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ABSTRACT

During the first and second years of the national evaluation of the Statewide Systemic Initiatives (SSI) program, a sample of 11 case study states was drawn from the universe of awards the National Science Foundation made to 25 states and Puerto Rico. This document reports on three case studies for Connecticut, Delaware, and Montana. The cases provide a level of detail about the SSI program greater than can be captured in analyses cutting across all the SSI's. Each one situates systemic reform activities in its specific and unique state context. The case studies include good practice in mathematics and science education, implementation of the SSI, preliminary impacts of the SSI, and reflections on the SSI. Significant accomplishments are: creation of a new nonprofit institution in Connecticut which is taking its place as a leader in education reform in the state and is supported by many professionals in the mathematics, science, and engineering communities; contribution of the Delaware SSI to the development of draft state curriculum frameworks in both mathematics and science; and the writing of more than 1,000 pages of a new integrated high school mathematics curriculum in Montana. (JRH)

Evaluation of the National Science Foundation's Statewide Systemic Initiatives (SSI) Program

Second-Year Case Studies: Connecticut, Delaware, and Montana

Conducted by SRI International, Menlo Park, California in collaboration with:

The Consortium for Policy Research in Education
Policy Studies Associates
Woodside Research Consortium
The Council of Chief State School Officers

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EVALUATION OF THE NATIONAL SCIENCE FOUNDATION'S STATEWIDE SYSTEMIC INITIATIVES (SSI) PROGRAM

SECOND-YEAR CASE STUDIES: CONNECTICUT, DELAWARE, AND MONTANA

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The Nature and Purpose of the Case Studies

During the first and second years of the national evaluation of the SSI program (June 1992 to June 1994), a sample of 11 case study states was drawn from the universe of awards NSF made to 25 states and Puerto Rico. The sample was selected to include a diverse group of states, representing a wide range of contexts for and approaches to systemic reform. These 11 states have been studied more intensively than the others and provide one important source of data for the national evaluation.

The three case studies published this year are for Connecticut, Delaware, and Montana. These are the 3 states in the sample of 11 that received their SSI awards in 1991, placing them within the first cohort of SSI awards made by NSF. The information was current as of October 1994. The remaining case studies, reporting on states in the second and third cohorts, will follow at a later date.

The cases provide a level of detail about the SSI program greater than can be captured in analyses cutting across all the SSIs, and each one situates systemic reform activities in its specific and unique state context. At the same time, the case studies allow one to draw lessons about systemic reform that may generalize across many states.

Major Findings

As these first cohort states finished the third year of their work, there were some significant accomplishments to report. For example, in Connecticut a new nonprofit institution has been created, the Connecticut Academy for Education in Science, Mathematics and Technology, which is taking its place as a leader in education reform in the state, supported by many professionals in the mathematics, science, and engineering communities. In Delaware, the SSI has contributed to the development of draft state curriculum frameworks in both mathematics and science. In Montana, more than 1,000 pages of a new integrated high school mathematics curriculum have been written, and thousands of students, especially at the 9th-grade level, have used it. Comparisons of classes using these materials with others not using the materials show some favorable outcomes for the experimental classes. Institutions of higher education in Montana have agreed to accept completion of 3 years of the new curriculum for college entry.

All three states have chosen to begin by working intensively on a selected piece or pieces of the education system in mathematics and science, not equally at all grade levels and in all schools in the state. Connecticut—like Michigan, New York, and several other SSI states—has chosen to concentrate funds on a particularly difficult part of the education system, in this case selected poor, urban districts. The problem of how to scale up to include larger pieces or all of the education system in reform efforts is a difficult one, and none of these states has yet solved that problem.

Delaware restructured its SSI during its first year, as the staff came to better understand how to carry out systemic reform, and at least a half dozen other SSIs have experienced similar periods of restructuring. Another lesson illustrated by these case studies is that garnering long-term, widespread public and political support for reform is proving difficult in a number of states. In response, some SSIs are supporting targeted public outreach activities involving television, radio, newspapers, and other media. Public support for reform cannot be taken for granted.

Summaries of The Case Studies

Connecticut's SSI: Project CONNSTRUCT

Implementation of the SSI. The overarching goal of the Connecticut SSI is to make the reform of science, mathematics, and technology a high priority for state and local policy-makers and to keep their attention focused on this task. Project CONNSTRUCT has taken a unique approach, starting with the creation of the Connecticut Academy for Education in Science, Mathematics and Technology. It is a free-standing nonprofit organization whose members include respected educational leaders as well as other professionals in the math and science communities. The Academy is outside of state government, helping to ensure its viability across changes in state leadership, its capacity to build a broad-based collaborative, and its ability to bypass much bureaucratic red tape.

The initiative has five components. The first component is creating and sustaining the Academy itself. Component Two is managed by the State Department of Education and supports reform efforts in high-need school districts through a competitive grants program. Districts are required to provide matching funds. Component Three focuses on higher education, more specifically on teacher preparation in math and science. Component Four has focused on building partnerships between science-rich institutions and community organizations and the public schools. Component Five addresses the problems of building public understanding of the need for reforms in math and science education. Exhibit S-1 shows the SSI's progress on these components.

Preliminary Impacts of the SSI. One of the major accomplishments of the Connecticut SSI has been the acceptance in the math and science communities of the Academy as the lead education reform and improvement institution. A second accomplishment has been the development of a consensus within the math and science communities that change is not only necessary but possible. The Academy has also been successful at collaborating with other key institutions, including the State Department of Education and institutions of higher education. Academy staff are working with the Department to develop new curricular frameworks in science and mathematics and to revise the state's teacher development programs. The Academy also has built strong relationships with other NSF grantees and the recipients of Eisenhower funds.

A recent review of the 19 districts funded by the SSI found that the individual projects vary in quality. A few were described as exemplary and were being implemented

Exhibit S-1

Progress of CONNSTRUCT Components

Component	Progress to Date
1. The Connecticut Academy for Education in Science, Mathematics & Technology	The organization is functioning well and appears to have won respect from diverse constituents. The Board members remain committed to its success.
2. Financial and technical support for selected high-need districts	The 19 districts are implementing activities. There is concern about the quality of the projects and the small degree of impact of small grants ($30,000 to $60,000) on stressed districts.
3. Teacher preparation in institutions of higher education	Fifty-four grants over 3 years; 14 dialogues and 21 co-teaching projects were funded. Eleven of 15 preservice institutions are involved. Although the process is loose, faculty interest has been high, and partnerships have developed between colleges and schools.
4. Community institutions	The focus is on Family Math and Family Science. These programs have been popular and are expanding.
5. Building public understanding	A PR firm has helped the Academy develop an outreach strategy. An impressive statewide PR campaign was launched in June 1993. It has since been expanded and includes newspaper inserts as well as radio and TV spots. Connecticut is seeking support for the further expansion of this effort.

districtwide. In other sites, implementation suffered from budget cuts, poor staff morale, conflicts over contracts, lack of released time, weak professional development, and poor coordination. Full implementation of all these projects seems to be threatened by the effects of the state's fiscal crisis on management-labor relations, professional development, and equipment and supplies.

The action components of CONNSTRUCT have made solid progress, but there is not yet evidence of institutionalization of changes or of effects on student outcomes. However, it must be noted that CONNSTRUCT chose to concentrate on the most pressing and most difficult problems—urban schools and preservice teacher education—rather than seek easy victories. Slow progress is to be expected.

Reflections on the SSI in Connecticut. Project CONNSTRUCT seeks to balance the central guidance mechanisms, a realistic network of change agents just above the school level, and incentives for local improvement efforts. CONNSTRUCT has made a good start, but it is only a beginning.

Scaling up implementation in these districts will require considerable professional development, technical assistance, funds for equipment and technology, and stability of leadership. Ultimately, much will depend on factors out of the initiative's control or reach—in particular, resolving a serious state funding crisis and equalizing school funding. To a lesser degree, it will depend on the Academy's success in securing funding to sustain its efforts in these districts. It will be a challenge.

Delaware's SSI: Project 21

Implementation of the SSI. Although the basic goals of the initiative have remained constant, the SSI that is being implemented in Delaware today is considerably different from the more project-like initiative originally proposed. This case study focuses on the reinvented Project 21 that emerged in the second year of NSF funding. The current SSI is thus approximately 2 years old, and its implementation status is best viewed in terms of that time frame. Progress of the SSI is summarized in Exhibit S-2.

Delaware's overall plan for reform, New Directions for Education in Delaware, is a standards-based, K-12 reform effort designed to help the state meet 10 educational goals (the 6 national goals plus 4 added by the state). Delaware's SSI, Project 21, is the development arm of New Directions for math and science education. In particular, Project 21's primary implementation responsibility is the nurturing of improved math and science curriculum and instruction in 17 schools that have been identified as New Directions Development Sites (NDDS).

With assistance from the SSI's math, science, and school change specialists, these sites are charged with developing teaching and learning strategies that will allow students to achieve the state standards in math and science. Most of the schools have one or more standards-based learning units (called "polished stones") at some stage of development. However, they have been in the curious position of developing learning events for state standards in mathematics and science that are not yet fully defined. Triads of SSI specialists (science, math, school change) are assigned to each NDDS school as technical assistance providers. Some schools have made greater use of this resource than others. SSI staff have focused on the schools that sought them out.

In addition to supporting the NDDS schools, Project 21 fosters a number of partnerships and networks that bring together key math and science educators from all levels of the state-supported education system (including higher education), as well as members of the state's business community. Going beyond state borders, New Directions, Project 21, and individual schools are linked to several national and regional reform efforts, including the Re:Learning Network, the New Standards Project, and the Southern Regional Education Board's Schools That Work.

Exhibit S-2
Progress of Project 21 Components

Component	Progress to Date
1. New Directions Development Schools	These 17 schools, selected by a proposal process, have been variably engaged with SSI-sponsored technical assisters and other kinds of support in their first year of involvement. Although these schools were intended to form a strong improvement network, they have focused more on their own issues and less on the network. The number of sites is expected to increase.
2. Technical assistance	Project 21 supports nine technical assistance providers in the areas of math and science content and pedagogy, as well as school culture change. Their services are available to selected schools, and the impact on these schools varies widely. There are questions about how technical assistance can be scaled up effectively.
3. State curriculum frameworks commissions	SSI staff have participated in the development of draft frameworks in math and science. Project 21 is coordinating the framework review process and will support the involvement of outside experts in framework revisions.
4. Partnerships and collaboration	SSI established and supports statewide Science and Mathematics Collaborators Groups designed to bring together all levels of the system around standards-based reform.

Preliminary Impacts of the SSI. New Directions is clearly understood by educators and policy-makers to be a major state-level educational reform effort. However, many people are still struggling to determine what the essential difference is between a standards-based education system and business as usual. The legislature finds the conceptual base for the reform effort vague and has so far declined the Department of Public Instruction's request for funding to scale up implementation. As the development arm for New Directions, Project 21 and, in particular, the NDDS schools have a heavy responsibility to illustrate how different the expectations for teaching and learning are in a standards-driven, performance-based environment. Their capacity to serve this function is still developing.

The technical assistance provided by the SSI staff has been valuable and effective for a number of the NDDS schools, but other sites—often the schools that have the farthest to go—have made relatively little use of this resource. Working intensively with even a subset of the 17 NDDS schools seems to be stretching the SSI to its full capacity for technical assistance. This issue is a serious one for the scaling-up process.

Reflections on the SSI in Delaware. Delaware's basic approach to systemic reform is closely patterned on the model articulated for the policy and research community by Smith and O'Day: a clear vision of what students should know and be able to do and alignment of curriculum, instruction, and assessment to support the achievement of the vision by all students. This model presumes that policy-level consensus on the vision precedes the alignment and implementation processes. In Delaware, however, the vision is being formulated at the same time that NDDS schools are attempting to understand and illustrate it. The state is thus testing an adaptation of the model.

Like other Cohort 1 states, Delaware must now concern itself with scaling up to reach more of the state's schools and teachers. The core implementation strategy of schools as demonstration sites may work against systemic reform at this stage, where district commitment might be more helpful.

Delaware was a Re:Learning state before it was an SSI state. In a number of the NDDS schools, the allegiance to school-based restructuring around Ted Sizer's nine principles for school reform is very strong. There is no question that teachers are currently more familiar and comfortable with the Sizer vision than they are with the New Directions vision. The two strategies are not incompatible, but more effort needs to go into articulating their complementarity.

Largely because of staff involvement with Re:Learning, the Delaware SSI has a strong ethos of encouraging constructive criticism from outside observers and experts. Initially, Project 21 welcomed the NSF mid-point review process as formative evaluation that would help improve the SSI. Ultimately, however, the staff found the process less helpful than they had hoped. The review panel was quite critical of Project 21 and approved continuation only after a site visit and clarification of a number of issues.

Montana's SSI: SIMMS

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

The Montana SSI has made substantial progress in meeting its goals (see Exhibit S-3). More than 1,000 pages of the integrated curriculum (called SIMMS) have been produced. A year-long SIMMS course aimed principally at 9th-graders has been prepiloted and then piloted with 115 classes representing more than 20% of the 9th-grade cohort in the state. A second year-long course, primarily for 10th-graders, was prepiloted with 21 classes. Piloting of all the materials is on schedule. Importantly, institutions of higher education in the state are accepting completion of 3 years of the new curriculum for entrance to college.

Exhibit S-3
Progress of SIMMS Components

Component	Progress to Date
1. Design an integrated 9-12 mathematics curriculum.	A total of 96 modules, over 1,000 pages in all, have been drafted for grades 9-12.
2. Develop and publish curriculum and assessment materials for grades 9-16.	Levels 1 and 2 widely available and used in hundreds of classrooms. Assessment handbook developed and distributed.
3. Incorporate technology at all levels of mathematics education.	The SIMMS curriculum in grades 9-12 relies heavily on technology. More college courses also are using technology.
4. Increase participation of females and Native Americans.	A number of steps have been taken to make math more appealing to these groups, but results are still inconclusive.
5. Establish new teacher certification and recertification standards.	New teacher certification standards have been adopted.
6. Redesign teacher preparation programs.	NSF Teacher Collaboratives award, STEP, is providing substantial assistance.
7. Inservice on integrated mathematics for teachers in grades 9-16.	Approximately half of the 534 math teachers in grades 9-12 have been reached so far.
8. Support legislative action, public information, and outreach.	The legislature has provided millions for purchase of technology in schools. An active public outreach effort is supported.
9. Promote integration in science and mathematics education.	The science component of SIMMS is on a much slower track. The integrated high school math curriculum includes some science, as does a middle school math curriculum being developed with support from NSF.

To date, the state legislature has made $2 million available for technology grants to schools. More than half of the high schools in the state have received grants, and most of those have used the new curriculum. Because the technology costs $10,000 to $30,000 per classroom, this program has been very important to implementing the new curriculum.

Hundreds of teachers have 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 6 weeks long. Many other workshops for teachers and administrators were also held, and presentations were made in various forums, such as the State Board of Education.

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

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

Many teachers and more than 3,000 students have used the new curriculum materials. However, at the local level involvement is something of a patchwork, with certain schools in a district (but not others) using the materials, and within a school only certain teachers or selected classes. Comparisons of classes using the materials with others not using the materials show some favorable outcomes for the experimental classes. Nonetheless, not all districts, principals, or teachers enthusiastically embrace the new approach. The extent to which the curriculum will be used statewide is not yet known.

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

Scaling up is proceeding well for high school mathematics. The PIs believe that 50% to 70% of the high school students in the state will eventually use SIMMS. Resistance to using the new materials comes in part from districts, teachers, and families whose children have "succeeded" in traditional mathematics courses, and the effects of such resistance need to be watched, in part to see whether new patterns of tracking emerge. For K-8 mathematics and for science, although a comprehensive state plan is being developed, it is far less clear how many students will be affected by the SSI.

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

INTRODUCTION

With this report, we begin publication of a series of case studies of systemic reform in 11 of the states that have received awards from NSF's SSI program. The three case studies this year are for Connecticut, Delaware, and Montana. These states received their SSI awards in 1991, placing them within the first cohort of SSI awards made by NSF.

Next year, we plan to provide five additional case studies. These will focus on California, Kentucky, Michigan, Vermont, and Virginia, each of which is part of the second (1992) cohort of SSI awards made by NSF. In the following year, case studies will be published for three states in the third and last (1993) SSI cohort: Arkansas, New York, and Texas.[1]

The Case Study Sample

These 11 states are a carefully selected sample drawn from the universe of SSI awards NSF made to 25 states and Puerto Rico.[2] The sample was selected to include a very diverse group of states, representing a wide range of contexts for and approaches to systemic reform. Data were collected relating to each state's geographic and social context, the attributes of the state's education system, and the characteristics of its SSI initiative. (See Table 1 for an abbreviated list of the selection criteria.) These data were carefully reviewed in light of the selection criteria to provide a diverse set of states. The resulting sample includes large and small states, wealthy and poor ones, states with a lengthy history of education reform and others with little previous reform activity, and so forth.

Because every state is unique in certain important respects, no sample of states can ever fully represent all the remaining states. Nonetheless, we believe that the sample of 11 states selected for the SSI case studies will provide readers with a good understanding of systemic reform in a great many different contexts and using a range of quite different

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[1] The award for Texas was actually made in 1992. However, in 1994, NSF suspended the SSI in Texas until the state redesigned its SSI. When the Foundation decided that the Texas SSI was ready to begin again, it changed its designation to Cohort 3 in order to reflect the fact that it was virtually a new beginning.

[2] In 1994, NSF decided to phase out the Rhode Island SSI, leaving active awards in 24 states and Puerto Rico.

strategies. Taken both one at a time and especially all together, the case studies suggest both pitfalls and lessons for successfully undertaking systemic reform.

Table 1
Selection Criteria

State Geographic and Social Context	State Education System Attributes	SSI Initiative Characteristics
Region	Degree of local control	How systemic?
Size	Reform history	Primary strategy
Wealth	Availability of outcome data	Locus of control
Ethnic diversity	Math/science course patterns	Cohort (1, 2, or 3)

The 11 case studies provide one important source of data for the national evaluation of SSI. In addition, more limited data have also been collected about all the remaining SSIs, the 15—now 14, since the Rhode Island SSI was terminated in 1994—that are not part of the case study sample. As the evaluation continues, additional data will be collected in all of the SSI states. The three case studies included this year will be published once again, late in 1996, in a revised form that reflects the states' further work on their SSI initiatives.

Our evaluation has been guided, in part, by a conceptual framework for thinking about systemic reform (see Figure 1, page 4). This framework was useful in guiding data collection and in writing reports, including the case studies.

Characteristics of Each Case Study

SSI principal investigators in Connecticut, Delaware, and Montana had an opportunity to review and comment on the case studies for their own states before they were more widely distributed. We appreciate their assistance, and we also gratefully acknowledge the cooperation of many dozens of other people in each state who took time to speak with us and answer our many questions, typically with interest and candor. Without this help, we could not have proceeded. Nonetheless, responsibility for the written case studies rests with members of the evaluation team.

We promised all the individuals that we interviewed that we would not identify them by name. Many direct quotations are included in the cases, but we do not identify the individuals involved, to protect them if others disagree with what they say and to encourage a more open interchange. Similarly, we have avoided identifying by name school districts and schools where we have worked. These places were selected in each case study state in cooperation with the principal investigators, to include a variety of sizes, types, and conditions.

The outlines or tables of contents for all the case studies are nearly identical. This parallelism allows for comparability among them. However, the cases are necessarily unlike one another as one examines them in greater detail, reflecting very different conditions and strategies for systemic reform in different states—thus creating the need to write about somewhat different things.

Our goals and objectives in writing the cases are varied: to situate the SSI activities in a larger context, to strike a balance between being concise and yet telling a complete story in each state, to be fair in our presentations, and to begin drawing lessons about systemic reform. The ability of any person or group to reach conclusions, however, is limited by the fact that these are all stories of reform in progress, focusing on the first half of a state initiative slated for 5 years,[3] and one that may, in many cases, require even longer. The reader should approach the cases realizing that it is too soon for certainty about the outcomes of these reform efforts.

The Audience for the Case Studies

We hope these and future case studies of systemic reform will be useful to a wide variety of audiences. As the nation begins to implement the Goals 2000 legislation, these cases may be of interest to a broad range of federal, state, and local policy-makers. Even individuals in states that have not been part of the SSI program may find this information useful as they consider implementing Goals 2000 or other systemic reform initiatives, regardless of whether or not the focus is primarily on science and mathematics.

[3] The information in each case study was accurate as of October 1994.

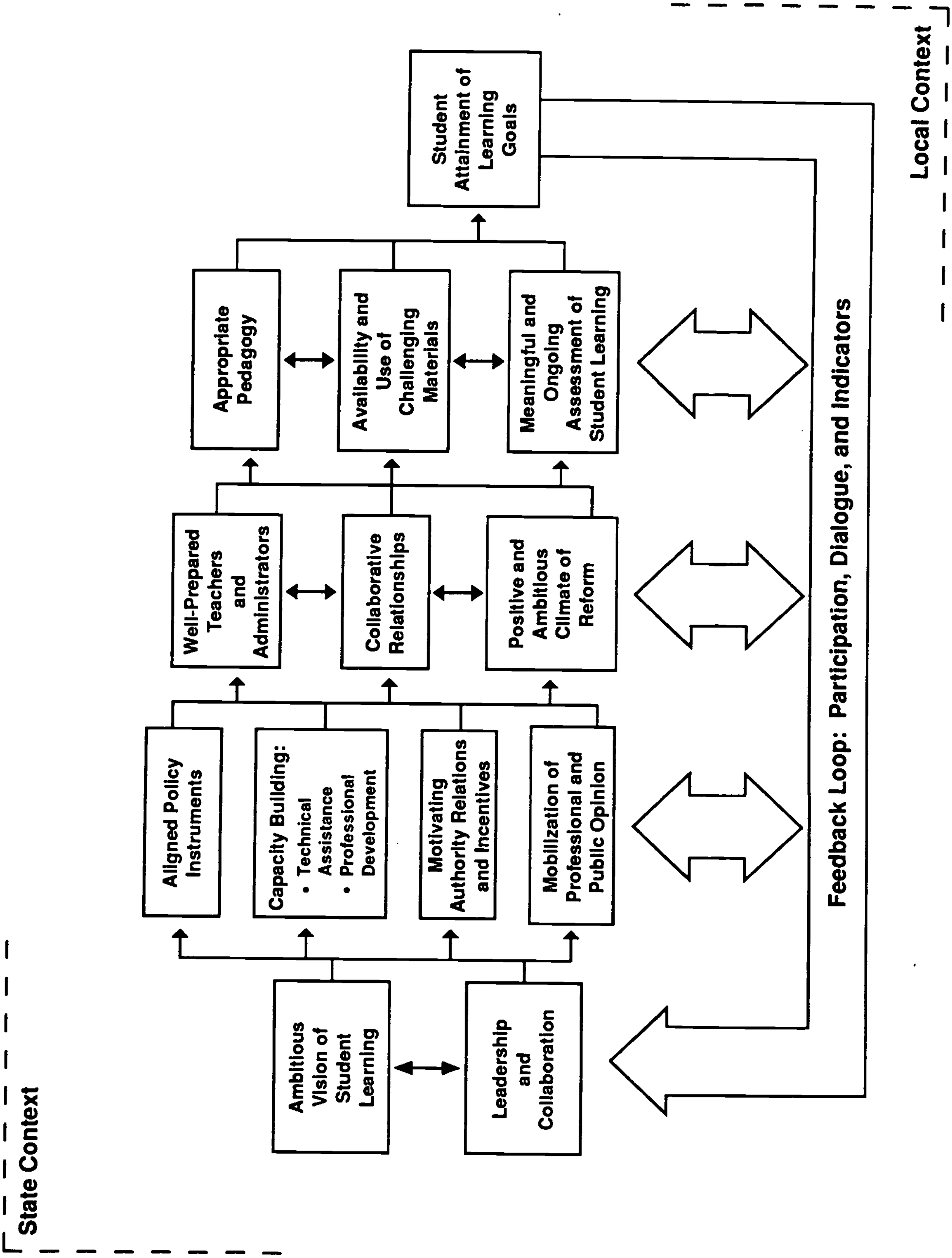

Figure 1 A FRAMEWORK FOR EVALUATING SYSTEMIC REFORM

A CASE STUDY OF CONNECTICUT'S STATEWIDE SYSTEMIC INITIATIVE: PROJECT CONNSTRUCT

Introduction: Connecticut and Its Education System

Connecticut is a state of sharp social and economic contrasts. It is the third smallest state in area and one of the most densely populated. The state's population was 3,287,116 in 1990. Although it is one of the nation's wealthiest states, and in 1990 had the highest per-capita income of all states, its cities are among the nation's poorest. It is a state with a relatively small minority population, comprising only 13% of the state's residents, but it is one of the most segregated. Although Connecticut's citizens take pride in the state's reputation for open, clean, progressive government, many of its communities lack adequate financing for core public services such as schools. Although Connecticut is a state with a reputation for good public schools, many of its urban schools suffer from low aspirations, low academic achievement, and high dropout rates.

The state's economy is suffering from the consequences of long-term declines in manufacturing, reductions in defense spending, the high cost of doing business in the state, and the lingering effects of the 1989-1992 recession. Most observers do not expect the state's economy to recover quickly. These economic problems have placed tremendous pressure on the state budget. The recession severely reduced state revenues and forced painful cuts. In 1991, Governor Weicker pushed an unpopular state income tax through the legislature to balance the budget and maintain essential state services. Even with these new revenues, it has been necessary over the past 4 years to make further cuts in state services, virtually freeze state aid for education, and lay off additional state employees.

The state's fiscal problems have led to program reductions, salary freezes, and layoffs in local school districts. On a per-pupil basis, Connecticut has been, and continues to be, one of the highest-spending states, and since the mid-1980s the state's teachers have been the highest paid in the nation. Connecticut relies more heavily than most states on local property taxes to fund its public schools. Although the state share of total education expenditures gradually rose during the 1980s, the recession reversed this trend and increased pressures on local property taxes. Local taxpayers paid 59% of the bill in fiscal 1993 (compared with about 47% nationally), and local tax rates, already viewed as too high, went even higher. Not surprisingly, there is growing public resistance at the local level to increasing school spending and raising teachers' salaries.

Home rule is a powerful and respected political tradition in Connecticut. There are 166 school districts, most of them small. The largest, Hartford, served only 25,418 students, and only four other districts had enrollments over 10,000 in 1992. Conversely, there were 46 districts with enrollments below 1,000, and an additional 43 with enrollments from 1,001 to 2,500. Local school boards and local citizens are fiercely independent, and the boards are responsive to the voters. School budgets are subject to a public vote if the tax rate must be increased. Local boards and school administrators have been under enormous pressure to hold down school spending.

The state's heavy reliance on the property tax also leads to resource inequities among school districts. The amount of property wealth in districts correlates with their ethnic and socioeconomic composition. Minority children and poor children are concentrated in the low-wealth communities. Nineteen school districts educated nearly 78% of the state's minority students, while 99 districts had less than 5% of the minority enrollment.[4] The distribution of state aid has not totally compensated for these differences in wealth. A cost-sharing (equalization) formula was introduced in 1989-90, and $919 million was distributed in 1992-93 according to this formula. The good news was that this was 77% of all state aid, but the bad news was that state aid covered less than 40% of total school expenditures.

Meanwhile, school enrollments are slowly increasing again. The public schools of Connecticut enrolled more than 482,000 students in the fall of 1992.[5] About 75% of the students were white, 12.7% African-American, 10.1% Hispanic, 2.2% Asian, and 0.2% Native American.[6] Minority enrollments are growing faster than majority enrollments; the percentage of the population under 18 that is minority increased from less than 18% in 1980 to over 23% in 1990. Thus, enrollment growth is the greatest in the school districts serving minority children, adding to the fiscal problems of communities with the least property wealth.

The public schools employed 34,549 teachers in 1990. The state's teachers are highly credentialed and experienced; in 1990, Connecticut ranked second in the percentage

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[4] *Connecticut Project CONNSTRUCT: Mid-Point Review*. Presented to the National Science Foundation, December 15, 1993.

