DOCUMENT RESUME

ED 368 544 SE 053 890

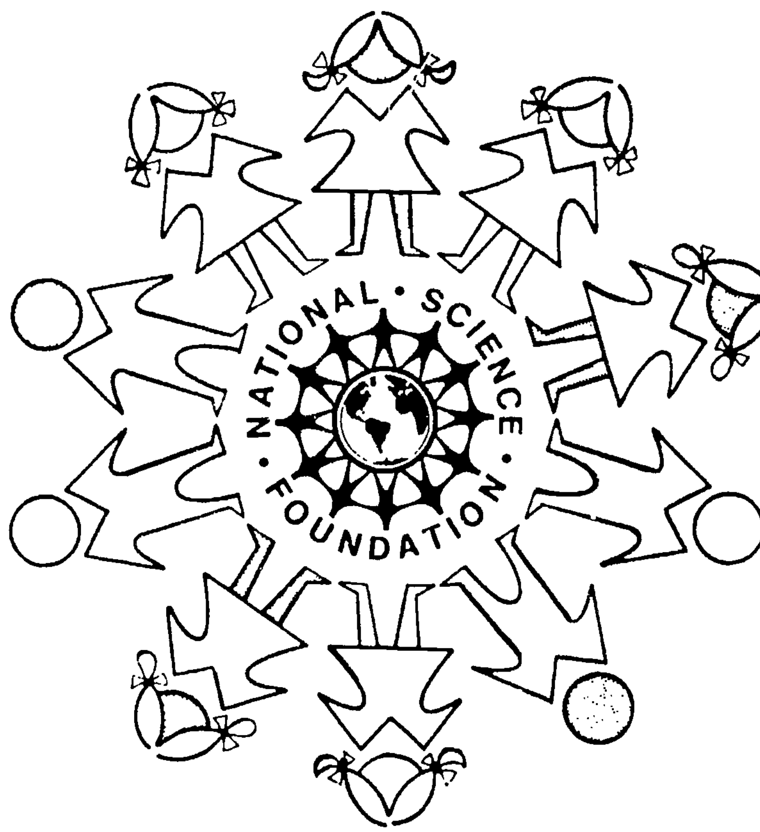
TITLE	Building the System: Making Science Education Work. Putting the Pieces Together. Proceedings of the Annual Conference (2nd, Washington, D.C., February 24-26, 1994).
INSTITUTION	National Science Foundation, Washington, DC. Directorate for Education and Human Resources.
PUB DATE	Feb 94
NOTE	96p.
AVAILABLE FROM	National Science Foundation, Office for Education and Human Resources, Publications, 4201 Wilson Boulevard, Arlington, VA 22230.
PUB TYPE	Collected Works - Conference Proceedings (021) -- Guides - Non-Classroom Use (055)
EDRS PRICE	MF01/PC04 Plus Postage.
DESCRIPTORS	*Educational Change; Elementary Secondary Education; Higher Education; Mathematics Education; Rural Education; Science Curriculum; *Science Education; Science Teachers; Teacher Education; Technology Education
IDENTIFIERS	National Science Foundation; Ohio; *Systemic Change

ABSTRACT

Systemic reform, by definition, requires a concerted effort on the part of many toward change. In an effort to continue to promote systemic reform in science and mathematics education, a 3-day conference provided the forum necessary for many to share their insights and concerns on the issues. A brief discussion of four components of the conference is provided: (1) issue sessions which discussed a variety of topics ranging in scope from the new role of technicians in our society to changes in the classroom; (2) theme sessions that considered the media, technology, undergraduate education and systemic reform, and measuring progress in the systemic effort; (3) 21 workshops; and (4) exhibits. Also included in this report are 6 briefing papers entitled: (1) "Indicators of Mathematics and Science Education" (Larry E. Suter); (2) "NSF's Programmatic Reform: The Catalyst for Systemic Change" (Joseph Danek, Roosevelt Calbert, and Daryl Chubin); (3) "Ohio's Statewide Systemic Initiatives: Lessons from the Trenches" (Jane Butler Kahle); (4) "Discovery about Systemic Change" (Ted Sanders); (5) "Issues in Rural Education and the Rural Systemic Initiative" (Wimberly Royster); and (6) "NSF Workshop Report: Learning and Technology in the Future" (Nora Sabelli and Lida K. Barrett). (ZWH)

BUILDING THE SYSTEM: MAKING SCIENCE EDUCATION WORK

Putting the Pieces Together



February 24-26, 1994
Washington, D.C. Renaissance Hotel
999 Ninth Street, N.W.
Washington, D.C. 20001
Telephone: 202/898-9000
Fax: 202/289-0947

NATIONAL SCIENCE FOUNDATION
4201 WILSON BOULEVARD
ARLINGTON, VIRGINIA 22230

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OFFICE OF THE
ASSISTANT DIRECTOR
FOR EDUCATION AND
HUMAN RESOURCES

January 1994

Dear Education Leader:

I am delighted that you have accepted my invitation to attend our second invitational conference, ***Building the System: Making Science Education Work***. I look forward to your participation and it is my hope that you will return home with new insights and new energy to move the reform agenda ahead.

This briefing book contains information about the conference that you may use as a basis to select those sessions you want to attend. Additionally, it contains a set of briefing papers that will provide you background for the conference activities. The information in Suters' Indicators paper points out areas of concern. The Danek, Calbert and Chubin paper describe NSF's programmatic responses. Royster discusses the rural initiative under development. The pair of papers by Kahle and Sanders give information on Statewide Systemic Reform in action. The papers on Technology and Technical Education report on two key areas that must play an increasing role in our thinking about systemic reform. Your reading of these papers in advance of the conference will assist in preparing you to take an active part in our sessions. Please remember to bring this briefing book to the conference.

Thank you for your commitment to take part in the conference, and for all that you contribute to educational reform.

Sincerely,

Luther S. Williams

Luther S. Williams
Assistant Director

Enclosure

Telephone (703) 306-1600 FAX (703) 306-0399

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Putting the Pieces Together

Thursday, February 24, 1994 (4:00 p.m. - 10:00 p.m.)

- Conference Registration
- Buffet and Exhibits (6:00 p.m.)
- Opening Plenary Session (7:30 p.m.)
  Neal Lane, Director, National Science Foundation
- Demonstration—How Networking Can Integrate Science Education
- Exhibits

Friday, February 25, 1994 (8:00 a.m. - 7:30 p.m.)

- Plenary Session and Keynote Address
  Hon. George E. Brown, Jr., Chairman, Committee on Science, Space & Technology in the U.S. House of Representatives
- Issue Sessions (see briefing book for choices)
- Luncheon Address
  Madeleine Kunin, Deputy Secretary, U.S. Department of Education
- Theme Sessions (see briefing book for listing and descriptions)
- Workshops (see briefing book for listing and descriptions)
- Exhibits (see briefing book for listing and descriptions)
- Buffet Reception

Saturday, February 26, 1994 (8:00 a.m. - 2:30 p.m.)

- Plenary Session—Educational Governance, Chaired by *Luther Williams*
  Panel includes *Walter Amprey*, Superintendent of Schools, Baltimore; *Edward Reidy*, Kentucky State Educational System
- Small Group Work Sessions
- Luncheon (with feedback from conference sessions)

Issue Sessions

Group 1: New American Work Force: Scientific and Technical Development

Issues: The role of the technician in the American work force is constantly changing as technology evolves and the demands of the national economy and society grow. Technicians transform the scientist's and engineer's discoveries and designs into products. They must have a strong working knowledge of science and mathematics to understand and translate the scientific concepts, a strong technical base with specific skills to carry out projects, and a social awareness of the environment. A multifaceted approach involving two- and four-year colleges and universities, secondary schools, business, government, and industry is necessary to prepare technicians for challenging careers. This session will focus on achieving a well-educated and technically skilled work force through coalition building, curriculum development, faculty and teacher preparation and enhancement, and program improvement.

The following issues will be addressed:

- Education versus training
- Content base of basic science and mathematics
- Articulation and collaboration among institutions
- Avoidance of dead-end tracking
- Complexity of the diverse student population entering technical fields
- Role of "Tech-Prep" in attracting, motivating, and training future technicians.

Presenters:
Robert F. Watson, EHR/DUE, National Science Foundation (Moderator)
Robert Parilla, Montgomery College
Flora Mancuso Edwards, Middlesex County College
Arnold Peskin, Brookhaven National Laboratory
William (Ed) Ball, Washtenau Intermediate School District

Presentation: The breakout session speakers will address the issues identified above. Presentations will be given at the breakout session by a college educator, a secondary school educator, and an industrial representative. A question and answer period to allow for audience interaction will be provided. Currently funded Technological Education projects will be showcased.

Outcomes: A multifaceted approach involving two- and four-year colleges and universities, secondary schools, business, government, and industry is necessary to prepare technicians for challenging careers. This session will focus on achieving a well-educated and technically skilled work force through coalition building, curriculum development, faculty and teacher preparation and enhancement, and program improvement.

