wanted.

Arkansas provides an example of an SSI with ambitious and comprehensive goals but less than complete success in reaching those goals. Although Arkansas used most of its SSI resources for teacher professional development, it also developed greater leadership capacity in the state, participated in the revision of policies concerning teacher preparation and certification, and worked with faculty in institutions of higher education to a greater extent than most SSIs. The SSI helped to change the way that mathematics and science are taught in Arkansas, particularly in elementary schools; however, many teachers still need additional assistance. Whether the SSI can sustain momentum in the face of political changes, scale up to include most or all mathematics and science teachers in the state, and find resources to continue capacity building on a large scale is unknown.

In summary, individual SSIs provided numerous examples of impressive reform efforts. Some of these were more narrowly focused, whereas a few approached the model of systemic reform outlined earlier.

Adding it up. As useful as these examples are to demonstrate success, they also show the significant challenges faced by reformers. Success implies that an SSI must have set very ambitious goals and also have been able to overcome the inevitable problems associated with management, implementation, quality control,

and, often, political change. Earlier discussion focused on continuing problems associated with successfully changing certain components of the system (such as building professional and public support and changing the incentive system to motivate teachers and administrators to undertake the hard work of change). Viewed either by component or by SSI, it is clear that there was a wide variation in the degree of success.

The question remains: did the SSIs succeed in carrying out systemic reform as it was outlined in the introductory section of this report? If all components of the education system (e.g., as shown in Exhibit 20) must have changed significantly for the better, or if all SSIs must have succeeded, then the answer is no. However, if modest progress to improve many components of the education system or if significant impacts in many SSIs constitutes success for the program, then the answer is yes.

The theory of systemic reform. This assessment assumes that there is an understanding of what systemic reform really means. Does the model of systemic reform make sense? Members of the evaluation team found that the model of systemic reform did, in fact, provide appropriate categories by which to describe, analyze, and assess the activities of the SSIs. In a sense, that is not surprising, because the SSI program established expectations about how the funds would be spent. However, NSF provided states with a great deal of discretion (which is one reason why SSIs varied so much in what they supported), and one might have found a serious mismatch between the model that was developed on the basis of NSF's program announcement and the actual activities conducted by the states. NSF's program announcement stimulated reforms that were, in aggregate, very comprehensive.

However, in terms of the theory of systemic reform, one might conclude that scale is one of the weak points of the theory. The amount of resources required and the time scale needed for system improvements to be reflected in tens and hundreds of thousands of classrooms across the United States are very large. Making this statement is not a reflection on the SSI program, per se, which accomplished a great deal, particularly for a relatively small federal program. Overall, the SSIs did a good job of establishing a vision for reform and building infrastructure to provide human and material support to schools—both of which are essential in scaling up. However, on some other key tasks required for scaling up, such as changing incentive structures for educators and building public support, the SSIs did not do nearly as well. Although some recent work has been done on theories of scaling up in education systems (Elmore, 1996), this remains a difficult and unsolved issue facing states.

Program Innovations

The accomplishments of the SSI program were in part an outgrowth of the unique way in which NSF decided to administer the program. Indeed, as has been noted in the introduction to this report, the SSI program represented a departure from past practices in numerous ways.

First, the size of the awards (up to $10 million) was unusually large for a competitive, discretionary awards program. Most federal education awards of that size had previously been associated with formula grant programs.

Second, each state was effectively limited to a maximum of a single application in any one of the three SSI cohort competitions (1991 – 1993), because each proposal had to have the backing of the governor and other high state officials.

Third, the instrument used to make each award was not a grant (NSF's typical way of awarding funds) but a cooperative agreement. Although cooperative agreements had been used by federal agencies on limited occasions for many years, it was unusual for NSF to design an entire program around cooperative agreements. The written agreements with each awardee specifically gave NSF an active role in making decisions about the course of each SSI.

Finally, before the SSI program, NSF discretionary grants were awarded mainly to institutions of higher education, museums and other independent nonprofit organizations, or school districts. For the SSI program, many of the awards were made to state agencies, and all of them were for promoting statewide reform, a far larger scope of work than usual.

The reason for these unusual features of the SSI program was clear. NSF's goal of having states simultaneously change or "restructure" many components of their education systems was ambitious, had never been tried before, and called for a special kind of program with distinctive features. Those features of the program should be considered in any examination of the nature and contributions of the SSI program as a federal strategy.

As an example of NSF's more active role in administering the SSIs, the Foundation instituted a series of "midpoint reviews" for each of the three SSI cohorts. Those reviews, which involved a panel of external experts convened to consider several days of written and oral presentations by the SSIs, provided NSF with another opportunity to take actions to influence those SSIs that the experts found needed help or reconsideration. SSIs quickly became aware of the fact that the midpoint reviews could have significant consequences. As a result, some of the SSIs arranged to rehearse their oral presentations in front of a different panel of experts or took other steps to prepare for the review.

Accompanying NSF's greater-than-usual involvement in the SSI awards was a set of support activities designed to provide these unique, challenging projects with special assistance. For example, NSF awarded a technical assistance contract to Education Development Center[13] that enabled states to call on expert consultants for help, as needed (including help preparing for the midpoint reviews). The technical assistance contractor also established an electronic mail system (which, for many states' SSI staff members, was the first encounter with that technology) and provided various other services. In addition, NSF invited the principal investigators (PIs) and other SSI leaders to meet twice yearly in the Washington, DC, area (with logistical and planning support provided by the technical assistance contractor). These meetings provided an opportunity for the exchange of information about the program and about statewide systemic reform more generally. Other program support activities included the evaluation contract with SRI International and its partners—which, among other products, resulted in a series of reports often discussed by PIs at the Washington meetings—and a monitoring contract with Abt Associates designed to supply NSF with frequent and rapid feedback about the status of each SSI.

One outcome of the more intensive federal involvement and scrutiny was that 4 of the 26 SSIs were terminated by NSF before their full terms had expired. SSIs in Florida, North Carolina, Rhode Island, and Virginia were concluded before expending funds up to the initial ceiling set in their cooperative agreement and before the full term of the award. NSF's judgment was that each of these SSIs had flaws that could not easily be remedied. Some of these flaws were related to NSF's view that an SSI was managing its funds poorly; others were linked to perceived deficiencies in the overall plan for systemic reform. Administrators of the program at NSF probably viewed the cooperative agreement as an advantageous funding mechanism in these cases, because it provided the agency with such a clear role in reviewing the SSIs and making decisions to terminate funding.

Key Issues in Program Administration

NSF's innovations in designing and administering the SSI program brought a number of issues to the forefront as the program evolved. This was not "business as usual" at NSF; the SSI program presented a unique set of challenges.

The cooperative-agreement mechanism itself was the source of some of these challenges. At the same time that they offered the agency greater participation in the SSIs, including an important role in making the SSIs accountable for their designs and accomplishments, the cooperative agreements placed on NSF staff significant time burdens and the need to exercise expert judgment about a host of different issues, ranging from the effectiveness of certain SSI management structures and personnel to programmatic decisions about many specific components of the SSIs. For example, NSF staff ended up "signing off" on a number of individual personnel decisions made by the SSIs, and, in a number of states, NSF required that new staff be hired to act as coordinators of the many NSF-supported projects being conducted throughout the state. In some cases, NSF also insisted on substantial

[13] In 1995, Westat succeeded EDC as the provider of technical assistance.

changes in the nature of the SSI-supported activities, such as the requirement to add a focus on science education in both the Montana and Nebraska SSIs—not just a focus on mathematics education, as had been the case during their first year of operation.

The greater involvement of the agency in the substance of the SSIs also brought to light the importance of continuity and consistency in administration. Turnover in NSF staff meant that some SSIs had as many as seven NSF program officers during the course of a 5-year award, which was difficult for those SSIs, and quite possibly for some of the program officers. NSF required the SSIs to report annually on their progress, sometimes at length; to provide uniform data to the agency, and to prepare a written report for their midpoint review. The nature of these requirements changed and evolved over time. The relationship between the SSI awards and other NSF programs and awards also evolved, with some NSF programs, but not others, requesting applicants to coordinate in particular ways with the SSI in that state. These and other features of the program's administration raised concerns in a number of the SSIs about the unpredictability of working with NSF as a partner in systemic reform.

In light of experiences such as these, it is evident that the use of cooperative agreements had both advantages and disadvantages. An assessment of the accomplishments of the program (reported in the preceding section), together with a consideration of its unique administrative structure, leads to the following reflections about the SSI program as a strategy for improving mathematics and science education.

Lessons Learned

The SSI program has been a valuable testbed for standards-based systemic reform. A variety of lessons have been learned that may be useful to state and federal policy-makers.

Lessons Learned about State Education Strategies

A host of lessons about improving state education systems have come out of the SSI program. For example, each of the 12 case studies of SSIs highlights certain lessons drawn from the experience of the particular state in question. (See the appendix to this report.) Some of the most important lessons for state policy-makers are discussed below.

No "one best way." The wide variation in the way that the SSIs conducted systemic reform is discussed in Section II (and further illustrated in the appendix.) This variation makes sense, considering that the approach adopted by any state ought to depend on the political culture, what the state has or has not yet accomplished with respect to reform, the key leverage points within the system, and the resources available relative to the size of the problem. It is important, however, for systemic reformers to ground their approaches in the best information that prior research and experience can provide.

Target multiple points of the system. The evidence suggests that the underlying premise of standards-based, systemic reform is correct, namely, that education system components should be aligned with each other and with ambitious goals for what students should know and be able to do. Thus systemic reform means paying attention not only to state curriculum frameworks and other policy documents, but also to local, regional, and state infrastructures and the capacity of educators to implement reform. Both "top-down" and "bottom-up" strategies are important and should be carefully designed to support each other.

Local control need not be a barrier. The theory of systemic reform was based largely on the experience of states with strong central-control traditions. On the basis of experiences of the SSIs, it turns out that a state tradition of local control does not have to be a barrier to systemic reform, but local-control states require a different approach than others. Maine, Montana, and Nebraska are examples of local-control states that accomplished a great deal under the SSI program. However, they worked within their existing political cultures, and, slowly, change has occurred. For example, state curriculum frameworks began to emerge in Montana only near the end of its SSI, whereas those documents were often starting points in other states, like California. In 1998, Nebraska—which has never had statewide assessment of student achievement—is considering a legislative bill that would require testing at certain grade levels.

The importance of leadership and vision. At the top, in the middle, and at the bottom of the system, good strategic thinkers are scarce but vital. The SSI program helped build leadership capacity in many states, and this may be one of its enduring legacies. Having some strategic thinkers on board in the early days contributed to the robustness of a state's vision for systemic reform, but the strategies employed to increase the number of leaders are the more important determinants for taking the SSIs to scale.