[5] National Center for Education Statistics (NCES). *Digest of Education Statistics - 1993*. Washington, DC: U.S. Government Printing Office, 1994, p. 53.

[6] National Center for Education Statistics (NCES). *Digest of Education Statistics - 1992*. Washington, DC: U.S. Government Printing Office, 1993, p. 60.

of teachers with master's degrees (58.4%) and sixth in teachers with more than 10 years of experience (72.1%).[7] About half of the current teaching force is expected to leave teaching in the next decade.

Good Practice in Mathematics and Science Education

In the Foreword to the state science guidelines published in 1991, the Commissioner of Education, Gerald Tirozzi, wrote:

> The Statewide Educational Goals for Students 1991-1995...and Connecticut's Common Core of Learning (adopted in January 1987) together are the heart and soul of the achievement we envision for all Connecticut students. This vision only becomes a reality, however, at the district level through the creativity, talents, and special understanding that local education professionals and citizens bring to the K-12 curriculum planning process.[8]

Setting the vision at the state level and then persuading and nudging local policy-makers to move in the desired direction and work out the specifics is a strategy that fits Connecticut's political culture. Local districts have considerable autonomy over curriculum, and local policy-makers are sensitive about their prerogatives. The educational goals adopted by the State Board of Education provide a very broad framework for local action in five areas: motivation to learn, mastery of basic skills, acquisition of knowledge, competence in life skills, and understanding society's values. The Common Core of Learning (CCL), which offers a broad vision of student outcomes, is only somewhat more specific. The desired student outcomes are listed under the headings of Attributes and Attitudes, Skills and Competencies, and Understandings and Applications. However, the CCL is not binding for local school officials, and the introduction in the CCL document states:

> ...the Common Core of Learning has been developed neither as a state mandate nor as a condition of graduation. It provides a statement of high expectations needed for all Connecticut students to become educated citizens. It also offers a catalyst for school improvement.[9]

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[7] National Center for Education Statistics (NCES). *Digest of Education Statistics - 1992.* Washington, DC: U.S. Government Printing Office, 1993, p. 77.

[8] G. Tirozzi. "Foreword," in State of Connecticut Board of Education, *Science: A Guide to Curriculum Development.* Hartford, CT: Author, 1991, p. vii.

[9] Connecticut State Board of Education, *Connecticut's Common Core of Learning.* Hartford, CT: Author, 1987, p. 4.

The CCL is consistent with the standards of the National Council of Teachers of Mathematics (NCTM) in its emphasis on communications, problem solving, applications, and the use of technology (see Exhibit 1). The science outcomes are expressed in disciplinary terms, and the CCL makes no explicit reference to the integration of mathematics and science (see Exhibit 2).

Exhibit 1
The Common Core of Learning:
Mathematics

- understand that mathematics is a means of expressing quantifiable ideas;
- apply mathematical knowledge and skills to solve a broad array of quantitative, spatial, and analytical problems;
- use mathematical skills and techniques to complete consumer and job-related tasks;
- select and use appropriate approaches and tools for solving problems, including mental computation, trial and error, paper and pencil, calculator and computer;
- use mathematical operations in describing and analyzing physical and social phenomena;
- demonstrate a quantitative sense by using numbers for counting, measuring, comparing, ordering, scaling, locating, and coding;
- apply basic algebraic and geometric concepts for representing, analyzing, and solving problems;
- use basic statistical concepts to draw conclusions from data.

Exhibit 2

The Common Core of Learning: Science and Technology

- understand and apply the basic concepts and language of biology, chemistry, physics, and earth and space science;
- understand the implications of limited natural resources, the study of ecology, and the need for conservation;
- identify and design techniques for recognizing and solving problems in science, including the development of hypotheses and the design of experiments to test them;
- the gathering of data, presenting them in appropriate formats, and drawing inferences based upon the results;
- use observation and analysis of similarities and differences in the study of natural phenomena;
- demonstrate the ability to work with laboratory measuring, manipulating and sensing devices;
- understand the implications of existing and emerging technologies for our society and our quality of life, including personal, academic, and work environments;
- recognize the potential and limitations of science and technology in solving societal problems.

There are state curriculum guides in mathematics and science, but they are simply sources of advice. Districts are free to use them or ignore them. Most observers felt that the guides were used by many districts, but also said that the selection of textbooks probably had more influence over curriculum than the guidelines. A former president of the math teachers' association described the situation as follows:

> There is no state curriculum. There are guides, and they are used. The districts write their own curriculum. There is a lot of local ownership. Local control is very important here; it is the one thing that people will come out to fight for—except for opposing [racial] integration. The curricula are written by teachers and are heavily influenced by textbook

selection. So there is considerable variation across districts, but they all have the same basic structure.

The next stage in the process of specifying the vision and changing the curriculum has already begun; committees sponsored by the Department of Education (DOE) and Project CONNSTRUCT (the state's SSI) are working on new math and science curriculum frameworks.

Within the broad parameters defined by the Connecticut State Board of Education through the state goals and the Common Core of Learning, local school districts have considerable discretion over curriculum. However, norms of good practice and content standards have emerged over time from interactions among state leaders, the professional communities, and local policy-makers. The Department of Education has led the way, using the state assessment program to provide ever greater specificity about content standards, and forcing local curriculum change.

The State's Vision and Strategies for Change

During the 1980s, Commissioner of Education Gerald Tirozzi set, and pushed, a reform agenda that earned Connecticut a reputation as a leader in school reform. He used the persuasive powers of his office to build local capacity and channel local energy in the direction set by the State Board, and made effective use of the limited policy tools available to him. He also assembled in the Department of Education a high-quality staff who were capable of influencing professional organizations to support the state's reform agenda. Pressures to do something about the deteriorating conditions in the state's urban schools led the legislature to support expansion of state assessment, increased accountability, and changes in policies on teacher certification and pay.

State Assessment. Connecticut had initiated state assessment in the 1970s, but it expanded dramatically during the following decade. The Connecticut Mastery Test (CMT), a basic skills test, has been administered to all students in grades 4, 6, and 8 since 1985. The CMT scores have been used to identify students who need remediation. They have also been used to identify districts with the greatest academic needs. Referred to as priority districts, they have received additional state support, assistance, and monitoring.[10]

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[10] Every year since 1983, up to 25 districts have been targeted to receive additional state aid under the Priority School District Program. $10 million was appropriated in 1992-93, and 12 districts, all urban, were identified. In 1992, Commissioner Ferrandino established an Office of Urban and Priority

In the 1990s, the assessment program has moved into higher-order skills and into other content areas. A revised, and more difficult, second-generation CMT was administered for the first time in 1993, and the first administration of the new 10th-grade Connecticut Academic Performance Test (CAPT) occurred in the spring of 1994. The second-generation CMT results surprised suburban educators, because their students did not perform as well as they had on previous state assessments, especially in writing. Statewide, the number of students who failed to meet the standards in grades 4, 6, and 8 in reading, writing, and mathematics tripled. The percentage of 8th-graders who achieved mastery on all three parts of the CMT fell to 50.8% in the most affluent suburbs, and to only 2.9% in the urban districts.

CAPT is designed to assess students' proficiency in the content and skills covered in the four core subjects in grades K-10. It includes multiple-choice items, open-ended items, performance tasks, and an integrated assessment that requires students to draw on knowledge from all disciplines to solve a problem. Districts have received CAPT "frameworks" in each subject area, including science and mathematics. These "frameworks" offer further specification of the state's curricular expectations. They are consistent with the Common Core but also draw heavily on the national work on content standards. For example, the science framework used Project 2061 *Science for All Americans* and NSTA's *Scope, Sequence, and Coordination's Content Core*. The science section covers life science, physical science, and earth/space science and focuses on conceptual understanding, experimentation, and application. The math portion of CAPT covers numbers and quantity, geometry and shape, and relations, functions, and algebra. The skill areas are problem solving and reasoning, communicating, and computing and estimating. Students do not have to pass the CAPT to graduate from high school, although those who do pass will get a certification on their transcript and permanent record. Results from the first CAPT will be available in the fall of 1994, and they are likely to have a shocking impact on the high schools, especially in science, which is being assessed for the first time.

Until 1992, these state assessments held relatively low stakes for most schools and students. Results from the Connecticut Mastery Test administered in grades 4, 6, and 8 were used to identify students who needed remediation. In that year, however, the Department released the first annual legislatively mandated strategic profiles for districts

Districts to help districts make better use of these funds. The priorities of this new office are expected to be preschool programs, reduction of dropouts, and parent involvement.

and schools, which provided the public with comparative information on school performance. The information was published by the press, and the profiles generated public pressure for changes in some local schools. However, until the introduction of the revised CMTs in 1993 and the CAPT in 1994, the state assessed only basic skills, and "pass rates" in suburban districts were so high that little public pressure was generated in those communities. Poor results did lead to some urban and rural districts' being designated as priority districts, which carries some stigma but no sanctions. With the advent of the new assessments with their higher standards, a larger number of schools and districts are likely to feel public pressure to improve their performance.

Teacher Qualification Policies. Another set of significant reforms was designed to recruit and hold better-qualified teachers. Connecticut adopted a preservice examination for teachers in 1985. Connecticut's Education Enhancement Act (EEA) of 1986 raised and helped equalize teacher salaries statewide. The average salary went up 16% in 1987-88, making Connecticut teachers the best paid in the nation, a distinction that the state still held in 1992. The *quid pro quo* for the salary increases was reforms in preservice education and higher standards for the certification and recertification of teachers. By 1993-94, all prospective teachers were required to have an undergraduate subject major, and no more than one-fourth of their coursework could be in education. The EEA created a three-tier system of certification with initial, provisional, and professional educator certificates. To obtain initial certification, teachers must pass examinations in both pedagogical and content knowledge. They then must work for a year with a mentor through the Beginning Educator Support and Training (BEST) program, after which they can obtain provisional certification, which they can hold for 8 years. They can earn the professional educator certificate by completing additional college courses, and they can retain it by earning 90 continuing education units (CEUs) every 5 years.

State-Local Relations. Commissioner Tirozzi used the CCL, the state assessment program, and teacher policies to communicate a vision of what should be taught and learned, and to circumvent local opposition to state-mandated curricula. As long as the state's focus was on basic skills and the burden of improving performance fell only on urban districts, this strategy was tolerated by suburban educators and legislators. Nevertheless, many local policy-makers felt that Tirozzi was too top-down in his approach.

Some superintendents and board members resented what they viewed as directives from Hartford and complained vehemently about mandates. Their perception was that Tirozzi had eroded home rule by drawing public attention to test results and by releasing comparative data on the results of state assessments. One leading superintendent said, "Tirozzi used tests and regulations to drive reform; it was always his agenda." Another complained that "the regulations might have been well intended and progressive, but they [DOE] don't think about the implementation problems or costs and we get stuck trying to make it work." However, a different view was expressed by one Department staff member, who said:

> Someone has to take the lead, like with the NCTM standards. You have to force the discussion and get something out there for people to react to. Then you get others to comment. Is this top-down? Perhaps. But it is not *ex cathedra*.

The difference between the state and local viewpoints about school reform might arise in part from different definitions of involvement. Local policy-makers wanted to be consulted in advance about policy formulation, and they wanted an institutional role. They did not accept the state's premise that statewide committees of teachers convened by the Department, invited as individuals, could adequately represent the institutional interests of local districts.

Responding to this pent-up frustration, Tirozzi's successor, Vincent Ferrandino, appointed in June 1992, promised an end to mandates. He wanted the DOE to be more service oriented and "more responsive to all of our customers and clients." However, relations between the SEA and districts do not seem to have changed in any significant way during the 2 years of Ferrandino's tenure. The expansion of the state assessment program has continued, and the stakes have been raised with higher standards. Ferrandino resigned in the summer of 1994, leaving the future course of school reform unclear. The Department's new leadership will be determined by the outcome of the gubernatorial election.

Other Reform Initiatives. Segregation became a major political issue in 1993 because of a court case, Sheff v. O'Neill, brought on behalf of minority school children in Hartford. The plaintiffs are seeking to redraw district lines to desegregate the public schools and achieve equitable conditions for learning. Filed in 1989, the case was heard in the spring of 1993, and a decision is expected in the fall of 1994. Many observers predict a dramatic backlash if the plaintiffs win the case, including white flight from the public schools. As one noted, "...many people moved to Connecticut's towns to escape school integration in New York City and Long Island, and they won't accept it here either."

To ward off a crisis, Governor Weicker proposed state support for voluntary regional desegregation activities. After lengthy and acrimonious debate, the legislature passed a weaker version of this proposal in early 1994. As a consequence, regional forums, composed of local municipal and school officials, parents, and teachers, were convened. They listened to input from local advisory councils and developed plans, which are now being reviewed by DOE. They are expected to be weak, and most likely will involve magnet schools, staff exchanges, joint professional development, cooperative student projects, electronic hook-ups, and pooling of some resources among districts. The initiative has been criticized by reformers because the plans are limited in their vision and are nonbinding, and because no state funds have been allocated to support them. However, it did bring people together to address the issue, and the regional structure may yet prove to be a useful vehicle for addressing issues of school reform. The issue of desegregation is dominating education policy discussions, and the court decision, or legislative action to avoid it, could redraw the educational map in Connecticut.

Another recent reform initiative was led by members of the state's Business Roundtable. William Connolly, CEO of ABB Business Services, and Commissioner of Education Vincent Ferrandino chaired the Commission on Educational Excellence, a 43-member commission appointed by Governor Weicker and charged with developing a comprehensive reform plan for the state. The Commission's report, released early in 1994, called for the creation of a results-oriented system with world-class standards and opportunities for all students to meet them; curriculum that prepares all students for work, higher education, and lifelong learning; a variety of assessments; school councils with control over budgets; removal of principals from failing schools; use of teacher portfolios for recertification; tenure after 4 years and more specific reasons for removal; holding teachers accountable for student performance; and other related changes.

There was vocal public and professional opposition to the Commission's report and to the legislative proposals intended to enact its recommendations. Although the reforms had the support of a few powerful legislators, the chief executive officers of the state's largest corporations, university presidents, the governor, and the commissioner of education, they were strongly opposed by the state teachers' union and well-organized suburban parents opposed to outcome-based education. The general public appeared to be either uninterested in, or unaware of, the debates in the legislature. In the end, legislators refused to pass any of the reform proposals in the spring of 1994. A simultaneous effort to pass a school-choice bill was defeated in the Assembly by only a tie vote. Both the Commission's recommendations and school choice are likely to come up again in the next session of the legislature.

Pre-SSI Reforms in Mathematics and Science

The state's visions for mathematics and science have developed in parallel with the emergence of national standards in these domains. Connecticut educators have also been active in the national efforts to set standards in both mathematics and science, and they have carried these visions of new curricula and pedagogy home to other teachers through the activities of their professional organizations. The NCTM *Standards* have already had considerable impact on curricula and teaching in the state.

The Department of Education has actively promoted these changes. Department staff have promoted developmentally appropriate mathematics since they developed a state math framework in 1981. Districts have moved away from sole reliance on textbooks toward increased use of manipulatives and supplementary materials. The Department has supported the efforts of the professional organizations to disseminate the new visions of mathematics and science and reinforced them through the Common Core of Learning. They also have made complementary changes in the state assessment program. For example, changing the nature of the items on the CMT to focus on problem solving and applications and developing performance tasks and an integrated assessment for the CAPT are all consistent with emerging national standards. Connecticut was also among the first states to require the use of calculators on state tests. Although districts have only recently received the first results from the revised CMTs, significant work is already under way to strengthen elementary and middle school math programs.

The Department's specialists in mathematics, Steve Leinwand and Mari Muri, and in science, formerly Sig Abeles and now Steve Weinberg, have played key roles both in the Department's efforts and in shaping the activities of school districts and professional organizations. They are widely respected and are often consulted by district staff. They have been leaders in the Association of Teachers of Mathematics in Connecticut (ATOMIC) and the Connecticut Science Teachers Association (CSTA). Eisenhower funds and state personnel have been used to expand the annual meetings of the two organizations and to get them more involved in professional development. ATOMIC has been active in disseminating information about the NCTM standards to its 1,300 members through their annual conferences, which are attended by more than 1,000 teachers, and regional workshops. ATOMIC has also offered calculator workshops on long weekends, and they have been well attended.

There has been less progress in science. The science community in Connecticut, as in the nation, has been divided by disciplinary boundaries, and there is less consensus about standards than in math. A state framework in science was developed in 1991, but it has had only limited effects on district curricula. Nor have the debates over national standards had much effect on practice so far. The lack of state assessment in science before 1994 has also contributed to the lower priority given to reforms in science by local districts. However, the introduction of science assessment in grade 10 with the CAPT is putting pressure on schools and districts to improve student performance in science. Although districts have yet to receive the CAPT results, many districts are already doing significant work to revise their science courses in grades 9 and 10.

The widespread belief held by many parents, students, and educators that science is for "smart" students remains an obstacle, as do resources. There is a desperate need for funds to upgrade laboratories and equipment in the urban areas; even textbooks may be outdated and in short supply. Even some suburban schools have old and outdated labs. Many schools have too few computers or are using hardware that is unable to operate new instructional software. Budgets for equipment and consumable materials are inadequate in all districts. One teacher leader said, "We simply lack the technology to be competitive, and the public doesn't want to pay to catch up."

Partnerships. There also have been some significant initiatives by higher education and business to improve K-12 math and science. The best-known initiative may be the Project to Increase Mastery of Mathematics and Science (PIMMS) at Wesleyan. Led by Bob Rosenbaum, now one of the leaders of the Connecticut SSI, PIMMS' primary mission has been to improve teaching in the K-12 system. PIMMS Fellows are given content training in summer institutes and are expected to be resources for other teachers in their schools and districts. There are now more than 400 Fellows, who form a network of teachers committed to reform. Although the quality of PIMMS training is regarded as excellent, participation has been limited by funding and by the number of teachers willing to give up most of their summer to participate in a demanding program. One superintendent said that he had been "aggressive about getting his people [to enroll] in the program, but after 5 years only 10% to 15% have been exposed." High-quality professional development has also been offered by the State Department of Education's

Institutes for Teaching and Learning, the Talcott Mountain Science Center, the SmartNet 2000 program at Sacred Heart University, other NSF grantees, and the regional education service agencies. Much of this activity—the development of state guidelines, workshops on NCTM standards and calculators, the support for the content associations, PIMMS, etc.—has been supported with Eisenhower money.

Connecticut's SSI

The broad vision of reform and the long-term goals of the Connecticut SSI are similar to those of most other SSIs, but its leaders take a broader view of systemic reform than the conventional recipe of aligning state curriculum, assessment, and certification policies, and helping locals implement the new mandates. They view the central task of reform as building public and professional support for a new vision of math and science teaching and learning, and for the long-term effort needed to transform public education accordingly. They have set out to change the norms of good practice and to generate public and professional pressure on local districts to transform their standards, curricula, professional development, and organization to be consistent with the new norms. They view this cultural transformation as the route to change that best fits the political culture of Connecticut and as a strategy that has the best chance of sustaining the long-term effort that is needed.

To this end, a small but influential group of state education leaders has used Connecticut's SSI, Project CONNSTRUCT, to launch a new institution, the Connecticut Academy for Education in Science, Mathematics, and Technology, whose mission is to serve as an advocate and catalyst for reform. Writing in the newsletter of the Academy, Richard Cole, one of leaders in Project CONNSTRUCT and the executive director of the Academy, contrasted the SSI's work with the recent legislative struggle over the Commission on Educational Excellence's report, using the familiar parable of the tortoise and the hare:

> The hares obviously view reform as a quick, massive explosion of change. The tortoises, on the other hand, focus on transformation, which calls for resolve, hard work, and the expectation that all of us must change some of what we have done in the past to accomplish new, higher expectations. Ah. We may be the tortoises, but we wear Nikes.

This vision fits the political norms and realities of the state. For in spite of the powerful influence of the state assessment program, Connecticut remains a local-control state.

Thus, the SSI places somewhat less emphasis on the development and use of state policy instruments than it does on diffusing a shared vision of teaching and learning in mathematics, science, and technology within the profession. The Academy's primary mission is to mobilize the mathematics and science communities in support of the vision, and to build the capacity to guide and support local efforts to implement the vision.

Project CONNSTRUCT originally had three goals: (1) increasing the number of students who take and master science, mathematics, and technology; (2) increasing the effectiveness of teacher preparation and professional development programs at colleges and universities that prepare teachers; and (3) heightening the public's awareness of the importance of science, mathematics, and technology to the state and to its children, and enlisting their support for reforms that would help improve the performance of schools and students. The leadership of the SSI recently modified the first goal, which is now "providing the state's most needy school districts with technical, financial, and community support to raise the quality and quantity of students' engagement with mathematics, science, and technology to ensure that all students take courses that are useful in the technical workplace, are preparatory for higher education, contribute to their intellectual development, and that they increase their level of mastery of the courses they take."[11] The interesting thing about these goals is that they all focus on building capacity to stimulate, support, and implement local reforms intended to improve academic outcomes rather than on changing state policies, although the leaders of the SSI clearly look for opportunities to make state policy more coherent as well.

The overarching goal of CONNSTRUCT is to make the reform of science, mathematics, and technology a high priority for state and local policy-makers and to keep their attention on this task. One of the key participants said, "We will have succeeded when we have made the improvement of math and science education one of the top three priorities for state policy-makers." He views this as a long-term process in which professional commitment and consensus, public support, and the ability to mobilize resources matter most. Obviously, he and the others involved in CONNSTRUCT want to see classroom practice change and student performance improve. That is the bottom line, but they believe that these changes will be achieved only if the Academy develops the political and professional capacity to define the reform agenda and support its implementation.

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[11] *Connecticut Project CONNSTRUCT: Mid-Point Review*, p. 3.

The central strategy is to expand, mobilize, and increase the influence of the forces supporting the reform of science, mathematics, and technology education. Project CONNSTRUCT is designed to build a reform movement that can be sustained even if there are changes in state leadership or reductions in federal funding. They hope to achieve this sustainability by creating new institutional relationships that simultaneously demonstrate the power of their vision and recruit new supporters to the movement. While they are giving considerable attention to the neediest districts, they are also building linkages to other institutions and organizations that will spread the vision to the suburbs, and through these collaborations they are creating the scaffolding that will support the implementation of reforms. They are trying to increase public awareness of the importance of the issues and support for their vision of reform, and they have energetically recruited science, mathematics, and technology professionals from all sectors. One way to look at Project CONNSTRUCT is to see it as an effort to build a powerful network of professionals committed to a common vision and collectively able to shape the formulation of public policy through the influence of their institutions, the respect and stature accorded to them individually, and their personal commitment.

The Components of the SSI. To achieve its broad goals, Project CONNSTRUCT has created five interrelated components, each with its own director and distinct mission. Each component is designed to address a significant aspect of the problem, to promote institutional change, and to alter the climate of expectations with regard to science, mathematics, and technology education.

- The first component is a new institution, the Connecticut Academy for Education in Science, Mathematics, and Technology. The Academy staff manage the NSF grant, coordinate the work of the components, and attempt to build relationships with other institutions and organizations interested in reform of math and science education. A free-standing nonprofit organization, the Academy is expected to serve as a catalyst, advocate, and broker and to be a continuing force for reform after the SSI funding ends.

- Component Two supports reforms in high-need school districts and is managed by DOE. The vehicle for change is a competitive grants program supporting the development and implementation of model elementary and middle grade math and science curricula in urban and rural districts. The objectives are districtwide implementation of the new curricula and their diffusion to other districts.

- Component Three fosters changes in mathematics and science curricula in higher education, both in teacher education and in undergraduate programs. These grants have been aimed at the redesign of preservice curricula through increased collaboration among liberal arts and education faculties and public school teachers.

- Component Four has worked with science-rich institutions and community organizations to create new partnerships with the public schools. Its most visible activities have been Family Science and Math programs. Grants have also been made to community organizations, nonprofits, and science-rich institutions to provide enrichment experiences for students from underrepresented groups or support for teachers.

- Component Five is focused on building public understanding of the need for reforms and their support for the SSI's vision of math and science education. A vigorous statewide media effort has been launched with help from a public relations firm, newspapers, television and radio stations, and community organizations. A second stage of this effort to reach the public is concentrating on community outreach targeted to particular communities.

The Academy has intertwined the activities of these components so that they contribute to each other's successes. The higher-education initiative, Component Three, has supported links between universities and the districts funded under Component Two to improve professional development. Similarly, Component Four has brought Family Math and Science into these districts and forged other partnerships to enrich their programs. It has also melded its activities with those of Component Five to assist with the outreach effort. Component Five has worked with Component Two to get the message out to minority communities through weekly newspapers and local radio stations, use of Spanish-speaking papers and radio, and meetings with local churches and civic groups. Looking across the components, the commitment to increased equity and to improving the quality of education in the urban areas of Connecticut is striking.

Implementation of the SSI

Development of the SSI and Its Governance

The Connecticut SSI proposal was initiated by a small, close-knit group of professional colleagues that included Sig Abeles, the DOE science supervisor; Steve Leinwand and Mary Muri, the DOE math supervisors; Bob Rosenbaum from Wesleyan, who founded PIMMS; Richard Cole from UTTC, an aerospace firm and Connecticut's largest private employer; Bob Gelbach from Southern Connecticut State University; Bob Content from the Science Museum; Jerry Franklin, a public relations expert; and the heads of the math and science teachers' associations. These people brought in others, and eventually the group expanded to a 27-member board, the Project CONNSTRUCT Board.

Committees were formed that produced the plans for the five components. However, the original core managed the process and created the structure that emerged. All but one of the original core group members remain involved in the SSI.

The core group made some major decisions early on that shaped the proposal. First, they decided that it should be broad rather than focused on particular grade levels. However, they also decided that priority had to go to the cities. This was perhaps the most contentious issue addressed by the group. They also decided to place the leadership of the SSI in an advocacy organization because "issues get lost in the Department; priorities change and there is no continuity." There was initially resistance to this approach in DOE because some feared "an outside group who could go directly to the legislature and conflict with the role of the State Board of Education." This potential conflict was worked through and resolved because the Academy would have no legal authority.

The Academy was intended to provide a focal point for math and science reform in Connecticut. It is attempting to bring all the groups together to promote a common reform agenda. The uniqueness of the Academy lies in its autonomy from the bureaucracy and freedom from red tape, and its capacity to convene key players from different sectors who have seldom talked in the past. The most important thing accomplished in the first year was getting policy-makers to identify the Academy as the lead agency in the area of math, science, and technology. The Academy has the active support of the lieutenant governor, several key legislators, the commissioner of higher education, and the acting commissioner of education. The legislature also adopted a resolution recognizing the Academy's role.

The Academy is responsible for monitoring expenditures to ensure that the funds go to implementing systemic reforms. The Academy staff initially worked with two boards—the Academy Board and the Project CONNSTRUCT Board, which represented the original coalition that wrote the proposal and provided linkage to other reforms. Because this dual decision-making structure was cumbersome, in the third year the Project CONNSTRUCT Board was melded into the Academy Board. CONNSTRUCT Board members were invited to join the Academy Board, become Fellows of the Academy, and asked to assist in other ways. This transition could have been difficult but appears to have been accomplished skillfully and without any loss of support.

The members of the Academy Board are influential and diverse. The board includes representatives from business, government, the public schools, higher education, civic and professional organizations, and, of course, the mathematics and science communities. They are described by observers as being deeply engaged in the work of the Academy and committed to its success.

The Academy has developed a solid working relationship with DOE staff. However, until quite recently, its relationship with the Department's leadership was uncertain. There has been no representative from the State Board of Education on the Academy Board, and former Commissioner Ferrandino did not take much personal interest in the Academy. In contrast, the commissioner of higher education has been an active participant in the Academy's initiatives and has helped develop support within the higher education community. The relationship with DOE may be changing for the better, since the new acting commissioner of education is said to be quite supportive. At the operational level, the relationship between the two organizations has been expanding. DOE has cooperated with Academy staff and Fellows in the provision of technical assistance to the 19 districts funded by the SSI, and sought their support for a new initiative to develop math and science frameworks. Other bureaus within DOE have invited the Academy to assist with the redesign of the BEST program, the continuing education program, and the professional development program.