Group 2: Teacher Preparation: Forging New Alliances

Issues: Faculty in the academic disciplines and faculty in education must work together to prepare teachers who are knowledgeable in both content and pedagogy. However, many barriers stand in the way of creating teacher preparation programs that are shared between these two groups and that benefit from the full attention and input of the two groups. Faculty who have traditionally had the responsibility for subject area content and faculty who have had the responsibility for teaching pedagogy have often worked in isolation from each other. The focus of this breakout group is to examine what keeps the groups apart and how to overcome those barriers and promote cooperation, sharing of knowledge, and joint responsibility in the preparation of the next generation of teachers.

Presenters:
Tina H. Straley, EHR/DUE, National Science Foundation (Moderator)
Raymond Johnson, University of Maryland
Karen Worth, Education Development Center, Wheelock College
Elizabeth Goldman, Vanderbilt University
Glenn Crosby, Washington State University

Presentation: The participants will form four groups. Although the participants in each group will represent both discipline and education faculty, each group will assume the role of either science education faculty or science faculty and discuss the issues from that perspective. The discussions will be preceded by 5-minute presentations of the discussion leaders, who will also report back at the end of group discussions.

Suggested topics for discussion:

- Whose responsibility is the recruitment and preparation of pre-service teachers?
- How can we use research in teaching and learning to improve our teaching and to model effective teaching for prospective teachers?
- How can a faculty member do research and be involved with curriculum issues and the K–12 schools? Is there a difference in crediting work that may be defined as applied research? Can faculty do any thing besides basic research and still get tenure?
- How can the "others" help me? How can I help "them?" What if they don't want my help?
- What are the barriers between the scientific disciplines and education faculty and what practical steps can remove those barriers so as to be able to share the program and the responsibility for pre-service teachers?

Outcomes: Participants will gain a better understanding of the contributions of colleagues in other departments and have ideas for a framework for working together in creating exemplary programs for the preparation of teachers in mathematics and science.

Group 3: Indicators of Higher Education

Issues: Indicators of research resources and performance, and of K–12 educational capacity and achievement, are now commonplace. Comparable indicators of higher, especially undergraduate, education have not been developed. Without such indicators, measuring the contribution of higher education to systemic reform will be difficult at best. The issue of higher education indicators centers on the following:

- What should such indicators encompass?
- What databases, e.g., Astin's *American Freshman* surveys and the NAEP for postsecondary students, exist as possible sources of indicators?
- How would such indicators be used, and by whom, e.g., academic administrators who seek to evaluate faculty performance and faculty who seek to assess student learning?
- What lessons derived from the *Science & Engineering Indicators* series and various K–12 indicators reports should guide the development of higher education indicators?
- How might higher education indicators, whose production will require some change in academic culture (i.e., self-assessment) inform systemic reform efforts?

Presenters:
Mary Golladay, SRS/SBE, National Science Foundation (Moderator)
Jeanne Narum, Independent Colleges Office
Willie Pearson, Jr., Wake Forest University
Steve Riter, University of Texas—El Paso

Presentation: The session will feature an indicators expert, representatives of different academic sectors (e.g., four-year college, research university), and an academic administrator. The ensuing dialogue will focus on points of convergence and areas of concern.

Outcomes: The session will identify a variety of disincentives to developing indicators of higher education that all participants raise. In this sense, the issue is a microcosm of systemic change: the barriers, misgivings, and fears of misinterpretation and misapplication seem to override the reasons to challenge the status quo. Once these concerns have been compiled and discussed, attention will turn to issues of measurement and possible uses of these indicators, which will also be catalogued. A set of candidate indicators will be produced.

Group 4: Is There a "Correct" Use of Indicators?

Issues:

Indicators of mathematics and science education have become part of the educational research and policy making arsenal. Indicators describe the state of affairs, or the "health" of the system. A bigger question, however, is the use of indicator data for systemic action: How can trends in indicators be used by decision makers? Such prescriptive use addresses the gap between what researchers find and what consumers of these data do with them.

This session is motivated by the suspicion that different participants in educational systems have different perspectives on what is relevant, reliable, and actionable indicators to them. Furthermore, indicators require a framework for interpretation. Questions to be addressed include the following:

- When is a statistic an "indicator," and when is it not?
- What are some common examples of the misuse of indicator data?
- About what should the newcomer to education indicators worry?

These are the kinds of question that preclude potential users of indicator data from learning more and including indicators in their analytical work.

Presenters:

Larry Suter, EHR/RED, National Science Foundation (Moderator)
Joy Frechtling, WESTAT, Inc.
David Goldston, U.S. House of Representatives
Andrew C. Porter, Center for Education Research, University of Wisconsin

Presentation:

This session will present a dialogue among producers, users, and would-be users of indicators, moderated by NSF staff: an indicators expert, a Congressional interpreter, and a State policy representative. After an overview on what is an indicator and illustrative data, the three interpreters or users will respond: why they trust, like, use, or are unconvinced by indicators either as a measurement tool or as a basis for action.

Outcomes:

The session will clarify where communication breaks down between the producers and potential users of indicators. The hope is that there will be some converts to indicators. At the same time, the session participants will try to identify

- the kinds of information about system reform that indicators could effectively highlight;
- how to reduce ambiguity and misinterpretation of an indicator; and
- the requirements ("reality checks") of a potential user to take action on indicator data.

Group 5: Opportunities to Learn: Reforming Math and Science Education in Urban and Rural Communities

Issues: An increasingly technological work force will demand a stronger science, mathematics, engineering, and technology (abbreviated as "science" below) skills base than high school graduates inclined either to higher education or entry to the work force now possess. Students in both urban and rural communities are comparatively disadvantaged in their opportunity to learn science because of the system in which they are enrolled. Standard measures of student preparation and achievement point dramatically to "performance gaps" that exist between students with different demographic characteristics and schools in different geographic regions and settings. This diagnosis, however, provides no prescription for reducing the gaps given the particular school system. This session asks the following:

What resources are needed to improve the opportunity to learn (e.g., course offerings, instructional work force, new technology) in each school setting? Systemic change means that the science skills base for all children is raised, not just for those in certain school settings. What is peculiar to each kind of school system that will require a certain mix of strategies and resources? What data would be useful for planning and implementing educational changes in urban and rural communities?

Presenters: **Joseph G. Danek**, EHR/OSR, National Science Foundation (Moderator)
Thomas Corcoran, Rutgers University

Presentation: Presenters will include an educational policy researcher and representatives from urban and rural school districts. The discussion will be moderated by an NSF program officer from the EHR Directorate's Office of Systemic Reform.

Outcomes: Data describe differing opportunities to learn mathematics and science. Systemic change requires that whole communities rethink strategies for serving all students. This session will mobilize participants to define an institutional role for bringing about change in the delivery of learning opportunities. Dialogue will focus on common ground and distinctive needs.

Group 6: How Informal Science Education Programs Add Capacity to the System

Issue: Informal science education community programs and sites such as museums, science centers, aquaria, zoos, and botanical gardens are institutional resources, like schools and libraries, that are part of the Nation's educational infrastructure. They add capacity to the system. They bridge the gap between popular culture and school learning.

Infrastructure enables a system to extend itself overall and facilitate its reach. Some redundancy is necessary, e.g., between formal and informal components. How can this be accomplished? Informal science education programs and resources can be seen as gap-filling as well. Where school-based programs are lacking, the functioning of the whole system is inhibited. How can gaps filled by informal science be identified?

Presenters: **Richard Ponzio**, University of California at Davis, 4-H Center
Robert Sullivan, National Museum of Natural History, Smithsonian Institution
Curtis Howard, Office of Curriculum Support, School District of Philadelphia

Presentation: The session will pair a science museum person with a school administrator or classroom teacher to kick off the discussion. Each will offer 5 minutes on the perceived role of the other in the system and proceed to interact for 10 minutes more to raise issues and questions for full group discussion. A community-based representative will comment on their role for 5 minutes. The ensuing discussion will be guided by an NSF moderator who will clarify the questions and move toward closure on them.

Outcomes: In addition to answers to the questions posed above, three others will be vital:

- If informal science did not exist as a resource, how would the system function (or accommodate the needs addressed by informal programs and sites)?
- How can informal science resources better leverage other resources, especially human, to improve the whole system?
- What specific connections can be identified between informal science and other institutions that contribute to education, and what is the evidence that these connections are adding capacity to the system?

Group 7: The Media and Science Education: Friend or Foe?

Issues: The education media—electronic and print—have enormous potential to inform and influence citizens' perceptions and understanding of the state of science education in the U.S. Arguably, scientists and science educators have not harnessed the power of media to induce changes in the way audiences learn and utilize scientific and mathematical information. How can the media play a positive role in spreading the "word"—the correct word—on systemic reform in education?