Quality control. Without strong quality control mechanisms, leaders of statewide reform initiatives cannot be sure what will be implemented at the local level. The challenge is how to exert quality control when an SSI, or any state reform initiative, is several steps removed from the classroom. Mechanisms observed included quite specific written documents (frameworks and other policy documents outlining the state's vision for the improvement of mathematics and science education) and support for on-site staff in demonstration sites. Several SSIs did a good job with this issue, but it is unclear whether the mechanisms that they employed can be sustained when federal money disappears. A further concern is that large-population states have more difficulty in this area than the small-population states that tend to dominate the success stories among the SSIs.

Keeping track of progress. Although the process has sometimes been painful, NSF has been insistent that the SSI states must provide data to document their progress (or lack of it). The SSI program made a big public investment in mathematics and science reform. Both the funder and the public have a right to examine the scale of what was accomplished. Along the way, a number of states have learned a good deal about the need for improvement in existing data sources in order to answer many important evaluative questions. In addition, some states have learned important lessons about the usefulness of data for examining and adjusting reform strategies. Although some states resented and resisted NSF's focus on accountability, others adapted the agency's approach in working with their own local demonstration sites.

Going to scale. States—especially large-population states—have not yet found adequate resources or strategies to work with teachers, schools, or districts representing different levels of sophistication about standards-based reforms in a systematic fashion. Indeed, simply finding the resources for ongoing, high-quality professional development for all the teachers who need it is a great challenge. In response, many states are building or improving different kinds of infrastructures to sustain long-term change: for example, teacher networks, regional centers, and technological delivery systems. However, some states do not yet have a viable plan for scaling up even as their SSI funding is coming to an end. In these cases, there are serious questions about how the work of the SSI will be sustained and whether successful components will become institutionalized.

Coordination of multiple reforms. Successful SSIs took advantage of other promising reform efforts that were under way in their states. Conversely, some SSIs that didn't fare well seemed to work at cross-purposes with other initiatives in the state. Harnessing existing resources at the school, district and state levels can be done (as in Connecticut and Maine), but inventorying resources in large states is a major challenge. A number of states have been moderately successful in leveraging resources beyond the SSI funding, but much more could and should be accomplished in this area before reforms can be called fully systemic.

Equity: a challenging goal. Some of the greatest challenges to improving mathematics and science education lie in poor urban and rural areas or are associated with students historically underrepresented in mathematics and science, such as members of non-Asian minority groups. Nearly all the SSIs addressed these concerns in some way, and some of them were able to show reductions in achievement gaps between groups of students. Leaders of the SSIs acknowledge, however, that there is a long way to go in changing the belief systems of educators and the public about the ability of **all** students to learn rigorous mathematics and science content.

Lessons Learned about Federal Education Strategy

More than 8 years have passed since the SSI program was first announced, and a majority of the 26 SSIs that were funded by NSF have completed their work under the auspices of the

program. In the meantime, federal programs and federal agency strategies for improving education have changed in significant ways. Interestingly, a number of lessons that have been learned from the SSI program are already reflected in current federal strategies for education improvement. These are discussed below.

Clear and ambitious education standards. Interest in education standards has remained high in nearly all states (Blank et al., 1997; Massell et al., 1997). Many federal programs and activities have also focused on the importance of education standards. One good example is the U.S. Department of Education's Eisenhower Curriculum Frameworks program, which has helped 15 states and the District of Columbia to develop new or improved frameworks in mathematics or science education, or both (Humphrey et al., 1997). However, simply having standards is not enough. Successful SSIs paid attention to legitimating the vision that their standards represent by engaging policy-makers, practitioners, and the public in a deeper understanding of what the standards mean. Doing so required SSIs to maintain a hands-on approach during both the standards development and standards implementation processes.

The time that is needed. Having seen that even the most successful SSIs were not able to complete systemic reform in 5 years, NSF encouraged the existing SSIs to apply for new awards to continue their activities. To date, six SSIs have been provided with new 5-year awards: Connecticut and Louisiana, from Cohort 1; and Massachusetts, Puerto Rico, Texas and Vermont, from Cohort 2. Some other states that have already completed the 5-year SSI cycle have found ways to continue their work with state or foundation funding. Other federal funding, such as the U.S. Department of Education's Title I and Eisenhower Professional Development programs also provide funding for long-term improvement activities in the states. However, the process of institutionalizing and sustaining the momentum built up by the SSIs has just begun and is, so far, undocumented. Previous research about the diffusion of innovations (Rogers and Shoemaker, 1971), suggests that widespread adoption of innovations may take up to 25 years.

The role of school districts. Although, by law, the states are the unit of government responsible for ensuring that education is available to all citizens, the role of school districts is critical and must not be ignored. At NSF, SSI was the first systemic initiative program, but not the last. There are now 20 Urban Systemic Initiatives working in some of the nation's largest urban districts. In addition, 17 midsized cities received Comprehensive Partnerships for Mathematics and Science Achievement awards, which are also systemic in nature, and 4 rural regions have Rural Systemic Initiatives. Although the urban districts in particular serve a high proportion of the nation's children (especially its poor children of color), there are 15,000 school districts in the United States and 87,000 schools. Going to scale with standards-based reform requires states, districts, and schools to work together.

Changing certain components of state education systems. Changing state assessment systems, for example, has been slow work in most states, because it is fraught with both technical and political challenges and is expensive. To speed up the process, both NSF and the U.S. Department of Education initiated grant programs focusing particularly on improving large-scale assessments of students' learning. Similarly, improving teacher education is a massive, difficult undertaking. NSF created a separate, new program, Collaboratives for Excellence in Teacher Preparation, to improve preservice teacher preparation programs in selected states. The federal government, in effect, is working to help states "fill gaps" in reforming certain components of their education systems.

Mathematics and science content knowledge. The SSI program, to its credit, has constantly emphasized the importance of selecting appropriate materials and teaching science and mathematics well. As a result, the SSIs themselves have involved many experts in mathematics and science education as professional developers, curriculum developers, and advisors. Other federal programs are also focusing states' attention on the importance to education reform of a sophisticated understanding of content knowledge. For example, the Eisenhower Regional Consortia program has funded additional mathematics and science technical assistance for educators in states, districts, and schools. The success of all combined efforts to improve student achievement in mathematics and science depends on the capacity of individual teachers themselves to thoroughly understand what they must teach students. Keeping the focus of all reform efforts on teaching and learning is critical and requires vigilance at all levels of the system.

Capacity building. In the end, the most important accomplishment of the SSI program has been its contributions to building the capacity of individuals and organizations that can provide the nation's children with world-class mathematics and science education. Building this capacity took different forms in different states (e.g., teacher networks, new regional assistance centers, a technology infrastructure, or improved procedures for selecting instructional materials), but, in any event, it required well-conceived strategies appropriate to the state context. Since the SSI program was initiated, much important federal education policy (e.g, the Improving America's Schools Act, Goals 2000) has become aligned with NSF's governing vision for mathematics and science reform. The changes that have taken place in federal education strategy reflect a unanimity of purpose across the political spectrum to raise educational standards and develop the capacity of educators and schools to serve all students well.

As noted earlier, the timing of the SSI program was excellent. The program has helped propel standards-based reform forward and has contributed, at least in a small way, to increasing student achievement in science and mathematics. The program will be progressively less active as the remaining SSIs (and perhaps a few Cohort 3 continuations) complete their work. However, federal education policy has already built on and extended the program's many achievements, and in many of the SSI states, structures are in place to continue the progress under other auspices.

An Overall Assessment of the SSI Program as a Federal Strategy

The SSI program has provided a substantial contribution to standards-based, systemic reform. The benefits of the program, which cost roughly $50 million each year, have been greater than one would have expected simply on the basis of its size.[14] The federal investment has stimulated a large number of different, coordinated, and valuable education improvement efforts. The program has affected tens of thousands of classrooms directly and many more indirectly (e.g., through changes in state policies).

The SSI program has also been a valuable testbed for the concept of standards-based, systemic reform. Some of what has been learned through the program is very positive, such as the important role that nongovernmental, nonprofit institutions can play in improving education. Other lessons are not as positive, such as learning how difficult it has been in some states to reach a consensus about education goals and to develop new standards or frameworks based on those goals. Overall, the program has provided many useful lessons about carrying out reform.

One of the contributing factors that helped the SSI program make a substantial contribution to standards-based, systemic reform was timing. The program began not long after the National Council of Teachers of Mathematics (NCTM) published its *Curriculum and Evaluation Standards for School Mathematics*. In 1993, just as the third cohort of SSIs began, the American Association for the Advancement of Science published *Benchmarks for Science Literacy* (having published *Science for All Americans* in 1989). By the end of 1995, the National Research Council completed the

[14] By comparison, from 1991 through 1996 the annual federal investment in the Eisenhower Professional Development program was about $250 million, and the Title I program cost about $7 billion per year.

National Science Education Standards. In other words, the SSI program was well timed to take advantage of the rapidly growing interest in mathematics and science education standards.[15] Without exception, the SSIs paid close attention to, and made good use of, the mathematics and science education standards developed by these three organizations.

Nonetheless, a number of important problems inherent in the idea of systemic reform remain unsolved despite the SSI program. Within SSI states, for example, there has been a limited amount of "scale-up," and, as a result, only a fraction of all mathematics and science teachers (and students) have been directly affected by the SSIs. Some key system components (such as the programs and policies affecting the preparation of new teachers, as well as incentive systems for educators), have been relatively unaffected by the program. Given a limited amount of resources, it was inevitable that SSIs would need to be selective in their work. Nonetheless, neither researchers nor policy-makers can yet say how it will be possible for states to dramatically increase the scale of their efforts, or how they might improve and align *all* the key system components—except to suggest that change is a long-term proposition.[16]

Because of its innovative features, the SSI program was something of a bold experiment. Although this experiment has been a valuable one, there are two aspects of the program in particular that have been problematic.

First, NSF made the decision to fund all the SSIs at nearly the same level, namely, about $10 million over 5 years. Although the student populations in the SSI states varied by a factor of about 50 (5.4 million public school students in California, compared with fewer than 100,000 in Vermont), the amount of funding provided by NSF did not depend on the number of students in the state, the state's education budget, or similar factors. As a result, given states with equally well-developed SSI strategies and strong management teams, we found that the low-population states had an advantage in "scaling up" their reform efforts, compared with the high-population states. It is true that some low-population states, such as Rhode Island, were not able to design and carry out a set of effective systemic reform strategies, and thus did not reap much benefit from the SSI program. Being a low-population state was not a *guarantee* of success. However, those low-population states that were able to use the funds well, such as Montana and Vermont, were able to reach much higher fractions of eligible teachers and students than high-population states.