Activities Supported by SSI Funds

The Academy. The SSI has supported the activities of the five components of CONNSTRUCT. The progress of these activities is summarized in Exhibit 3. The first component's activities are the operation and institutionalization of the Academy itself. The Academy has proved to be a successful collaboration among state and local officials, business leaders, K-12 educators, college educators, scientists, mathematicians, representatives of civic organizations, the media, community-based organizations, education organizations, and almost anyone with an interest in science, mathematics, and technology education. The Academy staff work to strengthen existing links and develop new ones among organizations and individuals with shared interests in such reforms. They are mobilizing these forces in support of a common reform vision to develop a "professional community" with the capacity to stimulate, support, and sustain state and local initiatives in support of a shared vision of reform. For example, the Academy held a dinner for all national Presidential Award winners in the state and signed them up as Fellows of the Academy.

Exhibit 3
Progress of CONNSTRUCT Components

Component	Progress to Date
1. The Academy	The organization is functioning well and appears to have won respect from diverse constituents. The Board members remain committed to its success.
2. High-Need Districts	The 19 districts are implementing activities. There is concern about the quality of the projects and the impact of small grants on stressed districts.
3. Higher Education	Fifty-four grants over 3 years; 14 dialogues and 21 co-teaching projects were funded. Eleven of 15 preservice institutions are involved. Although the process is loose, faculty interest has been high and partnerships have developed between colleges and schools.
4. Community Institutions	The focus is on Family Math and Family Science. These programs have been popular and are expanding.
5. Building Public Understanding	A PR firm has helped the Academy develop an outreach strategy. A statewide PR campaign was launched in June 1993. It has since been expanded. Connecticut is seeking support for the expansion of this effort.

Fellows assist school districts, work with collaborating organizations, and assist with public relations. Seventy-two Fellows have been recruited and are giving time to various programs. The Academy is also working with the American Association of University Women, all colleges and universities, the Department, and the math and science teachers' and supervisors' associations to develop and disseminate information about math and science programs for women and girls.

Connecticut's ongoing process of specifying its vision of what children should know and be able to do is entering a new phase as the Department has initiated work on new state curriculum frameworks in both mathematics and science with the support of the Academy. Statewide committees have been convened in both mathematics and science. The 20-member committees include teachers, curriculum supervisors, university faculty, businessmen, and Department staff. Based on the new, revised Common Core, the frameworks will not be mandated when they are completed in 1996, but they will provide guidance for local curriculum development. They will also give advocates of reform another tool to use in stimulating local change. In the meantime, the Academy is disseminating examples of new curricula in math and science through its electronic network. These materials have been developed by local districts and organizations like the Talcott Mountain Center and PIMMS with the support of the SSI, other NSF grants, and private funds.

The Academy has expanded its partnership with the Department by responding to the latter's request for assistance with the redesign of the BEST program. Academy Fellows and the math and science teachers' organizations will help the Department develop new standards and assessments for beginning teachers and redesign the local professional development requirements. The Academy is also working with the Department's Institutes for Teaching and Learning to align their programs with CONNSTRUCT's objectives. The newly created Statewide Network of Professional Development Providers is yet another vehicle for dissemination of the Academy's vision, and a forum for the discussion of improvements and priorities in professional development.

The Academy has helped 10 other organizations develop and submit applications for teacher enhancement grants and other funds from NSF. As of May 1994, eight were funded for a total of $9.2 million, one rejected, and one pending. Each of the new grants is connected to CONNSTRUCT and supports its activities in some manner. For example, New Haven received a $2.5-million NSF Partnership for Minority Student Achievement (PMSA) grant, and a collaborative of four museums is working with eight of the Component Two districts on another grant. The Academy also convened 23 of the Eisenhower Higher Education and NSF Teacher Enhancement Program directors, representing over $5 million in funding. They agreed to meet regularly to discuss how they could work together to improve professional development, and the number involved grew to 50. The Academy also convened a partnership among organizations that provide professional development in Connecticut, and this collaborative is developing a statewide resource network that will be useful to schools.

Recognizing that local adoptions of curricular reforms and support for changes in teaching require support from school administrators and board members, the Academy has launched a series of initiatives to reach these important groups. They have formed principals' and superintendents' advisory councils, are reaching out to the professional organizations that represent these groups to develop joint professional development initiatives, and are supporting the efforts of the state's regional education service centers to make local policy-makers aware of the national standards in math and science and support local change initiatives.

The Academy has convened numerous statewide meetings to bring people together to discuss national standards, teacher education, and environmental education. It also has launched an ambitious statewide public relations effort to build public understanding of and support for the reform of math and science education (see Component Five below). The Academy also took a lead role regionally by hosting a 2-day New England SSI Conference in October 1992, and coordinated another regional conference in June 1994 that was hosted by Governor Weicker and Dr. Luther Williams of NSF.

Local School Districts. During the first 3 years, Component Two of CONNSTRUCT has given grants to 19 urban and rural districts. Eligibility for the grants was based on district performance on the state assessment and the proportion of children from low-income families. Initially, only the state's priority districts, which included most of the urban districts, were targeted. In the third year, in response to frustration expressed by suburban and rural educators, eligibility was broadened to include rural districts. Each year, DOE issued an RFP, and district proposals were reviewed by a committee of educators, including DOE staff. The funded districts serve 32% of the students in the state, and over 70% of the minority students.

There have actually been only 15 grants, since 6 districts are participants in 2 consortia. The grants are relatively small—about $50,000 annually for 3 years—but they have been supplemented by matching funds from local sources, including Eisenhower funds. The grants initially have been awarded on a competitive basis, but the second- and third-year continuation grants were reviewed and awarded noncompetitively. DOE has provided training and technical assistance for district staff. In the third year of funding, the districts are expected to develop plans to implement the curricular revisions systemwide. Another round of grants was envisioned for 1994, but it was canceled to concentrate limited resources on implementation in the 19 districts already funded.

The districts are using the funds to support curriculum development and teacher development in the primary and middle grades. Given the NCTM standards and the relative lag in the development of national science standards, it is noteworthy that only 9 of the 15 proposals have focused on the math curriculum, whereas all but one address science. Six districts are working on science alone. One explanation is that districts had revised and upgraded their math curricula earlier in response to the state assessment program. In contrast, there was no state assessment in science until 1994; therefore, science has not been a high priority in these districts until now.

The character and impact of these local efforts are revealed in the following quotes from site visit reports by SSI consultants to Bridgeport, Hartford, Meriden, and Norwich:

> **Bridgeport:** "In all, it is clear that CONNSTRUCT is having an impact on the science program.... CONNSTRUCT has helped bring along outstanding teachers to assist in the program and to motivate others. It has helped develop new materials and approaches, which are finding their way into the schools. It has provided needed professional development to bring about these changes and it has helped...to organize for the implementation of the new science program. A number of these changes are being institutionalized and will, in all probability, remain when the CONNSTRUCT grant is concluded."[12]

> **Hartford:** "The most notable intermediate effect is that the middle school math and science curricula have been written and coordinated, and have been integrated with a computer technology program.... CONNSTRUCT funds were also used to purchase all of the AIMS [Activities Integrating Math and Science] curriculum units. These changes have reached about 65 teachers and about 3,000 students in Hartford's three middle schools."[13]

> **Meriden:** "The elementary school science project teacher coordinated the development of new science curriculum units in the early intermediate grades [4 and 5] and in the primary grades. She was responsible for working with science resource teachers in each elementary school to give them the expertise necessary to assist teachers in that school. She also has demonstrated science activities and served on teaching teams to all teachers in the 3rd grade. The evidence provided for the success of this approach, while anecdotal, is worth consideration. Middle school teachers are saying that youngsters coming to their classrooms are better versed in techniques of inquiry and investigation...."[14]

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[12] Sig Abeles and Richard Mace, "Bridgeport," in *Project CONNSTRUCT: Annual Report, 1993-94.*

[13] Ralph Yulo and Dan Lawler, "Hartford," in *Project CONNSTRUCT*, op. cit.

[14] Sig Abeles and Lois Lehman, "Meriden," in *Project CONNSTRUCT*, op. cit.

Meriden: "It is clear that CONNSTRUCT support has brought changes in the science program of the Meriden schools. The model for support of elementary school science program adopted by Meriden is worthy of continued discussion regarding the means of continuation there and implementation in other districts. Funding for this approach will always be an impediment. However, if it is a worthwhile approach for helping youngsters learn and appreciate science—as it appears to be—creative methods for providing such help should be explored."[15]

Norwich: "Time, money, and materials are persistent problems, but the PI also noted that a major impediment is 'all the pathology that goes with a veteran staff.' It is difficult to break the mold of teachers working alone, teaching one subject at a time."[16]

The first cohort of five districts have completed their 3 years of SSI funding and are working toward districtwide implementation. The Department and the Academy are continuing to assist them. Recognizing that one of the major obstacles to full implementation is the lack of professional development, the Academy has helped the Cohort 1 schools develop a proposal for a *Local System Change Through Teacher Enhancement* grant. The idea is to find a way to continue the partnership and sustain the effort in the districts.

The districts have committed themselves to districtwide implementation over a period of years, and each district is required to develop a long-term implementation plan in the third year. Recognizing the problems that the local project leaders have had securing commitment to the reforms from their superintendents and boards of education and securing the resources needed for districtwide implementation following the 3 years of support from the SSI, the Department and the Academy developed a novel technical assistance strategy: they jointly formed a high-level technical assistance team that visited each district and met with the superintendent and district leadership.

Institutions of Higher Education. Component Three of CONNSTRUCT is working with 11 of the 15 institutions that train teachers in Connecticut. These institutions graduate over 90% of the teachers completing their programs each year. The Academy has fostered new efforts at collaboration between the education and arts and science faculties and between the institutions and the surrounding school districts. The focus is on preservice reform and improved teacher development programs. Over 3 years,

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[15]Ibid.

[16]Ralph Yulo with Susanne Murphy, "Norwich," in *Project CONNSTRUCT*, op. cit.

54 grants have been awarded on a competitive basis to 11 institutions for year-long "dialogues" involving college faculty from both sectors and local teachers, partnerships between institutions and districts, restructuring projects within the institutions, and co-teaching projects involving faculty and public school teachers. Ten priority districts and more than 40 other districts have been involved.

Each of the 13 "dialogues" involved a series of meetings attended by faculty from the host institution, teachers from neighboring school districts, and professionals from local businesses. They discussed curriculum, standards, teacher preparation, and related topics. Conducted over a year, the dialogues broke down institutional barriers and led to new forms of collaboration. Co-teaching initiatives in which college faculty and public school teachers worked together in each other's classrooms were one form of collaboration. Restructuring efforts in which liberal arts faculty and education faculty worked together to redesign courses were another. Collaboration on new approaches to clinical training for new teachers was a third.

To maintain the momentum at institutions like Southern Connecticut State University, the Academy switched to a more focused strategy in year 3 to support activities in three areas: co-teaching collaboratives, new initiatives in student teaching, and dialogues and co-teaching collaboratives at institutions that have not participated as yet. This component also awarded a grant to the PIMMS program at Wesleyan for support of a summer program for middle school math and science teachers. Half of the participants will come from the 10 priority districts funded by CONNSTRUCT. The long-range intent of Component Three is to change preservice education in some fundamental ways.

Science-Rich Institutions. Component Four funds museums, science centers, and other community organizations to work with the schools to share their resources and provide enrichment programs for students and professional development for teachers. The component involved 126 schools, 249 teachers, 2,400 students, and 395 families in 20 districts in 1992-93. By 1993-94, the component was reaching 236 schools, 1,050 teachers, 7,000 students, and 650 families. Much of this activity has been in the urban districts.

Family Math and Family Science programs have proved to be particularly popular. Participating districts view them as effective strategies for improving performance in elementary and middle schools. The Discovery Museum of Bridgeport and the

Connecticut Science Center train the teachers and provide the materials for both programs. All 10 of the urban districts involved in Component Two sent teachers to training in July 1993. Overall, teachers have been trained in Family Math and Science for more than 20 school districts, and the demand is growing.

Other organizations have contributed to the SSI in different ways. The Talcott Mountain Center developed the CT-SSInet that links all the schools involved with Project CONNSTRUCT and carries information on successful programs. With the support and assistance of the Academy, they won an NSF Teacher Enhancement grant to develop an Urban Resource Network for Middle School Science Teachers that is assisting the Component Two schools. The Connecticut Business and Industry Association received a small grant from the Academy to support a staff person who works with local communities to develop partnerships between small businesses and the schools. Some of these partnerships support the continuation or expansion of Family Math and Science. The Academy also has worked closely with the Connecticut Pre-Engineering Program (CPEP). CPEP is active in seven districts, five of which are supported by CONNSTRUCT. CPEP is designed to identify and motivate minority students who might pursue careers in math, science, engineering, or technology. CPEP staff work with students and teachers in grades 5-7. CPEP also has been working closely with a number of the organizations involved in CONNSTRUCT and helped New Haven develop its PMSA grant. Overall, these initiatives have been so well received that the Academy has been able to help some of the organizations attract other funds to sustain their work. For example, a collaborative of four museums and science centers working with the Academy recently won a 3-year, $2-million grant from NSF to work with middle school teachers and students. Through such funding, these initiatives are becoming self-sustaining, enabling SSI funds to be redirected to other priorities.

As a consequence, technology will be a priority for Component Four during the final 2 years of SSI funding. The ultimate goal is a unified state plan for utilization of technology in the schools. The Academy is working with the Joint Committee on Educational Technology, which is charged with developing a statewide technology plan. The more immediate objective is to develop electronic links among the schools, organizations, and individuals working on reforms in math and science. The CT-SSI computer network mentioned earlier links all of the Component Two schools and some additional groups. They are identifying "best practices" to share over the network. By adding new databases, they hope to increase its utility and add more users.

Public Awareness. Component Five addresses the complex problem of building public support and demand for reform. One of the noneducators who were involved in developing the SSI proposal said, "At the beginning of the SSI, we knew the key would be public support, and we knew that educators were terrible at selling their product, and so we needed expert help." He was afraid that the SSI would be a well-kept secret within the math and science communities. He also was concerned about the public's apathy toward reforms. Therefore, the fifth component of CONNSTRUCT focused on building public support and understanding. One of the media experts who assisted the Academy offered a somewhat different view of the vision for Component Five; he said: "No one knew exactly what this component was all about; they had a vigorous media campaign in mind, but their thinking was conventional."

What has emerged, however, is far from conventional. A major state public relations firm developed a comprehensive and creative public awareness campaign. The campaign has used TV, radio, newspapers, events, speakers, and take-home materials. The object has been to have many messages appear frequently and in different media, letting people know that they should care about what is happening in math and science education. All five television stations in the state and the only statewide newspaper have participated. The Academy staff and board have been prepared to do media events and meet with editorial boards. Small weeklies and "shoppers" are also being brought in to reach ethnic communities. A statewide campaign was initiated in mid-June 1993 around the theme "Learning Doesn't Take a Vacation." It included math and science activities for families in the newspapers, public service ads on TV, TV and radio news spots on math and science programs, math problems during Red Sox broadcasts, ads on buses, and so on. The newspapers printed inserts of family math/science materials. All of this was done at minimal cost because of "equity partnerships" the Academy negotiated with major newspapers and television and radio stations. These partnerships continue.

This campaign has been complemented by an ambitious outreach effort into minority communities in targeted school districts. A variety of means are being used, including a speakers' bureau, public and commercial TV news stories and public service ads, newspaper stories and pages for parents, editorial board meetings, direct mail, other materials for parents, community meetings, and a slick newsletter. The Academy wants to reach parents and other interested parties, such as small businesses and civic organizations that have not participated in school reform, and make them aware of the "critical importance of mathematics, science, and technology education." The plan is to help the school districts already involved with CONNSTRUCT through Component Two convene grassroots networks of parents, community leaders, civic organizations, business, media, and educators dedicated to community outreach. The Academy intends to help these groups develop strategic plans for building public support and involvement in their communities and then support the most promising efforts with small grants. This approach has been piloted in New London and will be extended to Bristol; New Haven; the rural consortium of Killingly, Plainfield, and Putnam; and other districts during the 1994-95 school year. The Academy also will help these local partnerships with major events and fundraising. The initial focus will be on parents with children in grades K-6.

Component Five is also working with another NSF project, the United Connecticut for Women in Science, Mathematics, and Engineering (UCWSME), a coalition of groups seeking to change girls' and women's access to and participation and achievement in science, mathematics, and engineering. The Academy will assist in this effort by emphasizing special initiatives for girls and women in its community outreach efforts.

Initial Effects of the SSI

One of the major accomplishments of the Connecticut SSI in the first 3 years has been the acceptance of the Academy as the lead institution in the math and science communities and as a resource for improvement and reform. A second major accomplishment has been the development of a consensus within the science and mathematics communities that change is not only needed but is possible. People are beginning to believe that the Academy can be successful. The new institution is off to a good start.

The members of the small staff at the Academy are talented and energetic. In a short time, they have developed a positive reputation for being responsive and for getting things done. They have had some success at broadening their base of support among policy-makers and business leaders, and they have established credibility with local school officials and teachers' organizations. The collaboration with the Department of Education seems to have grown in spite of the former commissioner's preoccupation with other issues; the two organizations are cooperating in a number of areas. They are working together to develop math and science frameworks, to provide technical assistance to the Component Two districts, and to revise policies and programs for teacher certification and recertification. The Academy's relationships with institutions of higher education also appear to be flourishing. There are countless examples of collaboration in this sector, including the Academy's relationships with PIMMS, the President's Council, the other NSF grantees, and the recipients of Eisenhower funds. The commissioner of higher education is an ardent supporter of the Academy and the SSI.

The Impact of the SSI Components to Date

The action components of CONNSTRUCT have made progress in implementing their initiatives during the first 3 years, but there is not yet solid evidence of institutionalization of changes or of effects on student outcomes. For example, in the projects funded by Components Two and Three, the progress has been quite uneven, and there has not yet been much impact on students. However, it must be borne in mind that CONNSTRUCT chose to concentrate on the most important, and the most difficult, problems—urban schools and preservice teacher education—rather than look for easy victories. Slow progress is to be expected.

Effects on Local School Districts. A recent review of activities in 10 of the 19 funded districts by consultants hired by the Academy found that the progress made by the projects varied. Several were described as exemplary and were moving into districtwide implementation. In other sites, however, implementation was hampered by budget cuts, poor staff morale, conflicts over contracts, lack of released time, weak professional development, and poor coordination. Full implementation of all these projects appears to be threatened by the effects of the state's fiscal crisis on management-labor relations, professional development, and equipment and supplies.

Interviews with teachers and administrators in 8 schools in 4 of the 19 districts found that there is broad acceptance of the need for more active student learning, for more application and problem solving, and for greater use of technology. In all four districts, considerable curriculum work has been done in mathematics to be consistent with the NCTM standards and the changes in the CMT assessment program. New materials and professional development were being provided for teachers to support these changes as resources permitted.

However, the specific visions of good practice varied, as did teacher acceptance of the new approach. In the rural districts, many teachers spoke of integrating other subjects into mathematics, especially science and writing. In the urban schools, there was less mention of integration and more concern that the basics would still be taught under the new approach. In all the schools, there were teachers who either resisted or who were worried because they feared that students were not learning their fundamentals. One teacher described the changes in her practice as: "The kids are asked to reason more, have more verbal exchanges, do more writing. There are more hands-on activities. [I] just don't assign problems, worksheets. We are using calculators more." However, another said: "I know the new ideas, working together, thinking skills, but I have to do some operations so everyone will master the fundamentals."

In a district implementing a new curriculum, a teacher described the changes as follows:

> The focus is now developmental, more concrete and hands-on. The curriculum was scaled down to provide deeper understanding of basic concepts. We use geo boards, color tiles, cubes, dice, and calculators. Teachers have to find or develop their own materials, but we help each other and share them. I like it better, and I think the kids do, too.

All four districts were still relying heavily on math textbooks, although some teachers used them only as supplements. The textbooks themselves were changing and were more consistent with the new vision. Some included manipulatives along with the books, but most schools had not been able to buy enough texts, let alone buy the other materials. Calculators were available in the CMT grades in all schools, but in other grades teachers often shared them.

In science, there was greater discrepancy between rhetoric and practice. Less work had been done to develop and communicate a clear vision to teachers. They were generally unaware of Project 2061 or the AAAS standards, but they did have a sense of what was being presented as "good" science. A typical response was: "We need to get away from the book; go to more hands-on teaching." For many elementary teachers, this appeared to mean developing thematic curricula or doing projects with the students. The science curriculum was under revision in three of the four districts. Lacking a coherent and specific curriculum to guide them, teachers had grabbed whatever was available to them from workshops or commercial sources and had patched together curricula. In one district, elementary teachers were using FAST (Fundamental Approach to Science Teaching) in grades 7 and 8 and SCIS (Science Curriculum Improvement Study) materials in grade 6, but they were not sure how they fit together. In that same district, K-5 teachers had been told they would use SCIS, but there were not sufficient funds to buy the materials. Science texts are old in most of the schools, although several teachers reported that they were piloting new texts. Supplemental materials and lab equipment were limited in most of the schools.

In general, science in the elementary schools was organized around themes (plants, bears, dinosaurs, weather, planets, etc.), and often integrated with reading. It still was not a high priority in most classrooms. Some teachers admitted rarely doing science lessons, and most taught science only two or three times a week. In the middle schools, science was more hands-on (unless there were no labs) and often organized around kits or projects. There were two schools in which some interdisciplinary instruction was going on and there were connections across math and science.

In all four districts, both elementary and middle school teachers were using science kits (Delta, AIMS, CEPUP). They were enthusiastic about the kits and reported that the students liked them, but they were not sure how they fit together to make a curriculum. Frequently, the kits were shared, which meant they were used in different order by different teachers. Some teachers expressed concern about the lack of connections or the lack of fit with other subjects. One said, "Our curriculum is not developmental; it is based on what is available and what works." In most cases, the teachers had received training in the use of the kits, but often this was only a half-day workshop.

The nature and quantity of professional development opportunities varied widely among and within the districts. In an urban district, Chapter One funds, Eisenhower funds, the SSI funds, and other grants meant that there was plenty of money. Teachers involved with math and science had many opportunities. They also were receiving inservice from the publisher of their new math series. However, strained relations between the teachers' association and the district over contract negotiations meant that many teachers would not volunteer time or go to after-school events. Furthermore, the opportunities for teachers seemed to vary by school.

In the rural districts, the continuing fiscal crisis had almost eliminated opportunities for going to workshops or conferences. Two of the districts had 4 days of inservice scheduled annually, and the third offered 3 days. One of the districts was trying to do more in-house and had stopped sending teachers to events, but they were still able to support local workshops. In a second district, the SSI events, workshops provided by publishers, and courses that teachers paid for themselves were the primary forms of inservice. In the third, teachers had little inservice during 1993-94.

Generally, teachers had received more professional development in mathematics than in science. Some complained that science had been slighted in the past. Math had received more attention because of the CMTs, the National Council of Teachers of

Mathematics *Standards*, and new texts. Many felt that more training was needed in hands-on science. However, not all teachers were enthusiastic about more professional development. In an urban district, the union had offered to pay for subs to free teachers to go to workshops or conferences, but few availed themselves of this opportunity. Attendance at district-sponsored workshops was often poor. There seemed to be two distinct subcultures in the schools: those who sought these opportunities and fought to get them and those who worked 8-3 and wanted to be left alone. However, all teachers had to earn CEUs to maintain their certification. The latter group just took what the district offered free and met the requirement in the most convenient way. Teachers in the rural districts generally were more enthusiastic about professional development and more willing to do it on their time.

Overall, teacher support for the changes is mixed, and there is more change observable in mathematics than in science. However, teachers and curriculum staff in the urban districts are going to be deeply concerned about student performance on the new state tests in the next 2 or 3 years. They will give elementary and middle grade curriculum reform a high priority if it helps raise student performance on the tests. However, given their resources and their contextual problems, it is hard to see how they can be expected to develop model sites of sufficient quality that others might learn from and emulate.

Commitment by district leaders to the SSI's vision of reform may also be soft. The leaders of the urban districts are preoccupied with fiscal stress, discipline problems, raising performance on the state mastery tests, and a host of other problems. To address this issue, the Academy and the Department put together a team in the spring of 1994 who met with the superintendents to discuss their support and mutual expectations. The districts in the first cohort recently submitted their plans to go to scale with the curricula developed through these SSI projects. Only time will tell whether they have the will and the capacity to make the envisioned changes. They may need further support and assistance to institutionalize the changes.

There also is the question of the quality of the new math and science curricula developed by the local districts. There have been no external reviews of the curriculum materials developed with the assistance of CONNSTRUCT. Perhaps such reviews are not necessary because of the capacity of the Department staff to provide quality assurance. However, it is not clear how this issue is being addressed.

Institutions of Higher Education. The effects of the SSI's initiatives on the participating institutions of higher education are even harder to assess at this point. Some sharply divergent opinions have been expressed about the "success" of the dialogues. Some respondents say that they have been marvelous and have broken down the institutional barriers between the public schools and the teacher education programs. Teachers who participated said that, for the first time, they felt they were treated as professionals. Yet another respondent described them as "a disaster," and several others as just "more talk." Nevertheless, the prevailing opinion seems to be that they have played a catalytic role at some of the institutions and led to restructuring projects. They have created a stimulus for change, and at least two institutions have altered courses and institutionalized co-teaching.

The Academy has fostered this interest in change by convening faculty and administrators from the participating institutions to share their approaches and discuss common problems. Three design seminars were held for the college faculty and teachers involved in co-teaching. In addition, three restructuring seminars were held for the institutions that received grants. The outcome of these shared experiences was a network of individuals who share similar visions for the reform of undergraduate and preservice teacher education. They are continuing to work together.

At one public university, the coordinator of the program feels that the SSI will change the way teachers will be trained. He points to the growing interaction between his institution and the neighboring urban school system, and the dialogue on campus between education and liberal arts faculty as evidence of the changes that are under way. Both are firsts for that campus. He forecast that:

> ...the next generation of teachers will have different experience and different expectations. They will expect a different and more constructive relationship with the university after they are on the job. They will expect to be treated as professional peers.

Everyone is enthusiastic about the co-teaching experiences, and they are viewed as successful. However, it is not at all clear whether they will be institutionalized or will produce lasting curricular changes in preservice programs. The test will be the willingness of the institutions to sustain them. However, even if not sustained, they could serve as catalysts for dialogues between the colleges and the schools that lead to other changes, such as the restructuring of student teaching.

Although neither the dialogues nor the co-teaching projects have produced dramatic results as yet, both institutional representatives and Academy officials are optimistic about the overall effects. An external evaluation of the projects prepared for the Connecticut SSI's mid-point review by the National Science Foundation found considerable enthusiasm but soft institutional support and only small numbers of students and faculty involved so far. It also found the expected problems: it is hard to get liberal arts faculty involved and keep them involved; it is hard to attract minority school teachers; and so on. However, the objective data may not fully capture what is happening because there does seem to be some new momentum for reform on some of the participating campuses.

Science-Rich Institutions. Component Four is widely regarded as successful, and if demand for services is any measure, it is. A review of the programs prepared for Project CONNSTRUCT rated 11 of 14 projects in this area as above average in performance, one as average, and two as below average. The criteria applied were the project's fit with Project CONNSTRUCT's overall goals and successful implementation of activities. The evaluator was impressed with the vision, commitment, talent, skill, and energy of the individuals running the programs.

However, celebrations of success are probably premature. Enthusiasm for the program is a good beginning, but unanswered questions remain: do these extracurricular efforts raise student performance, and if they do, what are the range and levels of their effects? There are no data available to link family participation in the Family Math and Science programs to changes in student performance and, of course, no evidence of sustained effects on student performance. Nevertheless, the impressions that the programs "work" have produced a boomlet. One other concern is that the programs have recurring costs for materials and teacher time to run the workshops. The costs are not high relative to school budgets, but they are new costs and the districts are under fiscal duress. The Academy and the Connecticut Business and Industry Association are seeking support from small businesses in the participating towns to pay for the continuation costs. More than 30 businesses have participated so far.