Presenters: **Joel Schneider**, Childrens' Television Workshop
Soames Summerhays, Summerhays Films, Inc.
Peter West, Education Week

Presentation: The session will feature three representatives of the media; one a television person, one a film producer, and one a newspaper person. Each will bring snippets of their trade to support their assertions. A moderator from NSF will conduct a "Meet the Press" type forum for a half hour with audience involvement following. Questions asked will include the following:

- What were you trying to accomplish when you created ... ?
- Television and films are purely entertainment; where is the active learning?
- What safeguards exist so that the media do not misrepresent mathematics and science education reform?
- How can the media improve the public understanding of science and science literacy for all Americans?
- How are audiences identified, and how do you know when you have reached them and have made a difference?

Outcomes: In addition to answers to the questions posed above, three others will be vital:

- How can the media and others disseminate and make more visible current educational system changes?
- How can the media better disseminate science information?
- How can mathematics and science educators, as well as scientists and engineers, aid the media to be more effective in creating change?

Group 8: Classroom Teaching is Different Today—The Curricula, The Assessment, and The Pedagogical Styles are Different

Issues: Mathematics, science, and technology education reform is beginning to affect classrooms across the country. Such reforms include cooperative learning, the teacher as coach rather than lecturer, students moving freely around the classroom, exams that have questions with no single right answer, and computers in the classroom. Many parents, members of the general public, decision makers, and even teachers are unaware of these reforms and how different these classrooms are and can be.

Presenters: **Eric Robinson**, EHR/ESIE, National Science Foundation (Moderator)
Laurel Robertson, Developmental Studies Center
Kay Toliver, FASE

Presentation: The session will feature a mock school board meeting in which attendees will constitute the school board. An agenda will be prepared to include discussion of such topics as (but not exclusively) the following:

- The necessity for professional development programs that train teachers in the use of the new technologies, assessment strategies, curricula, and pedagogical techniques. How can we obtain such programs for our schools? Where can we find assistance in running our own programs? Do any programs exist for remote areas? What are the forms that teacher enhancement can take?
- A review of the state test scores for the school in this district—where do we stand comparatively, and how do we improve our scores. Are the tests aligned with the curricula we use and national standards? What is the interface between classroom assessment practices and the state mandated tests? Are our teachers able to see the differences?

Outcomes: Pursuant to the above, the following questions will be vital:

- What general characteristics of classrooms do we want to be prevalent in the 90's?
- What are the new methods of assessing student learning? What are the pitfalls? How can we prepare parents and others for the use of these new methods? Does high-stakes testing versus classroom assessment make a difference?
- How can we better prepare teachers for these classroom reforms?

Group 9: Classrooms *Look* and *Are* Different

Issue: Mathematics, science, and technology education reform is affecting classrooms across the country. Such reforms include cooperative learning, the teacher as coach rather than lecturer, students moving freely around the classroom, exams that have questions with no single right answer, and computers in the classroom. Many parents, members of the general public, decision makers, and even teachers are unaware of these reforms and how different these classrooms are and can be.

How can we better inform members of the general public about systemic reform? How can we make the public feel good about these reforms? How can school boards, superintendents, and other decision makers better understand and deal with increasing demands for equipment, release time for teachers, parents who are threatened by reform, and more?

Presenters:
Michael Haney, EHR/ESIE, National Science Foundation (Moderator)
Judith M. Garcia, Fairfax County Public Schools
Elizabeth Black, Boulder Valley Schools

Presentations: The session will feature a mock school-board meeting in which attendees will constitute the school board. The two presenters will request funding for extensive technology projects that will require significant funding and thinking of how education is delivered to students.

- Judith M. Garcia will request funds for a telecommunications system that would link classrooms as well as draw upon resources and contribute to other school system nationally. She will describe the costs and argue for the benefits this technology provides.
- Elizabeth Black will request funds to tie the K–12 classrooms of one school district into the Internet. She will describe the benefits, the resources, and the training needed as well as the costs.

Outcomes: In addition to answering the above questions, three others will be vital:

- What general characteristics do we want to be prevalent in classrooms in the 90's?
- How can we pay for the increased use of technology in schools?
- How do we train teachers to use these new technologies?

Group 10: States as a Unit of Systemic Reform: Putting It All Together

Issue: The Statewide Systemic Initiatives Program is now going into its third year, and states funded in the first year have now had time to learn lessons about strategic planning; coordination of curriculum, assessment, and teacher development; collaboration; policy development; public information; and governance.

This session will feature comprehensive case studies prepared by two SSI states. States will "tell their story" about their state context, strategies, challenges, and opportunities in implementing the SSI Program. The Connecticut SSI targets low achieving, high poverty school districts and has components that address collaboration with higher education, business and industry, and informal science institutions. They have also mounted a statewide public information campaign on the need for mathematics and science education reform. The Louisiana SSI (LaSIP) is a collaborative venture between the Board of Regents and the Board for Elementary and Secondary Education. LaSIP focuses on regional teacher development programs that are partnerships between universities and local school districts as a vehicle for systemic reform.

Presenters:
Janice Earle, EHR/OSR, National Science Foundation (Moderator)
Richard Cole, Connecticut Academy
Mary Keeney, Connecticut Academy
Steve Leinwand, Connecticut Department of Education
Kerry Davidson, LaSIP (with other LaSIP staff)

Presentations: Each session will have an SSI team, composed of the PI and/or PD, key component leaders, and state policymakers who will give a brief, focused presentation on the state's approaches to systemic reform and the place of the SSI Program in the overall state context (30 minutes). The remaining time will be spent in interaction with the audience who will probably have a number of questions about getting started, scaling up, marking progress, creating successful partnerships, leveraging funds, etc.

States that will make presentations are Connecticut and Louisiana.

Outcomes:
- Participants will gain an understanding of how states fit into the systemic reform picture.
- Participants will gain a sense of the dynamic quality of working with a comprehensive systemic initiative (how to respond to changes in leadership at the top, how to take advantages of new opportunities, etc.)
- Participants will better understand the advantages and complexities involved in using the systemic approach.
- Participants will understand how strategies have to add up to programs in which the "whole equals more than the sum of the parts."

Group 11: Systemic and Comprehensive Reform of Underrepresented Minorities in the S&E Work Force

Issues: Comprehensive and systemic approaches facilitate the orderly progression of educational concepts within the classroom and, when combined with innovative teaching strategies, produce a cadre of students who are motivated to enter college and pursue meaningful careers, including those who choose to major in science, engineering, and mathematics. These approaches consist of formal and informal interactions between several groups who are stakeholders in the nation's educational system. It is quite clear that special interventions such as mentoring, motivational seminars, peer counseling, community-based activities, and parental guidance are key elements that provide and maintain systemic learning environments that are supportive to students, both culturally and socially. NSF's minority-focused programs utilize the aforementioned supportive activities within individual schools, school districts, regions, and states.

Presenters:
Roosevelt Calbert, EHR/HRD, National Science Foundation (Moderator)
Eugene DeLoatch, Morgan State University
Gilberto Ramon, University of Texas at San Antonio
Edmonia T. Yates, Morgan State University

Presentation: This session will showcase two Human Resource Development projects, representing NSF's precollege programs in the Human Resource Development division. The first speaker, Eugene DeLoatch, will represent the Comprehensive Regional Centers for Minorities (CRCM) program. The underlying issues of systemic reform as related to minority students will be analyzed. Dr. DeLoatch will also discuss the merging of a productive CRCM program with an Urban Systemic Initiatives (USI) program in a city that has a USI planning grant. The group will discuss what is and is not effective in systemic reform intervention.

The second speaker, Gilberto Ramon, will focus on the progress of systemic reform activities in a school district that obtained an NSF Partnerships for Minority Student Achievement (PMSA) grant.

Outcomes: The following questions will be addressed during the presentation and subsequent discussion session:

- How can systemic reform efforts for the educational development of underrepresented groups become a primary and integral part of an educational unit, rather than just a supplement?
- What strategies can be used to change the behavior of teachers, administrators, and educational specialists toward minority students, including the belief that all students can learn?
- Which elements of partnerships between schools, administrators, parents, and industry are critical to successful and large-scale systemic reform efforts?

Group 12: Gender Equity as System and Component

Issues: Gender equity can be achieved as a systemic effort on its own or as an important component of other systemic reform. When viewed as an entity itself, gender equity can be achieved throughout the scientific and technological community only through pervasive, systemic efforts. Examples of such systemic reform efforts are NSF's Experimental Projects for Women and Girls; the AWIS (Association of Women in Science) Mentoring Program; and WE PAN's Regional Training Seminars. As a part of other systemic efforts gender equity can infuse a previously ignored, or at least underutilized, dimension. Gender equity components can be incorporated into systemic reform in teacher education, curriculum, pedagogy, etc.