Second, the use of cooperative agreements presented NSF and the SSIs with a real dilemma. On the one hand, there was a general acknowledgment of the fact that, because the awards were discretionary, NSF had a legitimate role to play in monitoring the nature and quality of the SSIs. This oversight role resulted in active decision-making by NSF about many SSIs. On the other hand, there were also many participants, both in states and in the federal government, who questioned whether NSF had sufficient time and expertise to become deeply involved in making decisions about so many issues involving the design, management, conduct, and monitoring of the 26 SSIs, each with its own set of state traditions and norms that needed to be understood in order to make sound decisions. In short, whereas the reason for using cooperative agreements in the first place is clear, the success of that strategy is less clear.

[15] Even though the science standards were not completed until 1995, the general direction that they would take was clear to many people much earlier, in part because drafts of the standards were circulated widely several years before the final version was published.

[16] A number of measures (e.g., NAEP scores) indicate that education outcomes have steadily improved in mathematics and science in recent years, so suggesting that future systemic reform efforts will continue to pay off seems both reasonable and useful counsel.

On balance, however, the SSI program has been a remarkable partnership between federal and state agencies that helped jump-start—and certainly enriched—what is now a national movement toward standards-based reform of K-12 mathematics and science education. In the process, it has created and strengthened not only within-state infrastructure and leadership for reform but also a large interstate network of strategic thinkers who will continue to share ideas and move forward with creative solutions to tough problems. This is no small accomplishment, and, in the process, many have learned much.

References*

*Adelman, N. E., Shields, P. M., Goertz, M. E., Zucker, A. A., and Corcoran, T. B. (1998). *Doing Systemic Reform: The Experiences of the SSI States*. Menlo Park, CA: SRI International.

Adelman, N. E., and Walking Eagle, K. P. (1997). Teachers, time, and school reform. In A. Hargreaves (Ed.), *Rethinking Educational Change with Heart and Mind: 1997 ASCD Yearbook*. Alexandria, VA: Association for Supervision and Curriculum Development.

Blank, R. K., Langesen, D., Bush, M., Sardina, S., Pechman, E., and Goldstein, D. (1997). *Mathematics and Science Content Standards and Curriculum Frameworks: States' Progress on Development and Implementation*. Washington, DC: Council of Chief State School Officers.

Blank, R. K., Hemphill, C., Sardina, S. L., Langesen, D., and Braithwaite, B. (1995). *State Education Policies on K-12 Curriculum, Student Assessment, and Teacher Certification: 1995*. Washington, DC: Council of Chief State School Officers.

*Breckenridge, J. S., Goldstein, D. S., and Zucker, A. A. (1996). *The Impact on Students of the SSI Program: A Pilot Study of the Impacts of the Louisiana and Montana SSIs (draft)*. Menlo Park, CA: SRI International.

Clune, W. H. (1993). The best path to systemic educational policy: Standard/centralized or differentiated/decentralized? *Educational Evaluation and Policy Analysis*, *3*(15), 233-254.

Cohen, D. K., and Hill, H. C. (1998, January). *CPRE Policy Briefs. State Policy and Classroom Performance: Mathematics Reform in California*. Philadelphia: Consortium for Policy Research in Education.

*Consortium for Policy Research in Education. (1995, May). *CPRE Policy Briefs. Reforming Science, Mathematics, and Technology Education: NSF's State Systemic Initiatives.* New Brunswick, NJ: Rutgers (CPRE).

*Consortium for Policy Research in Education. (1995, July). *CPRE Policy Briefs. Tracking Student Achievement in Science and Math: The Promise of State Assessment Systems*. New Brunswick, NJ: Rutgers (CPRE).

*Corcoran, T. B., Shields, P. M., and Zucker, A. A. (1998). *Evaluation of NSF's Statewide Systemic Initiatives (SSI) Program: The SSIs and Professional Development for Teachers*. Menlo Park, CA: SRI International.

CSMEE (Center for Science, Mathematics, and Engineering Education, National Research Council). (1998). *Every Child a Scientist: Achieving Scientific Literacy for All*. Washington, DC: National Academy Press.

Darling-Hammond, L. H. (1996). Teaching and knowledge. In J. Sikula (Ed.), *Handbook of Research on Teacher Education* (2nd ed.). New York: Association of Teacher Educators.

David, J. (1990). *Results in Education: State Actions to Restructure Schools: First Steps*. Washington, DC: National Governors' Association.

* Publications produced as part of the evaluation of NSF's Statewide Systemic Initiatives program are marked with an asterisk.

David, J. L., Shields, P. M., Young, V. M., Glenn, B. C., and Humphrey, D. C. (1997, October). *Pew Network for Standards-Based Systemic Reform: Year One Evaluation Report*. Menlo Park, CA: SRI International.

Elmore, R. F. (1996). Getting to scale with good educational practice. *Harvard Educational Review, 66*(1), 1-26.

Elmore, R. F., and Associates. (1990). *Restructuring Schools: The Next Generation of Educational Reform*. San Francisco: Jossey-Bass.

Fuhrman, S. H., and Massell, D. (1992). *Issues and Strategies in Systemic Reform*. New Brunswick, NJ*:* CPRE (Rutgers).

Fuhrman, S. H. (1997). *What Has Been Learned about Systemic Reform?* Madison, WI*:* National Institute for Science Education.

Fullan, M. G. (1996, February). Turning systemic thinking on its head. *Phi Delta Kappan, 77*(6), 420-423.

Humphrey, D.C., and Shields, P.M. (1996). *A Review of Mathematics and Science Curriculum Frameworks.* Menlo Park, CA: SRI International.

Humphrey, D. C., Anderson, L., Marsh, J., Marder, C., and Shields, P. M. (1997). *Eisenhower Mathematics and Science State Curriculum Frameworks Projects: Final Evaluation Report.* Menlo Park, CA*:* SRI International.

Knapp, M. S., and Associates. (1995). *Teaching for Meaning in High-Poverty Classrooms*. New York*:* Teachers College Press.

Knapp, M. S. (1996). *Between Systemic Reforms and the Mathematics and Science Classroom*. Madison, WI*:* National Institute for Science Education.

*Laguarda, K. G., Breckenridge, J. S., and Hightower, A. M. (1994). *Assessment Programs in the Statewide Systemic Initiatives (SSI) States: Using Student Achievement Data to Evaluate the SSI*. Washington, DC*:* Policy Studies Associates.

*Laguarda, K. G., (1998). *Assessing the SSIs' Impacts on Student Achievement: An Imperfect Science*. Menlo Park, CA: SRI International.

Little, J. W., et al. (1987). *Staff Development in California*. San Francisco, CA: Far West Laboratory.

Massell, D., Kirst, M., and Hoppe, M. (1997). *CPRE Policy Briefs. Persistence and Change: Standards-Based Systemic Reform in Nine States.* Philadelphia*:* University of Pennsylvania (Consortium for Policy Research in Education).

National Commission on Teaching and America's Future. (1996). *What Matters Most: Teaching for America's Future*. New York*:* Author.

National Council of Teachers of Mathematics. (1989). *Curriculum and Evaluation Standards for School Mathematics*. Reston, VA*:* Author.

National Council of Teachers of Mathematics. (1993). *Professional Standards for Teaching Mathematics*. Reston, VA*:* Author.

National Council of Teachers of Mathematics. (1995). *Assessment Standards for School Mathematics*. Reston, VA*:* Author.

National Research Council. (1995). *National Science Education Standards*.

Washington, DC: National Academy Press.

National Science Foundation. (No date). *The National Science Foundation's Systemic Initiatives*. Arlington, VA: Author.

O'Day, J. A., and Smith, M. S. (1993). Systemic reform educational opportunity. In S. H. Fuhrman (Ed.), *Designing Coherent Education Policy: Improving the System* (pp. 250-312). San Francisco: Jossey-Bass.

Project 2061, American Association for the Advancement of Science. (1993). *Benchmarks for Science Literacy*. New York: Oxford University Press.

Purkey, S., and Smith, M. S. (1983). Effective schools: A review. *Elementary School Journal, 83*(4), 427-452.

Resnick, L. B. (1987). *Education and Learning to Think*. Washington, DC: National Academy Press.

Rogers, E. M., and Shoemaker, F. F. (1971). *Communication of Innovations: A Cross-Cultural Approach*. New York: Free Press.

*Shields, P. M., Corcoran, T. B., and Zucker, A. A. (1994). *Evaluation of the National Science Foundation's Statewide Systemic Initiatives (SSI) Program: First Year Report. Volume I: Technical Report*. Washington, DC: National Science Foundation.

Shields, P. M., and Knapp, M. S. (1997, December). The promise and limits of school-based reform. *Phi Delta Kappan*, pp. 288-294.

*Shields, P. M., Marsh, J. A., and Adelman, N. E. (1998). *Evaluation of NSF's Statewide Systemic Initiatives (SSI) Program: The SSIs' Impacts on Classroom Practice*. Menlo Park, CA: SRI International.

*Shields, P. M., Marsh, J. A., Marder, C., and Wilson, C. L. (1998). A case study of California's SSI (CAMS), 1992-1997. In P. M. Shields and A. A. Zucker (Eds.), *SSI Case Studies, Cohort 2: California, Kentucky, Maine, Michigan, Vermont, and Virginia*. Menlo Park, CA: SRI International.

*Shields, P. M., and Zucker, A. A. (Eds.). (1998). *SSI Case Studies, Cohort 2: California, Kentucky, Maine, Michigan, Vermont, and Virginia*. Menlo Park, CA: SRI International.

Smith, M., and O'Day, J. (1991). Systemic school reform. In S. Fuhrman and B. Malen (Eds.), *The Politics of Curriculum and Testing*. Bristol, PA: Falmer Press.

Spillane, J. P., & Thompson, C. L. (1997). Reconstructing conceptions of local capacity: The local education agency's capacity for ambitious instructional reform. *Educational Evaluation and Policy Analysis, 19*(2), 185-203.

Tharp, R., and Gallimore, R. (1989). *Rousing Minds to Life*. Oxford: Oxford University Press.

Vinovskis, M. A. (1996). An analysis of the concept and uses of systemic educational reform. *American Educational Research Journal, 33*(1), 53-85.

Zucker, A. A. (1997). *Reflections on State Efforts to Improve Mathematics and Science Education in Light of Findings from TIMSS*. Menlo Park, CA: SRI International.

*Zucker, A. A., Shields, P. M., Adelman, N., and Powell, J. (1995). *Evaluation of the National Science Foundation's Statewide Systemic Initiatives (SSI) Program:*

Second Year Report. Part I: Cross-Cutting Themes. Washington, DC: National Science Foundation.