Public Awareness. Connecticut's SSI has put together a creative and ambitious effort to build public support. They clearly have reached large numbers of people through newspapers, radio and television, and community outreach efforts. However, there is no evidence available that these efforts have had any significant effect on public understanding of and support for reforms. There are no regular opinion polls in Connecticut, so there is no inexpensive way to gauge the public's support for reform.

Anecdotal evidence suggests that the Academy's efforts are reaching parents. However, increasing public demand for reform and a willingness to support it financially and politically must be viewed as the long-term goals, and there is clearly a great deal of work to do.

Reflections on the SSI in Connecticut

How Systemic Is Project CONNSTRUCT?

If one believes that a complete and authoritative specification of ambitious goals for students and teachers and the alignment of state curricular, assessment, and teacher development policies are the essential first steps in systemic reform, then Connecticut does not quite measure up. The vision is evolving but not yet embedded in statute or regulation. There are no curriculum frameworks, although they are being developed. The assessment system examines mathematics in grades 4, 6, 8, and 10, but includes science in only one grade. The tests in grades 4, 6, and 8 have recently been revised to reflect higher standards and include more problem-solving and applications. The new 10th-grade test includes performance tasks, including an integrated task that requires students to draw on all the disciplines. Certification policies are being revised, again in order to reflect the changing expectations of teachers' knowledge and classroom practice. The pieces of systemic reform are all being addressed, but it is very much a work in progress.

On the other hand, if one takes a broader view of systemic reform and considers the question of the fit between the reform strategy and the political environment, Connecticut's SSI may be a model that others should examine and emulate. Michael Fullan recently described the critical problem facing reformers as maximizing the "productive mix of top-down pressures, incentives, and responsiveness on the one hand, and bottom-up initiatives, development, and accountability on the other."[17] This is exactly the question that the leaders of the Academy and Project CONNSTRUCT have been addressing with considerable success.

The Connecticut approach to systemic reform deviates from the model developed by Marshall Smith and Jennifer O'Day (1991), which might be described as the "standardized centralized" approach. Connecticut's strategy is closer to the "coordinated decentralized"

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[17] Michael Fullan. "Coordinating Top-down and Bottom-up Strategies," in R. F. Elmore and S. H. Fuhrman (Eds.), *The Governance of Curriculum*. Alexandria, VA: The Association for Supervision and Curriculum Development, 1994, p. 199.

strategy described by Clune (1992), which seeks a balance among the central guidance mechanisms, a realistic network of change agents just above the school level, and incentives for local improvement initiatives. Clune argues that the goal of systemic reform is to create greater coherence without greater centralization. Whether this is the "best" strategy under all conditions is debatable, but it is certainly a more appropriate strategy in a state with strong traditions of local control and strong professional networks. The leaders of the Connecticut SSI have added a few twists of their own to Clune's theory by recognizing the powerful influence that new institutional relationships can have on vision and practice and by recognizing the importance of momentum in building a movement for change.

The Future of Systemic Reform in Connecticut

Making Math and Science Reform a High Priority. Although Project CONNSTRUCT may not realize its goal of making math and science improvement one of the top three priorities in the state, the work of the Academy, in combination with the recent changes in the state assessment, has raised the priority of mathematics and science for local school districts. Math and science curricula are undergoing change. The changes vary with the quality of district, leadership, staff sophistication, and resources.

The changes in the state assessment program, and its continuing evolution, will help keep mathematics and science on the agenda. The mission of the Academy, and the success of CONNSTRUCT, would be furthered by the inclusion of science on the CMTs administered in grades 4, 6, and 8. This change depends on the legislature and the State Board of Education, but the Academy's networks in the schools, universities, business, and civic and professional organizations may have enough influence to persuade policy-makers to make the change. Without it, the Academy will face a continuing struggle to gain and hold the attention of decision-makers in low-achieving districts, whose highest priorities will be to raise scores on the state assessment, and that could mean continuing to neglect elementary science.

Strengthening CONNSTRUCT. In January 1994, NSF conducted a mid-point review of the first cohort of SSIs, which included Connecticut. NSF's external reviewers gave CONNSTRUCT good marks. Although the review entailed a lot of work, the leaders of the Academy and Department staff viewed the mid-point review as a highly constructive process. They say that it made them take a close look at their activities and that some important strategic modifications resulted, both from their internal review and from feedback from NSF's external reviewers. For example, criticism that their evaluation process had produced too little information about the impacts of CONNSTRUCT on school practices led the leadership to commission independent evaluations of all the projects funded by Components Two and Four, both in school districts and in science-rich institutions. The resulting reports led to a series of important changes. To cite three examples: funding for any new districts in Component Two was eliminated in order to focus greater attention on the 19 districts already funded; the number of new initiatives in Component Three was also reduced in order to increase attention to ongoing work; and more minority representatives were added to the Academy's Board.

Scaling Up. There is no doubt that the vast majority of schools in Connecticut will change their math and science curricula in concert with the emerging national standards. This change would have happened, albeit more slowly, even without an SSI. The strong professional networks in the state and the state assessment system provide sufficient incentives for most districts to make the changes (with the possible exception of elementary science, as discussed above). There will be some communities in which parent or teacher resistance will slow down or prevent the changes, but they will be the exceptions. The degree to which changes will be made in the practice of teaching is less clear. Although the new standards imply—some would say require—changes in pedagogy, teachers often incorporate new techniques within their existing practices. Both research and common sense suggest that such incremental changes are the most likely outcome in the short run. Fundamental changes will take much longer as teachers need time and opportunity to master the content and become comfortable with the new pedagogy.

The Academy will hasten those reforms by spreading the vision, by providing encouragement and legitimation to those who want to see change, by providing opportunities for teachers to learn the skills and content required by the changing practice, and by changing the relationships among institutions. Fifty-four of the 166 districts in Connecticut have already been involved with CONNSTRUCT in some way. These contacts are likely to grow in quantity and intensity as the networks continue to expand. The release of the new state curriculum frameworks will broaden the reach of the SSI and speed up the process of change. There are probably many districts in which Academy materials or a Fellow are already stimulating discussions of reform.

However, it seems premature at this point to conjecture about the success of the SSI in promoting reforms in the urban and rural schools. CONNSTRUCT has made a good start, but it is only a beginning. Going to scale in those districts will require considerable professional development, technical assistance, funds for equipment and technology, and stability of leadership. Ultimately, much will depend on resolving the state's fiscal crisis and equalizing school funding. To a lesser degree, success will depend on the Academy's success in securing funding to sustain its efforts in these districts. It will also depend on the ability of the SSI to keep urban educators focused on math and science and to prevent them from being derailed by new initiatives, priorities, or fads. It will be a challenge.

Sustaining the Initiative. As has already been made clear, the Academy has established itself as a force for reform and built a solid base within the math and science communities. The problem of sustaining the initiative is not political but fiscal. Where will the Academy find the $1-2 million annually needed to maintain its level of activity and its momentum?

The Academy's plan is to seek a mix of public and private funds to sustain its work and the reform initiatives that the SSI has supported. The Academy has already established its capacity to raise public funds. It has joined other statewide organizations and science-rich institutions to develop proposals for 10 Teacher Enhancement grants. Eight have been funded. One of these is the Talcott Mountain Science Center, whose application to NSF for a Teacher Enhancement grant proposed to establish an urban resource network for middle school science teachers in Connecticut. This was funded and will be closely linked to CONNSTRUCT.

However, there have been no significant contributions of funds by business as yet. In part, this is by design. There have been in-kind contributions from public television, and both the PR firm and the commercial TV stations have worked for reduced fees. The Academy does hope to raise significant private money to continue its operation after year 5. The Academy's plan is to establish credibility first, to demonstrate to business that it can stimulate change, and then to ask them to make a commitment. However, given the economic stress afflicting many of the state's larger corporations, and given the potential of competition from other fund seekers such as the Commission on Excellence or possibly a choice initiative, the Academy appears to face a difficult task in raising significant private funds.

The Academy has had limited success in gaining fiscal support from the state. Again, this has been by design. The state's contribution to the SSI has largely been in-kind, and a number of DOE staff are actively involved. There has been a tight linkage between the Departments of Education and Higher Education and CONNSTRUCT in the allocation of Eisenhower funds. Eisenhower money pays for teachers to attend Family Science training, it is used as the match by the priority districts receiving SSI funds, and it has supported complementary higher education initiatives. However, there have been no direct allocations of state funds to the Academy, and given the state's fiscal condition, there are not likely to be.

The Academy's best chance of sustaining its work appears to be through obtaining continued federal funding that is supplemented by some private funds and Eisenhower funds. However, if fund-raising has to be given priority over leadership to sustain the Academy, the institution will lose its luster and its momentum and become merely another competitor for soft money. Attracting both additional federal support and a state subsidy from the legislature probably will be needed to allow the Academy to continue its work.

Some Lessons Learned

How to Stimulate Change in a Local-Control State. As has been previously indicated, Connecticut's strategy of mixing top-down and bottom-up strategies with "through the middle" mobilization of the profession is a fresh and sophisticated approach to systemic reform. The Connecticut SSI has developed a strategy that fits the state's political traditions, resources, and institutional structure. Their strategy could be a model for other states with similar political traditions.

The Importance of Context. If context shaped the design of CONNSTRUCT, it also is shaping its implementation and ultimately will determine its fate. Context is always the most powerful factor in determining the success of change efforts. Unfortunately, the context in Connecticut is not stable, and there are some events on the horizon that could overwhelm a fragile change effort. For example, there is the possibility that statewide reorganization of districts and resource reallocation will result from the decision in Sheff v. O'Neill and subsequent legislative action. This could shift state priorities, preoccupy the attention of local policy-makers, further undermine public support for the schools, and seriously disrupt the work of the Academy. There is also the possibility that Connecticut will elect a governor who supports choice and that some version of a choice program will be passed by the legislature. Finally, there is talk of tax reform, including reducing the state's income tax. It is difficult to imagine the effects such dramatic developments might have on the SSI. Could the Academy make math and science high priorities for state or local policy-makers in such a chaotic environment? Probably not.

Then there is the matter of a new commissioner of education to be appointed in the next few months. Will the new commissioner be a friend of the Academy? What will be the Department's priorities under a new administration? These are all unknowns.

The SSI leadership may face some difficult decisions. For example, should they link math and science reform to desegregation efforts by getting involved in development of magnet schools or supporting cooperative programming among urban and suburban districts? Or should they avoid this connection altogether and focus on math and science teachers to avoid the consequences of a political backlash? They remained neutral in the recent debates over the Commission on Excellence recommendations and avoided being associated with "outcome-based" education. But they may not be able to remain neutral in future debates and retain their credibility with the various communities who are supporting them. The point is that even an apparently well-conceived and well-led initiative like CONNSTRUCT is vulnerable in the current political and economic climate. The leaders of the SSI undoubtedly will do their best to cope with the challenges provided by their context, but what they must wish for is some stability in which they can pursue their agenda and demonstrate the efficacy of their vision.

The Difficulty of Building Public Support. There is little public demand for school reform in Connecticut—with the possible exceptions of the public's desires to reduce the costs of the schools, lower teachers' salaries, and prevent involuntary desegregation. Like most Americans, parents in Connecticut are generally satisfied with their local schools. The prevailing attitude was described by one observer as "...if it was good enough for me, it is good enough for my kids." As a consequence, there was little public pressure on the legislature to pass the Commission on Excellence recommendations. However, there was vocal opposition from newly formed conservative groups opposed to outcome-based education and values education. The appeal of these groups and their ability to organize at the grassroots are causing concern among reformers. These groups can appeal to anti-tax feelings and the concerns of suburban parents about desegregation or detracking to put considerable pressure on school boards or on the legislature. The SSI in Connecticut has made a tremendous effort to get its message to the public, but there is little evidence to date that it has succeeded. This is why it remains vulnerable to sudden changes in the policy environment or changes in political leadership.

The Potential of Nonprofits. The Academy is a nonprofit organization that stands outside of, but is closely linked to, state government. Its board and leadership are not dominated by state agencies, and it is able to operate independently of the state bureaucracy. Business and civic leaders play a larger role in guiding the SSI than they might if it were led by the Department of Education. The rationales given for placing the locus of decision-making for the SSI with a nonprofit include:

- The avoidance of red tape and restrictions.
- The capacity to act faster.
- The ability to hire or attract higher-quality people.
- The capacity to build greater credibility with the math and science communities.
- The capacity to attract greater involvement and support from the business community.
- The ability to serve as more effective advocates for reform, uninhibited by other state agendas or changes in state priorities.
- The ability to sustain a long-term effort, surviving changes in state leadership.
- The ability to make the initiative bipartisan.
- Increased capacity to raise private funds.

It is probably premature to assess these claims in the case of the Academy, but the early returns suggest that the arguments have some merit. The Academy has demonstrated its ability to attract high-quality people, to move quickly, to be responsive, to change direction, and to build credibility in both the education and business communities. It is a model worth watching.

The Difficulty of Urban School Reform. This is an obvious lesson, but it is worth reminding the reader that no one has a recipe for raising the performance of poor and minority students in mathematics and science. The obstacles are formidable. Therefore, it is not surprising that after only 3 years CONNSTRUCT is still working on the problem. There is a real possibility that the Academy will not have successful demonstration proofs in the urban districts after 5 years. Its arguments for state and private funding will be severely weakened if it has no clear success stories after spending over $10 million. The Academy has chosen to invest heavily in districts overwhelmed with serious problems, and even DOE staff agree that the grants to the districts are so small that it is hard to gain local commitment for the projects. They have decided to forgo a fourth cohort of districts and focus their resources on the districts already funded in order to produce some successes. So there is no possibility that any SSI funding will find its way into the suburbs, and the Academy seems likely to keep its "urban image."

Both CONNSTRUCT and this case study are works in progress. The story emerging after the first 3 years of the initiative is an encouraging one, but there are major questions still to be answered. The central questions, of course, are whether all of this activity will raise student performance in math and science and reduce the achievement gaps between white males and various groups of underrepresented students. Project CONNSTRUCT deserves credit for concentrating its resources on the state's urban districts. This is where the need is greatest in Connecticut, and they are addressing it. They are attempting to raise standards in schools in which failure has become endemic. This initiative also is taking place during a period when severe fiscal constraints and considerable political volatility make implementation of reforms more difficult. If Project CONNSTRUCT achieves even limited success under these conditions, it will constitute a demonstration that its balanced strategy was sound. And, at this point, there do appear to be some success stories emerging from the 19 districts. However, both the National Science Foundation's and CONNSTRUCT's timelines and expectations about results may have to be adjusted to fit the severity of the challenges in these high-need schools.

A CASE STUDY OF DELAWARE'S STATEWIDE SYSTEMIC INITIATIVE: PROJECT 21

Introduction: Delaware and Its Education System

Delaware is a small state, with 3 counties, 19 school districts (including the county vocational districts), 182 schools, and a total elementary and secondary school enrollment of about 105,500 (1993). Members of minority groups (principally African-American) represent about 33% of total enrollment. The boundaries of public school districts in the northern portion of the state have been rearranged by a court-ordered desegregation mandate such that a piece of the city of Wilmington is assigned to four otherwise largely white, suburban districts. This desegregation plan, in place for 16 years, is currently back in court for reconsideration.

Educational policy-making in Delaware is traditionally a function of the Department of Public Instruction (DPI) and the State Board of Education. The legislature responds to budget requests presented by the State Board. Business and industry, dominated by the du Pont Corporation, are strong supporters of the schools in general and science education in particular. For example, du Pont underwrites the costs for dozens of teachers to attend the National Science Teachers Association convention annually.

Nationally, Delaware generally ranks near the national mean on various indicators of educational health: average SAT score, average NAEP scores, dropout rates, and per-pupil spending. Historically, the state and its citizens have been quite satisfied with their schools and the performance of students. School districts typically have had great latitude to make their own decisions and set their own goals and standards. Three years ago, however, the State Board of Education undertook a national search for a new superintendent of public instruction, who would have an explicit mandate to change and improve the education system statewide.

State Superintendent of Public Instruction Pascal Forgione brought to Delaware a vision for educational improvement called New Directions for Education in Delaware. The watchwords for New Directions are clear expectations, real-world standards, and excellence for all students.

The changes envisioned, discussed in detail in the next section, are in the developmental stage. To support the design and implementation of the planned educational reforms, the state superintendent and the president of the State Board of Education raised funds from the state and local school districts to underwrite the development of curriculum frameworks in all core subject areas and from the business community to establish an educational research and development center at the University of Delaware.

In 1988, several years before New Directions was introduced, Delaware became the first state to join the Re:Learning network formed by the Education Commission of the States and the Coalition of Essential Schools. Re:Learning promotes educational change around nine principles developed and articulated by Theodore Sizer. Although the aim of Re:Learning is to change state systems to reflect these principles, the change strategy is carried out school by school. Over the past 5 years, the Re:Learning philosophy and resources (i.e., training institutes and workshops) have been an important influence in many Delaware schools.

Good Practice in Mathematics and Science Education

Delaware's Statewide Systemic Initiative (SSI)—called Project 21—is the development arm for math and science in the larger reform effort, New Directions for Education in Delaware. The original Project 21 plan was submitted and approved before the articulation of New Directions as the overarching reform vision. Although the goals of Delaware's SSI have remained constant, strategies and activities have been adapted to support and elaborate the conceptual framework for statewide reform of mathematics and science education. In this section, we talk first about New Directions and then about Project 21's specific contribution to the endeavor.

The State's Vision and Strategies for Change

In 1991, the Delaware State Board of Education adopted the six national education goals and added four more concerning (1) school restructuring, (2) school leadership, (3) parent and community involvement, and (4) technology. New Directions for Education in Delaware represents the plan through which these 10 goals are to be achieved. The initiative is moving on many fronts simultaneously—from early childhood to school-to-work transition. For the purpose of this case study, the key goals are improved student achievement in all core subject areas (Goal 3) and math and science achievement (Goal 4).

New Directions is officially described as "a standards-based approach to educational reform that calls for the institution of challenging academic standards of performance for all students and for the regular monitoring of progress by students and schools against these appropriate benchmarks." It combines a statewide, "top-down" approach to defining and measuring what all students should know and be able to do, with school-based, "bottom-up" determination of the specific curriculum and instruction students will encounter. Exhibit 4 is a pictorial representation of the New Directions approach to academic reform.

Exhibit 4
Outline of New Directions Components

E: Context

A	B	C	D
Content Standards	Performance Assessment	Learning Events	Instructional Practices

In this schematic, boxes A and B are referred to by state leaders as the "givens," that is, the new standards and accountability measures that will apply to all districts and schools in the state K-12 education enterprise. Curriculum framework commissions in the four core subject areas (math, science, English/language arts, and social studies) were formed in 1992 and began working on content standards (Box A). The commissions are broadly based and were established by a nomination process that generated approximately 1,200 candidates. Each commission has 45 members and is co-chaired by a teacher and either a university faculty member or a representative of the business community. Every commission includes representation from each of the state's 19 school districts. Staff from Delaware's SSI serve on the math and science commissions. Other constituencies represented include business and industry, collaborative organizations such as the Science Alliance and the Math Coalition, DPI staff, and higher education faculty. We talk about the results of the commissions' efforts in a later section of this case study on preliminary impacts.

Box B represents a change in Delaware's accountability system. Beginning in spring 1993, the state replaced the norm-referenced Stanford Achievement Test with an "interim assessment" instrument—the ITBS (short form). This instrument was chosen because it was determined to be the best available and because it includes a small number of performance assessment items in reading and mathematics. A performance-based writing assessment was also instituted. These changes in the accountability system had some cost ramifications. A standard norm-referenced tests costs about $2.00 per student; the ITBS, even with just a few performance assessment items, will cost $3.50 to $3.75 per student. In the long term, Delaware plans to develop its own assessments that are fully aligned with the curriculum frameworks. Its involvement with the New Standards project is one strategy for building in-state capacity for developing and scoring performance-based assessments. In addition, the state is drawing on the expertise of consultants and other states, such as Connecticut, that are farther along in conceptualizing and developing alternative forms of assessment.

The statewide content standards are intended to be broadly framed educational objectives that will be filled up (or out) at the district, school, or even classroom level. Boxes C and D in Exhibit 4 represent the specific, content-rich experiences that students will encounter and how they will be delivered. There is no presumption that all students in the state will use the same books or other materials. Rather, New Directions—through the SSI (Project 21) and the Re:Learning network—is encouraging local administrators and teachers to reexamine curriculum and pedagogical approaches in light of current theory and research on best practices. The letter "E" in the schematic—Context—represents the state's awareness that each district and school has a unique profile of constituents, educational traditions, and experiences with reform that will shape its approaches to implementation of the state vision for educational improvement. Project 21's strategic plan for contributing to development and implementation of the statewide reform plan is discussed in the next section.

To underscore the need for change and improvement at all levels of the education system, the state superintendent also called for a reorganization of the Department of Public Instruction and brought in some new personnel. DPI is now organized into four branches: the Administrative Service Branch, the Standards and Curriculum Branch, the Assessment and Accountability Branch, and the Improvement and Assistance Branch. Within and among branches, teams have been organized around work that needs to be accomplished. Teams are focusing, for example, on equity, assessment, and curriculum frameworks. The stated purpose of the reorganization is "to build effective working teams that can serve as resources to Delaware schools and educators in their process of redesigning local delivery systems and instituting the new standards of performance for all students."

So far, New Directions has not broadened its scope to encompass a reexamination of preservice teacher education. Delaware has three public higher education institutions, two of which (the University of Delaware and Delaware State University, an historically black institution) have teacher education programs. For the past 10 years or so, the Colleges of Arts and Sciences at these institutions have had responsibility for the preparation of secondary school teachers; preservice education of elementary school teachers remained in the Colleges of Education.

In 1993, the state Professional Standards Council made recommendations to the State Board of Education regarding revision of certification and continued professional development credentialing requirements. A state committee continues to work on aligning these professional requirements with New Directions' reform objectives. Policy changes in this arena would be the most likely lever for revamping teacher education programs.

Delaware's SSI

When Project 21 was awarded, before the advent of New Directions, some policy-makers and educators viewed it as the potential driving force for reform of math and science education in the state. However, its original design (which we will not dwell on here) was project-like and lacked articulation of a statewide vision for reform. Its recreation as the math and science development arm for New Directions—which does offer a strategy for systemwide change—makes sense. In this section, we describe the general responsibilities and structure of Project 21 and its relationship to the New Directions initiative.

Project 21 has the following responsibilities in relation to New Directions: (1) providing support for standards development (Box A of Exhibit 4); (2) supporting the development of exemplars of learning events and new instructional practices (Boxes C and D of Exhibit 4) that include performance assessment tasks (Box B); (3) fostering collaborative relationships throughout the state in the interests of improving math and science; (4) fostering better understanding of the New Directions strategy for educational reform, particularly in math and science; and (5) ensuring that equity issues are kept at the forefront of the reform agenda for math and science education. In addition to these five core areas of responsibility, the State Board of Education has charged Project 21 with review and identification of state policies and practices that either impede or encourage progress toward implementation of reform.

Support for Standards Development. The math and science standards commissions began their work in 1992. A math education specialist and a science education specialist from the Project 21 team have served on the commissions since the outset of deliberations, although there has been turnover in personnel. The SSI has thus contributed content and pedagogical expertise to the work of these 45-member bodies, which are determining what Delaware students should know and be able to do. The commissions met frequently from the spring of 1993 through the spring of 1994, when a full draft of the math standards and drafts of three of seven science standards emerged.

In year 4 of the SSI (1994-95), Project 21 will increase its support for the work of the commissions by purchasing extra days of consulting time from the national math and science experts who serve on the SSI's own external Technical Review Group. These consultants will work directly with the math and science commissions as they revise the draft standards that were circulated for review in June 1994. The science commission continues to work on defining the remaining four science standards, with the participation of the Project 21 science specialist.

Supporting the Development of Exemplars of Learning Events and New Instructional Practices. Project 21's primary responsibility is the nurturing of improved math and science curriculum and instruction in 17 schools that have been identified as New Directions Development Sites (NDDS). Schools attained this status through an RFP process and are bound to the SSI through a cooperative agreement spelling out specific responsibilities of both the schools and Project 21. The schools agreed to (1) organize a development team that includes teachers, a building administrator, and a district-level person; (2) participate in various meetings and a summer professional development institute; (3) work collaboratively with Project 21 staff; and (4) develop and share exemplary teaching and learning activities. The parallel Project 21 responsibilities include (1) provision of resources; (2) planning, convening, facilitating, and linking activities; and (3) documentation and publication of NDDS accomplishments. NDDS schools have available the consultative services of the SSI content and school change specialists. Project 21 brings teams from the 17 schools together regularly during the school year and organizes a 2-week Professional Development Institute (PDI) each summer. Participation in the PDI is gradually expanding beyond the NDDS sites as part of the SSI strategy for scaling up involvement in math and science education. Approximately 80 teachers and administrators participated in 1993, growing to about 160 in 1994.

Participation as an NDDS site does not actually cost a school or district money; it does require commitment and time, particularly time out of the classroom at meetings and networking events. The release time is paid for by the SSI. In 1993-94, NDDS sites were basically supported to begin development of "polished stones" (the metaphor frequently used in Delaware for new units of instruction that embody the desired new standards-based approaches to curriculum and instruction at the classroom level) or to begin local efforts to flesh out the curriculum frameworks that are part of New Directions. The idea has been that polished stones would be shared among the NDDS schools and then with other schools in the state as a means of illustrating new kinds of learning events and teacher practices. One draft polished stone was submitted with Delaware's mid-point review presentation to NSF.

Fostering Collaboration. A key function of Project 21 is the development and care of partnerships in the interest of math and science education reform. The relationship between the SSI staff and the NDDS schools is obviously one key partnership, as are the multiple roles played by the PI and the project director linking the Department of Public Instruction, the SSI, and to some extent the institutions of higher education. However, the SSI responsibility extends considerably beyond this to encompass liaison work with the state Math Coalition; the Science Alliance; the Quest program, which pairs scientists with schools; and numerous other parallel and potentially complementary activities in the state. Project 21 has established forums of Math Collaborators and Science Collaborators (leaders of various math and science reform initiatives). The SSI has also forged linkages beyond the state through participation in the New Standards Project and the Re:Learning network.

Fostering Better Understanding of Delaware's Educational Reform Strategy. Communicating the New Directions/Project 21 vision beyond the NDDS schools and the obvious collaborative partners is a newer responsibility for the SSI in Delaware. A communication plan for New Directions was prepared in 1994; embedded within it is an SSI communication plan. The most immediate outgrowth of the plan is a newsletter—*The Standard Bearer*—that features the activities of Project 21 and the NDDS schools but is distributed widely throughout the state. Other features of the communication plan include presentations by SSI staff and NDDS teams at their own schools and others. Videos of classrooms at the NDDS sites are also planned for use in other schools.

Equity. A basic principle of New Directions is that the standards developed are for all students. It is Project 21's responsibility to focus the NDDS schools on equity issues. An ongoing SSI equity task force of SSI staff, principals, and teachers oversee equity efforts, and each NDDS school must develop an equity plan. In addition, the SSI funds a program, developed for it by the Junior Achievement program, that provides tutoring and mentoring for students from groups that are typically underrepresented in math and science fields.

Structure. The staffing structure and physical space occupied by Project 21 are a key indication of how entwined the SSI is with the larger state reform effort. The principal investigator, Paul LeMahieu, wears several other official hats in addition to his SSI role. He has a joint appointment as (1) faculty member and director of the newly established Education Research and Development Center at the University of Delaware and (2) a cabinet-level position in research and policy development with the Department of Public Instruction. Other Project 21-supported staff based at the University include a director of science education and development, a director of math education and development, two educational associates for mathematics, two educational associates for science, and two graduate students. These people represent the ongoing content expertise available to the New Directions Development Sites.

The project director for the SSI, Helen Foss, is based in the Project 21 administrative headquarters on the campus of Delaware State University in the state capital. She (like all other headquarters staff) is an employee of the Department of Public Instruction and, like the PI, works closely with the state superintendent. Her specific job responsibilities include chairing the Project 21 Management Team, coordinating all SSI activities, and acting as official liaison between the SSI and the New Directions reform agenda. The Delaware State University headquarters is also home to the component of the SSI that focuses on support of organizational change. Project 21 itself employs two organizational change associates who, like the content specialists, operate as resources to the NDDS schools. The SSI leadership places a particular premium on the importance of developing a school's understanding of the change process, which tends to involve lurches forward followed by dips in enthusiasm or even setbacks. The position of organizational change associate is designed to help the sites work through the process problems that are viewed as an inevitable part of school improvement.