Presenters:
Jane Zimmer Daniels, EHR/HRD, National Science Foundation (Moderator);
Carmen Cid, Eastern Connecticut State University
Yolanda George, American Association for the Advancement of Science
Suzanne Brainard, University of Washington

Presentation: This session will include information and discussion on gender as a systemic effort itself and gender as a component of systemic efforts. Carmen Cid will present information on a proposal submitted to NSF's Experimental Projects for Women and Girls which would create permanent, statewide changes for providing greater access, participation, and achievement of women and girls in science, engineering, and mathematics. Yolanda George will discuss the work of the American Association for the Advancement of Science as they infuse gender issues into other systemic reform programs, especially in community based organizations. And, Suzanne Brainard will describe the work of WEPAN (Women in Engineering Program Advocates Network) to initiate institutional change at engineering schools throughout the United States which will result in greater enrollment and graduation of females.

Outcomes: The following questions need to be addressed during the presentations and subsequent discussion session:

- How can gender issues be incorporated into other systemic reform programs?
- What methods would encourage those involved in systemic reform to include gender equity as a goal of their efforts?
- What is the potential impact of gender equity upon the scientific and technological community?
- What additional efforts (NSF and other) to achieve gender equity in science and engineering education and professions should be encouraged?

Group 13: How Students with Disabilities Achieve Full Inclusion and Participation in the Science, Mathematics, Engineering, and Technology Educational System

Issues: Tens of thousands of scientists and engineers who have disabilities are competitively performing their responsibilities as researchers and academicians while thousands more face difficulties in entering classes leading to majors and careers in these disciplines. Systemic reform in science, mathematics, engineering, and technology (SMET) will not be fully realized until barriers to the inclusion and participation of persons with disabilities are removed. These barriers are encountered in many places: attitudes of educational gatekeepers; inaccessibility of instructional materials, media, and technology; and the appropriateness of classroom, laboratory, and examination experiences. EHR is supporting projects that have identified methods of addressing and overcoming many of the barriers to inclusion of persons with disabilities in SMET education and career development. Many of these intervention strategies require replication and evaluation, and others should be internalized into the nation's SMET educational enterprise. How can this be accomplished? Information concerning successful models and pedagogical "best practices" must be disseminated, promoted, and adopted.

Presenters:
Lawrence Scadden, EHR/HRD, National Science Foundation (Moderator)
Sheryl Burgstahler, University of Washington
Linda De Lucchi, Lawrence Hall of Science
Larry Malone, Lawrence Hall of Science

Presentations: Sheryl Burgstahler will discuss strategies used to increase the acceptance of teachers, counselors, and parents of students with disabilities and the importance of insuring that these students participate fully in science and math educational experiences and SMET career development opportunities. Linda De Lucchi and Larry Malone will provide, in a second presentation, information on the development and selection of educational materials, media, and technologies that can be utilized by all students including those with disabilities.

Outcomes: The following questions will be addressed during presentations and subsequent discussion sessions:

- What strategies can be used to change attitudes of educational staffs and family members who counsel disabled students outside of math and science courses?
- What guidelines can educational administrators and instructors use to insure that newly selected instructional materials, media, and technologies will be accessible and appropriate for all students?

Group 14: Technology for Motivating and Empowering the Classroom: Models and How To Fund Them

Issues: The audience will be able to interact with implementers of ongoing school-based programs that

- use technology to empower and motivate students and teachers
- use different strategies for funding
- led to significant educational growth

Presenters: **Michael Haney**, EHR/ESIE, National Science Foundation (Moderator)
Leona Williams, formerly of the California Val Verde School District
Sharon Carruth, Oliver Johnson High School, Alabama
John Richards, BBN, with the NASDC Co-nnect school

Presentation: This session will be chaired by an experienced school administrator and will feature a school superintendent, a high school teacher working with State agencies, and an educational contractor working with an inner city school.

Outcomes: Individuals attending this session will learn about

- measures of influence and success
- strategies for funding and increasing productivity and effectiveness
- how to link with others with similar interests
- using networking Technology to leverage multiple investments and tie in multiple aspects of education reform.

Theme Sessions

Theme 1: Undergraduate Education in Systemic Reform
2:00 - 3:30 p.m.

Robert F. Watson, EHR/DUE, National Science Foundation
Sadie Bragg, City University of New York
Patrick E. Cassidy, Southwest Texas State University
Melvin George, St. Olaf College
Ronald Douglas, SUNY at Stony Brook
Eli Fromm, Drexel University

Universities and two- and four-year colleges are undertaking fundamental reforms affecting all facets of undergraduate education including curriculum, faculty roles, and institutional missions. Because of the central role of undergraduate education, these reforms are critical to achieve reform in our Nation's educational system.

Undergraduate education has a central role for systemic reform in our Nation's educational system. Indeed, Luther Williams has noted that "successful reform of the schools will not occur without concomitant reform in the colleges and universities."

More specifically, undergraduate science, engineering, mathematics, and technological education is the central enterprise that links the Nation's schools with entry into the skilled technical work force, professional fields, and graduate education. Undergraduate education provides principal preparation of students for direct entry into high-tech employment, for careers as scientists and engineers, as future teachers of mathematics and science, and as future citizens of our increasingly technology-based society.

In colleges and universities, many of the academic decisions are decentralized. There is also considerable diversity among institutions and their missions, as well as institutional cultures. These factors pose particular challenges to incur systemic changes within the institutions providing undergraduate education. This session will address issues particular to stimulating systemic reform in undergraduate education, including

- developing an institutional plan for systemic reform
- achieving consistency with change in schools, with graduate education, with job market needs
- using coalitions among institutions: two- and four-year colleges, universities, and schools
- fostering faculty creativity and support for change
- using individual projects collectively to effect systemic reform
- reducing barriers among academic units

Theme 2: **The Media**
4:00 - 5:00 p.m.

Margaret Cozzens, EHR/ESIE, National Science Foundation
Rapporteurs from the following issue sessions will discuss the role of the media in systemic reform: "The Media and Science Education: Friend or Foe?" and "How Informal Science Education Programs Add Capacity to the System."

Each rapporteur will be asked to relate the outcomes of his/her session to possible media roles in reporting, indeed showcasing, efforts (programs, projects) to induce change in science education. The main focus of the discussion will be as follows:

- The various strengths, and therefore roles, of different media (film, TV, newspaper, magazine, educational versus mass) to reach different audiences;
- The difference between disseminating, teaching, and entertaining about science (the case of a technology-based classroom—how it changes instruction, demands different teaching skills, reshapes the school day, etc.);
- How the media can better utilize the insights of scientists, mathematicians, and educators in their science and education reporting;
- How the focus on student achievement, especially achievements by underserved populations who beat the odds of their environments, can be broadened and sharpened; and
- How media presentations can help to create "attentive publics" and assist in systemic reform at the same time.

The NSF moderator will draw lessons out of the reports on the issues and craft preliminary responses to the five questions above.

Theme 3: **Measuring Progress**
3:00 - 4:00 p.m.

Daryl Chubin, EHR/RED, National Science Foundation
Rapporteurs of the following issue sessions will discuss how we—researchers, policymakers, the local community—know that we are making progress toward the systemic reform of education: "Indicators of Higher Education," "Is There a 'Correct' Use of Indicators?," and "Opportunities to Learn: Reforming Math and Science Education in Urban and Rural Communities."

Discussion will focus on measurement issues that underlie systemic action. For example,

- What has and has not been measured, and how well? Where are the gaps and inconsistencies? Which trends seem real, and which are open to various interpretations?

- How do existing assessments of student learning, e.g., NAEP, and reports, e.g., NSF's Indicators of Science and Mathematics Education, inform interventions in the education system? Where do they fall short?
- What constitutes "progress," i.e., what have been established as goals and benchmarks? Who is responsible for achieving them: students, teachers, school districts, States? How do perceptions differ as to what is a realistic systemic goal and a timetable for achieving it?
- How can the "system"—education, community, political—act on these measures of progress? In other words, how can descriptive information be translated into prescriptive actions? Who should spearhead (and pay for) such efforts?

The NSF moderator will move beyond the issues reports to place measurement at the center of the systemic reform movement. The limits of measurement, therefore, will be highlighted as well.

Theme 4: Technology
2:00 - 3:00 p.m.

Presenters from Thursday evening

This technology theme session will look at the various components of the Thursday evening presentation and explore the contributions of each and how they interrelate to achieve meaningful science work. Various groups working collaboratively across the Nation will collectively present their perspectives and key issues to date, followed by a panel question-and-answer session. They will address different aspects of the key issues that affect educational reform and which they have all addressed: access and interface design; teacher support—what seems to work, what doesn't; student learning, including what we know about how using "today's knowledge" real- or near-time data changes; what learning is possible, mentoring with each other and experts, etc.

This session will enable participants to engage in extended conversation with the presenters from Thursday evening, including classroom teachers, and participate in additional hands-on demonstrations.