*Zucker, A. A., and Shields, P. M. (Eds.). (1995). *Evaluation of the National Science Foundation's Statewide Systemic Initiatives (SSI) Program: Second-Year Case Studies: Connecticut, Delaware, and Montana*. Menlo Park, CA: SRI International.

*Zucker, A. A., and Shields, P. M. (1997). *SSI Strategies for Reform: Preliminary Findings from the Evaluation of NSF's SSI Program.* Menlo Park, CA*:* SRI International.

*Zucker, A. A., and Shields, P. M. (Eds.). (1998). *SSI Case Studies, Cohort 1: Connecticut, Delaware, Louisiana, and Montana*. Menlo Park, CA*:* SRI International.

*Zucker, A. A., and Shields, P. M. (Eds.). (1998). *SSI Case Studies, Cohort 3: Arkansas and New York.* Menlo Park, CA*:* SRI International.

Appendix*

SUMMARIES OF 12 SSI CASE STUDIES

---

* In addition to the 5 authors listed on the title page for this report, the following people contributed to the research and writing for the 12 SSI case studies:

Daniel C. Humphrey
Camille Marder
Julie A. Marsh
Barbara S. Matson
Choya L. Wilson
SRI International

Rebecca Carver (Stanford University)
Diane Massell (University of Pennsylvania)
Consortium for Policy Research in Education

John S. Breckenridge
David Goldstein
Kate Laguarda
Policy Studies Associates

SUMMARY OF CONNECTICUT'S SSI (CONNSTRUCT), 1991-1996

Implementation of the SSI. The goals of Connecticut's SSI (CONNSTRUCT) were to enhance the effectiveness of mathematics and science education in the state and to raise public awareness regarding the importance of mathematics, science, and technology education for all students. The foci of SSI activities were on: (1) building capacity to stimulate, support, and implement local reforms intended to improve academic outcomes, and (2) helping the state's neediest districts to develop effective strategies for professional development, instruction, and assessment in mathematics and science.

Desirous of developing a permanent, autonomous organization that could sustain reform efforts outside politics and despite possible reductions in federal funding, the SSI leadership created the Connecticut Academy for Education in Mathematics, Science, and Technology (the Academy). Chartered in 1992 by the state legislature, the Academy is a nonprofit organization that governs the CONNSTRUCT initiative and manages it jointly with the Connecticut Department of Education (CDE). The Academy assumed a leadership role in efforts to develop a statewide vision for mathematics and science education reform and mobilize the professional community to support the reform program.

Impacts of the SSI. A major objective of the SSI was to improve the quality of mathematics and science instruction in K-12 classrooms in the state's economically disadvantaged urban and rural districts. Survey results, coupled with school and district interviews, indicate that the impacts of new materials, technical assistance, and professional development that were provided through the SSI differed across the participating districts. Although teachers typically accepted the need for more active student learning and greater use of technology, their vision and implementation of good practice varied, as did their enthusiasm and willingness to participate in reform activities.

Closing the achievement gap between advantaged and disadvantaged students was likewise a key objective of the SSI. Initial steps toward achieving this goal were evidenced by growth in students' test scores on the statewide mathematics test between 1993 and 1997 in most of the 19 urban districts served by Connecticut's SSI. In more than half of these districts, test score growth surpassed the state average change.

Efforts to leverage additional funding, connect districts and schools with external resources such as museums and institutions of higher education, and build community awareness and support for education reform were generally successful. These efforts were dependent, however, on the availability of district and school leadership, commitment, and community resources. In those places where district administrators, school principals, and a critical mass of teachers were committed to reform, the districts and schools accessed outside resources and used them to change the way that mathematics and science were taught.

Reflections on the SSI in Connecticut. The Connecticut SSI's approach of mixing top-down and bottom-up strategies with "through the middle" mobilization of the profession fit the state's political traditions, resources, and institutional structure. The success of this strategy, however, was dependent on the willingness and capacity of participating districts and schools to identify their needs and use the networks and external resources sustained by the SSI to change curriculum and instruction in ways that would improve student performance. Because the Academy chose to invest heavily in districts overwhelmed with serious problems, few of the districts or schools had the capacity to take these steps. The award of continued funding from NSF for Phase 2 of CONNSTRUCT permits SSI leadership to address capacity issues by providing a more focused and structured approach with ongoing technical assistance to urban schools and school districts.

Exhibit A-1

PROGRESS OF THE CONNSTRUCT COMPONENTS

Component	Progress through Spring 1996
Connecticut Academy for Education in Mathematics, Science and Technology	The Academy developed a network of leaders committed to a common vision of science, mathematics, and technology education and enabled them to promote reforms. More than 75 percent of Connecticut's districts have staff who have been involved in the Academy.
High-need districts	Assistance was provided to 15 high-need districts and minority students via a competitive grants program that supported development and implementation of model elementary and middle grade mathematics and science curricula.
Higher education	To foster change in teacher education and undergraduate mathematics and science programs, grants were provided to redesign curricula and increase collaboration among liberal arts and education faculties and public school teachers. Five universities initiated 16 teacher education restructuring programs. Eight institutions instituted 28 co-teaching partnerships, in which K-12 and college faculty jointly taught content and pedagogy courses.
Community institutions	Originally, the focus of this component was on creating partnerships between science-rich institutions or community organizations and the public schools. Its most visible activities were popular Family Math and Family Science nights. The focus then shifted to instructional technology, in part because the science-rich institutions received an independent grant from NSF, and in part because of an urgent need for the state to develop a technology infrastructure.
Building public understanding	A statewide media effort was launched with help from newspapers, television and radio stations, and community organizations. In 1994, the Academy began an outreach effort in selected school districts.

SUMMARY OF DELAWARE'S SSI (PROJECT 21), 1991-1996

Implementation of the SSI. Delaware's SSI, Project 21, was designed to provide support for improved mathematics and science curriculum and instruction in 17 schools (34 after the midpoint review) known as New Directions Development Sites (NDDS). The state's overall standards-based reform agenda, covering all disciplinary areas, is known as New Directions for Education in Delaware. With assistance from mathematics, science, and school change specialists, the NDDS sites were charged with development of teaching and learning strategies that would allow students to achieve the state standards in mathematics and science. Perceived initially as basically a teacher enhancement project, Delaware's SSI encouraged classroom teachers to design curriculum units ("polished stones")—an approach that was discouraged by NSF after Delaware's midpoint review process. Instead, during the final years of the initiative, Project 21 staff turned to the review of existing, high-quality curriculum materials for which they developed profiles for posting to a Web site. In addition to its model school strategy, Project 21 supported summer professional development activities, invested resources in the development of curriculum frameworks for mathematics and science, and facilitated networking among mathematics and science educators in the state (see Exhibit A-2).

Impacts of the SSI. By the fifth year of the initiative, Delaware's SSI had involved 30 percent of the state's schools, 25 percent of its mathematics and science teachers, and more than 25 percent of its students. More than 475 teachers in the 34 model schools had participated in activities, including 360 who had attended one or more of the annual Professional Development Institutes. Only a handful of the NDDS schools had made significant, whole-school progress toward school change and reform of instruction. The lack of district support and administrative leadership within many of the schools contributed to the disappointing results of the model schools strategy, as did the inability of some SSI staff to shift their focus from technical assistance for individual teachers to support for overall school change. In April 1996, the Delaware SSI learned that it would not receive funding from NSF for another 5-year period.

Reflections on the SSI in Delaware. The legacy of Project 21 is not overt. Both the leadership and components of the initiative became embedded in the state's overall standards-based reform efforts. Nevertheless, participants credited Project 21 for its supportive role in Delaware's educational reform efforts, including provision of technical assistance to the NDDS schools, participation in the development of mathematics and science curriculum frameworks, and work on a future state assessment. Project 21 was likewise credited for its facilitation of linkages among initiatives at all levels of the education system that were working to achieve the same general goal: reform of mathematics and science teaching and learning in Delaware's classrooms.

Exhibit A-2

PROGRESS OF THE PROJECT 21 COMPONENTS

Component	Progress through Spring 1997
New Directions Development Schools (NDDS)	A group of 17 schools were selected via a proposal process to be recipients of technical assistance aimed at improving instruction and learning in mathematics and science. The original group of 17 schools was expanded to 34 after the NSF midpoint review process. By the fifth year, only a few of the schools had made progress toward curricular and instructional reform.
Technical assistance	Technical assistance providers in mathematics, science, and organizational change were supported by Project 21. Their services were available to the NDDS schools. Impact on the schools varied widely.
State curriculum frameworks commissions	Project 21 staff participated in development of draft frameworks in mathematics and science. The initiative coordinated the framework review process and supported involvement of external experts in revision of the framework.
Partnerships and collaboration	Project 21 developed and supported statewide Science and Mathematics Collaborators Groups designed to bring together all levels of the education system around standards-based reform.

SUMMARY OF LOUISIANA'S SSI (LASIP), 1991-1996

Implementation of the SSI. The basic goal of Louisiana's SSI was to promote standards-based reform of mathematics and science instruction at the classroom level so that all children in the state would graduate with the skills to pursue high-quality employment opportunities. The Louisiana Systemic Initiatives Program (LaSIP) was the lead organization for the state's SSI. As a new, independent organization with financial support and endorsement from the Louisiana Board of Regents and the state Board of Elementary and Secondary Education, LaSIP became the vehicle for establishing Louisiana's vision of high-quality mathematics and science education.

LaSIP's primary strategy for facilitating education reform was to provide professional development for classroom teachers of mathematics and science, primarily middle school teachers. Approximately 70 percent of LaSIP's resources were used to fund professional development projects in the form of summer institutes with academic-year follow-up. A competitive proposal process that included external review by boards of out-of-state experts was used to determine which projects were funded.

In addition to its intensive support for professional development, LaSIP was substantively involved in teacher preparation via another NSF-funded initiative, the Collaboratives for Excellence in Teacher Preparation, and in educational technology via grants from NSF and the U.S. Department of Education.

Impacts of the SSI. Over the course of 5 years, LaSIP was instrumental in facilitating increased cooperation among key leaders in Louisiana's K-16 educational policy arena. The SSI was also influential in coordinating statewide efforts to reform mathematics, science, and technology education via several federally funded initiatives, as noted above. Focused specifically on the professional development of teachers, LaSIP funded over 125 mathematics or science professional development projects involving more than 4,100 teacher participants from around the state. Anecdotal evidence indicates that participation in these institutes resulted in more positive attitudes toward mathematics and science education reform and increased involvement in teacher professional organizations. However, the degree to which LaSIP-prepared teachers were able to integrate the principles of reform into their classroom practice varied widely, as did the degree of support received from fellow teachers, administrators, and district personnel. Evidence also indicates that the initiative had a positive impact on student attitudes, behaviors, and learning. Students in classrooms of LaSIP-prepared teachers scored slightly higher on a statewide mathematics test than did non-LaSIP students. The LaSIP approach, however, was one of limited reach. The intervention was at the individual teacher level and not at the school or district level, thus limiting administrative and schoolwide support for any reform efforts.