Despite their physical separation, communication linkages between SSI staff and the Department of Public Instruction are strong and regular. For example, the SSI staff employed by DPI serve on the teams that characterize DPI's reorganization under New Directions. Similarly, the PI and the project director are regular participants in discussions and decision-making about the status of and future steps for New Directions. Being of the DPI but not in it has also protected SSI staff to some extent from the upheavals associated with the DPI's own restructuring process.

Implementation of the SSI

Development of the SSI and Its Governance

Delaware applied for its SSI funding during the first round of competition. The decision to write a preliminary proposal for SSI funding came from the office of the previous governor. Primary oversight of the proposal development process became the responsibility of the former lieutenant governor, who was a scientist with the du Pont Corporation before going into politics, and the current SSI project director, who was, at the time, education aide to the governor. They recruited some staff at the Department of Public Instruction to help prepare a preliminary proposal. NSF responded with interest but requested more creativity in approach.

Development of the full proposal was more broadly based, involving both a writing team (including a professional proposal writer) and a steering committee composed of stakeholders such as business leaders, scientists, mathematicians, educators, university faculty, and politicians. Delaware State University offered to house the SSI on its campus—an offer that was warmly accepted. In retrospect, some stakeholders perceived a bias toward science in the original proposal, arguing that math people were less involved in proposal preparation and development. The mild rivalry between math and science in Delaware seems to be a result of the du Pont Corporation's long history of support for science education in the schools. Unlike those in some other states, Delaware's plans for its SSI always included goals for improving both subject areas.

Delaware received its SSI award in 1991, but Project 21 did not really begin to cohere as a systemic initiative until 1992-93 (its second funding year), when its relationship to New Directions became explicit and the role of principal investigator stabilized. When the new state superintendent of public instruction first arrived in 1991, all SSI activities were actually suspended for a time while a revised role for the initiative was thought through. (The SSI received some additional funding from NSF to support the regrouping process.) Throughout its first 2 years of operation, the SSI contended with significant differences of opinion among the staff and between some staff and other stakeholders about purpose, design, and operations. The decision-making structure for the SSI was particularly unclear, and at one point, the program officer at NSF who oversees the Delaware SSI was asked to help mediate and clarify the situation. Project 21 was not fully staffed and operating in the configuration described in the preceding section until the summer of 1993, almost at the end of its second year of NSF funding.

On paper, the line authority structure of Project 21 is now quite straightforward. The single principal investigator, Paul LeMahieu, reports directly to the state superintendent of public instruction (DPI is the SSI fiscal agent). The project director, Helen Foss, in turn reports to the principal investigator and is responsible for overall, day-to-day project management, decision-making, and supervision of other project staff. However, the actual management style of the project is highly collegial. All staff members are part of the Management Team, which meets regularly despite the fact that staff are housed in two locations. The SSI Management Team also includes the state's restructuring coordinator, supported by the Re:Learning initiative, and will be augmented in 1994-95 by a director of the Center for School Change based at Delaware State University.

A number of groups advise the Project 21 staff. Collectively, they are thought of as the SSI's "critical friends," a term that comes out of the state's experiences with the Coalition of Essential Schools and the Re:Learning network. The Grassroots Committee, a group of teachers from New Directions Development Schools, meets regularly with the management team. The purpose of this committee is both to facilitate the flow of information from the SSI to the partner schools and to provide grassroots input into the planning and execution of SSI-sponsored staff development activities.

The governor-appointed Steering Committee for Project 21 has 30 members and is chaired by the president of Delaware State University. This committee is essentially a stakeholder group with broad representation: teachers, school administrators, higher education, boards of education, the governor's office, the legislature, business and industry, and so on. Representatives from DPI, Project 21, Re:Learning, and the math and science Curriculum Framework Commissions attend meetings ex officio. The committee, which meets three or four times a year, advises the SSI on policy and direction, although its suggestions are nonbinding. It reviews draft documents before their submission to NSF and raises concerns coming from various constituencies in the state.

A third group, the Technical Advisory Committee, consists of nationally recognized math and science content specialists who convene in Delaware three times per year. Their reviews, comments, and critiques of Project 21's activities and strategies have been targeted, substantive, and quite helpful to the SSI staff.

Because Project 21 is so intertwined with the larger state education reform effort, it has also benefited from review and comment by the New Directions National Advisory Council. This group includes some of the most respected education policy experts in the country, most of them university based.

Activities Supported by SSI Funds

New Directions Development Sites. Project 21 has supported four major components, which are summarized in Exhibit 5. Project 21 describes the New Directions Development Sites as the heart of its development activity. The initial 17 NDDS schools were selected in the spring of 1993 from among 26 applicants. The schools are distributed across the state (12 of 19 districts) and include high schools, middle schools, elementary schools, primary schools, and vocational-technical schools. The idea is for these sites to become exemplars of both reformed math and science curriculum and instruction **and** school/classroom change processes such as action research, collaborative inquiry, peer coaching, and site-based decision-making. Schools selected vary considerably in terms of their previous experience with school restructuring and reform. Some had several years of experience with other restructuring networks, notably Re:Learning and the Southern Regional Education Board's Schools That Work. Others are initiating change efforts with the support of the SSI.

Much of Project 21's time, energy, and resources were concentrated on the NDDS schools from the summer of 1993 through the summer of 1994. In these schools, the SSI is attempting to put into practice a philosophy of professional development rooted in the best research on the subject. Its vision of high-quality professional development includes the following elements:

- A focus on the whole school as the unit of change.
- Intensive and ongoing technical assistance at the school level.
- A simultaneous focus on content, pedagogy, and school culture.
- Built-in time for reflection as well as action.

Exhibit 5
Progress of Project 21 Components

Component	Progress to Date
1. New Directions Development Schools	These 17 schools, selected by a proposal process, have been variably engaged with SSI-sponsored technical assisters and other kinds of support in their first year of involvement. Although these schools were intended to form a strong improvement network, they have focused more on their own issues and less on the network. The number of sites is expected to increase.
2. Technical Assistance	Project 21 supports nine technical assistance providers in the areas of math and science content and pedagogy and school culture change. Their services are available to selected schools, and the impact on these schools varies widely. There are questions about how technical assistance can be scaled up effectively.
3 Curriculum Frameworks Commissions	SSI staff have participated in the development of draft frameworks in math and science. Project 21 is coordinating the framework review process and will support involvement of outside experts in framework revisions.
4. Partnerships and Collaboration	SSI established and supports statewide Science and Mathematics Collaborators Groups designed to bring together all levels of the system around standards-based reform.

Work with the NDDS sites began with the first Professional Development Institute (PDI) in July 1993. Full participation in the PDI by a school team, including a building administrator and a district staff person, is one of the requirements of the cooperative agreement between the schools and the SSI. This first PDI offered the first sustained opportunity for Project 21 and the school teams to become acquainted. During the first week, teams were introduced to the state's reform agenda and its national context (e.g., NCTM standards), the SSI's role in state reform, and the specific role of NDDS. The remainder of the 2-week institute provided workshops (primarily on constructivist approaches to the teaching of math and science) and time for teams to work on plans for developing a "polished stone" that would exemplify innovative learning events and instructional practices (recall Boxes C and D of the New Directions schematic).

During the school year that followed the first PDI, Project 21 convened the NDDS teams four times for professional development meetings and workshops. Some of the topics covered included reform of assessment, action research, equity and diversity, and constructivist teaching and learning. Each school is also assigned to a "triad" of the nine Project 21 math, science, and school change specialists. School teams may call on these people for technical assistance. At the request of the sites, one specialist is designated as a school's single point of contact for initial requests and consultation.

With a ratio of 9 site coaches to 17 schools, there appears to be the possibility of intensive technical assistance in the reform of math and science curriculum and instruction. However, the assistance seems to be unevenly distributed. One issue seems to be confusion about who should initiate communication. Some schools have quite aggressively sought out what they needed from the SSI staff and, by their own accounts, have received valuable help with their restructuring efforts; others have proceeded on their own, waiting for Project 21 to come to them or happy to be left alone. The result is that the SSI team is very familiar with the nature and quality of the development work in some schools but is hazier about what is happening in others.

Another issue for Delaware's technical assistance strategy is that the ratio of 9 to 17 is deceptive. All nine specialists have other New Directions/Project 21 responsibilities beyond the direct work with the NDDS schools: management and administration, participation on the Curriculum Frameworks Commissions, coordination with other state and national reform efforts, planning and execution of the Professional Development Institutes and other events, and so on. They often appear to be stretched quite thin. During school year 1994-95, Project 21 plans to reduce some of the role fragmentation experienced by its staff through the scheduling of all meetings during one week of each month.

The sites continued to work on their polished stones during the 1993-94 school year. The first of these was "published" in December 1993—a science learning task for upper elementary grades illustrating how students might learn about materials and their properties (one of the draft science standards). Project 21 published abstracts of 35 polished stones in various stages of development in February 1994.

The second 2-week PDI was held in June 1994 with somewhat expanded participation. For example, an interdistrict team of science teachers attended. The general format of the institute was similar to that of the previous year—workshops and presentations as well as time for teams to work together. Some of the workshops were offered by the NDDS teams themselves.

Project 21 plans to continue the same level of support for the NDDS schools in the fourth year of operation. However, according to its May 1994 annual report to NSF, as the SSI focuses more on scaling up, the emphasis will shift from providing professional development opportunities **for** the school teams to capacity building **through and with** the teams.

Curriculum Frameworks Commissions. Although SSI financial support of the math and science Curriculum Frameworks Commissions has been quite modest, participation of Project 21 staff on the commissions has been an important means of keeping the SSI linked to New Directions and making information about the draft standards available to the NDDS schools. Nonetheless, simultaneous development of the standards and of learning events to implement standards that are not yet completed is not an optimum implementation situation.

Draft standards in all four core subject areas were released for review and comment in the spring of 1994. According to the math standards document, the standards represent "a set of essential mathematical thinking processes and unifying themes." The Mathematics Framework Commission endorses the NCTM standards but packages them differently "because we feel our format communicates more clearly to the teacher."[18] There are 10 standards in all. The first four, directly derived from NCTM, involve

[18] Mathematics Curriculum Framework Commission. (June 1994). *Delaware Mathematics Curriculum Frameworks* (draft). Dover, DE: Department of Public Instruction, p. 8.

mathematical thinking processes: problem solving, communicating mathematically, reasoning mathematically, and making mathematical connections. The six unifying themes are: (1) estimation, measurement, and computation; (2) number sense; (3) algebra; (4) spatial sense and geometry; (5) statistics and probability; and (6) patterns, relationships, and functions. The implications of the document are that **all** students in the state will be exposed to the same content and that the study of higher mathematical concepts, such as algebra, begins in kindergarten with illustrations of equalities and inequalities.

For each of the 10 math standards, the frameworks document provides performance indicators and examples of learning events. Sample performance tasks and scoring rubrics are under development but not included in the current document. The framework is very explicitly **not** a fully developed curriculum that tells teachers what to do on Monday for a full school year. Exhibit 6 illustrates the level of detail provided for each standard.

The science curriculum frameworks document is in an earlier stage of development. So far, three of the seven standards planned have emerged for general review: Materials and Their Properties, Earth's Dynamic Systems, and Life Processes. Each of these broad areas is broken out further into concept strands and then into concepts and student expectations at three grade-level clusters. The current document has no introductory material explaining rationales or sources drawn on in document development. The SSI reported in its mid-point review document to NSF that the science standards are being informed by Project 2061, Science for All Americans, and the work of the National Research Council.

The mathematics and science frameworks commissions have worked independently of each other. The draft documents they have produced do not reflect any emphasis on integrating the two disciplines. Districts and schools, however, would certainly not be prohibited from adopting cross-disciplinary implementation strategies.

In written comments to the Project 21 leadership after a March 1994 site visit, the mid-point review panel recommended establishment of a stronger relationship between the SSI and the frameworks commissions. Project 21 now has the responsibility of facilitating review of the standards at the NDDS schools. The SSI content specialists will help synthesize the feedback for the commissions' use in refining the frameworks as part of the broader review process. As we noted earlier, the SSI will also support additional time for consultants from its own Technical Advisory Group to work directly with the commissions in the revision process.

Exhibit 6

A Sample of the Mathematics Curriculum Framework

STANDARD #1: Students will engage in PROBLEM SOLVING as the core of the entire mathematics program. Problem solving provides the context in which concepts and skills are introduced and learned; requires the application of a variety of strategies; develops persistence, self-reliance and confidence; integrates mathematical reasoning, communication and connections; and emphasizes the *process* that could lead to a reasonable solution.

PERFORMANCE INDICATORS

Through the investigation of meaningful problems, individually or in cooperative groups while using appropriate technology, all students in grades K-10 should be able to:

1.01 read and understand the problem;

1.02 develop a plan for solving the problem;

1.03 implement the plan and solve the problem;

1.04 reflect on their answer with respect to the original problem;

1.05 generalize strategies and solutions to new problem situations.

[Text goes on to define "meaningful problem" (multistep, nonroutine, etc.), appropriate teacher roles, and examples of strategies (act it out, make a table, look for patterns, etc.).]

LEARNING EVENTS
(Examples)

Grades K-3:

There is 57 cents in a bag. What possible combinations of coins could be in the bag?

Grades 4-5:

How many hot dogs should you order for the concession stand on opening day at the School Fair? Explain how you arrived at your answer.

Grades 6-8:

If you rode your bicycle to school, how many times would your bicycle wheel turn? Explain how you arrived at your solution.

Grades 9-10:

Design the most efficient container for shipping 50 loose golf balls.

Eventually, the curriculum framework documents will have illustrations of learning units that include "embedded assessments" and scoring rubrics. Project 21 supports the work of Mathematics and Science Performance Task Development Groups who are developing these tasks. This work, which has turned out to be quite challenging and is taking somewhat longer than expected, builds on the expertise of the Delaware educators who have been involved with the New Standards project. There is also an expectation that the best of the polished stones will be appended to or incorporated into the curriculum frameworks as exemplars. The first "published" polished stone, usually referred to as The Backpack, illustrates a learning event related to the standard on materials and their properties.

Other Partnerships and Collaboration. Work with the NDDS schools is the most important and time-consuming partnership for Project 21. However, Project 21 is also developing mechanisms to strengthen other relationships important to systemic reform. In 1993, for example, it established the Science and Mathematics Collaborators Groups, which meet regularly. The groups involve key mathematics and science educators from all levels of the system and representatives of Curriculum Frameworks Commissions. Part of the agenda is to come to a common understanding of what the New Directions/Project 21 vision and goals mean philosophically and operationally. Meetings are also used to identify resources and activities that would be strengthened by collaboration. The Collaborator Groups are viewed as a particularly important mechanism for forging stronger bonds with the higher education community.

The relationship between Project 21 and the state's Re:Learning activities is a critical one. The school culture change piece of Project 21 relies heavily on the nine principles articulated by Ted Sizer that guide Re:Learning and the Coalition of Essential Schools.[19] Indeed, the SSI school change staff have extensive training in and commitment to the Sizer philosophy of school improvement, as do principals and staff at several of the NDDS schools. Although there is arguably more rhetoric than action associated with Re:Learning in some schools, others are highly engaged in the restructuring process. We would hazard a guess that, should any aspect of the statewide reform initiative ever come into serious conflict with the bottom-up restructuring efforts of Re:Learning, the latter would retain the allegiance of the most proactive schools. Currently, the SSI and

[19] The nine principles that drive the Coalition of Essential Schools and the Re:Learning network are too lengthy to reproduce verbatim here. However, several of the principles contain language that has become part of a broader rhetoric about the reform of curriculum and instruction, e.g., "less is more," "student as worker," "graduation by Exhibition" (a specific vision of performance assessment).

Re:Learning are playing complementary roles. In addition to participating on the Project 21 management team and participating in SSI events, the director of Re:Learning has formed a Principals' Network to support school leadership for reform—an important linking strategy for the systemic reform effort.

Local Evaluation. Project 21 has quite recently engaged Horizon Research Incorporated (HRI) as an independent evaluator for the SSI at a relatively low level of effort. As the evaluation plan now stands, SSI staff will develop and administer the evaluation instruments (surveys, focus group protocols, observation protocols, attitude inventories, and goal attainment scale). HRI will review and refine the instruments; conduct interviews with certain key people, such as state leaders; analyze the data; prepare reports; and conduct occasional briefings in the state.

The local evaluation is organized around four strands that match the organization of the SSI's work plan: polished stones, capacity building, system coordination, and administration. Data collection is scheduled to begin in the fall of 1994. The answers to a number of the evaluation questions will require evidence of changes in teachers' practices, attitudes, and beliefs. The baseline against which change will be measured is not clear from the written plan.

Preliminary Impacts of the SSI

The Impact of SSI Activities to Date

Awareness. New Directions is clearly understood by educators and policy-makers to be the name of a major state-level educational reform effort in Delaware. So far, however, the nature of the planned reform and what it will mean for classrooms throughout the state has been vague to people not participating in the work of the Curriculum Frameworks Commissions.

The most tangible thing that has happened as a result of New Directions is a change in the state assessment instrument. The interim assessment, with its limited number of performance assessment items, has now been given twice. When the results of the first test administration were reported in the fall of 1993, there was remarkably little public reaction of any kind to the fact that Delaware's students performed quite poorly. Some secondary school teachers interviewed shortly after the second test administration voiced some irritation about the fact that, whereas they were being encouraged to allow students to use calculators in class, students were not allowed to use them on the state test. (This rule was imposed because the state could not ensure that all students would have access to calculators.)

To lend some concreteness to the New Directions vision, state leaders—including Project 21 staff—organized a statewide professional development day in February 1994 designed to give all teachers in the state a preview of the content and student performance standards being developed by the Curriculum Frameworks Commissions. With state agency staff, Project 21 staff, and commission members acting as group leaders/facilitators, every teacher had a chance to look at, engage with, question, and discuss a draft task (that is, a rough polished stone). All teachers were given an evaluation form and a 3 x 5 card on which to write comments. They were free to comment on either the inservice session itself or the overall thrust of reform in the state. A synthesis of more than 450 comments received indicates that teachers are most concerned about the availability of resources for implementing the standards-based curriculum envisioned by New Directions and Project 21. Specific kinds of resources mentioned included: (1) time (for staff development, for evaluating new kinds of assessments, for providing extra help to special populations, etc.), (2) curricular and instructional materials and equipment, and (3) technologies to support new kinds of teaching and learning. Teachers also had many questions about how the standards would affect other programs, initiatives, and typical features of schooling ranging from early childhood programs to libraries to students' preparation for the SAT to the restructuring of schools in connection with the Re:Learning network.

In comparison with New Directions and the work of the Curriculum Frameworks Commissions, Project 21 is not broadly understood as an integral part of the state reform effort. Although the principal investigator and the project director are well known and clearly identified with the state superintendent's vision of reform, Project 21 itself tends to be viewed by the New Directions Development Sites as a set of activities and resources. Beyond these 17 schools, Project 21 has very little widespread visibility. At one non-NDDS school that we visited, the principal had a vague idea that it would be nice to be part of Project 21 because of the extra resources. In general, Re:Learning seems to have a higher profile in Delaware than Project 21.

The level of public awareness about New Directions—that is, awareness beyond the education and policy-making community—is harder to judge. There is beginning to be some resistance to the vision for reform (see discussion on page 71), which suggests that citizens are paying some attention. Recognizing the need for better communication with the public, state education leaders and Project 21 staff fairly recently developed a communication plan for New Directions with an embedded plan for the SSI. The monthly newsletter now produced by Project 21 (*The Standard Bearer*) is part of the plan. Other planned activities include speeches at local school board and PTA meetings as well as national conventions, development of videos about polished stones, recruitment of new Development Sites, a brochure (already developed) and other marketing materials, and press coverage of events and activities.

The New Directions Development Sites. The core of the SSI strategy in Delaware is the partnership with the New Directions Development Sites. If these schools, or at least several classrooms in each school, can be restructured to represent the vision of teaching and learning that drives New Directions, then the state will have models to point to as the systemic reform goes to scale. If students in these schools or classrooms are doing better than others their age on the state performance assessments, then the case will be even stronger that reform is moving in the right direction. At this point, of course, the affiliation between New Directions, the SSI, and the NDDS schools is only about 18 months old, and it is far too early to judge the success of this strategy. Below, we offer some observations about the early stages of implementation in a few of the partnership sites.

A very basic issue for the success of the SSI strategy in Delaware is the readiness and willingness of the NDDS schools' faculties to comprehend and undertake implementation of the state vision for the reform of math and science curriculum and instruction. From observations and interviews with teachers and administrators in about one-third of the sites, it appears that the NDDS schools entered into the partnership arrangement with New Directions and Project 21 at very different stages of readiness for reform. This diversity is probably a good thing, since they are thus more representative of all the schools in the state. However, it also suggests that each site will need different kinds and levels of technical assistance from the SSI if all sites succeed in becoming exemplars of the systemic reform vision. We discuss the SSI's capacity to offer assistance in the next subsection. Here, we focus on the status of reform activity in the schools that we visited.

One way in which the NDDS schools vary is in their previous experience with reform-related activities. In some of the NDDS schools, commitment to and engagement with reform are quite intense, extending well beyond the official NDDS team of teachers and administrators to involve substantial portions of the school faculty. Thus, for example, at one elementary school, the entire faculty has spent several years learning how to make good use of school-based decision-making authority. They now operate as a cohesive governance team on a consensual model—a fact that has contributed to development of a strong vision for school improvement.

By contrast, at other sites the NDDS teams appear to be somewhat isolated pockets of reform activity. In these schools, although there may be considerable reform-oriented activity, there is not the same sense of an agreed-on common purpose. Thus, two or more teachers may be collaborating on a polished stone or writing a curriculum, while their colleagues are resistant or simply not yet involved. In one case, the school has not been involved with any reform activity in the recent past. They are using participation in the SSI partnership as a starting point for developing a restructuring plan.

In the schools where a reform vision was relatively well developed and the change process is under way, the visions often originally derived from the schools' involvement with something other than New Directions, primarily Re:Learning and the Southern Regional Education Board's Schools That Work. This is not to say that the local visions are incompatible with the statewide systemic reform initiative. For example, the two vocational-technical schools that are part of the SREB network are both intent on becoming exemplary comprehensive vocational schools (that is, schools where students receive both their academic and occupational instruction). In a general way, the ideas of polished stones and performance-based assessment fit well with their other reform emphases, such as applied learning, integration of academic and vocational content, and graduation by exhibition or portfolio. However, it remains to be seen whether the state's idea of standards (i.e., the level at which students perform) meshes with what these schools expect or are willing to accept from their students.

The structure of the Project 21 staff is designed to blend process and content expertise, and, in general, the leadership of the SSI believes that both elements are important, although different individuals would tend to emphasize one over the other. Similarly, some of the NDDS schools buy into the school culture change or process orientation more than others. The elementary school mentioned above is a good example of a place where a lot of process preceded substance. In other sites, however, teachers expressed some frustration with the SSI's tendency to "philosophize" and discuss when teachers wanted to get on with the business of reviewing or writing curriculum or researching instructional strategies.

The SSI staff are working hard to turn the NDDS schools into a network of cutting-edge places where the principles of standards-based curriculum underlying New Directions and best teaching practices for delivery of such a curriculum can be seen in action. So far, the network is slow to develop. Schools are very much focused on their own issues; most are not yet at a stage to fulfill their intended "capacity building" role in the statewide implementation of the New Directions vision. The sites themselves cannot really be faulted in this regard because the "big picture" of state reform has not yet been very visible, and they have not known what they are to be exemplars of. The coming year may be a critical one for New Directions, the SSI, and the NDDS schools as all the pieces of standards-based reform in Delaware finally emerge and the concrete debate about the vision begins in earnest.

Polished Stones. All of the NDDS schools are working on polished stones, some on more than one. This has continued to be a requirement of their cooperative agreement with Project 21, although the originally very vague expectations for these learning units have been refined somewhat, and the poorly understood term "polished stone" is used less and less.

NSF's mid-point review panel found considerable confusion about "the nature and purpose of polished stones" and enjoined the SSI to continue to refine its thinking about the role that development of these teaching and learning units should play in a systemic reform effort. In its strategic plan for 1994-95, Project 21 acknowledges that "only a few of the products [exemplary learning units] will end up serving as exemplars in the Commissions' documents [curriculum frameworks]...." NDDS teams and individual teachers will continue to work on their polished stones, but the development process will now be viewed primarily as professional development. This adaptation of the original SSI strategy reflects the NSF review panel's concern about the quality of the locally produced polished stones and the appropriateness of putting them forward as curricular exemplars for the whole state. (The SSI's Technical Advisory Group had expressed similar concerns.) Now there will be greater emphasis on identifying the best published curricula available as the starting point for learning units linked to Delaware's standards. Locally generated products will also be judged against a common set of criteria developed by the Project 21 staff.

Technical Assistance. On a day-to-day basis, the primary activity of most Project 21 staff is technical assistance to the NDDS schools and to assorted other groups and individuals who are contributing to the development or implementation of the New

Directions vision of reform. The technical assistance and support function of the SSI staff encompasses two main types of activities: (1) convening people for professional development purposes and (2) helping individual teams, in their school settings, with whatever their assistance needs are. Impacts of the technical assistance function have been variable, and issues continue to emerge as the implementation process unfolds. The SSI staff report mounting anecdotal evidence from teachers themselves that the technical assistance is paying off in terms of changes in school culture, such as greater collegiality, and in classroom practices. Delaware's local evaluation is scheduled to capture this kind of evidence more systematically during the fall of 1994.

The major professional development events related to New Directions and Project 21 are the annual summer Professional Development Institute and several statewide meetings of the NDDS teams during the school year. Attendees at these events generally rate them positively, and enrollment at the PDI nearly doubled from the first year to the second. However, head counts are a little deceptive; the best measure of effective professional development experiences is the sustained engagement of the participants.

The PDIs are designed to be intensive professional development opportunities—2 weeks of exposure to new ideas and practices, as well as time to work in teams. Although Project 21's cooperative agreement with the NDDS schools requires them to fully commit to participation in the PDIs and other meetings, it is proving difficult to hold the schools to their commitment. The involvement of district and school administrators in NDDS team events is particularly problematic for many—maybe most—sites. But teachers, too, are becoming protective of their time—time out of the classroom during the school year and time for their families or other interests and responsibilities during the summer. The second PDI accommodated this reality by allowing ad hoc participation rather than commitment to the full 2-week period. However, this approach certainly dilutes the overall impact for individuals, for teams, and for statewide reform.

As we noted earlier, on-site technical assistance provided by the SSI specialists has been very effective and helpful at some NDDS schools and nonexistent at others. In all fairness, this role is a difficult one to fill. Given the different stages of development of the sites, the specialists must be prepared to intervene at many levels of sophistication about good content and practice in math and science education or the change process itself. Further, the schools have often not known precisely what kind of help they needed or when to ask for it. The schools that have been more focused and perhaps more receptive to outside help have benefited the most from the partnership arrangement so far.

Delaware's SSI faces several issues regarding its on-site technical assistance activity as it moves into the fourth year of operation. First, in the summer of 1994, two specialists (math and school culture change) left the team for other positions. Project 21 is thus faced with the problem of finding new expertise for jobs that may last only 2 more years. This situation may bring the SSI and New Directions face-to-face with the institutionalization issue sooner than they expected.

A second issue for the on-site technical assistance function is capacity. Assuming that departing staff can be replaced, this will only bring capacity back to 1993-94 levels. During that time, the SSI did not have enough workhorses to adequately fulfill their responsibilities to the NDDS schools under the cooperative agreements. It seems particularly important for the schools that are at the earliest stages of planning for change to receive larger doses of technical assistance in order to step off on the right foot. Further, much can be learned through intensive support of these sites about what it will take to create understanding of and commitment to the state vision when starting virtually from scratch. In terms of scaling up to bring systemic reform to all schools in a state, the odds are that the majority of schools will be starting from this point as well.