Workshops

NSF INVITATIONAL CONFERENCE
WORKSHOP SCHEDULE

	2:00 p.m.	2:30 p.m.	3:00 p.m.	3:30 p.m.	4:00 p.m.	4:30 p.m.	5:00 p.m.	5:30 p.m.	6:00 p.m.
Meeting Room (TBA)	Workshop #2		Workshop #8		Workshop #5		Workshop #1		
Meeting Room (TBA)	Workshop #4					Workshop #3			
Meeting Room (TBA)	Workshop #7		Workshop #12		Workshop #9		Workshop #6		
Meeting Room (TBA)	Workshop #11		Workshop #15		Workshop #13		Workshop #10		
Meeting Room (TBA)	Workshop #16		Workshop #18		Workshop #		Workshop #14		
Meeting Room (TBA)	Workshop #17				Workshop #19				
Meeting Room (TBA)	Theme Session #4		Theme Session #3		Workshop #20				
Meeting Room (TBA)	Theme Session #1					Workshop #21			
Meeting Room (TBA)					Theme #2				
Exhibit Hall	EXHIBITS WILL BE OPEN FROM 2:00 P.M. - 7:30 P.M.								
	2:00 p.m.	2:30 p.m.	3:00 p.m.	3:30 p.m.	4:00 p.m.	4:30 p.m.	5:00 p.m.	5:30 p.m.	6:00 p.m.

Workshop 1: Indicators of Systemic Reform: A Scenario-Building Workshop
5:00 - 6:00 p.m.

James Dietz, EHR/RED, National Science Foundation
Ramsay Selden, State Education Assessment Center

Enter the hypothetical State of Patucket. Brainstorm as part of a diverse group of consultants charged with designing an indicators system that can be used to monitor improvements in the education of Patucket's youth. As consultants, each group will report their recommendations to Patucket policymakers. Each group will be limited to eight participants.

Workshop 2: Learning How To Think Systemically: The Case of Assessing Student Learning
2:00 - 3:00 p.m.

Richard Lesh, EHR/RED, National Science Foundation

RED's Richard Lesh is developing a computer-based presentation for contrasting "mechanistic" and "systemic" thinking about how to assess student learning. The goal is to design 2–3 templates for the Urban Systemic Initiative.

Workshop 3: The Collaboratives for Excellence in Teacher Preparation
Large Systemic Projects: Fact and Fiction
Benefits, Challenges, and Creative Solutions
4:30 - 6:00 p.m.

Elisabeth Charron, Montana State University
Lyle Anderson, Montana State University
James Fey, University of Maryland
Susan Boyer, University of Maryland
Charles Groat, Louisiana State University

This session will provide participants with an opportunity to explore with a set of NSF-supported pioneers the advantages and challenges of systemic approaches to reform in the way teachers are prepared in mathematics and the sciences. Issues: (1) Changes in the way teachers are prepared in mathematics, the sciences, and technology need to be approached in a systemic manner. (2) Cooperation among faculty and administrators from universities, four-year colleges, two-year colleges, and school districts is crucial to the success of planning and implementing these changes. (3) Within undergraduate institutions new alliances need to be established between teaching- and research-oriented faculty within the mathematics, engineering, and science departments and their colleagues in science and mathematics education. (4) Course content, teaching methods, the implications of the new technologies, and field experiences need to be examined and reordered to reflect advances in knowledge about the subjects and how they are best learned. (5) Administrators at all levels need to recognize the current pressures for reform and support those engaged in the reform effort.

Workshop 4: Interdisciplinary Curricula: Can They Be Particularly Effective in Involving Students from Groups That Are Underrepresented in Science, Mathematics, and Engineering?
2:00 - 3:30 p.m.

Jacqueline Ross, University of Wisconsin
Robert A. Desharnais, California State University at Los Angeles
Bob Kearney, University of Idaho

This workshop will offer insight into the role that interdisciplinary courses and curricula can play in addressing the problem of involving students from underrepresented groups in science, mathematics, and engineering. PI's from three very different projects will present their individual approaches to this problem and consider what the commonalities and differences are among the projects. Workshop participants and PI's will consider questions such as (1) Are there particular attributes that underrepresented groups possess and perhaps share that make them disinclined toward science, and (2) Is there something special about interdisciplinary courses and curricula that can address this disinclination?

Workshop 5: Revitalizing Laboratory Instruction through New Technologies I
4:00 - 5:00 p.m.

John Jungck, Beloit College
Helen Kuznetsov, University of Illinois
Nathan Lewis, California Institute of Technology

The use of new technologies has revolutionized the delivery of undergraduate science, mathematics, and engineering instruction. This workshop will provide details on the implementation of these changes and any roadblocks or impediments that may have occurred. The technological innovations will be demonstrated in the exhibit area.

Workshop 6: Revitalizing Laboratory Instruction through New Technologies II
5:00 - 6:00 p.m.

Thomas Banchoff, Brown University
Kathryn Cruz-Uribe, Northern Arizona University
Laurence Marschall, Gettysburg College

The use of new technologies has revolutionized the delivery of undergraduate science, mathematics, and engineering instruction. This workshop will provide details on the implementation of these changes and any roadblocks or impediments that may have occurred. The technological innovations will be demonstrated in the exhibit area.

Workshop 7: **Interactive Mathematics Project**
2:00 – 3:00 p.m.

Edward Wolff, Beaver College

This is a four-year secondary mathematics curriculum featuring problem-based units. Each unit provides problems with intrinsic mathematical applications to physics, economics, art, sociology, or other fields. Concepts and skills are learned in the context of solving problems. Manipulative materials, cooperative learning, writing as an adjunct to mathematics learning, and the use of graphing calculators and computers are incorporated into classroom instruction. Families become involved in the curriculum through the addition of Family Math classes.

Workshop 8: **Investigation in Number, Data, and Space**
3:00 – 4:00 p.m.

Cornelia Tierney, Technical Education Research Center

This is a demonstration of a hands-on, comprehensive mathematics curriculum for grades K–5 based on investigations in number, data, and space, and emphasizing depth and understanding. The curriculum stresses mathematics as a pattern-finding science, builds on teachers' knowledge of how students learn mathematics, and provides 10 developmentally appropriate curriculum modules for each grade level.

Workshop 9: **"Operation Smart" and "Smart Eureka!"**
4:00 – 5:00 p.m.

Ellen Wahl and Libby Palmer, Girls Incorporated

This workshop will highlight concrete strategies from informal science education programs that are applicable to systemic reform in math and science education. "Operation Smart" is an inquiry-based, hands-on, equitable, and fun math and science program for girls held at nationwide Girls Incorporated centers. "Operation Smart" has been adopted by other youth organizations nationwide and is increasingly sought by school systems and state education departments.

"Smart Eureka!" is an intensive summer program that takes place on a college campus and combines math, science, and sports. It connects the summer experience and the school year through coordinated curricula and school year follow-up. The community, postsecondary institution, and the school system attempt to foster girls' persistence and achievement in math and science. The project is particularly directed toward girls of color and girls from poor families.

Workshop 10: Cleveland Inquiry-Based Science Program
5:00 - 6:00 p.m.

Karen Worth, Wheelock College
Judy Sandler, EDC
LaWanna White, Cleveland Board of Education

The Cleveland Public Schools and the Cleveland Education Fund, with the support of the Education Development Center, have formed a partnership to implement an exemplary, inquiry-based science program. The goal of the program is for every elementary school in Cleveland to adopt a hands-on science program and to employ an informed principal and team of educators ready to introduce students to the new program. This project provides an opportunity to examine closely the process required to change the science program in a system that is firmly committed to decentralization and school-based management.

Workshop 11: Montana State Teacher Enhancement Project
2:00 - 3:00 p.m.

Gerald Wheeler, Public Understanding of Science, AAAS
Kim Obbink, Montana State University

This three-year project provides an opportunity for 150 teachers, through an on-line computer network, to take six courses selected from a prior successful NSF program. These courses have been revised to conform to the requirements of the electronic delivery system. Teachers will be provided with text, a study guide, and a kit of materials for hands-on activities. A final evaluation of the project will study the effectiveness of this approach and of the changes made in classrooms due to the project. These findings will be compared with those of on-site teaching-enhancement programs.

Workshop 12: Integrated Mathematics, Science, and Technology
3:00 - 4:00 p.m.

Franzie Loepp, Illinois State University

The Center for Mathematics, Science, and Technology is developing integrated materials concerning biotechnology, manufacturing, and forecasting. Each unit includes objectives, experiential learning, appropriate use of multimedia, appropriate technology, and evaluation instruments. This year-long, 120 minutes per day curriculum includes an 18-week Bio-Related Technologies unit with modules in Food Production, Wellness, Waste Management, and Energy Transformation; a 9-week Manufacturing unit; and a 9-week unit in Forecasting. Attention is given to preparing materials that motivate all student, especially those from groups underrepresented in technological careers, to learn the foundational mathematics, science, and technology concepts by involving them in enriched learning experience relevant to their daily lives.

Workshop 13: **Developing Public Awareness: The Connecticut SSI**
4:00 – 5:00 p.m.

Mary Keeney, Connecticut SSI

Mary Keeney will describe how Connecticut has developed a successful public awareness campaign for mathematics and science education reform through partnerships with commercial and public television, the state's largest newspaper, and private corporations.