Reflections on the SSI in Louisiana. LaSIP undertook an enormous challenge—the reform of an educational system that consistently ranked at or near the bottom nationally on numerous indicators of effectiveness and quality. Concluding that the most serious problem was a lack of capacity within the teaching workforce, LaSIP chose to dedicate the major portion of its resources to teacher professional development. This strategy, however, did not involve school principals and district administrators in any significant way. Isolated in their classrooms, LaSIP-prepared teachers lacked the support from administrators and colleagues necessary to effect significant reform of classroom teaching and learning. Without the benefit of active leadership from school and district administrators, efforts to change mathematics and science education were substantially diluted.

Exhibit A-3

PROGRESS OF THE LASIP COMPONENTS

Component	Progress through Spring 1997
Professional development for teachers	Approximately 70% of LaSIP's resources funded 129 professional development projects via Campus Renewal Grants. More than 4,100 teachers participated.
Teacher preparation	The Louisiana Collaborative for Excellence in the Preparation of Teachers (LaCEPT) was funded by NSF in June 1993 to address statewide reform of teacher preparation in mathematics and science. It was functionally an integral part of LaSIP.
Teacher certification	State guidelines for teacher assessment and requirements for certification were revised but are not compulsory because of state education budget cuts.
Curricula, curricular materials, and assessment	Funded by an Eisenhower grant, the Frameworks Project worked on developing both mathematics and science curriculum frameworks.
Evaluation	A comprehensive, ongoing evaluation includes classroom observations, attrition studies, collection of attitudinal data, and student outcome measures.
Education technology	A separate NSF grant funded development of a statewide educational technology plan. A Technology Challenge Grant was awarded in 1995 to extend the planning and develop pilot sites.
Information and dissemination	A nonaggressive approach via information packets, videos, and presentation materials was used at the local level.
Equity and diversity	The focus was on representation of minority teachers in the professional development workshops. LaSIP was also able to disaggregate student achievement data (e.g., by race).
Community partnerships	Regional Partnership Initiatives competed for grants of $64,000-$100,000 to encourage reform activities at the local level.

On the other hand, LaSIP's organizational independence and politically savvy leaders minimized interagency turf tensions, helped to balance the interests of various constituencies, and avoided bureaucratic inertia that might have otherwise undermined the well-intentioned reform efforts. Louisiana's progress toward the reform of science and mathematics education earned it continued funding from NSF.

SUMMARY OF MONTANA'S SSI (SIMMS), 1991-1996

Implementation of the SSI. Montana's SSI focused principally on reforming mathematics education in grades 9-12. The vision for high school mathematics was clear: integrated mathematics—meaning integration across mathematics topics, integration with other disciplines, and integration with technology. The revised curriculum developed by the SSI was significantly different from typical norms; for example, it required that full class sets of graphing calculators be available, as well as at least one powerful computer, loaded with mathematics software, for every four students.

The Montana SSI made substantial progress in meeting its goals (see Exhibit A-4). Six levels of the curriculum were tested and refined, and the first four were published for national distribution by Simon & Schuster Custom Publishing. The title of the curriculum series is *SIMMS/MCTM Integrated Mathematics: A Modeling Approach with Technology*. Importantly, institutions of higher education in Montana (as well as some outside the state) agreed to accept completion of 3 years of the new curriculum for entrance to college.

Through 1997, the state legislature made $3 million available for the awarding of technology grants to schools. More than two-thirds of the high schools in the state received one or more of the grants, and most of them also used the new mathematics curriculum with students. Because the technology is expensive, this program was an important element of implementing the new curriculum.

Hundreds of teachers participated in inservice professional development, during either the summer or an academic year. The inservice was offered at multiple sites, and most of the summer sessions were 3 to 6 weeks long. Many other workshops for teachers and administrators were also held, and presentations were made in various forums throughout the state, such as for the State Board of Education.

More than 120 teachers participated in workshops aimed at using the new curriculum with Chapter 1 and special education students. Improving mathematics education for Native American students was also a focal point.

Preliminary Impacts of the SSI. Awareness of the SSI in Montana was high, particularly within the high school and university mathematics education community. There was less awareness of reform in mathematics at the elementary or middle school level, or in science education.

Hundreds of teachers and many thousands of students used the new curriculum materials as they were being developed and tested. In all, SIMMS materials were used by perhaps one-third of Montana's high school students (although not all of these students were enrolled in a year-long SIMMS course). Comparisons of classes using the materials with others not using the materials show some favorable outcomes for the experimental classes. Many more mathematics teachers than before embraced the use of technology, real-life applications, cooperative groups, and integrated mathematics. However, at the local level involvement was something of a patchwork, with certain schools in a district (but not others) using the SIMMS materials, and within a school only certain teachers or selected classes using them.

Reflections on the SSI in Montana. Montana's SSI began with a focus principally on high school mathematics, and in one sense this was a narrow focus. However, in terms of including various components of the education system, such as teacher preparation, public support, and college entrance requirements, the Montana SSI was clearly systemic.

Scaling up proceeded well for high school mathematics, with SIMMs or other integrated mathematics materials being used by a significant proportion of teachers and students. Resistance to using new materials came in part from districts, teachers, and families whose children have in the past "succeeded" in traditional mathematics courses. For K-8 mathematics and for science, far fewer students were affected by the SSI.

Exhibit A-4

PROGRESS OF SIMMS COMPONENTS

Component	Progress through Spring 1997
1. Design an integrated 9-12 mathematics curriculum. 2. Develop and publish curriculum and assessment materials for grades 9-16.	A total of 96 modules, about 2,000 pages in all, were written for grades 9-12. Levels 1-6 were tested in classrooms. Levels 1-4 were published for national distribution. A separate assessment handbook was also developed and distributed.
3. Incorporate technology at all levels of mathematics education.	The SIMMS curricula in grades 9-12 rely heavily on technology. More college mathematics courses in Montana are also using technology.
4. Provide professional development on integrated mathematics for teachers in grades 9-16.	More than 3/4 of Montana's high school mathematics teachers participated in SIMMS professional development activities, often for many weeks.
5. Support legislative action, public information, and outreach.	The legislature provided millions for technology in math education. An active public outreach effort was supported, and many hundreds of local news articles were written about SIMMS.
6. Design mathematics curricula for ***all*** students. Increase participation of females and Native Americans.	Curriculum materials and teacher professional development were designed to help make math more appealing and accessible to females, Native Americans, and special populations. For example, an estimated 1/4 of all Native American high school math students used SIMMS.
7. Redesign preservice teacher preparation programs.	The SSI helped develop new undergraduate courses for prospective teachers. Also, the NSF Teacher Collaboratives award, STEP, provided substantial assistance to improve teacher preparation.
8. Establish new certification and recertification standards.	New teacher certification standards were adopted. No change was made to recertification standards.
9. Promote integration of science and mathematics education.	The Montana Mathematics and Science Society (MMASS)—the first of its kind in the U.S.—formed and became active. The SIMMS integrated high school math curriculum included some science.

The small size of the population in this state was an advantage in implementing systemic reform, and the strategies for reform were well matched to the state context. The use of instructional materials as a centerpiece for reform was powerful, and other states might wish to consider using a related strategy.

SUMMARY OF CALIFORNIA'S SSI (CAMS), 1992-1997

Implementation of the SSI. The core of CAMS was two professional development networks, which accounted for about 80 percent of the initiative's expenditures. Mathematics Renaissance (MR) provided intensive professional development through the use of replacement instructional units in middle school math courses. The California Science Implementation Network (CSIN) worked to introduce high-quality science education into the elementary grades. The strategy of both MR and CSIN was to create broad networks of teachers working with conceptually oriented and content-rich math and science education. Participating teachers benefited from a locally available "critical friend" to whom they could turn for assistance. And because there was some natural turnover, teachers rose to positions of greater authority in the network. Moreover, both networks required that schools and districts pay to participate, which increased local commitment to and ownership of the network.

Both of the teacher professional development networks began before California received an SSI. They were designed as an integral part of California's broader systemic reform strategy. With the curriculum frameworks and materials adoption process in place, and an aligned assessment system planned, state education leaders saw a need for a professional development strategy to ensure that teachers had the capacity to use the new materials, adopt the new practices, and prepare students for the new examinations.

The SSI united MR and CSIN in a single initiative and supplemented it with an effort to build public support for math and science educational reform, which later became an effort to build systemic connections throughout the state. As part of this systemic focus, CAMS built on the teacher networks to create a Mathematics Alliance and Science Advisory Committee that brought together most of the major reform initiatives in the state. An ongoing external evaluation was conducted throughout the life of the project. The progress of the SSI in these four activities is summarized in Exhibit A-5.

Impacts of the SSI. The teacher networks reached many teachers and classrooms during the life of the initiative. Through school year 1996-97, CSIN and Mathematics Renaissance together provided direct services to more than 38,500 teachers in approximately 2,400 schools in more than half the school districts in the state. Both networks were able to demonstrate positive impacts on practices in participating classrooms—although there was wide variation even among these teachers in the degree to which their classrooms reflected CAMS' vision of high-quality mathematics and science teaching. Moreover, limited studies of impacts on students generally showed better results for students in classrooms of participating teachers compared with students in control groups. Case studies documented impacts on schools and local districts, especially in the area of instructional materials adoption.

The impacts of the systemic connections component is much less clear. CAMS succeeded in mobilizing a diverse reform community to attempt to counteract a back-to-basics movement in the state, especially in the area of mathematics. But broader political forces outside of CAMS' control generally shaped the policy debate, with the CAMS-organized alliances hardly at the center of the debate.

Reflections on the SSI in California. CAMS as a stand-alone entity was never designed to be fully systemic—it was meant to be one component of a broader systemic effort. It provided the human and material support designed to improve teachers' skills, knowledge, and attitudes. This strategy was not only reasonable but probably one of only a few options available to the reform leadership in a state as large and diverse as California.