Impact on Students. Few students have yet been directly touched by Delaware's systemic reform effort. Some draft polished stones have been piloted in classrooms, and the generally positive reactions of students have been informally reported on in the SSI newsletter and at meetings. Student learning from these units is measured through embedded assessment activities—performance and otherwise—but is not currently reported in a systematic way.

Delaware has established baseline data on the mathematics performance of 3rd-, 5th-, 8th-, and 10th-graders on its newly adopted interim assessment instrument. There is currently no science assessment. In math, student performance was measured against a state-determined standard of acceptability. The baseline showed that there is a long way to go. The proportion of all students meeting or exceeding the standard ranged from 17% in 3rd grade to 11% in 10th grade. For minority students, the proportions were considerably lower—3% for African-Americans and 6% for Hispanics at the 8th-grade level, for example. These results are disturbing but not surprising in light of similar patterns for NAEP results all across the country. They do suggest that an emphasis on equity issues is critical in Delaware and in all the SSI states.

Resistance. The new state superintendent and his ideas about systemic reform enjoyed a honeymoon period for nearly 2 years. However, by the spring of 1994, New Directions was beginning to encounter some resistance from several quarters: (1) religious conservatives, who suspect that values-laden, outcomes-based education is lurking in the New Directions agenda; (2) business interests and the legislature, who are unhappy with the vagueness of the reform vision; and (3) members of the education establishment, who are feeling that their past and/or current efforts are not being valued with all the talk of statewide reform.

Although the tone of resistance from the religious right is not as strident in Delaware as in some other states, Delaware state education leaders are nevertheless finding it necessary to pay special attention to this group. The rhetoric surrounding New Directions and Project 21 does not use the term "outcomes-based education," the usual red flag for conservative groups. Indeed, the draft curriculum frameworks are assiduous in adhering strictly to content-based standards that all students should achieve. Nevertheless, suspicion exists, quite probably because the draft standards have not been available for public examination until very recently.

New Directions and Project 21 certainly have their friends in the business and legislative communities. However, these sectors wonder what systemic reform really is and question both its cost and lack of immediately noticeable results. The legislature has so far denied a Department of Public Instruction budget request of $100 million over 5 years for implementation of New Directions. One district superintendent offered the opinion that a far more effective and extensive public awareness campaign would need to be conducted before the legislature would feel any pressure to budge from its current position.

Finally, there is inevitable resistance to change within the education community. There will always be individuals, of course, who are content with the status quo and see no reason to change it. However, some of the resistance in Delaware (mainly passive resistance) is the result of the core implementation strategy selected—pilot schools. Although the NDDS teams are supposed to include a member from the district staff, district involvement in the systemic reform effort has so far been minimal, and late-in-the-day attempts to draw them into the fold have been received neutrally at best. In our local sites visits, nearly all the superintendents were surprised that, given our purpose of learning about the SSI, we wanted to talk with them. They professed little contact with Project 21 and not much more with New Directions, toward which they took a "wait and see" position. One superintendent put it this way: "We will do what they [state agency staff] ask us to. If it [New Directions] fails, they can't say it was because of us." Not exactly a ringing endorsement statement. Project 21 intends to increase its outreach to district-level personnel in 1994-95. From a cross-state analytic perspective, however, it seems likely that choice of the initial intervention unit (i.e., teacher, school, district, region) could affect the long-term impacts of the SSIs.

Reflections on the SSI in Delaware

How Systemic Are New Directions and Project 21?

The basic approach to the reform of mathematics and science education (as well as the other content areas) in Delaware quite closely follows the model first implemented in California and articulated for the education policy and research community by Smith and O'Day[20]: setting high standards for what all students should know and be able to do, and facilitating achievement of these standards by aligning high-quality, challenging curriculum, appropriate instructional strategies, and performance-based assessment. Set against the conceptual framework for systemic reform that is guiding the national evaluation (see Figure 1, page 4), New Directions and its implementation arm, Project 21 (the SSI), are addressing or have plans to address all the elements that should take the reform effort from an ambitious vision of learning for all students (both math and science, K-12) to student attainment of the ambitious learning goals (referred to as standards in this state). A key difference between the way systemic reform has developed in, for example, California, and the way it has unfolded in Delaware concerns the order of events.

Our conceptual model for evaluating systemic reform, represented by Figure 1, by no means presumes that systemic reform is a fixed and linear process. It does, however, assume (1) that defining a state vision for the improvement of math and science precedes the point of entry for implementation strategies (represented by the middle part of the diagram), which will vary from state to state, and (2) that improved student attainment at some time in the future is the key indicator of a reform strategy that has worked. In some sense, then, the model reads from left to right. In Delaware, the precondition of a well-articulated statewide vision for the reform of math and science education was not present when the implementation strategies were selected and teachers began work on curriculum

[20]M. Smith & J. O'Day. (1991). Systemic School Reform. In S. Fuhrman & B. Malen (Eds.), *The Politics of Curriculum and Testing*. Bristol, PA: Falmer.

and instructional reform. New Directions (with some support from the SSI) has focused on establishing the vision through the Curriculum Frameworks Commissions. At the same time, the SSI has put its most significant resources and efforts into producing illustrations, but illustrations of what? This is a variation on the standard model of systemic reform that bears watching as New Directions continues to unfold.

Despite this anomaly in the order of events, New Directions and Project 21 between them incorporate most of the elements associated with systemic reform to a greater or lesser degree. The SSI's greatest emphasis has been on our right-hand column of boxes—appropriate pedagogy, challenging materials, and meaningful assessment—with considerable attention to the middle column as well, particularly collaborative relationships and building a climate for reform. The SSI's basic strategy has been capacity building within the state's education community through technical assistance, professional development, and the convening of key members of the mathematics, science, and business communities. Thus far, it has given less attention to broadly based public awareness strategies and mobilization of opinion in the wider community. More attention is now being directed to this area of the model.

On balance, then, we conclude that Delaware's approach to reform is an adaptation of systemic reform in the sense that the term is currently understood. It is, in a sense, an experiment testing the proposition that vision and a common understanding of it do not necessarily have to go first.

The Future of Systemic Reform in Delaware

Scaling Up. As a Cohort 1 state, Delaware's SSI is now moving into its fourth year of operation. Because of its false starts, however, the real development and implementation work is less than 2 years old. During NSF's mid-point review process, Project 21 was urged to give serious consideration to its plans for expansion beyond the 17 NDDS schools. The increased number of participants at the 1994 Professional Development Institute reflected a first step toward scaling up. The general model for scaling up—usually referred to as "roll-out" in Delaware—involves use of the NDDS teams of administrators and teachers as leaders/facilitators of workshops in their own districts and beyond. The SSI also plans to begin more systematic conversations with the University of Delaware and Delaware State University about the relationship between New Directions and teacher preparation programs—including possible heavy use of some

NDDS schools as venues for student teaching assignments. Obviously, not all of the NDDS sites are ready to serve as demonstration schools in this way.

Delaware is a small state, and its size alone tends to nurture the idea that the SSI can touch every teacher in a short time. It is true that, with the assistance of SSI and DPI staff as well as frameworks commission members, the state education agency successfully brought off one staff development experience in 1994 that literally did focus every teacher's attention on New Directions for a day (2 days were planned, but weather intervened). The purpose of this event was to introduce the concept of a standards-based education system to all of the state's K-12 educators and demystify the work of the frameworks commissions. This was an enormous undertaking and not a level of effort that can currently be sustained. With its present structure and capacity for providing technical assistance, Project 21 probably should not add schools to the NDDS network. It has been hard pressed to establish solid working relationships with the 17 schools already involved. An infusion of extra state funding for implementing New Directions might help, but the first-order problem to be solved is a structure that will allow a much larger segment of the state's teachers to grapple with the changes inherent in the curriculum frameworks and a standards-based assessment system. Districts, rather than individual schools, are the logical partners for the state in scaling up. To this point, however, district leaders and central office staff have not been much involved with the implementation effort. Some resent this fact. Earning the good will and cooperation of, for example, district math, science, and staff development specialists may now be costly and time consuming, yet it appears to be essential.

Although the SSI has perhaps paid less attention to building district support than it should have, it has nevertheless successfully created, participated in, or strengthened a number of math and science networks in the state. These networks—which include educators, politicians, and representatives of the private sector—have the potential to be important elements in both scaling up and building public awareness. It is not yet clear, however, how the expertise in these networks can be capitalized on to expand understanding of and commitment to the New Directions approach.

Reform after NSF Support Ends. Like other SSI states, Delaware is coming to realize that its audience is not just the professional education community but the general public as well. If the superintendent quoted earlier in the case study is correct, then continued support—fiscal and philosophical—for New Directions will be contingent on a carefully considered public awareness campaign. Without some pressure or enthusiasm for change from the community at large, the legislature is unlikely to appropriate sufficient extra funding to ensure statewide implementation of the changes in curriculum and instruction required by a standards-based system.

The resistance to reform of math and science education in Delaware should not be underestimated. Passive resistance from within the system could cause standards-based reform to suffer the fate of many previous education reform efforts throughout the country. However, the greater barrier to institutionalization of change may come from the highly educated sector of the public—the families of college-bound students. The old system worked for them, and their children are doing well. In fact, in one district that we visited, the secondary schools were backing away from mathematics reform (an integrated course of study in mathematics implemented before the SSI began) under pressure from parents who attribute a decline in SAT scores to this curriculum. Teachers, too, seemed relieved to be returning to the standard sequence of Algebra I-Geometry-Algebra II.

Lessons Learned

Timing. With the arrival of a new state superintendent, Delaware moved on many education reform fronts simultaneously: a new, albeit temporary, standards-based state assessment system; development of curriculum frameworks; and identification of pilot schools with the responsibility of creating learning units that would flesh out and illustrate the frameworks. In other words, what a state like California has accomplished sequentially over nearly 15 years, Delaware is trying to do on a much tighter schedule. Given that the ultimate goal of all this activity is alignment of curriculum, instruction, and assessment to help all students achieve to higher standards, then concurrent development might make some sense. However, at least in Delaware, there has been a timing problem.

At its broadest level, New Directions is a visionary agenda for a standards-based system of public education. For most of its brief life, it has been waiting for the standards that will define it to emerge from committee. Until recently, when draft curriculum frameworks emerged for review, most people in Delaware (including teachers) had no way of really comprehending what the vision for reform was in substantive terms. At the same time, the SSI has been working intensively with selected teachers in selected schools to implement—via the learning units called polished stones—a vision not yet defined. It is little wonder, then, that outside reviewers of the draft polished stones have questioned whether they are up to standard when they were developed with little knowledge of the standard to be met. The lesson seems to be that, at a minimum, the vision should be clearly articulated before implementation activities begin.

Other Reform Efforts. In Delaware, and probably in other states as well, New Directions is only one of several kinds of changes affecting schools and teachers. We have said at earlier points in this case study that many schools and educators in Delaware at least "talk the talk" of the Re:Learning network and Sizer's nine principles for restructuring schools. In our local visits, the rhetoric and processes associated with the Re:Learning movement were very prominent and commonly understood in a way that New Directions (and, by affiliation, Project 21) is not—at least not yet. The SSI instinctively sought to tap into this strong commitment by including a school culture change component as a companion to providing the NDDS schools with access to expertise in math and science content and pedagogy. There is a sense, though, that more could be learned from exploring how Sizer's vision of reform is so effectively communicated and why it is so appealing. How can restructuring, reculturing, and systemic reform be packaged together effectively for the scaling-up process? The answer to this question seems to be just outside the SSI's grasp but worth an extra effort to capture.

Other reforms or changes do not, of course, always involve out-of-state networks or activities. New Directions itself encompasses reform of language arts and social studies instruction as well as math and science. All Delaware teachers are about to be asked (or required) to reexamine how and what they teach across the board. For the elementary school teachers, who are primarily generalists rather than specialists, this is a massive undertaking. Further, districts may be adopting new materials that require training and a breaking-in period. In one elementary school, for example, the NDDS team was trying valiantly to keep math and science at least on the radar screen, but their colleagues were far more focused on becoming familiar with a new literature-based reading textbook. The principal of this school acknowledged that she views literacy for all students as the primary mission of her K-3 school. The main point, however, is that everything cannot be of equal importance at the same time. Reform of math and science is often in competition with many other priorities. Ultimately, districts and schools are likely to conduct some type of triage to make the change process seem manageable. In some places, math and science reform will not head the list.

The Role of NSF. Delaware views its cooperative agreement with NSF as a partnership in which both parties have rights and responsibilities and are committed to learning from each other. In this state, partnership has some very specific connotations, primarily involving discussion of issues and problems in order to reach a reasonable and consensual resolution. Generally speaking, the relationship has worked in the way that the state expected. NSF has been valued as one of several groups of "critical friends," that is, interested parties whose only concern is to help New Directions and the SSI improve. On one notable occasion, the state actually asked a representative of the federal agency to step in as arbitrator and facilitator to resolve an organizational issue, with very positive results. Indeed, Delaware thought highly enough of the partnership structure implied by the cooperative agreement with NSF to structure its own relationship with the NDDS schools in a similar way.

Receptiveness to constructive criticism is a very central ethos among Project 21 leadership and staff. They approached NSF's mid-point review process as an opportunity to conduct formative evaluation by taking stock of where they were and what they had accomplished. They looked forward to the comments of the NSF review panel, whom they viewed as "some of the best minds in American education." Feedback from outside reviewers and NSF staff to Delaware's mid-point review presentation in Washington was quite critical, and the state was asked to prepare for a site visit.

An overarching concern for the review panel was the lack of a strong and well-understood theoretical or philosophical underpinning around which the several SSI components could cohere. This observation, developed at some length in the written feedback to the state from NSF, seems to mirror our reflections about embarking on systemic reform without a clear vision firmly in place.

Other specific comments from the NSF review panel focused on the level of influence that the SSI has on the Curriculum Frameworks Commissions; the quality of the "polished stones" and the significance of their role in the overall reform process; confusion in the state over the true meaning of "constructivist teaching and learning"; and the need for stronger linkages to higher education, other NSF-funded projects in the state, and projects funded with Eisenhower money.

Delaware was able to clarify its rationale and strategies for reviewers during the site visit and was given the green light to proceed. When the mid-point review process had been completed, however, Project 21 leaders were disappointed with it as a learning experience and felt that it violated the spirit of partnership established in previous exchanges. They particularly objected to the limited opportunity to interact with the outside reviewers from whom they hoped to elicit responses that would help them improve their efforts. They also found the official written feedback to be unduly harsh, with no indicators that anything was proceeding well or an expectation that problem areas could be fixed. Since the comments inevitably had to be shared with higher levels of the education governance system, this created the potential for serious political problems for both New Directions and Project 21.

The reaction to the mid-point review in Delaware illustrates an essential ambiguity about the cooperative agreement as a strategy for funders. When the norms of interaction between funder and recipient are established early in the relationship, work has not yet begun and all things are possible. An equal partnership seems viable. As the funding cycle plays out, however, accountability becomes an increasing priority for the funder, changing the dynamic of the partnership. At mid-point, Delaware's SSI examined its work from the perspective of the glass being half full; NSF found the glass half empty. Whichever view one takes, it seems clear that the real start of systemic reform in Delaware began 12 to 18 months after the SSI award when the new state superintendent of schools arrived. In terms of its current reform agenda, Project 21's time frame is more like that of a Cohort 2 SSI state. Even viewed through that lens, the Delaware SSI has been hampered by the fact that a strong, coherent vision for math and science reform is only now beginning to emerge.

A CASE STUDY OF THE SYSTEMIC INITIATIVE FOR MONTANA MATHEMATICS AND SCIENCE (SIMMS)

Introduction: Montana and Its Education System

Montana is an enormous state in area, with a very small student population. As a result, the number of public school students per square mile is almost exactly one. In 1990, the state had an elementary and secondary enrollment of about 151,000, of whom 10% were members of minority groups, predominantly Native Americans. The state has 536 school districts (1992). Many, of course, have very small enrollments.

The state superintendent for public instruction, Nancy Keenan, and many others in Montana see their small population (about 800,000) as an asset despite the large area the state covers. With fewer students, things are "manageable," and there is a sense of community that includes the schools. The dropout rate is low. Nonetheless, the state is not immune to such national trends as the rapid increase in single-parent families. Social issues related to education (early childhood education, integrated services, improving outcomes for minority students, school-to-work transition) are therefore on the minds of policy-makers, as in many other states.

Nationally, Montana ranks near the top in terms of adult literacy (4th highest), high school graduation rate (94% in 1989, 4th highest), ACT scores (3rd highest), and ASVAB (Armed Services Vocational Aptitude Battery) scores (highest). However, one state leader has been quoted as saying that although Montana ranks high in national comparisons, "we are the leaders of a slow pack." In other words, the leadership is still committed to education improvement.

The school districts have a lot of independence. There are no curriculum frameworks, for example, although the Office of Public Instruction (OPI) has begun to develop frameworks for science and mathematics. However, new accreditation standards for schools, which are being phased in, are having some impact on districts throughout the state and may lead many of them to seek out new, high-quality curricula and assessments.

Two recent developments affecting education policy in Montana are the state's budget deficit and litigation that is requiring school finance equalization. In 1993, the state deficit was approximately $300 million—a large amount for a small-population state. Since about half of the average district budget comes from the state, many districts will be experiencing education budget cuts. At the same time, the state not long ago lost a suit relating to equal funding of education and has had to develop new funding plans. To date, it has proven difficult to find a way to produce equal funding while satisfying taxpayers, who objected to the first new method of funding that was proposed as a solution.

Good Practice in Mathematics and Science Education

The Statewide Systemic Initiative (SSI) is part of a larger set of developments affecting mathematics and science education within Montana. We begin this section by examining the vision of good practice in science and mathematics education independent of the SSI, and then describe how the SSI fits into this larger picture.

The State's Vision and Strategies for Change

During 1987 and 1988, the State Board of Public Education managed a project to define the kind of education desired in Montana for the year 2000. *Project Excellence: Designing Education for the Next Century* involved more than 2,500 people—a large number for a state this size—in an effort to establish standards for a high-quality education. The results were incorporated into a set of school accreditation standards published in 1989 and administered by the Office of Public Instruction.

The 900 or so schools in the state are required to meet these standards, which are viewed as minimums, and they also must assess and review their education programs. Districts are required to develop or adopt curricula that meet the accreditation standards. Similarly, the standards mandate districts to develop or adopt appropriate assessments.

According to education leaders in the state, the accreditation standards are creating a demand for high-quality curricula and assessments because schools and districts are hungry for suitable materials that will address the state mandates. In spite of some concerns within the state about the cost and the speed of implementation of the standards, no one really argued against the validity of having standards. Opposition was minimal.

The subject-matter portions of the standards are brief; mathematics and science together are less than a page long. Within these constraints, the language in the standards is certainly compatible with the NCTM *Curriculum and Evaluation Standards for School Mathematics* (1989) and the emerging science standards being developed by the National Research Council (1994). For example, the mathematics standards emphasize the importance of problem solving and the use of appropriate technology to solve mathematics problems, and state that "priorities for basic mathematical skills include more than computation" (Board of Public Education, 1992, p. 16). The science section of the standards emphasizes science as a process, not just a body of knowledge.

There was some opposition in the state to including more specific learner goals as part of the standards. As a result, although "model learner goals" were developed, they were placed in an appendix and do not have the same force of authority as the body of the text. The model learner goals for mathematics are 5 pages long and for science, 4 pages. Thus, they are more specific than the accreditation standards but far less detailed than national documents such as the NCTM *Standards* (250 pages).

The leadership within OPI and within the SSI are aware of the importance of making sure that the SSI's efforts to change science and mathematics education are compatible with the accreditation standards, and vice versa. One specific synergy that they have noted is that the SSI is helping to meet the demand for curricula and assessment created by the standards, especially in the area of high school mathematics.

The science education community in the state—including the Montana Science Advisory Council, the Montana Science Teachers Association, and OPI—decided that schools and districts would benefit from more specific assistance related to curriculum and assessment in science. Together, they worked to produce a *Toolkit for Science Curriculum Development* that was distributed by OPI throughout the state beginning in 1990. The toolkit consists of a series of short documents, attractively packaged, that emphasize curriculum as "something you do more than something you have," and it provides references and suggestions for what to do and how to do it.

The mathematics education community did not produce a document similar to the toolkit for science, but it was very actively engaged in developing the proposal for the SSI. Also, because the NCTM *Standards* had already been published, there was a great deal more consensus nationally about standards in mathematics education. There was perhaps less need, then, to develop a mathematics toolkit specifically for Montana. Indeed, membership in the Montana Council of Teachers of Mathematics (MCTM) has historically been very high (relative to what it could be, given the low state population), and mathematics educators in the state are an unusually active group. About half of all secondary mathematics teachers belong to the MCTM. An NSF-supported national project to produce a revised middle school mathematics curriculum (Six Through Eight

Mathematics, or STEM) was already planned (and is now under way), based at the University of Montana. STEM focuses especially on applications of mathematics.

More recently—within the past year—additional initiatives have begun within Montana to further develop the vision of K-16 science and mathematics education. These initiatives have been stimulated at least in part by the SSI, and the SSI is participating in them. First, a process has begun to develop a plan to reform all of K-16 science and mathematics education. A series of meetings have taken place, there has been a survey of the state leaders in mathematics and science education, and a statewide teleconference was held. Frameworks in both science and mathematics are being drafted (the latter is mostly done), based on a broad process of collaboration. The science director for the SSI, Bob Briggs, who is also a former state science supervisor for OPI, and the current mathematics and science supervisors are leading the process. Montana's NSF-sponsored collaborative for reforming teacher preparation (Systemic Teacher Excellence Preparation, or STEP) has also been involved. In addition, OPI, the SSI, and the Northwest Consortium for Mathematics and Science Teaching (sponsored by the U.S. Department of Education) held five town meetings in the fall of 1993 to promote reform in mathematics and science education. Additional meetings are planned for 1994-95.

The vision and written plan for K-16 mathematics and science education in Montana is still emerging from activities such as these. The vision cannot yet be described as definitive, except for high school mathematics, which will be more fully described below. The preliminary ideas that are being discussed are: integration of science and mathematics in grades K-5, an integrated science program in grades 6-10 (i.e., one in which multiple science subjects are taught each year, rather than the traditional "layer cake" curriculum), which will be connected with an integrated mathematics program for grades 6-12. In addition, teacher preparation will be redesigned to enable new teachers to do well in school systems emphasizing integrated teaching, and both state and district inservice professional development activities will be aligned to support the integrated approach to instruction.

The state has a mixed strategy for implementing its vision. First, the accreditation standards have some teeth in them. For example, a number of schools must add assistant principals to meet the state's requirements, and we visited one school that must build a new library to be accredited. However, in mathematics and science education it seems fair to say that persuasion, consensus building, and technical assistance are the most important strategies being used by the state to develop and implement its vision of good practice.

(In contrast, the state is **not** planning any special scrutiny of school or district test scores and has no rewards or sanctions associated with testing.) To some extent, the history of "local control" dictates that this relatively nondirective approach is necessary. For example, one high school principal—who is, in fact, very interested in reforms of mathematics and science education—expressed the view that "If someone came in and told me what my curriculum should be, I'd go to war!"

In this light, there seems little doubt that the state's small population makes a consensus-building process and extensive person-to-person networking attractive ways of promoting reform. Linked to this natural appeal is what appears to be a state in which the norms allow power and plaudits to be shared much more readily than in many states. It is not unusual to hear people crediting others, often in different agencies, for their good work. Also, individuals will give away power or authority to others. In one case last year, an effort was being made by people with a lot of power to "season" a newcomer in another institution by providing her with experience and responsibility that would later translate into greater authority—for the purpose of developing an ally and maintaining a balance of responsibility across agencies. In other cases, agreements have been made that certain people in the state, but not others, will apply for grants in a particular program, with an eye to balancing interests. As a result of this inclusive approach, the visions that get developed for good practice in mathematics and science education in Montana appear to have a greater chance of taking hold and being implemented than if they were dictated from on high.

This is notably the case for the SSI itself, which has focused most of its resources on reforming mathematics education in grades 9-12. To date, about 300 of Montana's 534 high school mathematics teachers have participated in summer institutes and academic-year continuing-education courses. Many of these teachers have also been writers of the new high school mathematics curriculum or pilot teachers providing feedback to the developers, or have helped lead inservice sessions, or have taken other active roles in promoting reform.

Cooperation and involvement is also a noteworthy aspect of the STEP project funded by the NSF Collaboratives for Excellence in Teacher Preparation (CETP) program, as one might expect from the program's title. There are only 9 4-year institutions of higher education in Montana, public or private, and only 10 2-year institutions (15 if vocational-technical centers are included), of which 7 are tribally controlled. This small number of institutions makes it feasible in Montana to be very inclusive in discussions of teacher preparation, and this seems to be the case for the STEP project, which directly involves a dozen institutions of higher education, a large proportion of the total number in the state.

None of this is to say that strong leadership is unimportant. Indeed, we heard many people credit someone who has since left the state as an unusually effective leader who greatly helped Montana win its SSI award, and many other examples of leadership could be cited. But this democratic, broad-based, consensus-building approach (which, like any other, has problems as well as virtues) does seem to be a hallmark of Montana's strategy for building a vision of good practice in science and mathematics education.

Montana's SSI: Systemic Initiative for Montana Mathematics and Science

Most of the resources and energy in Montana's SSI, which was awarded in 1991, have been directed at improving high school mathematics education. In this sense, the SSI mainly fills a particular niche in the state's larger vision, while at the same time it is highly compatible and coordinated with the state's overall plans for improving mathematics and science education. But this is not the whole story, because the SSI has many components (not only high school mathematics education) and because the SSI has evolved over time to be more comprehensive in its scope.

Montana's original SSI proposal focused only on reforming mathematics education. In the proposal, the authors stated that there was also a recognized need to reform science, but that the science education community was not as ready as the mathematics education community to undertake systemic change. The science education community in Montana would not necessarily have agreed with that statement, but from a national perspective (in which the mathematics standards were published 5 years before the science standards) it makes sense.

In any case, during the first year of operation of the SSI, NSF insisted that Montana incorporate science into the SSI project. Because the award is a cooperative agreement (not a grant), NSF has authority to be part of the decision-making team for the SSI. Montana agreed to include science, and the state has done so, hiring first Gerald Wheeler and then, when Wheeler left to join AAAS, Bob Briggs to head up the science portion of the SSI. The acronym for Montana's SSI was changed from SIMM to SIMMS as the name of the initiative became Systemic Initiative for Montana Mathematics *and Science*. Still, in light of the portion of SSI funds allocated to science each year (less than 10%), it is fair to say that the planning and implementation, and in fact the vision itself of what good practice will look like, are much better defined and farther along for mathematics education, especially at the secondary level, than for science education.

For high school mathematics, the vision is and has been very clear: integrated mathematics—meaning integration across mathematics topics, integration with many other disciplines (from art to science), and integration with technology. The revised curriculum, according to this vision, should be accessible as well as attractive to females and ethnic minorities—in particular, Native Americans, the state's largest minority group. Tracking should be minimized; for example, the first 2 years of the revised curriculum are to be a "core" that is taken by all students, regardless of previous achievement.

This vision for high school mathematics is compatible with and inspired by the NCTM *Standards*, although it is not the only possible interpretation or instantiation of them. SIMMS is *one* concrete plan for institutionalizing the *Standards* in Montana's high schools. (Note that some of the pilot sites are outside the state, too, and SIMMS is planning for national distribution of the finished materials.)

It is important to keep in mind what a dramatically different vision of high school mathematics education SIMMS is, as compared with prevailing national norms. Currently, only one state (New York) has a fully integrated high school mathematics curriculum, in which traditional courses such as algebra and geometry disappear so that mathematics is taught as a unified whole. Only college-bound students in New York use the integrated curriculum, which is therefore "tracked."

Thus, the implementation of integrated mathematics is itself unusual. But the SIMMS high school mathematics curriculum is considerably more novel than simply adopting an integrated approach to traditional subject matter. Quite a few topics not often treated in traditional high school mathematics courses are part of the SIMMS curriculum. In addition, the year-long courses, especially those for the first 2 years (which have been tested), emphasize the use of applications of mathematics to real-world situations, with many course modules being anchored to a particular application, such as growth rates in populations or purchase of a car. This is unlike most algebra and geometry courses in use now and in the past. Furthermore, the SIMMS curriculum encourages the use of very active methods of instruction— laboratory activities, if you will—and of cooperative groups as a method for students to engage in these activities. For mathematics, especially, this is a highly unusual departure from national norms. Mathematics teachers are not used to running labs.