Workshop 14: **Developing K–12/Higher Education Partnerships: The Louisiana SSI**
5:00 – 6:00 p.m.

Kerry Davidson

Kerry Davidson and other members of the LaSIP staff will describe how professional development efforts are at the heart of Louisiana's statewide systemic initiatives program.

Workshop 15: **The Urban Systemic Initiatives Program (USI): Initiating Reform**
3:00 – 4:00 p.m.

Madeleine Long, EHR/OSR, National Science Foundation (Moderator)
Alfredo de los Santos, Maricopa County Community College
Angie Johnson, General Superintendent
Charles Meredith, New York Technical College

Cities initiating the Urban Systemic Initiatives Program face a number of complex issues including establishing appropriate leadership configuration, incorporating existing SMT programs into the USI, and implementing city-wide reforms with different governance structure. Madeleine Long will chair a panel of representatives from Phoenix, Chicago, and New York.

Workshop 16: **The Rural Systemic Initiatives (RSI) Program: Providing Feedback to a New Systemic Initiative**
2:00 – 3:00 p.m.

Jody Chase, EHR/OSR, National Science Foundation

Jody Chase will give participants an opportunity to respond to NSF's thinking about this new program.

Workshop 17: Ventures in Reform: Improving SMETE in the D.C. Public Schools
2:00 - 3:00 p.m.

Betty Ruth Jones, EHR/HRD, National Science Foundation (Moderator)
Maxine Bleich, Ventures in Education
Franklin L. Smith, Washington D.C. Public Schools

This workshop will focus on a variety of intervention efforts in the Washington, D.C., public schools designed to increase the academic achievement of minority students. The general strategy is to amplify the synergistic effect between the various projects. (The monitoring and evaluation activities will be of special interest since there may be overlap in some funded projects.)

Workshop 18: Reforming Milwaukee Public Schools Through Equity 2000
3:00 - 4:00 p.m.

Wanda Ward, EHR/HRD, National Science Foundation (Moderator)
Vinetta Jones, The College Board;
Howard Fuller, Milwaukee Public Schools

Equity 2000 is an educational component of the College Board. The general theme of "Academic Excellence for all Students" permeates several Equity 2000 systemic reform activities. Some specific projects include Principals, Institutes, and Staff Development Institutes for mathematics teachers and guidance counselors. One of the most successful systemic reform projects is in the Milwaukee Public School system.

Workshop 19: Using Database Dynamics for Systemic Reform
4:00 - 5:00 p.m.

Costello Brown, EHR/HRD, National Science Foundation (Moderator)
William McHenry, EHR/HRD, National Science Foundation (Moderator)
Alfred G. de los Santos, Jr., Maricopa Community College
Ernesto Ramirez, Jr., Maricopa Community College

Several programs in EHR have established databases for program monitoring and eventually evaluation. These databases can be manipulated to produce several kinds of reports regarding student grades, completed courses, ethnicity, gender, and more. This is a hands-on workshop demonstrating how a student can be tracked through the system with a database.

Workshop 20: Harold Stevenson: The Learning Gap
4:00 - 5:00 p.m.

Harold Stevenson

Harold Stevenson, author of The Learning Gap, will discuss how research on mathematics teaching and learning in Japan, Taiwan, and China is influencing the reform of mathematics teaching in the United States. The discussion will include Asian Curriculum Guidelines, how teachers introduce, develop, and bring closure to mathematics lessons to ensure optimum learning, as well as examples of Asian manipulatives, mathematics texts, workbooks, and magazines. Stevenson will also discuss attempts to implement some Asian practices in American classrooms.

Workshop 21: Kaleidoscope
4:30 – 6:00 p.m.

Patricia McGuire White, Agnes Scott College
James Callahan, Smith College
Joseph Priest, Miami University
Jeanne L. Narum, Independent Colleges Office

Project Kaleidoscope (PKAL) is an informal national alliance to strengthen undergraduate science and mathematics. This workshop will feature three programs that illustrate different approaches to making fundamental change in undergraduate programs. (1) SHARP!Women at Agnes Scott College brings together undergraduate researchers, high school teachers, and women high school students to work on a research project with a college faculty member. Through the research experience and by serving as mentors to the high school team members, the undergraduates begin to see what science is "really about." (2) The Five College Calculus Project (Amherst, Hampshire, Mount Holyoke, and Smith Colleges) encourages students to do collaborative work; use calculus as a language and a tool; become comfortable with large, messy, and ill-defined problems; and develop the sense that the understanding of concepts arises out of working on problems—not simply from reading a text and imitating techniques. (3) The Miami University Physics Introductory Sequence Education Project emphasizes the presentation of modern physics and hands-on experiences in the lab. The goal of the course is to convey to students early in their academic career an understanding that the 20th century has brought revolutions in physics and that these revolutions continue to occur within the students' own lifetimes.

Exhibits

Exhibit 1: **Interactive Computer Laboratory for Archaeology Students**

Kathryn Cruz-Uribe, Northern Arizona University

Archaeology, by its very nature, is an experiential, hands-on field. Yet ethical and legal concerns make it difficult to teach archaeology using actual archaeological materials. The project is developing interactive computer programs in Hypercard on the Macintosh to teach archaeology using visual images. The students analyze archaeological materials on the screen and interpret their results. Students learn how archaeological data are collected, analyzed, and applied within a problem-solving context.

Exhibit 2: **Laboratory Approach to Introductory Differential Geometry**

Thomas F. Banchoff, Brown University

Differential geometry of curves and surfaces has an important role in solidifying the standard courses in beginning calculus and linear algebra. The topic provides the tools for visualization of geometric phenomena and for applications to physics, engineering, computer science, and other areas of mathematics. The subject is particularly well suited to interactive computer graphics. A complete set of transportable, interactive computer graphics laboratory modules is being developed. The materials can be used to supplement standard courses in calculus and linear algebra, or to supplement a standard textbook in elementary differential geometry.

Exhibit 3: **Interactive Computer-Based Instruction**

Helen Kuznetsov, University of Illinois

This project has developed innovative methods for interactive teaching and testing of engineering students by computer. Courseware for engineering statics has been developed and tested. Problem-solving sessions and examinations are presented to students, with new problems selected each time the lessons are used. Appropriate feedback is given throughout the problem-solving process. The computer judges sophisticated responses, such as algebraic expressions, sentences, and cursor locations.

Exhibit 4: **Modernizing this Astronomy Laboratory with Simulation and CCD Imaging**

Laurence A. Marschall, Gettysburg College

Astronomy is the first and only experience in science for many college students. Yet laboratories in introductory astronomy have suffered because of difficulty of doing experiments with the faint light of the heavens. A series of new exercises is being developed for the introductory lab. Some will be hands-on exercises centered around observations with CCD cameras on small telescopes and others will be simulations of observations, which can be extremely realistic.

Standardized software tools are being developed for all the labs, and data taking and analysis are being integrated with existing spreadsheet programs. The finished lab will consist of software, writeups, teachers' guides, and technical manuals. Software, images, other data, and manuals are available on Internet.

Exhibit 5: **Development of Computer Graphic Visualization Aids for the Undergraduate Chemistry Curriculum**

Nathan S. Lewis, California Institute of Technology

This project uses workstation-quality computer graphics to aid in the visualization of concepts in the undergraduate chemistry curriculum. It focuses on visual presentation and real-time visual manipulations. Examples of the subjects include atomic and molecular orbitals, molecular geometry, organic dynamics and structure, and docking of drug molecules. Certain concepts and visualization programs will be developed for personal computers coupled with videotapes, laser videodiscs, and other media so that the images can be used in chemistry lectures, in student tutorials, and for open-ended inquiry.

Exhibit 6: **The BioQUEST Learning Tools Development Project**

John R. Jungck, Beloit College

The purpose of this project is to promote (1) curriculum and instructional materials development, (2) material dissemination, (3) the establishment and maintenance of a viable communication network among biologists, science educators, software developers, and other interested individuals. A workshop was held to promote the development of materials that support BioQUEST's problem-solving, long-term research approach to the teaching and learning of biology (the "3P's" approach: problem posing, problem solving, and peer persuasion).

Exhibit 7: **Innovative Electronics Laboratory Instruction for the New Work Force**

Bernard Mohr, City University of New York, Queensborough

This project is aimed at strengthening and modernizing academic preparation in Electrical and Computer Engineering Technology because employers have increased academic hiring requirements commensurate with revolutionary developments and growth of emerging computer-related technology. Minorities who are expected to account for a growing percentage of the work force are grossly underrepresented in technical occupations, and this project works with the CUNY Alliance for Minority Participation grant. This exemplar project employs a comprehensive strategy to improve student mastery of engineering technology, heighten student academic participation and achievement, emulate an industrial workplace environment, and enhance academic and employment opportunities. Activities in two fundamentals laboratories are being restructured to foster improvements in the mastery of laboratory skills. Project activities include the design and development of on-line instructional resources on the departments' local area network, computer-based data acquisition and analyses, and multimedia courseware for presentations and lectures.