Exhibit A-5

PROGRESS OF THE CALIFORNIA ALLIANCE FOR MATHEMATICS AND SCIENCE, 1992-97

Component	Progress to Date
Mathematics Renaissance	Middle school professional development network reached 2,500 teachers in 655 schools (approximately half of all middle schools in the state, plus some elementary schools). Teachers participated in professional development through regional and local meetings during the school year and summer institutes. Data suggest positive impacts on classrooms and students. Supported by an NSF Local Systemic Change grant, staff is planning to expand the program to K-12.
California Science Implementation Network	Elementary school professional development network provided professional development to entire school staffs on the content and pedagogy of new instructional materials aligned with state framework. Although science is the focus, the network expanded in recent years to assist schools with math curricula. The Network reached 36,040 teachers through 2,210 lead teachers representing 1,700 elementary schools (about 33 percent of the elementary schools in the state). Future plans include an expansion into other content areas tied to science (e.g., literacy) and articulation across K-12.
Public relations/systemic coordination	Early efforts to build public relations failed. A restructured effort to build systemic coordination among math and science reformers was designed in spring 1995. Alliances in the math and science communities were established. A statewide advisory group was formed. Several activities designed to build bridges with minority groups were supported.
Evaluation	Initial evaluation effort failed to provide formative information. A new evaluation team was established in spring 1995 to collect data on each CAMS component at each level of the education system.

CAMS' clear success was its almost immediate impact on thousands of California classrooms. CAMS was able to quickly mobilize and begin working directly with classroom teachers. The initiative demonstrated the power of a clear vision coupled with strong quality control, the efficacy of providing teachers access to high-quality professional development and instructional materials, and the strength of focusing on the whole school as the unit of change.

Ironically, it was the very same factors that allowed CAMS to reach classrooms so quickly—clear goals, immediate focus on professional development, and the devotion of the vast majority of resources to the teacher networks—that help account for the initiative's ultimate shortcomings. By 1994-95, the systemic reform context into which CAMS had been born had changed radically, and there was dwindling support at the top of the policy system for CAMS' vision. Within this context, CAMS was not able to mobilize sufficient public and professional opinion to sway opinion leaders, although it is unclear that anyone could have made a difference in California's disorganized and hostile political environment.

SUMMARY OF KENTUCKY'S SSI (PRISM), 1992-1997

Implementation of the SSI. Kentucky's SSI was closely linked to the Kentucky Education Reform Act (KERA), an ambitious and comprehensive state education reform initiative launched in 1990 by the legislature in response to a State Supreme Court decision requiring an overhaul of the state's public education system. KERA required the implementation of broad reforms in curriculum, school organization, and a high-stakes accountability system. The pressure on teachers and schools to improve students' academic performance created the opportunity for the SSI to work to improve mathematics and science instruction in the state.

Led by the Partnership for Reform Initiatives in Science and Mathematics (PRISM), the SSI initially focused the bulk of its efforts on the preparation of cadres of teacher specialists to serve as coaches, trainers, and curriculum developers in their schools, districts, and regions. The specialist programs were led by university educators in each region of the state and designed for middle grade and secondary mathematics teachers, and primary, intermediate, and middle grade science teachers. PRISM also supported model school sites, tried to build public support for reform, developed assessment tools and contributed to the refinement of mathematics portfolios, and awarded grants to higher education institutions to stimulate reform. After 3 years, PRISM adopted a new strategy that put the teacher specialists to different use. By establishing regional leadership teams and networks to assist schools, PRISM attempted to build teacher alliances that would sustain its work in the regions and assist its new Innovation Service with quality reviews of schools. It also established a new program to work with high schools (see Exhibit A-6).

Impacts of the SSI. Nearly 1,300 teacher specialists in mathematics, science, and technology were provided with intensive professional development, and almost 900 additional educators were involved in the model school program and other PRISM activities. The effectiveness, however, of the teacher specialists as coaches, trainers, and curriculum developers was limited because many specialists lacked the subject-matter knowledge, personal skills, and self-confidence needed to serve as trainers or coaches. Most also lacked the time to do so because local administrators and school councils were not always willing to give them release time to provide professional development.

As a consequence, PRISM's leaders shifted strategy late in the game from changing individual teachers to changing schools and building regional alliances of science and mathematics teachers. A select number of the teacher specialists, who were trained to provide professional development and technical assistance to schools, joined regional teams and began to work toward developing regional networks of mathematics and science teachers. Regional Centers were developed to support the teacher networks, broker the services of the regional leadership teams, and provide schools with assistance in planning and needs assessment. An Innovation Service was designed to provide schools with on-site consulting and diagnostic services to help them change their organizational culture and become high-performance organizations. The plan was for the Innovation Service to be self-sustaining eventually, with schools paying for services provided.

Reflections on the SSI in Kentucky. PRISM was a promising initiative with enormous potential. There was good leadership, talented and committed people leading the various components, a promising network of collaborators, and a shared vision of good practice in its early years. But the designers of PRISM made some assumptions that were flawed. As a consequence, the SSI's initial capacity-building approach did not produce the results that had been envisioned. The upshot was a dramatic change in strategy, a shift from teacher development to a regional, school-oriented approach. This strategic shift came late. With only 1 year of funding left, it was hard to build stable networks of mathematics and science teachers in the regions and demonstrate the efficacy of this new approach.

Exhibit A-6

PROGRESS OF MAJOR PRISM COMPONENTS*

Component	Progress through Spring 1996
Math specialists	A total of 419 K-4 specialists and 283 grade 5-8 specialists had been trained. Sample instructional units had been developed and reviewed. Town meetings and seminars had been held for high school teachers, and regional training teams had been selected and prepared.
Science specialists	174 K-3 teachers, 143 grade 4-5, and 130 grade 6-8 specialists had been prepared. Sample instructional units had been developed and reviewed.
Instructional technology specialists	48 technology specialists had been prepared and had offered training for hundreds of teachers.
Model sites	The initiative was closed down after 10 sites had participated for 2 years, and 9 for 1 year.
Performance assessment	91 teachers had worked on developing performance tasks. Sample tasks had been field-tested and distributed. A training manual on task development had been prepared.
Mathematics portfolio assessment (added in 1995)	Regional resource teachers were working in all eight regions, providing professional development, coaching, and technical assistance. They worked with the networks of Mathematics Portfolio Regional Coordinators and District Portfolio Cluster Leaders. A model for district analysis of portfolio results had been developed and piloted.
Undergraduate mathematics and science	There had been annual meetings of faculty, and 21 grants were awarded to 11 institutions for course development. A study group was formed on teacher preparation.
Access and participation	The strategic plan had been completed, an equity toolkit developed, and equity training modules developed. Manuals had been developed for the specialists. Partnerships had been formed with programs serving minority and disabled students.
Public awareness and public policy	Distributed 325,000 copies of a parents booklet. The PRISM newsletter was widely distributed. Obtained considerable media coverage. Conducted state polls. Initiated an ad campaign in 1994-95.

*The ninth component, the Mathematics Portfolio Assessment Project, was added in 1995.

SUMMARY OF MAINE'S SSI (ME-SSI), 1992-1997

Implementation of the SSI. The goal of the ME-SSI was to improve mathematics and science outcomes in grades K-12 throughout the state. Historically, Maine has characterized itself as a state where citizens have low educational aspirations, particularly with regard to participation in higher education. The SSI and other state initiatives sought to change this expectation.

The ME-SSI operated as a 501 (c) 3 nonprofit corporation, called the Maine Mathematics and Science Alliance (MMSA), that was independent of the state education department but closely aligned with it and with other partners. The SSI organized itself around four committees, each chaired by one or more SSI Principal Investigators. SSI leaders worked with and strongly influenced state policy-making activities, supported seven local demonstrations of systemic reform, provided technical assistance to local school districts on request, and developed statewide and regional leadership to institutionalize its vision of mathematics and science education reform (see Exhibit A-7).

Impacts of the SSI. The ME-SSI played a key role in (1) development of a curriculum framework for mathematics and science (content standards) and (2) legislative policy on performance standards (called Maine's Learning Results) aligned with the framework. The state student assessment tests were being aligned with the Learning Results in 1997-98.

The seven demonstration projects, called Beacon Sites, developed into regional leaders for the ongoing implementation of the state's vision for reform of mathematics and science education. These sites and staff of the MMSA continue to provide technical assistance to school districts as they engage with the curriculum frameworks, the Learning Results, and the student assessments. A network of teacher-leaders, called The Leadership Consortium (TLC), also helped with the scaling-up process. Over a 5-year period, leaders of the ME-SSI estimated that they had introduced standards-based education reform to approximately 60 percent of the state's teachers of mathematics and science and worked intensively with about 20 percent of them.

Maine's primary equity issues in mathematics and science education have been gender and class. A 100-point difference on the state mathematics test favoring boys largely disappeared during the first 5 years of the SSI's work. In addition, test scores of the state's Native American population increased considerably at the 4th- and 8th-grade levels.

Reflections on the SSI in Maine. On the basis of the top-down and bottom-up model of systemic change that has guided the national evaluation of the SSIs, Maine represented a highly systemic effort that successfully promoted a statewide vision of mathematics and science education reform within a strong tradition of local control of schools. It did this by being highly collaborative and by developing local leadership.

A key to the success of the ME-SSI was its extragovernmental status. In a local control environment, it represented a source of independent expertise that both state and local policy-makers could consult. Giving leadership roles to representatives of many key stakeholder groups also paid off in earning the SSI widespread support.

Like SSIs in other states, the ME-SSI was not very successful in engaging high schools in serious reform activity. It also was not a particularly strong presence in the state's largest cities.

Exhibit A-7

PROGRESS OF MAINE SSI COMPONENTS

Component	Progress through January 1997
Policy	Worked closely with many stakeholder groups to develop a Mathematics and Science Curriculum Framework, a learning results document, and alignment of the state assessment with the learning results.
Beacon Centers	Supported seven centers with annual grants of $50,000 and two full-time content specialists to develop local and regional expertise.
Academies for teachers	In collaboration with Eisenhower (Title II) and state higher education funds, supported 19 intensive summer academies with school-year follow-up.
The Leadership Consortium (TLC)	Helped develop a regionally based teacher network contributing to scale-up and sustainability of the reforms.
Community awareness	Supported Community Action Teams, widespread use of Family Math and Science programs, broad public awareness campaigns, involvement of Native Americans, and development of equity standards.
Maine Research Internships for Teachers and Students (MERITS)	Placed teachers and students in business and research internships with 40 organizations.
Statewide professional development activities and technical assistance	Co-sponsored five Problem Solving Conferences in Mathematics and Science annually; offered many workshops and on-demand technical assistance to individual districts and schools.
Technology	Leveraged $1.2 million in grants to network Beacon Centers and participants in academies.
Higher education initiatives	Established collaborative relationships with individual faculty and administrators in most state institutions of higher education.
Evaluation	Used multiple evaluation strategies to document all aspects of SSI activity.

SUMMARY OF MICHIGAN'S SSI (MSSI), 1992-1997

Implementation of the SSI. Embedded in the state's larger education reform efforts, the MSSI focused on improving the capacity of the education system to implement existing reforms. The overarching goal was to enable all students to achieve scientific and mathematical literacy by transforming the ways that mathematics and science were learned, taught, and assessed in Michigan's public schools. To achieve this goal, the SSI supported the development and communication of a statewide vision of mathematics and science education reform and funded separate components that addressed: (1) policy and program review, (2) the redesign of mathematics and science teacher preparation, (3) support for Models of Effective Learning (MELs), (4) professional development, and (5) communication (see Exhibit A-8).