In addition, the SIMMS curriculum incorporates alternative assessment techniques throughout the course, including some project work by students. Again, this practice is novel. But perhaps the most distinctive feature of the SIMMS curriculum is its heavy use of advanced technology, including graphing calculators (hand-held, programmable devices that can display small pictures or graphs on a built-in screen), powerful computers (either IBM-compatible or Macintosh machines), and a wide range of computer software, such as spreadsheets, geometry visualization programs, and symbolic manipulators. Since typical class sizes in Montana are small for high school mathematics (17.5, compared with a national average of 21.1), the student-to-computer ratio is small; SIMMS classrooms are expected to have no more than four students per computer and often have fewer. Each SIMMS classroom is also expected to have a full class set of graphing calculators.

The curriculum materials being written by SIMMS for students and teachers take advantage of the available technology; indeed, they require it. It is not possible to teach the curriculum effectively without access to graphing calculators and computer software.

Taken together, the variety of changes being made by SIMMS to the traditional high school mathematics curriculum is very dramatic. A 35-page monograph has been written just to explain the roots and philosophy behind this innovation.[21] One of the implications is that a great deal is being asked of teachers, who need to change content, instruction, assessment, class composition, and the tools they use all at once. In spite of the state's small population, this is not an easy or modest undertaking. It depends heavily on professional development for practicing teachers and, at a different level, on persuading legislators, parents, students, and others that the vision is worth supporting.

SIMMS is involving dozens of teachers in the process of writing the new curriculum materials, and developing and implementing the high school mathematics curriculum (including teacher professional development) is the heart of the SSI. However, SIMMS lists a total of nine components or goals for systemic change:

- Promote integration in science and mathematics education (a goal added after SIMM became SIMMS).

[21] The SIMMS Project Philosophy Statements (Monograph 1), January 1993.

- Redesign the 9-12 mathematics curriculum to use an integrated interdisciplinary approach for **all** students.
- Develop and publish curriculum and assessment materials for grades 9-16.
- Incorporate the use of technology in all facets and at all levels of mathematics education.
- Increase the participation of females and Native Americans in mathematics and science.
- Establish new certification and recertification standards for teachers.
- Redesign teacher preparation programs to use an integrated interdisciplinary approach.
- Develop an inservice program on integrated mathematics to prepare teachers of grades 9-16.
- Develop the support structure for legislative action, public information, and general education of the populace necessary for effective implementation of new programs.

We discuss implementation of SIMMS in the following section.

Implementation of the SSI

Development of the SSI and Its Governance

Montana was fortunate to have for many years a highly respected state mathematics supervisor, Dan Dolan. Dolan developed a reputation as someone who could effectively build bridges across institutions and agencies within the state. He was a prime mover in writing the proposal to NSF and was originally intended to be the lead principal investigator (PI) for the SSI award. For personal reasons, he moved to the East Coast before the proposal was approved and funded. Currently, Dolan, who is a member of the NCTM Board of Directors, remains active in SIMMS as chair of the national advisory committee. Johnny Lott, a professor at the University of Montana and one of the two PIs for SIMMS, chairs the editorial panel for *Arithmetic Teacher*, one of the major publications of NCTM. Maurice Burke, a professor at Montana State University and the other PI for SIMMS, is a former Rhodes Scholar. Both Lott and Burke are based in mathematics departments. Thus, the SIMMS leadership has unusually strong credentials in mathematics and mathematics education.

Indeed, the mathematics education community in Montana had been moving for some years toward implementing the NCTM standards, especially in the middle and high schools. The middle school curriculum materials project, STEM (which is still under way, but funded at a much lower level than SIMMS), has already been mentioned. In addition, other mathematics education projects (including some focusing especially on the role of technology) were funded in earlier years through NSF, state Eisenhower funds, and other sources, and these projects were often well coordinated with each other. One important project, supported by a 1988 grant from the Exxon Foundation, investigated the issues and implications related to implementing an integrated mathematics program. This project confirmed the support in Montana for moving to an integrated secondary mathematics program and also concluded that no suitable materials for implementing such a program yet existed.

Clearly, the Exxon project was a precursor of the SSI. Some individuals in Montana go so far as to say that the state would have implemented something like SIMMS even in the absence of SSI funds. (Of course, at best, progress probably would have been delayed for many years without those funds.) The important point has to do with the climate for change, which, especially in mathematics education, was very favorable.

However, the departure of Dan Dolan meant that the role of OPI in the SSI project changed significantly. OPI now is not represented by a principal investigator, and there is little question that its role in the SSI is therefore less prominent. However, the state superintendent is knowledgeable about and supportive of SIMMS, an associate superintendent has been actively involved with one of the committees (Government and Public Relations) that is part of the SSI governance structure, the former state science supervisor was hired to direct the science component of the SSI, and the current mathematics and science supervisors (Diana Oldham and Russ Hartford, respectively) are both involved in various ways. Both the SSI itself and OPI have thus accommodated well to the change in leadership/governance.

From the outset, the Montana Council of Teachers of Mathematics (MCTM) was to play a leading role in the SSI. MCTM was listed as the submitting organization in the SSI proposal, and the president of MCTM signed the cover page. Some NSF staff felt that they were taking a risk in making an award to a nongovernmental organization, whose address at that time was a post office box, but MCTM hired a full-time bookkeeper and put other mechanisms in place to assure accountability. On a day-to-day basis, Johnny Lott and Maurice Burke, PIs based in the two universities, direct SIMMS, but MCTM retains oversight responsibility. Its Board of Directors meets at least annually to review the progress of SIMMS, and all NSF SSI funds flow through it.

The office of the commissioner for higher education is also involved in governance of the SSI, in a variety of ways. For example, they were among those consulted when NSF decided to press Montana to include science education, they administer the higher education portion of the Eisenhower Mathematics and Science Education Program and help to ensure its alignment with the SSI, and they have a strong interest in reform of teacher preparation programs in institutions of higher education.

Six committees were formed to govern SIMMS: materials development, professional development, government and public relations, assessment, a steering committee, and the national advisory committee. An executive committee was also formed, consisting of the committee co-chairs, but steps have been taken to eliminate the executive committee in the interest of streamlining the governance arrangements. Also, because SIMMS is active in so many areas and the PIs felt there was some danger they would become overloaded, they decided to withdraw from chairing the materials development committee themselves. Other adjustments to the committee memberships have also been made as part of SIMMS' own "mid-course review."

The co-chairs of the government and public relations committee are Mignon Waterman, a state senator, and Larry Kaber, a teacher from Kalispell. Although Ms. Waterman does not lobby the legislature on behalf of SIMMS, she is an important link with them. Montana's legislature meets only every 2 years, but its support is needed in part because the state pledged matching money for the SSI, which comes from the legislature. The matching funds are used to conduct an annual competition for grants to school districts for the purpose of purchasing technology that can be used to implement the integrated high school mathematics curriculum. A variety of people, from several agencies and institutions, are involved in preparing the grants announcement and managing the review process.

The support of the governor has also been important to SIMMS, again in large part because of the need to raise matching funds from the legislature. Although in 1993 a new governor took office, both the current and the past governor have supported the SSI.

As noted earlier, the two PIs are based at the University of Montana and Montana State University. During preparation of the proposal, the universities were persuaded to treat the overhead charges on their portions of the budget in an unusual way. The funds they would normally receive in overhead are used instead to purchase computers and software for technology labs that are used in teacher preparation programs, not only on their own campuses but at other teacher preparation institutions, such as Western Montana College. Thus, although the university administrations are not formally part of the governance structure, they have nonetheless played a role in the SIMMS initiative, and the central administration at each of the universities is generally aware of various SIMMS activities.

Activities Supported by SSI Funds

SIMMS has supported nine components. The progress of these components is summarized in Exhibit 7.

Materials Development. By far the largest portion of the NSF funds has been used to support the development of the new curriculum and assessment materials for integrated high school mathematics. Between a quarter and a third of the funds have been used for this purpose directly, and other funds (such as those used to support various of the committees) support this component of SIMMS indirectly.

SIMMS is planning to develop six levels of the curriculum, each including a full year of material (see Exhibit 8). These are basically six textbooks and support materials, although they are packaged somewhat differently than typical texts. The idea is that all students would take Levels 1 and 2, typically in the 9th and 10th grades (although some begin in 8th and others in 10th grade), and then the majority of students would go on to take Level 4 and perhaps Level 6, which would complete their 3- or 4-year mathematics curriculum. Levels 3 and 5 are for students who require more time to make progress through the curriculum after Level 2 or who do not intend to become majors in science, mathematics, or engineering.

At this point, SIMMS has written Levels 1, 2, 3, and 4, and drafts of Levels 5 and 6. To provide a sense of what this undertaking entails, Level 1 includes 16 modules, as does each level, and the student version runs over 330 pages. Additional print materials are developed especially for the teachers. Assessment materials are incorporated into these materials and, in addition, an *Assessment Sourcebook* has been produced.

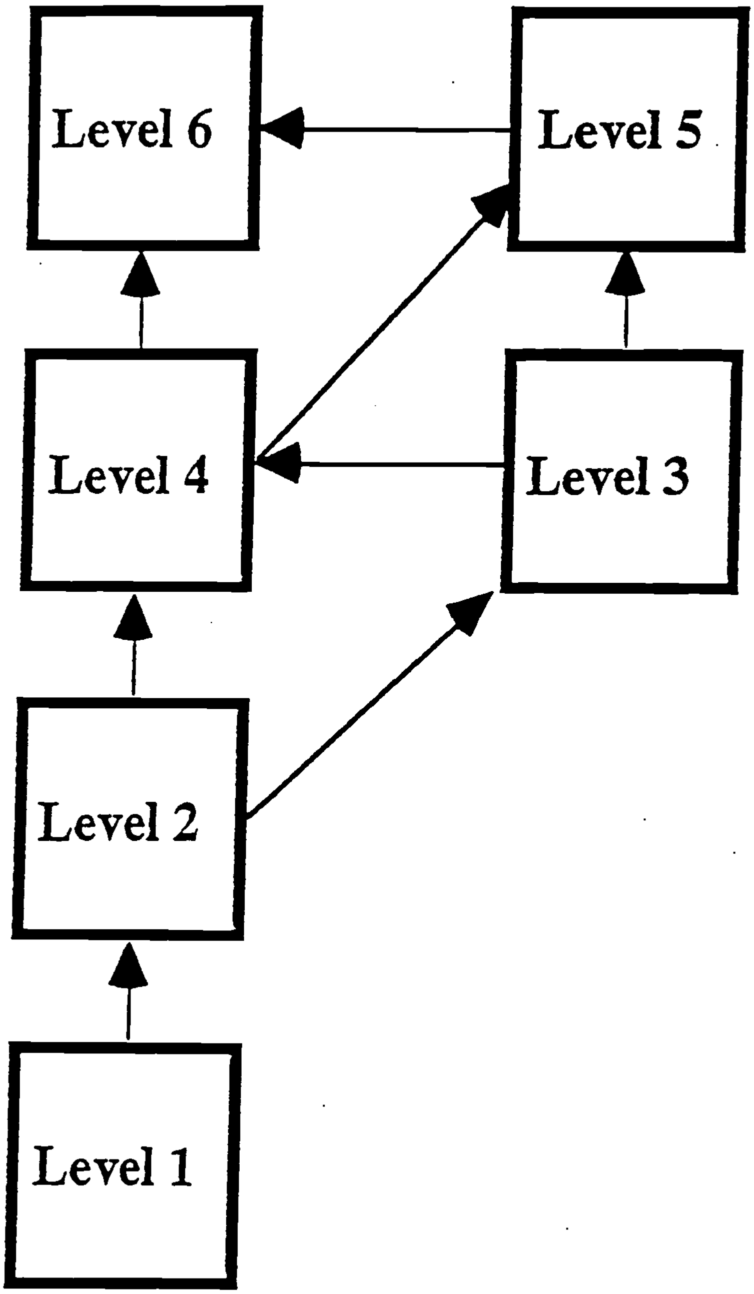
Many different authors are involved in producing the materials for each level. To date, about 70 high school mathematics teachers have been hired as writers, either for the summer or for a full academic year. They are the principal authors for the SIMMS modules, working in a carefully structured environment designed by the SIMMS leadership. During the summer of 1994, for example, nearly two dozen writers were in residence at each university, and every one, as a member of a three-person team, was given responsibility for helping to write two modules. Topics had already been established, and background materials were available for each topic when the writers arrived. Each writer also becomes involved in reviewing a number of modules written at the other campus, as do various other people. This procedure, involving many writers and reviewers for every module, is just the beginning, since testing with students, further revision, and professional editing will take place later. A fringe benefit for the writers is that the process is engaging and becomes a learning process in itself.

Exhibit 7

Progress of SIMMS Components

Component	Progress to Date
1. Design an integrated 9-12 mathematics curriculum.	A total of 96 modules, over 1,000 pages in all, drafted for grades 9-12.
2. Develop and publish curriculum and assessment materials for grades 9-16.	Levels 1 and 2 widely available and used in hundreds of classrooms. Assessment handbook 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 courses also are using technology.
4. Increase participation of females and Native Americans.	A number of steps have been taken to make math more appealing to these groups, but results are still inconclusive.
5. Establish new teacher certification and recertification standards.	New teacher certification standards have been adopted.
6. Redesign teacher preparation programs.	NSF Teacher Collaboratives award, STEP, is providing substantial assistance.
7. Inservice on integrated mathematics for teachers in 9-16.	Approximately half of the math teachers in grades 9-12 have been reached so far.
8. Support legislative action, public information, and outreach.	Legislature has provided millions for technology. An active public outreach effort is supported.
9. Promote integration in science and mathematics education.	Science component of SIMMS is on a much slower track. The integrated high school math curriculum includes some science, as does a middle school math curriculum supported by NSF.

SIMMS Course Sequence



Level 5 Content:
2/3 Level 4 Outcomes
1/2 Level 6 Outcomes

Level 3 Content:
2/3 Level 2 Outcomes
1/2 Level 4 Outcomes

THE SIMMS PROJECT

Level 1 was prepiloted in 1992-93; revised, largely during the following summer; and then pilot tested in 115 classes with 2,650 students during the 1993-94 school year. The great majority of the students were 9th-graders, representing more than 20% of the state's 9th-grade cohort.

The cycle of prepiloting and piloting allows two different opportunities for revisions based on actual experiences with students. A variety of information is collected at each of these two stages. The pilot test is the time during which evaluation data are collected for comparing SIMMS students and those enrolled in traditional mathematics classes.

The first draft of the Level 2 materials was completed during the summer of 1993 and prepiloted in 21 classes with 475 students during the 1993-94 school year. The revised Level 2 materials will be piloted with a larger group of students in 1994-95.

Levels 3 and 4 will be prepiloted during the 1994-95 school year; Levels 5 and 6 are scheduled to be drafted during the summer of 1994. Overall, SIMMS reports that it is on schedule in terms of producing the curriculum materials.

At an early stage, SIMMS was able to persuade institutions of higher education in the state to accept completion of Level 4 of the new curriculum as satisfying the requirements for entrance. This was accomplished with the cooperation of the office of the commissioner on higher education. Without this assurance, it would be extremely difficult to pilot test the materials with large numbers of students.

A professional editor was hired in 1993 to help with the development and publishing process. Half of his salary was paid by Addison-Wesley, which intended to publish the finished curriculum. However, Addison-Wesley withdrew from the project, also during 1993. A different publisher offered to publish the materials, but SIMMS and the MCTM Board of Directors decided that publication would be premature; thus, for the moment there is no publisher associated with SIMMS. The most immediate and direct impact that the absence of a publisher has on the project is that responsibility for producing thousands of volumes for use by students and teachers during the trials falls on the project staff. This was one role that Addison-Wesley played before it withdrew. The PIs believe it is very likely the materials will be commercially published and distributed nationally later. (For a sample of what the materials are like, see Exhibit 9.)

Incorporating the Use of Technology. To support the use of technology at all levels of mathematics education, SIMMS has been able to secure agreements with Texas

Instruments, Microsoft, Wolfram Research, and Key Curriculum Press for use of their equipment and software. The software is used at both the high school and postsecondary levels. The SIMMS Mathematics Computer Facilities were completed at the University of Montana, Montana State University, and Western Montana College. Comparable facilities for use in preparing science teachers are just being completed at both universities.

By the end of the 1993-94 school year, more than 100 schools had received state technology grants, representing about 55% of the high schools in the state. Some of the schools have received 2 years of funding, and others only 1 year. Most of the schools that received technology grants are implementing the SIMMS curriculum, but not all of them. Among the latter, some (but not all) have firm plans to do so in the next academic year.

The investment in technology that is necessary to implement the SIMMS high school mathematics curriculum is substantial, on the order of $10,000 to $30,000 per classroom (depending on class size, the need for new furniture, and other factors). At one school we visited, nearly $100,000 had been invested for powerful computers networked together, a wide range of software, and multiple class sets of graphing calculators. (The latter are very affordable now, costing about $75, and many students own one. MCTM distributes calculators at discounted prices, which makes them more affordable in the schools.)

A total of $2 million in state funds were used for the technology grants. This represents $1 million less than what had been expected, but the state legislature was faced with a large deficit at the time that the second million was appropriated. Even to obtain the second $1-million increment, it was necessary for the SIMMS leadership to lobby hard, despite the fact that the previous governor had proposed adding $2 million for technology grants to school districts over the next 2 years. These funds will come from timber sales, within a previously agreed-on overall limit on logging, not tax receipts. In light of the difficult budget environment, the SIMMS leadership considered the outcome largely a success rather than a setback.

Professional Development. Another significant budget activity has been using the NSF funds to support professional development activities for high school mathematics teachers. About 150 Montana teachers have participated in summer institutes focused on the new curriculum materials and associated instructional approaches. The summer institutes that took place in 1992 and 1993 were 6 weeks long. Although two of the three 1994 summer institutes were shorter (3 weeks), members of the SIMMS staff (e.g., Glenn Allinger at Montana State University and Michael Lundin at the University of Montana,

Exhibit 9: A Sample of the SIMMS Materials

This is the culminating assessment for the *Skeeters* unit, which is about growth in populations. The main mathematics concepts taught concern exponents and exponential growth, using a variety of techniques and formats to describe and analyze problems. Note that both graphing calculators and computer spreadsheets (which make it easy to compile tables and graph the results) are typically available to students as they answer these questions.

Module Assessment

1. Write an equation of the form $y = a \bullet b^x$ to describe the pattern in the following data.

Generation Number	Total Population
0	3
1	6
2	12
3	24
4	48
5	96

2. Discover a pattern and then fill in the missing number:

   1.5, 3.45, 7.935, 18.2505, ____________.

3. **a.** Express $3 \cdot 3 \cdot 3 \cdot 3$ using exponential notation.

   b. Write 4^3 as a product.

   c. Explain the meaning of x^5.

   d. Explain the meaning of 5^x.

   e. Write a rule that describes how exponents are used in this problem.

4. There are 30 deer in the Whitetail Wildlife Refuge. Each year the population changes by a factor of 1.3.

   a. Make a table showing total population for each of the next 10 years.

   b. Draw a scatterplot of the data.

   c. Write a mathematical equation that describes the growth of the population.

   d. Using a graphing calculator, predict the deer population in 20 years.

   e. Describe the shape of the graph.

5. The pocket gophers in Prairie County have a population density of 215 per square mile. The population is growing at a rate of 4% every five years. If no gophers leave the county, predict what the population density will be in 20 years.

6. *Boink!* You have wandered too close to a time machine and been transported to the year 2050. Describe this future world, particularly the size of the human population. Has the Earth's population increased or decreased? Explain what may have happened. Support your answers with evidence from the future world.

who jointly head the professional development committee) are aware that the changes being promoted by the new curriculum require a lot from many teachers and that a considerable amount of time is needed for professional development. Hundreds of teachers also enrolled in 10-week, 3-hours-per-week, continuing-education courses that were scheduled during the academic year. These courses were offered in both 1992-93 and 1993-94, at multiple sites each year. SIMMS expects that any teacher involved in either prepilot or pilot teaching will have had substantial professional development as preparation. Informal follow-up activities (e.g., "pizza bashes") have been held with teachers who participated in earlier formal professional development activities; in addition, high schools are being encouraged to develop their own summer professional development activities in mathematics.

Public and Professional Outreach. A variety of shorter workshops were also provided for teachers and administrators, focusing on the high school mathematics curriculum. Over 2 years, thousands of people have been involved, including dozens of mathematics department chairs, principals, and other school administrators. Some of these workshops are brief, but others last for several days. A few have focused on special topics, such as technology, assessment, and efforts to reform the teaching of calculus (a movement that is probably more active in postsecondary institutions than in high schools, but that ties closely to the types of changes SIMMS and NCTM are promoting).

Presentations about SIMMS have been made in a great many different forums, including to the Board of Public Education. To support public outreach, a speaker's packet was developed. This packet has been distributed to all SIMMS teachers and includes blackline masters for transparencies that can be used in public presentations. An additional handbook for administrators, counselors, and other educators has also been distributed widely, as have miscellaneous brochures, bookmarks, larger displays, and a videotape. Another videotape focusing on the use of SIMMS materials by Native American students was also produced. A newsletter, *SIMMS Update*, is distributed quarterly. Professional assistance in public relations has been retained by the SIMMS staff.

Focus on Underrepresented Students. Considerable attention has been given to special-needs students. For example, more than 120 teachers participated in workshops aimed at using SIMMS with Chapter 1 and special education students. Funds for this effort came from the Eisenhower program. In addition, 10 schools with Native American enrollments of 45% or more are participating in the SIMMS initiative, and for three summers Native American students have used the curriculum materials as part of other projects, such as Upward Bound. Some time was spent by SIMMS writers at a reservation school to gather information to meet the needs of Native American students.

Promoting K-16 Reform of Science and Mathematics Education. In an earlier section, a description was provided of how OPI—together with SIMMS and other organizations—is planning for comprehensive reform of science and mathematics education. These efforts build on earlier ones, including annual meetings held each fall, even before the SSI was funded, involving the Montana Science Advisory Committee and a Montana group known as Teachers of Teachers of Mathematics (TOTOM). In addition, special attention has been given in recent years to teacher preparation programs and teacher certification in mathematics.

Teacher Preparation. SIMMS has been actively engaged in modifying teacher preparation, notably at the University of Montana and Montana State University, where the PIs are located, but in other institutions, as well. New undergraduate courses are being developed for prospective teachers, and technology labs have been put in place that provide opportunities for students to use high-quality software. Mathematics content and methods courses are being modified to incorporate use of technology, partly because of SIMMS and partly because this is a reform beginning to be implemented in many institutions of higher education. An interdisciplinary core course is being developed for prospective teachers, and a course on mathematical modeling is also under development, with the goal that both will be in place by the end of the 1994-95 academic year. Also, SIMMS staff put on three workshops for teachers of mathematics methods courses statewide.

The new CETP award in Montana, STEP, is nearly as large as the SSI award and will be extremely important in revising teacher preparation in the state. Some of the activities listed above have been conducted in coordination with STEP; in addition, there is some overlap in staffing between SIMMS and STEP.

STEP will be paying special attention to the preparation of Native American teachers. Currently, only about 4 of the more than 500 secondary mathematics teachers in the state are Native Americans. If the SIMMS curriculum materials are successful with Native American high school students, this could help in developing future mathematics teachers.

Many people consider managing change in institutions of higher education in Montana to be more difficult than changing K-12 education. The Commission on Higher Education, although interested in reform, has limited powers. Even many professors supportive of change admit that too little has been done to date to reform undergraduate instruction. One dean spoke hopefully of a "trickle-up" influence, meaning that students who use the SIMMS high school materials will come to college demanding instruction that looks more like what they experienced in high school. He looks for results by 2005 or 2010. Clearly, the STEP award is intended to provide a big boost to teacher preparation reform efforts in Montana, aiming at both science and mathematics.

Teacher Certification and Recertification. Montana is in the process of revising certification standards for mathematics teachers. The state committee drafting the revised standards included co-chairs of two SIMMS committees and also others involved in SIMMS. In April 1994, the revised standards were submitted to the State Board of Public Education, which adopted them in September. The revised standards are well aligned with the changes being promoted by SIMMS.

The science education leaders in the state decided not to promote any revisions to certification requirements at this time. Another opportunity for review and revision will arise in 5 years. If any revision does take place, it will need to recognize the importance in rural states of teachers with broad-field certification in science—that is, teachers who are prepared to teach a wide variety of science disciplines.

Preliminary Impacts of the SSI

This case study is being written about halfway through Montana's 5-year SSI award. It is clearly too early to say what the ultimate impact of SIMMS will be in Montana. But it is not too soon to examine some of the preliminary impacts, as well as to reflect on how well the SSI fits into overall state education reform efforts.

The Impact of the SSI Activities to Date

Awareness of SIMMS. Awareness of SIMMS in Montana is high, particularly within the mathematics education community. SIMMS figures show that more than half of the high school mathematics teachers in the state have applied to participate in professional development activities, and most of them have received professional development in one form or another. A leader in OPI said, "I have yet to meet a math teacher in the state that doesn't know about SIMMS.... MCTM spreads the word very effectively." SIMMS is also known in the state legislature, the governor's office, the State Board of Public Education, and the universities, and there has been substantial coverage by the news media. Many businesses, such as Montana Power, are familiar with SIMMS, and the science and mathematics coalitions (which include business representatives) have helped pay for some materials used for outreach. Creating this level of awareness is an important accomplishment, particularly considering that the associations people make with SIMMS appear to be largely positive. Of course, awareness is not universal, and we were told that many Parent-Teacher-Student Associations (PTSAs) in the state would not know about SIMMS, if asked.

It is clear, of course, that awareness of reform activities under way involves mostly the integrated high school mathematics curriculum. It is also likely that awareness of reform activities for teacher preparation in both mathematics and science education is growing quickly, at least within institutions of higher education, because of both SIMMS and the CETP-funded program, STEP. But there is far less awareness, as yet, of reform in mathematics at the elementary or middle school level, or in science education at any level, since SIMMS has been much less active in these domains.

Use of the High School Mathematics Materials. The progress and penetration of the integrated high school mathematics curriculum after about 2-1/2 years is substantial. The fact that so much text material has been written and revised in this time and that about one-fifth of all 9th-graders are using the materials seems impressive. NSF's external review of the materials, and the additional reviews SIMMS has requested from engineering schools, are a quality assurance mechanism, and the materials are receiving good grades.

Obviously, a great many teachers are using the materials, often with enthusiasm. (See the related examples in Exhibit 10, which are drawn from observations made as part of this evaluation effort.) When SRI site visitors interviewed teachers, one said, "Proofs are over the head of most kids. This approach is much better. I like the visualization [on the computer]." Another said, "SIMMS has opened up so much for so many teachers, and especially so in small schools." Given the fact that adoption of SIMMS to date has been done largely on a volunteer basis, the involvement of so many Montana teachers speaks highly about the degree of interest and enthusiasm present.

At the local level, involvement in SIMMS is typically something of a patchwork, with certain schools in a district (but not others) using the materials and, within a school,

Exhibit 10: SIMMS in the Classroom

Michael's class: Michael begins by asking the students to look at four graphs showing growth and shrinkage of populations over time and then write a "story" about each of them. What does the graph "say," in plain English? The stories may add color, for example, by giving reasons why the populations grew or shrank, or they may be very dry. The emphasis is on making sense of mathematics. Later, students are asked to make up rules for the life and death of two populations represented by two types of candies shaken in a box. They are already familiar with typical rules, so they make up variations relating to proximity of the candies, for example. Using their rules, they set the populations going for about six life-cycles, or six shakes of the box, recording their data in a computer spreadsheet and producing on the computer a graph of the two populations over time. The students work in groups.

Debbie's class: Debbie is giving her SIMMS Level 1 class a "module assessment" for the *Skeeters* module, which is about exponential growth of populations. The students may work in groups, but they hand in individual papers. Most finish during class, but students are allowed to come at lunch time to finish, if they want.