Exhibit 8: Analog Circuits Design—A Systems Approach

David Hata, Portland Community College

The Analog Circuits Laboratory Project aims at major curricular revisions in the Electronic Engineering Technology program. Specifically, the analog circuits sequence is changed from an emphasis on circuits as closed systems to signal processing building blocks used to implement larger systems. This change results in an increase in systems-level and frequency-domain analyses. Computer-based tools and circuit simulation techniques are integrated into existing courses. The Tektronix 2630 Personal Fourier Analyzer and system controller are the major instruments used and are accompanied by Microsim PSPICE Circuit Simulation software. The students maximize their performance through computer-based analysis and simulation tools. Following the design, the circuits and subsystems are built and tested for verification of performance in both the time and frequency domains. The project responds to the shift in engineering practices in industry and targets curricular revisions which parallel the changes in the workplace. The principal investigator on this project, David Hata, is one of the recognized leaders in two-year college curriculum development in electronics. He has won a major award given by ASEE for curriculum and program improvement. His cooperative work with the microelectronics industry and his innovative programs are widely recognized throughout the country.

Exhibit 9: Demonstration of the EHR Database

Susan Gross, EHR/RED, National Science Foundation

The EHR database continues to grow. RED evaluation staff and QRC, the EHR contractor, will be on hand to demonstrate the contents and utility of the database. Enter an NSF program, such as AMP, and get a narrative profile of each State participant. See the statistics contained in the database. They can be used as a research tool, as well as a source of "answers" to practical questions about SMET education and the effects of EHR programs.

Exhibit 10: The Power of Networking and Other "Hands-On" Demonstrations

John Clement, EHR/RED, National Science Foundation

RED's educational networker, John Clement, will demonstrate how the Internet can be harnessed for education. In addition, Compuware staff, the EHR contractor, will demonstrate the latest in workstation technology for education to access information, images, and people around the U.S.

Exhibit 11: **Science, Engineering, and Technology Careers**

Steve Rabin, Educational Film Center
Judy Kass, American Association for the Advancement of Science
Alan Friedman, New York Hall of Science

Presenters will demonstrate a science, engineering, and technology (SET) careers exhibit created for distribution to science museums, technology centers, libraries, schools, and other community sites. The core of the exhibit kiosk is SET/QUEST, an interactive multimedia program for both the Macintosh and PC/Windows, with CD-ROM as the video source. With SET/QUEST, teens and preteens can explore 30 science and engineering careers through first-person video profiles, animated/reality video simulations of work experiences in these fields, decision screens, and a database of over 200 science and math-based professions. Specific emphasis is placed on reaching and attracting female, minority, and disabled youth.

A parent outreach component has been developed to work directly with and through the national offices of science museums, public libraries, schools, and community-based organizations to involve parents and families with SET Project materials and to provide them with information with which they can foster their children's pursuit of science and math education and careers in these fields.

Exhibit 12: **"Bill Nye the Science Guy" and "CRO"**

Bill Nye, KCTS TV
Joel Schneider, Children's Television Workshop

"Bill Nye the Science Guy" is a series of 26 weekly half-hour children's science education programs produced by KCTS in Seattle. The series is being syndicated to commercial stations by Bueno Vista Films, a division of Walt Disney Production. The goals of the series are to make science accessible and interesting to children in the fourth and fifth grades by relating science to their interests and everyday activities and to present basic concepts in a humorous and exciting format. The program's host, Bill Nye, conducts demonstrations and experiments in a variety of studio and field locations. Each program will feature a diverse cast of children, scientists, and celebrity guests. Experiments that viewers can conduct at home or in school using inexpensive and safe household items will be presented. (Ancillary and outreach components include a science activity kit for use in fourth grade classes, a home activity kit, and an urban center pilot project in Los Angeles.)

"CRO" is an animated television series designed to bring informal science education to Saturday morning television's large and demographically diverse audience of children. The series, which is broadcast nationally by ABC, draws upon animation's special capabilities to illustrate the workings of basic mechanical devices. As the series' characters solve problems using these devices, they introduce young viewers to basic scientific principles. "CRO" shows children that science and technology are accessible, empowering, and relevant to their daily experiences.

Exhibit 13: Life Sciences Technology

Bud Wendtz, Bud Wendtz Productions
Martin Weiss, New York Hall of Sciences

This exhibit uses Wendtz Scopes, microscopes that enable several people (three to four children, or several children and a teacher) to look into a microscope simultaneously. Wendtz Scopes were developed to make science-technology centers more effective in presenting the biological sciences. They are now used by science-technology centers nationwide, and a portable version is being developed for use in schools. The New York Hall of Science loans these microscopes to schools for a period of three weeks through a teacher enhancement project that trains teachers in the use of the scopes and in the subject matter during the summer.

Exhibit 14: Cooper Union Young Scholars Program

Arsete Lucchesi and Ron Adrezin, Cooper Union

The Cooper Union conducts a six-week Young Scholars project in engineering for 180 high-ability, high-potential students entering the 11th and 12th grades. This summer program emphasizes the study of urban engineering problems through a creative integration of classroom demonstrations, video instruction, lectures, field trips, and team-based, hands-on laboratory exploration with Cooper Union faculty and advance engineering undergraduates. High school students who participated in the 1993 summer research internship program will exhibit their original works and papers.

Exhibit 15: FOSS Elementary Science Curriculum

Mary McDonald, Encyclopedia Britannica
Linda De Lucchi and Larry Malone, University of California

Encyclopedia Britannica, publishers of FOSS, will exhibit and demonstrate K–6 science-education kits. These kits provide all the text material and equipment needed for a classroom science program.

Exhibit 16: Active Physics

Arthur Eisenkraft

"Active Physics" is a course developed by the American Association of Physics and the American Institute of Physics. For 9th and 12th grade students, it consists of six thematic units—sports, transportation, communications and information, health and medicine, home, and forecasting—that revisit fundamental physics concepts in a spiral approach, applying them to new and real-world contexts. The course is consistent with the AAAS 2061 themes, particularly materials and energy, and can be taught in a one- or four-year span. Students' mathematical level will be enhanced in accordance with the NCTM Standards. Students will be able to recognize and begin to understand the broad unifying concepts of physics and technology, to gain an appreciation of science as a process, to apply the concepts to realistic problem-solving and decision-making activities, and to identify and evaluate personal and societal effects of technology.

Exhibit 17: National Science Standards

Harold Pratt and Angelo Collins, National Research Council
Rodger Bybee, BSCS

The first complete, public draft of the National Research Council's Science Standards will be available for criticism and consensus at the booth.

Exhibit 18: Priming the Pump—Connected Geometry

Al Cuocco, Educational Development Center

The Educational Development Center will present a set of curriculum materials and accompanying teacher materials that use geometry to bring a culture of mathematical exploration into the high school classroom and to interconnect students' experiences. The materials include geometry software and hands-on activities.

Exhibit 19: Stevenson's Learning Gap Exhibit

Harold Stevenson

The exhibit will include the video "Polished Stones," examples of Asian mathematics textbooks, workbooks, mathematics manipulatives, and problems sets as well as illustrations of actual comparative data/research findings from Asian and American mathematics classrooms.

Exhibit 20: Revitalizing Laboratory Instruction through New Technologies I

John Jungck, Beloit College
Helen Kuznetsov, University of Illinois
Nathan Lewis, California Institute of Technology

The technological innovations that were discussed in the workshop and that have revolutionized the delivery of undergraduate science, mathematics, and engineering instruction will be demonstrated in this exhibit.

Exhibit 21: Revitalizing Laboratory Instruction through New Technologies II

Thomas Banchoff, Brown University
Kathryn Cruz-Uribe, Northern Arizona University
Laurence Marschall, Gettysburg College

The technological innovations that were discussed in the workshop and that have revolutionized the delivery of undergraduate science, mathematics, and engineering instruction will be demonstrated in this exhibit.

Briefing Papers

Indicators of Mathematics and Science Education

Larry E. Suter
National Science Foundation

Statistical indicators of the status of science and mathematics education are designed to inform the Nation about changes in schools, students, and teachers. Indicators are statistics that instruct us about significant changes in education. They are chosen with care from an ocean of numbers to address national questions facing policymakers. Often, they are created with a general model of systems in mind so that they reflect the factors that are "inputs" to schooling, the classroom "processes" that occur in schools, and the student performance "output" that is measured by student assessments. While such a general systems model oversimplifies the schooling process, it helps us choose among many possibilities.

Specific selection of topics to be addressed by statistical indicators are chosen by matching available statistical sources with the issues raised in national reports. For example, the 1983 Commission on Excellence focused a bright spotlight on the status of education in the United States by drawing attention to the results of a number of international comparisons of the achievements of U.S. elementary school students. Also, in 1990, the Nation's governors and the President approved a set of National Goals for education that increases attention to mathematics and science education by asserting that the United States must strive to be first in the world in mathematics and science by the year 2000. Thus, an indicators report would certainly include the latest information about international studies of student achievement. Furthermore, the NSF goal for the directorate of Education and Human Resources is to increase understanding of mathematics and science among all students. The NSF is concerned with the quality of education at the undergraduate level and with informal sources of learning science as well as at elementary and secondary schools. Thus, our indicators selection included charts on student achievement for minorities, and it included information on undergraduates.