Impacts of the SSI. Through the MELs, the MSSI provided grants and technical assistance to 24 Focus Districts to help them develop and demonstrate effective mathematics and science learning for all students, with a special focus on low-achieving populations. Eleven target districts—low-achieving, economically disadvantaged, urban or rural communities with significant minority student populations—received grants of up to $65,000 per year for 3 years. Thirteen affiliate districts, which included less disadvantaged communities, received technical assistance and improvement grants of up to $2,500 for activities linked to the district's strategic plan for reform. Overall, the pace of reform was uneven across the Focus Districts, reflecting variations in district context, capacity, leadership, and the size of MSSI awards.

The MSSI strategy of building district and state infrastructure and capacity limited direct involvement of teachers in the SSI to those who were members of their district's strategic planning teams. However, teachers benefited indirectly from the SSI activities through their participation in professional development programs, implementation of new curricula, and district curriculum redesign activities. Data from a sample of districts indicated that teachers in the MSSI Focus Districts were changing the way they taught mathematics and science but had a long way to go before they had truly reformed their instructional practice in ways intended by state and national standards.

The impact of the SSI on student performance was less clear. There was evidence, however, that some of the educationally disadvantaged districts targeted by the MSSI had improved their state test scores in mathematics and science during the 5 years of the initiative.

Reflections on the SSI in Michigan. The MSSI attempted to build a statewide infrastructure for mathematics and science education reform via a strategy that focused on institutional collaboration and leadership, access to human and material support, and professional and public support for reform. Such an approach relied on building connections between people and institutions (e.g., school districts and colleges and universities), and on the capacity and willingness of these institutions to support change. By focusing on disadvantaged students and communities, the MSSI chose to work with school districts that were complex, faced multiple problems, and had varying capacity for reform. In some cases, these districts were ready to change their mathematics and science programs and accessed resources created and sustained by the SSI to begin or continue their reform efforts. In other cases, a lack of leadership or understanding of the commitment and resources needed to reform mathematics and science hampered progress.

Exhibit A-8

PROGRESS OF THE MSSI COMPONENTS

Component	Progress through Spring 1997
Policy and program Review	Produced and disseminated reports that mapped and evaluated state policies and structures for mathematics and science education, examined how state policies influenced local policies, and studied the impact of state and local policies on mathematics and science instruction.
Models of effective learning	Awarded grants of up to $65,000 per year for 3 years and/or technical assistance to 24 districts. The grants supported efforts to develop programs and policies for improving mathematics and science learning, with a focus on low-achieving students.
Teacher education redesign	Developed guidelines with public and private colleges, universities, and community colleges for reforming the preparation of mathematics and science teachers in Michigan. Provided small grants to faculty teams to review and revise teacher education courses and programs in many institutions.
Professional development	Communicated a new paradigm of professional development to major providers. Developed guidelines and actions to restructure the state's professional development system. Helped create state professional development standards.
Communication	Disseminated information on the MSSI and mathematics and science reform to a statewide audience. Undertook a public engagement campaign to increase public awareness of the MSSI and the need for mathematics and science education reform.

SUMMARY OF VERMONT'S SSI (VISMT), 1992-1997

Implementation of the SSI. The goal of Vermont's SSI was to improve the way that science, math, and technology were taught in the state's schools so that all Vermont students graduated with the skills necessary to ensure their ability to pursue scientific and technical careers. The SSI was led by the Vermont Institute for Science, Mathematics, and Technology (VISMT)—a new quasi-public agency with strong links to the state department of education, the teaching profession, and the business community.

From its inception, VISMT was organized into nine components that addressed both the state and local levels of the system (see Exhibit A-9). Working in a participatory political culture supportive of home rule in public education, VISMT relied on dialogue, persuasion, and patience, and emphasized innovation, leadership, and collaboration in its quest for overall education reform.

Impacts of the SSI. VISMT's accomplishments were impressive. Although the state's consensus-building approach meant that for the first 3 years of the SSI there were no state mandates to generate local demand for VISMT's services nor formally adopted sets of standards to focus the initiative's efforts, VISMT's staff worked closely with the state department of education to build the components of a standards-based system. The SSI staff's leadership in the development of the science, math, and technology section of the state's curriculum framework and the piloting of new, aligned assessments in math and science yielded dividends by the fourth and fifth years of the initiative.

The state adoption of the framework in 1996 and the adoption of a more equitable funding formula and a related accountability law in 1997 provided VISMT with the focus and impetus it needed to truly become a coherent, statewide initiative. In the last 2 years of its SSI funding, VISMT developed local partnerships to support the implementation of the state framework, created a regional system of technical assistance and professional development to support these local efforts, reviewed available curricular programs against Vermont's standards to encourage local adoption of existing curricula, continued work on the evolving state assessment system, and renewed its efforts to engage higher education more actively in the reform effort. Vermont's progress toward reform of science, math, and technology education earned VISMT continued funding from NSF. Vermont is benefiting from VISMT's continued efforts to change the way that math and science are taught and student achievement is assessed.

Reflections on the SSI in Vermont. In many ways, Vermont was an ideal setting for establishing an SSI. The state was small, sparsely populated, and largely rural, with a relatively homogeneous culture. Schools and districts were also small and did not have complex bureaucracies. There was effective leadership in education at the state level, and the business community was strongly supportive of reform. On the other hand, there was a strong tradition of home rule in public education, a strong antipathy to rules and regulations, pervasive norms of professional autonomy, fiscal constraints at both the state and local level, and inequities in resources across districts. VISMT's challenge was to develop a strategy for education reform that considered its singular context—a strategy that addressed the key components of systemic reform but worked within the state culture and policy environment.

Constrained by limited resources, political traditions, and resistance to stronger accountability, VISMT catalyzed statewide reform via a grassroots effort and served as an R&D lab for the Vermont Department of Education. VISMT has quietly and effectively facilitated reform and worked with the department of education to develop standards, assessments, and technical assistance capacity where none had existed.

Exhibit A-9

PROGRESS OF VISMT COMPONENTS

Component	Progress through Spring 1997
Curriculum and content standards	The state science/math/technology curriculum framework was adopted in 1996. National curricular materials were reviewed against the state standards. Teacher Associates provided schools with assistance in selecting, developing, and implementing new curricula.
Assessment and accountability	VISMT developed the new state science assessment and extended the math portfolio system to secondary schools. VISMT's support for the development of state assessments influenced 1997 legislation that mandated a state assessment system that included both math and science.
Professional development	Summer residential institutes and regional workshops provided high-quality professional development. VISMT's Teacher Associates program provided a regional system of peer mentoring and professional development. This system was supported by the Virginia Department of Education and extended to other disciplines.
Business, community, and parent involvement	After initially viewing businesses as sources of funds or equipment, the focus shifted to building local school-business-government partnerships working in support of the new state framework of standards.
Support for local reform	Grants for local science/math/technology projects were awarded during the first 2 years. After mixed success, the strategy shifted to the provision of technical assistance and funding to local partnership schools.
Educational technology	The focus initially was on demonstration and local adoption, but lack of resources shifted attention to development of a state plan. VISMT obtained funding from NSF, the U.S. Department of Education, and IBM to increase access to the Internet and information technology.
Equity	The focus was on programs addressing gender bias during the first few years but eventually broadened to include Family Math and Science and outreach to high-poverty schools. Equity benchmarks were developed.
Improving teacher preparation	Work was initiated with the Professional Standards Board to revise certification requirements and align them with the standards.
Resource development	VISMT learned to effectively coordinate and leverage federal funding but was less successful in raising private funds. However, a large IBM grant was obtained with VISMT's assistance.

SUMMARY OF VIRGINIA'S SSI: V-QUEST, 1992-1996

Implementation of the SSI. Virginia's SSI aimed to make high-quality mathematics and science education available to all students in the state's public schools by providing a supportive system focused on improved student learning. Organized into seven components, the SSI supported primarily professional development activities and pilot projects. Three of the components provided professional development and technical assistance to teachers, administrators, and communities. The other four components developed products that V-QUEST hoped would one day have statewide application. The progress of each component is summarized in Exhibit A-10 below.

The SSI subcontracted to universities and districts to manage each of the seven components. The components developed their own strategic plans, issued their own RFPs for potential participants, and managed their own finances (during the first 2 years). Component coordinators were affiliated with a subcontracting institution and had a liaison in the department of education who collaborated in planning and implementation.

Impacts of the SSI. Approximately 25 percent to 30 percent of V-QUEST funds were dedicated to the lead teacher component. This was the only V-QUEST activity to reach large numbers of school divisions and schools. Each summer, approximately 240 elementary and middle school mathematics and science teachers participated in a 2-week professional development institute. During the academic year and for 1 week during the following summer, these same teachers participated in additional professional development activities. By summer 1996, 960 teachers from about one-third of Virginia's K-8 schools had been prepared as lead teachers. More than 5,000 K-12 students were indirectly affected by V-QUEST via its lead teacher and pre- and inservice components. The lead teachers brought new activities and materials into classrooms, and the preservice component piloted revised curricula in high school classrooms.

Perhaps V-QUEST's most significant contribution to the state's reform efforts was its support for development and implementation of Virginia's content standards—an important role in shaping some key components of state education policy. The SSI contributed $100,000 toward project work, and several key members of V-QUEST staff played a major role in development and evaluation of the standards.

Reflections on the SSI in Virginia. V-QUEST was basically a capacity-building initiative that had minimal impact on statewide reform. Although its lead teacher component succeeded in introducing new materials into some schools and changing teaching in some classrooms, the strategy of preparing a select number of teachers to lead reform efforts in their schools and districts proved to be an ineffective approach to comprehensive reform. The expectation had been that, after limited professional development during the summer, these teachers would be agents of change in their respective schools and communities. Beyond their own teaching responsibilities, the lead teachers were expected to provide inservice for their colleagues, manage mathematics and science resources, organize schoolwide and community activities, act as liaisons to the central office, and develop effective teaching methods to ensure success for underrepresented students. Teachers' lack of prior content knowledge, coupled with insufficient resources, administrative support, and release time, contributed to the ineffectiveness of this approach to reform.

V-QUEST also suffered from weakened impact because of ineffective coordination among its components. Because autonomy had been given to each component to design its own initiative, more than one component operated in the same district with minimal coordination of SSI activities across the initiatives. V-QUEST's lack of progress toward a coherent, integrated effort to reform science and mathematics education contributed to NSF's decision to withdraw financial support in summer 1995.