Students make use of the computers easily and naturally to work on the assessment. Some go and pick up one of the graphing calculators to help with certain questions. Debbie spends most of the class time making herself available for questions from students and provides hints when asked for help.

Almost all students are engaged in the classwork, although there is some chatter among students, not wholly math related. That this is not an easy class to manage is indicated by remarks that Debbie makes, such as "Some of you are on your third tardy; you're already on detention time." "Some of you blew off the work last time; that'll hurt [your grade] big time." A resource room (special education) teacher is available to help during the class. She comes for certain SIMMS modules to Debbie's class to provide help to any student who asks, not just special education students. The resource room and regular teachers developed this strategy because the resource teacher was unable to help the SIMMS students very well without being more grounded in what the nature of the class really is; homework for SIMMS is not like homework for a typical math class.

Rob's class: There are 16 students present in Rob's class. The room has six hexagon-shaped tables, each with a Macintosh computer on it. The students have used the computers to understand population growth. Rob is in front of the class leading a class discussion about the AIDS epidemic. Students had plotted data and were discussing whether the growth appeared "truly exponential." Most of the students said, "not truly." Rob began asking why they thought so. In his discussion, Rob also brought in information about how the government uses data like these to make policy decisions. He also talked about the Centers for Disease Control and how people can get updated data from them, and that he has done so and will share it with them when it comes so they can see whether the data are following the predictions they have made from their model. He reminds the students to question their conclusions and their assumptions. Rob is very good at getting students to think on their own and to answer their own questions.

only certain teachers using them, and sometimes only with selected classes. This situation should not be surprising, for many reasons, including the fact that only Levels 1 and 2 have been available, so that no school could yet use **only** SIMMS mathematics even if that was what they wanted (although some schools have committed to phasing out the traditional mathematics curriculum). Nonetheless, this situation is the one that the SIMMS leadership must understand and work with in order to scale up to include more teachers and students. (Scaling up is discussed further in the section, "Reflections about the SSI in Montana.")

Most teachers using SIMMS must be satisfied with it, or there would be a much higher rate of dropping out and a far lower rate of growth in the numbers of students using the materials. At the same time, this does not mean that teachers find it easy to master so many changes in curriculum, instruction, and assessment at once, or that all schools or teachers implement SIMMS in ways that the developers would consider ideal. Many teachers, even those who enjoy the challenge of change, find it hard to master all the new elements. For example, a number of teachers commented on the unfamiliarity of setting up activities using small, cooperative learning groups. One high school mathematics department chairman said, "That's hard for many students, and for me; maybe 1 of the 10 sessions in the SIMMS inservice course should be on cooperative learning." At a large urban school, the SIMMS materials to date have been used exclusively for lower-track students, which was not what was intended. Students logging on to networked computers sometimes experience network problems and must move to other terminals, slowing down the flow of classroom activity and frustrating teachers. The common point is that the road to reform is bumpy, and we should probably not expect otherwise.

Impacts on Students. At the level of the students—the most important level, really—there is evidence that the integrated high school mathematics curriculum is having some of its desired effects. During 1992-93, SIMMS administered two measures, the PSAT (1987 version) and a specially designed, four-question (open-ended) instrument, to SIMMS and non-SIMMS students in the districts in which Level 1 SIMMS materials were prepiloted. Results of a one-way ANOVA of scaled scores on the PSAT mathematics segment showed that there were no significant differences between the SIMMS and non-SIMMS students. This result led SIMMS to conclude that students learning by using SIMMS materials in nontraditional classroom environments and students learning mathematics in traditional settings by using traditional materials score similarly on a traditional mathematics test. Calculators and computers were not allowed on the PSAT, although these are tools that SIMMS students use regularly.

The four-task instrument was designed by the SIMMS project to evaluate students' progress toward SIMMS classroom goals. All students were given two tasks, and eight other tasks were rotated among students. Students worked on these questions independently, although group work is generally encouraged in SIMMS classes. Individual student responses were averaged to obtain the overall class performance representative of class units. A major finding was that SIMMS class units scored significantly higher than non-SIMMS class units on six tasks. Although there was no significant difference in the numeric scoring on Task 1, SIMMS students generally tended to use a greater variety of problem-solving strategies and they tended to attempt difficult tasks more often than non-SIMMS students.

During 1992-93, the SIMMS project staff also examined students' attitudes toward mathematics in four specific areas. Only one was found to have statistical differences between SIMMS and non-SIMMS classes, with the SIMMS students showing as becoming a bit more "mathematically confident." Later, the assessment committee developed a new "Attitudes and Beliefs" questionnaire, which was administered as a pretest to students in the fall and a posttest in the spring during the 1993-94 school year. (Analyses of these data have not yet been completed and reported.)

A new series of open-ended tasks was prepared for the 1993-94 end-of-year survey. The PSAT was to be administered again, this time to both Levels 1 and 2 students.

Preliminary program assessment indicates that the SIMMS curriculum is reaching the traditionally low-ability students and getting them excited about math. Some teachers told us that this intended 9th-grade course was being taken by sophomores, juniors, and seniors who had not successfully completed Algebra 1 or who had even failed pre-algebra but needed mathematics for their graduation requirements. Although many of the students were finding the amount and level of reading very challenging, they were still meeting with success in learning the mathematics. A number of teachers felt that some of the traditionally lower-achieving students who had experience with SIMMS were talking about taking more than the amount of mathematics required for graduation. A district superintendent said, "Our kids are inactive learners, so we are losing them." She felt that the more active, laboratory approach used by SIMMS was a welcome change, saying, "Kids have more 'ownership' in their learning that way."

Resistance. Not all districts, principals, or teachers enthusiastically embrace the new approach to high school mathematics. A few districts considered participating in the trials and then decided not to do so. Support for reform is not universal.

The degree of change represented by the SIMMS materials is very substantial, so it is not surprising that some local school boards, some principals, and some teachers either take a wait-and-see attitude or are simply in favor of traditional curricula. One teacher near retirement who has taken time to learn about SIMMS said, "Changing my teaching style would be hard. It used to be that you could look at the first page of a lesson or chapter and you'd know what to teach. Now, it's a lot more complicated." This teacher, who teaches 90% of the mathematics classes in a small school, has not adopted the SIMMS materials and may never do so. Clearly, there are others like him.

A principal in one of the many Montana high schools where the materials are being tried out said, "Usually here we adopt a model that's been proven elsewhere; SIMMS is unusual in that we're the ones to test it." But other principals and teachers prefer the wait-and-see approach. Within the same school, some teachers may be enthusiastic users of SIMMS, while others remain on the fence or even opposed.

As one teacher said, "Let's give kids a choice; we can teach SIMMS **and** the traditional curricula." But for most Montana schools, many of which are small, that is not a realistic option because it would multiply the number of mathematics sections (including teacher preparations) and reduce class sizes to unacceptably low levels. In many schools, therefore, a teacher with such an attitude might simply choose not to use SIMMS and instead continue using the curricula that he or she is familiar with.

People may resist SIMMS from the point of view of philosophy, practical considerations, or simply because it is new. One of the practical concerns is obtaining, maintaining, and mastering the graphing calculators and computers. The state technology money has made an enormous difference, making it possible to implement SIMMS where it would otherwise have been impossible, but there are still practical considerations of cost. For example, in one school we visited, a teacher had persuaded the principal to allow him to have one less study hall to monitor and, instead, use the time to maintain the computers and software. This was probably a smart move—but it has a real cost, too, especially in larger schools than this one, where more time may be required.

Tracking. The success of the SIMMS materials with many students who would normally be expected to be low achievers is an important accomplishment, but it is also a two-edged sword. There are some questions in the state about how well SIMMS materials will serve the better mathematics students. There are concerns that SIMMS could become the track for lower-achieving students, with some of the schools that are fully committed to Levels 1 and 2 questioning whether they will fully commit to Level 4 and especially to Level 6. What options will be available for honors and advanced-placement (AP) courses? Will the upper levels of SIMMS (Levels 4 and 6) be more challenging than the lower levels? One teacher whose school is fully committed to Levels 1 and 2 indicated that he has not seen the Level 4 modules, and, since his school has always done well with the students in higher-level mathematics courses, he is not sure he will support fully implementing additional levels at his school. (As indicated above, full implementation will usually mean that SIMMS replaces all courses at that grade level.)

A number of school principals and school superintendents expressed similar concerns, such as a district superintendent who said, "For some kids, AP [Advanced Placement] in America is the way to be. We need to provide for them, too." A high school principal said, "A lot of our kids go to colleges out of state, so I want to be sure they will accept Integrated Math 1 and the rest. Hopefully, universities will accept it over time."

It is not fair to expect SIMMS to have fully "solved" this problem at this stage. But preliminary impact data show that this is an emerging area of concern that bears watching carefully. Many different approaches remain possible. For example, the majority of teachers using SIMMS find that students cannot complete all the modules available at any given level. (Knowing this, the SIMMS staff provide advice to teachers on which few modules can be skipped with the least impact on successful completion of modules in subsequent years.) Some teachers are exploring the possibility of an Honors option that might require completion of all modules, or extra projects of some type, for students who choose this option. Exactly how this might work in practice is as yet undetermined.

The problem is one that extends beyond Montana. High schools nationwide will need help from colleges and universities to change the mathematics curriculum for college-bound students. The more it is possible to say, "this approach is fully consistent with what colleges and universities are doing and what they expect of high school students," the greater the chance that significant reforms will take hold in large numbers of schools.

Preservice Teacher Preparation. SIMMS is well integrated into both of the universities at which the PIs are located, and the commitment to change both undergraduate education generally, and teacher preparation specifically, extends beyond the individuals on the SIMMS staff. Some changes have taken place—technology labs have been put in place using the universities' funds, for example—and the momentum for change is growing as the STEP initiative gets under way. Independent of SIMMS, graphing calculators were being introduced in some mathematics sections. Nonetheless, change is likely to come slowly.

The sheer size at major universities of a service department like mathematical sciences is a barrier to change. At the University of Montana, there are nearly 60 people teaching mathematics, including the teaching assistants and part-time faculty. Far more is required than the efforts of a handful of faculty, and laboratory facilities must be very extensive to serve the numbers of students enrolled even in lower-division courses. The financial pinch affecting many universities nationwide, including those in Montana, is another barrier. However, the University of Montana was fortunate in obtaining a private $1 million gift that will be used to set up a technology center in the College of Education, and this will be used for preservice preparation of all teachers, including those specializing in science and mathematics.

A seminar was offered to undergraduate and graduate students at the University of Montana in 1993-94 focusing on SIMMS itself and on underlying changes in mathematics education related to SIMMS. A diverse group of about a dozen students enrolled, including some experienced teachers back at school for graduate work. In thinking about the emerging vision of mathematics education (which emphasizes integrated mathematics, applications, technology, group learning, and so forth), one student in the seminar said, "The only course I've had that gets into that approach is this one." Other students could point to a handful of additional courses with somewhat similar philosophies or methods, but the majority of courses still appear to be in the traditional mold.

The infusion of funds from the STEP award, the meetings that are being held statewide focusing on teacher preparation, and the development of new courses, such as mathematical modeling, will help to speed the process of change. In a few years, an accelerated pace of change may be much more apparent.

How the SSI Fits into Overall State Education Reform Efforts

As previously indicated, the efforts of SIMMS fit well with a number of ongoing reform efforts in Montana, notably the recent school accreditation standards. In this section, we discuss the fit between SIMMS and various other initiatives.

Technology. Montana has had an education technology initiative under way for some time, and SIMMS has made use of this to the extent possible. Montana supports an electronic mail network for education called METNET, and SIMMS staff used this as one means of supporting teachers using SIMMS. The results were mixed—the network is as yet not quite good enough to be of maximum utility—but certainly the directions of the two reforms are compatible. The likelihood of rapid progress nationally in developing the Internet for educational applications is encouraging for SIMMS, and the state hopes to take advantage of this possibility.

The budget situation in the state, however, is a factor that is somewhat discouraging not only for reform generally, but for technology in particular. One area that we visited had twice voted down bond issues to be used for educational technology. A parent in the area commented that "calculators are a hard sell for many parents." Many parents still believe that the use of calculators erodes basic skills (although most research shows that this is not true). The person we spoke with believed it would be useful for students to show parents how the graphing calculators and computers are actually used in SIMMS classes.

Mathematics versus Science. The fit between SIMMS and other reform efforts is clearly best in high school mathematics, the area into which SIMMS has put the most effort. Part of the reason is the long history of mathematics education reform that stretches back to 1980 and NCTM's *Agenda for Action*, if not earlier. There is simply much more consensus about what to do in mathematics education than in science education. SIMMS has selected a somewhat unusual target—not only are elementary and middle school mathematics reforms much more common than high school reforms, but in addition, no other state has emphasized the integration of technology to this extent. Especially for this reason, it is probably the high degree of consensus surrounding the goals for mathematics education that allows SIMMS to be as successful as it has been.

By contrast, in science we were told on an early visit that Montana's science education community "is more interested in professional development than in curriculum." One reason could be that there simply are few available blueprints for a reformed curriculum, especially one that integrates different science disciplines each year. If Montana were to create an integrated science curriculum comparable to the integrated mathematics curriculum, and win comparable support for it statewide, in some respects it would be an even greater achievement than doing so for mathematics. Of course, in the absence of advance evidence of consensus, such an effort might well be viewed as a much more risky venture.

Small Schools. In the many small, rural schools that exist in states like Montana, teachers need to teach a variety of courses. In contrast to the situation in a large urban school, teachers in small schools cannot usually specialize and teach, for example, only freshmen. Sometimes, one teacher teaches all the high school mathematics courses. Often, a teacher will teach both mathematics and science courses. SIMMS presents a certain problem for these schools, as noted before, in that they cannot maintain both an "old" and a "new" curriculum. They are likely either to adopt SIMMS entirely at a given level or not at all. But at the same time, integrated mathematics enjoys a real advantage in these schools precisely because teachers are already familiar with a wide array of subject matter. At this point, it appears that the positive fit between SIMMS and small schools outweighs the negatives. This is a reform that is largely compatible with the culture of these schools. (However, some of the school boards in rural areas are apt to be especially conservative and thus opposed to using a novel approach to mathematics education, which is another factor influencing adoption of SIMMS. But at least this is a factor that may change over time, as SIMMS becomes more familiar and accepted statewide.)

Other Federal Funds. Several federal categorical programs are especially important to states' efforts to reform mathematics and science education. One of the most important is the Eisenhower Mathematics and Science Education Program administered by the U.S. Department of Education. SIMMS is making use of the Eisenhower funds, as has already been noted. Nearly all of the higher education portion of the Eisenhower funds are used to support SIMMS' goals, which is a priority that has been set at the state level (the Commission on Higher Education administers the funds). However, a much smaller portion of the district Eisenhower funds (allocated to districts by OPI) is used directly to support SIMMS. This small contribution is understandable, given that only a small proportion of all mathematics and science teachers in the state (including teachers in the elementary grades) currently are engaged with SIMMS directly. Over time, as SIMMS expands its activities (e.g., becoming more active in science education), this situation may change.

Reflections about the SSI in Montana

How Systemic Is SIMMS?

Montana was awarded its SSI during the first competition that NSF ran under the program. At that time, states were not required to include both mathematics and science, nor to focus on all grade levels. Even after NSF insisted that Montana add science, the predominant focus of SIMMS remained the integrated high school mathematics curriculum. In one sense of the term "systemic," this means that SIMMS is not focusing equally on the entire state system for mathematics and science education, and some people may find this not sufficiently "systemic" and thus objectionable.

The fact remains, however, that few SSI states have been able to focus equal attention on all grade levels and subjects (see Shields, Corcoran, and Zucker, 1994). The extent to which Montana focuses on both a single discipline and a single grade range may be unusual, but the fact of focusing on less than the whole certainly is not.

Another way of thinking about what it means to be "systemic" is to review the conceptual framework that underlies NSF's original SSI program solicitation. This framework (in a simplified form developed by members of the national evaluation research team) is shown in Figure 1 (see page 4 in the Introduction). According to the framework, systemic reform involves setting ambitious goals for all students and then supporting them through a variety of leadership activities, as well as through state and local policies. It means mobilizing public opinion in support of the goals set for students and creating a climate for change in districts and schools, including preparing teachers to use new curricula, new methods of instruction, and new assessment tools. The end result of systemic reform is intended to be changes in students' achievement and dispositions.

Using this way of thinking about what is systemic, SIMMS appears to include nearly all elements of systemic reform that NSF set out in its solicitation. To review a few elements present in SIMMS: the ambitious goals for all high school students include becoming familiar with a wider range of mathematics applications than ever before and being able to use technology to solve mathematics problems; the state has changed its policies for entrance to college so that the SIMMS high school mathematics curricula are acceptable, and it is in the process of reforming preservice and inservice teacher professional development so they are more compatible with the goals set for students; and extensive efforts have been made to mobilize public and professional opinion in support of the new goals.

SIMMS, from this point of view, is clearly a systemic initiative. But the states implement systemic reform in unique ways, and they are likely to emphasize specific components of systemic reform to different degrees. One element that some people might say is missing in Montana is state-mandated testing of students. Montana does have a requirement that districts annually test students in grades 3, 8, and 11. However, the districts choose from any of six state-approved standardized, commercially available tests. The belief is that the test should, as best it can, reflect the local curriculum. The state wants assessment to be used to inform reform efforts and to reflect what is happening in the district, but the state does not make or publish any comparisons among schools or districts. In fact, some key education leaders in the state are simply not big believers in standardized tests. Possibly, the accreditation standards will push districts to adopt more "authentic" assessments, and in this regard SIMMS, as part of its overall plan, is developing assessment instruments consistent with its vision of mathematics education. However, these are designed to be used at the classroom level more than at the state level. Given that there is an ongoing assessment of the quality and impact of the curriculum materials as part of SIMMS' self-evaluation, the SSI leadership believes that adequate mechanisms are in place to ensure that the materials themselves are thoroughly tested. If large numbers of districts and schools continue to adopt and use the materials, it is not clear that the absence of uniform statewide testing or district-by-district indicators poses a great barrier to systemic reform in high school mathematics in Montana.

As a systemic reform strategy, Montana's approach targets a large set of resources on a relatively discrete set of issues: revising the high school mathematics curriculum (and supporting current and future mathematics teachers to make this feasible). Particularly in light of Montana's small population, this strategy should improve the odds of success simply because of the large amount of NSF funds available for this targeted goal, as compared with strategies that might have spread the same funds more thinly across a greater number of grade levels or disciplines. At the same time, the state is not ignoring the need for other reforms, such as in science education; those are, however, on a slower timetable, and fewer resources are being used to address them. We may later be able to compare and contrast this "concentration" strategy with a more "holistic" strategy used in other states.

The Future of Systemic Reform in Montana

Scaling Up. The problem of expanding SIMMS' scope consists of two parts, one related to high school mathematics and the other to everything else. In high school mathematics, expansion is likely to occur both to more grades, as new levels of the curriculum go through pilot testing, and to more schools. Clearly, a very good start has already been made in terms of reaching a significant number of districts, schools, teachers, and students. (More than 3,000 students have used SIMMS for a full year, including over 20% of the 9th-grade cohort.)

What would constitute a measure of success, in terms of students using SIMMS materials? The PIs do not believe that 100% of the schools or students in the state will ever adopt the integrated high school mathematics curriculum. However, they believe that, over time, at least 50% and perhaps 70% of the roughly 43,000 students enrolled in Montana's high schools is a realistic expectation. By the end of the 5-year award, it should be possible to say whether these targets are likely to be realized or not. Although we have identified above some reasons that universal adoption is unlikely, we have no reason to question the estimates made by the PIs.

For levels and subjects apart from high school mathematics, it is much more difficult to predict how many students SIMMS (and related state efforts) will affect in any significant way. There is clearly movement in the direction of reform, but concrete numbers of any kind, or even appraisals of what reformed classrooms may look like, are difficult to make. Nonetheless, the fact that the state is planning for K-16 reform of mathematics and science education is encouraging.

Reform after NSF Support Ends. Every SSI faces the question of how work on the components of its plan for systemic reform will be continued after NSF funding is gone. In Montana, the place of MCTM as the lead agency is viewed as very important in this regard. The best "insurance" of the survival of the integrated high school mathematics curriculum, in this view, is broad support by the mathematics education community even after the SIMMS award expires. It is apparent that MCTM, which has overall responsibility for managing SIMMS, as well as a very large membership, has a natural role to play here. Similar comments apply to reform of elementary and middle school mathematics, although there has been less activity at those levels than at the high school level.

At the same time, this line of reasoning raises questions about the future of reform in science education, perhaps underlining the need to find an agency that will be the long-term champion for change in this discipline. Perhaps the Montana Science Advisory Council, now chaired by Bob Briggs, will take on this role, or the Montana Science Teachers Association. Thinking about agencies external to OPI is not to discount the role that OPI must play in promoting reform. However, in examining SIMMS, we can clearly see how the mobilization of resources and energy from other agencies, institutions, and individuals has been extremely important, and it is only logical to assume that science would benefit from comparable activities.

Montana has been extremely effective in obtaining external support, from NSF and other agencies, to support its reform efforts in science and mathematics education. For example, the STEP award is one of only three collaborative awards for teacher preparation that NSF's CETP program made in 1993. It seems likely that external support, including the STEP project in particular, will continue to be an important force for reform in Montana even after the SSI award has expired. Again, this is not to discount the importance of state funds—it is clear that the legislature's appropriation for technology funds has been crucial, for example—but simply to note that Montana has effectively used a wide combination of different funding sources, and probably will continue to do so.

Lessons Learned

Lessons about systemic reform in general, and about SSI in particular, can be drawn from integrating information across states or from an examination of individual states' experiences. Here, we consider some lessons that seem apparent from the Montana SSI.

State Size. In an earlier report (Shields, Corcoran, and Zucker, 1994), we speculated that making SSI awards all roughly comparable in dollar size would be an advantage to smaller states. Comparative data are needed to confirm or reject this hypothesis, but even looking at Montana alone, it is clear that larger states would either have a far greater problem scaling up a similar high school mathematics initiative or would need to use very different strategies to accomplish the same goals. In a large state, it would just not be possible to involve such a large proportion of high school teachers and students so quickly, particularly with a curriculum still in the trial stages. For example, whereas more than 20% of the 9th-grade cohort in Montana has already been affected, reaching an identical *number* of students in California, say, would affect far fewer than 1% of its 9th-graders.

New Instructional Materials as a Reform Strategy. The notion of systemic reform is that no component of the education system stands alone, and each must reinforce the others. Without calling this idea into question, the experience of SIMMS does suggest the great power that can be found in using instructional materials as the centerpiece of a reform strategy. Students, teachers, parents, and others in Montana can literally see for themselves what the vision is for high school mathematics reform. There is not a lot of guesswork as to what reform really means in the classroom, how to implement it, or how much it will cost.

Undoubtedly there are trade-offs involved. For example, there will be more uniformity from school to school when the materials are the same in each school, and there is therefore less initiative called for from each school building, compared with what some reformers seem to have in mind who call for school-by-school restructuring. However, it is not clear that individual schools, or even school districts, have the wherewithal to create such complex, high-quality materials as a large project like SIMMS. And those states or districts wanting more variety could simply endorse or disseminate a larger number of materials. Overall, the tangible, practical nature of instructional materials, particularly those that have gone through rigorous trials, seems to provide a powerful motive for using them as a centerpiece of reform, and other states might wish to consider doing so.

However, this is not necessarily an argument that more states should support instructional materials development themselves. Montana had to answer questions such as: are appropriate materials already available in high school mathematics to accomplish what we want, and, if not, do we have the capacity to develop these materials? Only if a state answers a series of such questions in appropriate ways would it make sense to promote materials development as a major activity, particularly in a single large project such as SIMMS. Adoption or adaptation of existing materials is far cheaper and easier than development of new materials and, in many states, would be a preferable alternative.

Measuring Student Achievement. SIMMS is conducting an assessment of the effectiveness of the new curriculum materials in good faith. That is, an effort is being made to collect pertinent data, using experimental and comparison groups, and this effort is likely to result in interesting findings—indeed, to some extent it already has. For this very reason, SIMMS provides an interesting case to examine the premises on which such an evaluation is made.

When new goals are included for student learning, such as using computer software to solve mathematics problems or understanding linear regression (one of the topics in SIMMS that are seldom taught in traditional high school curricula), against what prior goals or baseline data should these be assessed? If new goals are added, it is usually necessary to eliminate some old goals, and one strength of the NCTM *Standards* is that they make very clear what one expects to see **less** of in schools, such as teaching logarithms, reducing complex algebraic expressions to simplest terms, and two-column geometry proofs. In short, new curricula seldom aim simply to teach the old material better; instead, they add new goals and eliminate old ones.

In comparing student scores, how does one account for the fact that some goals are new and others have disappeared? Is there a common metric, so that a gain of 5 points in using computer software is offset by a loss of 5 points in using logarithms? Can a single test adequately represent both the new goals and the old goals? Is the public willing to accept that students may do less well in certain areas in order to make time to teach other topics? These are difficult but important questions. In terms of Montana's evaluation of SIMMS, the focus is primarily on (1) problem solving, not specific, detailed content knowledge, and (2) the use of the PSAT to determine how students who use SIMMS compare on a traditional standardized test with non-SIMMS students.

Test scores are important—for example, one certainly wouldn't endorse curriculum or instruction that didn't result in substantial learning by students. But comparisons of test scores probably do less than a host of other factors to convince most people that new directions, such as SIMMS is charting, are the right direction to go in. Ultimately, value judgments guide us: in the year 2000 and afterward, what do we think it is important for students to know and be able to do?

The Role of NSF. The SSI program is unusual for NSF in a number of ways. The size of the awards is relatively large, they are made as *cooperative agreements*, and the activities supported often are close to the heart of state government responsibilities. As a result, NSF is involved in making some key decisions affecting states in ways that would rarely be true for *grants*, the more typical funding vehicle used by NSF.

Apart from the initial funding decision, two other NSF actions stand out as noteworthy with respect to SIMMS. First, NSF insisted during the first year of the award that science be added, and NSF staff approved the particular individual (Gerald Wheeler) selected to head the science component. Second, to ensure that the curriculum materials being developed are of high quality, in 1993 NSF insisted that a panel of external reviewers examine the materials and report their findings to NSF. The results in both cases have been positive for SIMMS. The PIs now believe that including science is the right thing to do. Also, the external reviews of the materials were positive, and, partly as a result, the PIs decided to commission additional reviews by faculty at engineering schools, because they are potential recipients of the students who have used SIMMS materials and their opinions could affect the acceptance of SIMMS by districts, parents, and others. Thus, in the case of Montana, NSF's active role in managing the cooperative agreement has worked out quite well.

One reason is that NSF also offers its opinions in some cases **without** insisting that SIMMS accept them. For example, following the mid-point review in January 1994 (which went very well for Montana), NSF suggested that the Montana SSI consider "a truly integrated mathematics and science approach," by which presumably is meant an approach in which science and mathematics textbooks and other materials are in some sense merged, or instruction in science and mathematics classrooms is very closely coordinated. At a minimum, this is an extremely tall order, and it departs to some extent from the vision that was clearly laid out in Montana's original SSI proposal. NSF showed good judgment, in our view, by taking a much more tentative stance on this matter than on those where it insisted that certain actions be taken. SIMMS continues to include many science and technology topics in the integrated high school mathematics materials and is involving science educators in reviewing them. Also, OPI is exploring the option of an integrated mathematics and science curriculum in grades K-5, as noted earlier. But a full integration of mathematics and science is beyond the scope of what SIMMS considers either feasible or desirable.

Another way of summarizing these thoughts is that NSF staff, who have the power of the purse and therefore a substantial degree of authority, must carefully balance their interests in making sure that federal funds are spent responsibly and in accordance with the spirit of systemic reform, with their responsibility to allow each SSI the independence that states expect. No simple recipe exists for describing how this balance should be established, but respect between NSF and SSI staff is obviously one important ingredient, and NSF needs to take care to intervene only in very important situations. The case of Montana demonstrates that the outcomes of an active partnership can be positive.