Exhibit A-10

PROGRESS OF V-QUEST COMPONENTS

Component	Progress through 1995
Lead teachers	By 1996, V-QUEST had provided professional development to 960 lead teachers from 480 K-8 schools. The teachers participated in 2-week summer institutes, monthly follow-up activities during the academic year, and 1-week summer institutes during a second summer.
Pre- and inservice models	Grants were awarded to three consortia of universities, community colleges, and schools to restructure and pilot curricula. Approximately 20 college-level mathematics and science courses were developed or revised, but there were no plans to disseminate the courses to other teacher training institutions. During Year 4 of the initiative, the main focus was on providing professional development activities for high school teachers.
Communications and technology	This component provided media and public relations support to other V-QUEST components and began several projects to introduce educational technology into a few schools. V-QUEST staff influenced development of a new state technology plan and purchase of graphing calculators for statewide use in algebra and geometry classes.
Instructional materials	In collaboration with a multistate consortium, the component coordinator and the department of education liaison developed criteria for evaluating textbooks and instructional materials that supported Virginia's content standards. The criteria were intended to be used in the textbook adoption process. Although considerable resources were devoted to this component during the first 3 years, the work had almost no influence on state policy regarding instructional materials selected.
Student assessment	This component trained 70 teachers in week-long summer institutes to develop performance tasks and scoring rubrics, which they assembled into a handbook for other V-QUEST teachers. V-QUEST did not establish the technical quality of the tasks or their value for large-scale assessment. None of these assessments were used on new state tests.
Community action	Seven part-time regional action coordinators worked with school divisions to raise public awareness of V-QUEST and to enlist community support. In the initiative's third year, the component began to identify sites where all seven V-QUEST components could be implemented simultaneously.
Local educational leadership/ administrative support	This component made little progress. Staff worked to strengthen the administrators' training at the lead teacher institutes and provide technical assistance in a small number of school divisions.

SUMMARY OF ARKANSAS' SSI (AR SSI), 1993-1997

Implementation of the SSI. The goal of the AR SSI was to improve teaching and learning of mathematics and science in Arkansas' K-12 schools so that all students would graduate with the knowledge and skills to be successful in the workplace. The AR SSI leadership aimed to change teachers' practice and their attitudes about mathematics and science education, and to foster community involvement in the reform efforts.

With the political support of the governor and the legislature, and the cooperative efforts of Arkansas' Departments of Education and Higher Education (ADE and ADHE), the AR SSI dedicated the bulk of its resources to intensive professional development. Using the state's Math Crusade initiative as a model, the AR SSI expanded this professional development program for teachers of grades 5-16 to include both a K-4 Integrated Math and Science Crusade and a 5-16 Science Crusade. The initiative also embarked on an ambitious effort to build the leadership capacity in the state and to participate in the revision of policies concerning teacher preparation and certification.

Impacts of the SSI. The initiative played a key role in the development of new state policies and helped to focus attention on K-12 standards-based mathematics and science education via its statewide programs of professional and leadership development and involvement with the higher education community. The SSI also leveraged resources from a variety of sources and successfully involved every major group in Arkansas that was invested in the mathematics and science education of the state's students.

By fall 1996, about 35 percent of the K-4 teachers in the state had participated in the K-4 Integrated Crusade, and about 35 percent of all mathematics 5-12 teachers had participated in the Math Crusade. In addition, by fall 1997, approximately 22 percent of all 5-12 science teachers had participated in the Science Crusade and more than 4,000 superintendents, principals, and ADE staff and teachers had participated in the Academy for Leadership Training and School-Based Management retreats. Although the professional development offerings of the Crusades were intensive and reached large numbers of teachers, much remained to be done to strengthen many Arkansas teachers' content knowledge and pedagogical skills.

With no student achievement data available, the AR SSI was unable to demonstrate the effects of Crusades training for teachers on student outcomes. However, statewide test results in mathematics and science, along with course-taking patterns and other indicators of educational progress, clearly document strong gains during the 1990s. That said, the achievement gap between whites and minority students remains unacceptably large.

Reflections on the SSI in Arkansas. Given the condition of Arkansas' educational system when the SSI was implemented, its leadership faced a daunting challenge. Building capacity in a state that historically had lagged far behind most other states in indicators of a healthy educational system required more resources and more time than was available to the AR SSI. However, by choosing to focus intensive energy and resources on building the professional skills of Arkansas teachers and developing the leadership capacity in the state, the AR SSI leadership went far toward changing the way that mathematics and science are taught in Arkansas, particularly in the elementary schools. But there is much work yet to be done. The challenge is to sustain the reform effort despite political changes, continue to build the skills and knowledge of teachers and administrators, and scale up the initiative to all teachers in the state. Whether the reform leadership will have access to the necessary resources, will gain the support of the state's new political leadership, and can instill the spirit of the Crusades in all of the state's teachers is an open question.

Exhibit A-11

PROGRESS OF THE AR SSI COMPONENTS

Component	Progress through Fall 1997
System Change	ADE and ADHE increased their collaboration; IHEs were involved in Crusades training; AR SSI staff were involved in state teacher certification.
Leadership	More than 4,000 superintendents, principals, teachers, and school teams participated in the Leadership Academy.
Professional Development	K-4 Crusade: 4,163 K-4 teachers participated. Math Crusade: 1,616 teachers of grades 5-12 participated. Science Crusade: 836 teachers participated.
Equity	Equity Benchmarks were developed. 400 teachers participated in EQUALS workshops. 20,000 parents and students participated in Family Math and Family Science.
Regional Partnerships	Regional partnerships have been established in all five Arkansas regions. These partnerships work with the 15 educational cooperatives to provide technical assistance and professional development to teachers.
Public Awareness	The position of AR SSI Communications Director was established. Brochures, newspaper articles, and a semiannual newsletter were sent to 7,000 individuals. The Arkansas Business & Education Alliance supported the AR SSI through public awareness and outreach activities.

SUMMARY OF NEW YORK'S SSI (NYSSI), 1993-1997

Implementation of the SSI. The New York Statewide Systemic Initiative (NYSSI) aimed to dramatically improve mathematics, science, and technology education in 12 urban research and demonstration schools, and then use those schools as models for statewide reform. During the first 2 years of the initiative, the NYSSI leadership devoted most of its time and resources to helping the research and demonstration schools change the way mathematics, science, and technology were taught. At the state level, the NYSSI supported the state department of education's efforts to align policy and develop high standards and new assessments.

After the first year, the NYSSI leadership recognized that progress was uneven at the 12 research and demonstration schools. Typically, the school cultures were slow to change, only a handful of teachers embraced the reforms, and existing reform programs at the schools blurred the SSI's efforts. By January 1995, the NYSSI leadership sharpened its focus around inquiry-based education, bolstered support of the schools through professional development and the use of "coaches," and tried to work more closely with the districts to promote districtwide change. All of the NYSSI efforts were occurring against a backdrop of massive cuts in the New York State Department of Education and changes in the state's political and educational leadership. Following the midpoint review, the NYSSI coordinator resigned and her replacement began to refocus the initiative on statewide activities instead of the research and demonstration schools.

Impacts of the SSI. Despite numerous barriers, the NYSSI made modest impacts overall on student achievement and teachers' practices at the research and demonstration schools. However, transforming the whole school culture proved much more difficult than anticipated. By fall 1995, only 10 of the 12 research and demonstration schools remained in the initiative. Progress in these schools was largely dependent on factors such as administrative and district support, school climate, and availability of resources. By fall 1996, only 4 of the original 12 schools were clearly poised to carry on with their reform agendas.

With increasing pressure from NSF to expand the initiative beyond the research and demonstration schools, the NYSSI shifted its focus to the six districts in fall 1995. Leveraging change in districts via the research and demonstration schools was less than successful—partially because of leadership changes and ensuing instability at both the district and research and demonstration school levels. However, by fall 1996, several of the research and demonstration schools did make significant improvements, including gains in student achievement. By the fourth year of the initiative, the focus of the NYSSI switched from the schools and districts to statewide activities in support of the standards-based reform.

Reflections on the SSI in New York. The NYSSI's bottom-up/top-down approach to reform focused on school change supported by state policy alignment. At the state level, SSI leadership participated in, but seldom led, various mathematics, science, and technology (MST) reform projects under the purview of a statewide management team charged with coordination of all MST reform efforts in the state. The NYSSI's hope was to ground state policy development in the real world of the research and demonstration schools. They chose the difficult task, however, of changing urban schools in a short period of time. Despite efforts to have standards guide reform activities at the research and demonstration schools, change was more dependent on local contextual factors than on state policies. With little time, resources, or state and district support to make dramatic changes, the majority of research and demonstration schools made only modest improvements and were unable to serve as catalysts for district reform efforts.

Exhibit A-12

PROGRESS OF THE NYSSI COMPONENTS

Component	Progress through Spring 1997
Urban Network	Ten of the 12 R&D schools remained active in the initiative. Four of the schools were poised to continue their reform agendas.
Urban Network Partnerships	Partnerships were slow to develop in most of the R&D schools.
Summer Institutes	Significant professional development opportunities were available for some teachers. Inquiry became the unifying theme of the institutes and the initiative after the first year.
Coaches	University faculty, who were recruited to serve as coaches in the R&D schools, had a significant impact on the practice of a few teachers. Finding qualified coaches was problematic.
Scaling Up	An ambitious scaling-up plan from R&D schools and districts to the state level was developed following the NSF midpoint review.
Governance and Policy Alignment	State policies were increasingly aligned with the goals of the NYSSI. The assessment system was under development, the state standards were adopted, and the Commissioner called for all students to take Regents exams. The NYSSI leadership played a support role in these efforts.

The National Science Foundation

The Foundation provides awards for research and education in the sciences and engineering. The awardee is wholly responsible for the conduct of such research and preparation of the results for publication. The Foundation, therefore, does not assume responsibility for the research findings or their interpretation.

The Foundation welcomes proposals from all qualified scientists and engineers and strongly encourages women, minorities, and persons with disabilities to compete fully in any of the research and education-related programs described here. In accordance with federal statutes, regulations, and NSF policies, no person on grounds of race, color, age, sex, national origin, or disability shall be excluded from participation in, be denied the benefits of, or be subject to discrimination under any program or activity receiving financial assistance from the National Science Foundation.

Facilitation Awards for Scientists and Engineers with Disabilities (FASED) provide funding for special assistance or equipment to enable persons with disabilities (investigators and other staff, including student research assistants) to work on NSF projects. See the program announcement or contact the program coordinator at (703) 306-1636.

The National Science Foundation has TDD (Telephonic Device for the Deaf) capability, which enables individuals with hearing impairment to communicate with the Foundation about NSF programs, employment, or general information. To access NSF TDD, dial (703) 306-0090; for FIRS, 1-800-877-8339.