The Indicators Program of the Division of Research, Evaluation, and Dissemination has focused research studies specifically on the subjects of mathematics and science. The findings of those studies are summarized every two years in a report on the Indicators of Science and Mathematics Education. Major new indicators that have been created to describe changes in student performance, in selection of science and mathematics fields, and in qualifications of teachers will be summarized here.

Student Performance

Are elementary and secondary school students performing better today in mathematics and science subjects than they were previously? Are improvements in achievement levels being made by minorities and women or in specific regions of the country?

Mathematics proficiency scores were stable for white students between 1970 and 1990 while they increased for African-American and Latino students. Scores for African-American students have improved significantly (about 20 points) since 1973 at ages 9, 13, and 17. Younger Latino students (ages 9 and 13) and white students (age 9) also experienced gains in their average mathematics proficiency scores, while scores for the older students remained about the same. The greatest increases for minority groups occurred for those who were in the lower half of their age group.

Science proficiency did not change in quite the same way as mathematics. Scores for white students declined for all age groups until 1982, then rebounded for younger students (ages 9 and 13) and had not returned to 1970 levels by 1990. However, scores for African-American students in 1990 have returned to their original 1970 level. Only young African-American and Latino students (age 9) experienced real growth over the 1970's scores.

Of special interest in the changes in test scores during the 1970's and 1980's was a narrowing of the gap between highest achieving and lowest achieving students in mathematics for African-American students. Increases in student achievement are especially noticeable among those students in the lower half of performance levels.

The distribution of scores for students who intend to enter college and take the SAT shows that more females than males took the test but that they scored significantly lower.

Curriculum and Instructional Practices

Have schools and States increased student course-taking requirements in mathematics and science?

The number of states requiring more than two years of mathematics courses for graduation increased from 2 percent in 1980 to 24 percent in 1990. Enrollment in some advanced science and mathematics courses increased as State graduation requirements for science and mathematics were raised across the country. However, few students took the most advanced science courses offered in schools.

Quality of Teaching Force

How well prepared for teaching mathematics and science are today's U.S. elementary and secondary school teachers?

Recent surveys of the elementary and secondary school teaching force address the issue of teacher preparedness. Most elementary teachers who specialized in teaching science or mathematics did not earn bachelor's degrees in science/science education or in mathematics/mathematics education. Fewer science teachers than, for example, reading teachers reported that they felt very well qualified to teach their subjects.

Many teachers of high school science and mathematics subjects taught those courses as a second assignment. Teachers with a second assignment in science or mathematics instruction were less prepared than teachers whose main assignment was science or mathematics—that is, they were much less likely to have degrees in mathematics or science.

How is the profile of current and prospective science and mathematics teachers changing with respect to age, race and ethnicity, and gender?

Most minority students do not have minority teachers. In an increasingly heterogeneous society, however, all students need to see effective teachers who come from different backgrounds, ethnic groups, and races.

Male teachers were underrepresented at the elementary level, accounting for only 10 percent of all teachers in 1987–88; however, the male underrepresentation was less pronounced for teachers who specialized in teaching mathematics (18 percent) and science (34 percent). At the secondary level, women were underrepresented in chemistry and physics.

Student Interest in Science Fields

Do a large number of students leave elementary school with an interest in the science fields only to find them changed during secondary school and college?

High school sophomores who were studied for six years expressed a decreasing interest in science and mathematics fields. Approximately 13 percent of the students expressed an interest in scientific fields when they were high school sophomores. This fell to 9 percent when they were high school seniors and to 7 percent when they were of age to be seniors in college. Only 18 percent of the students who expressed an interest in science as sophomores were still interested as college seniors. Thus, most of the college graduates in the sciences are most likely to be drawn from students who did not express an interest in the science fields during early years of high school.

Conclusions

The national indicators that have been highlighted in the first volume of *Indicators of Science Mathematics Education* help dispel some myths about recent trends in education and suggest some priorities for educators. The ultimate purpose of most education policies is to improve student learning. The national surveys have shown that student achievement levels improved measurably for minorities during the 1980's. The reasons for these changes are not immediately obvious; however, changes in the curriculum provided in the schools may be the answer. Since the Commission on Excellence Report was released in 1983, many States have altered their level of requirements for students so that additional courses in mathematics are needed for graduation. More students are taking more courses in mathematics during high school. However, the indicators about training of teachers suggest that additional efforts to improve the training of the teaching force is needed. These findings suggest that continued emphasis on improving the curriculum of mathematics and science and efforts to obtain teachers with college level training in the mathematics and sciences in all schools will continue to improve student performance in the future.

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NAEP SCIENCE, 1970-90: TRENDS IN AVERAGE SCIENCE ACHIEVEMENT BY GENDER, AGES 9, 13, AND 17

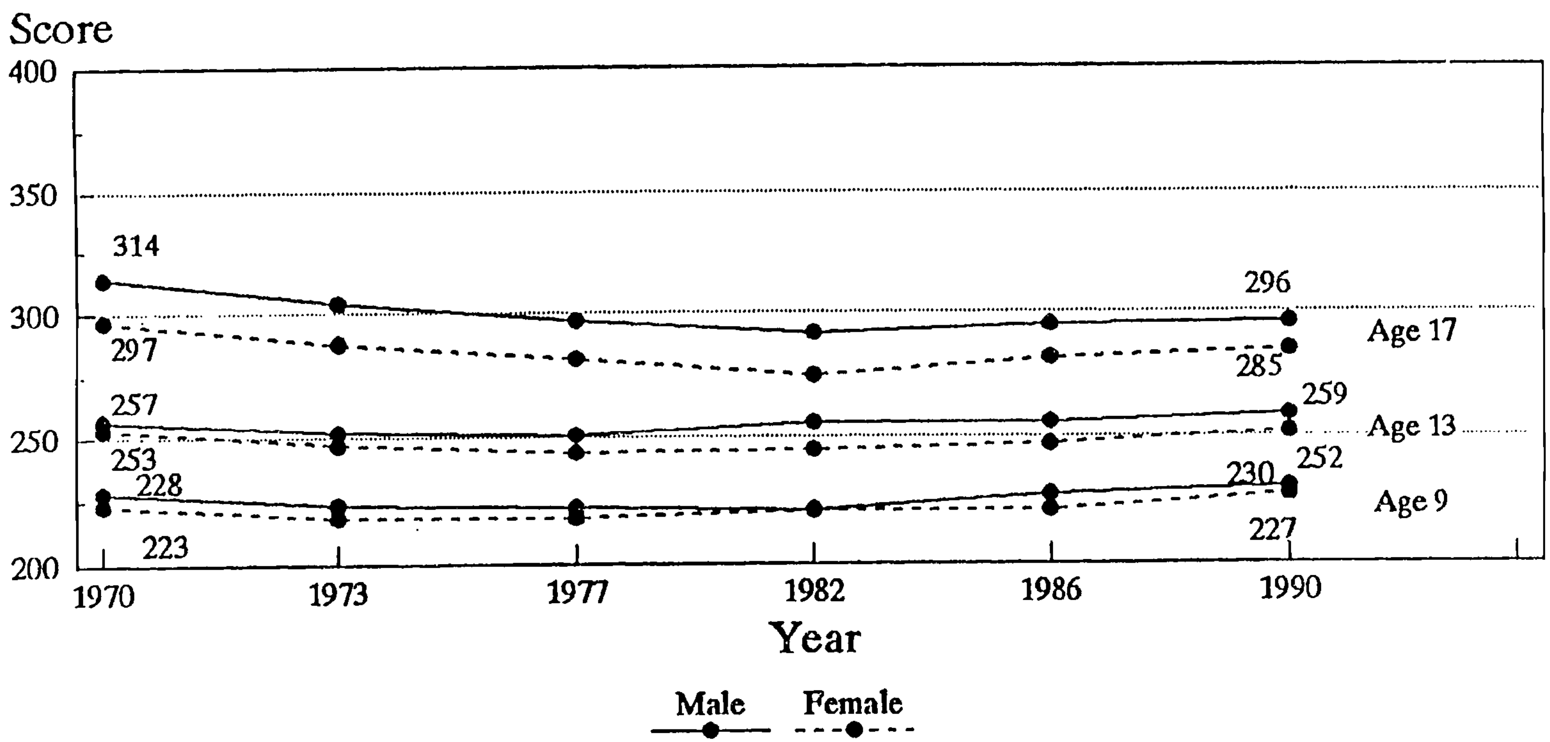

Exhibit reads: In 1970, 17 year old males scored 314 on the NAEP science test, and 17 year old females scored 297.

Source: NCES Trends in Academic Progress, 1991.

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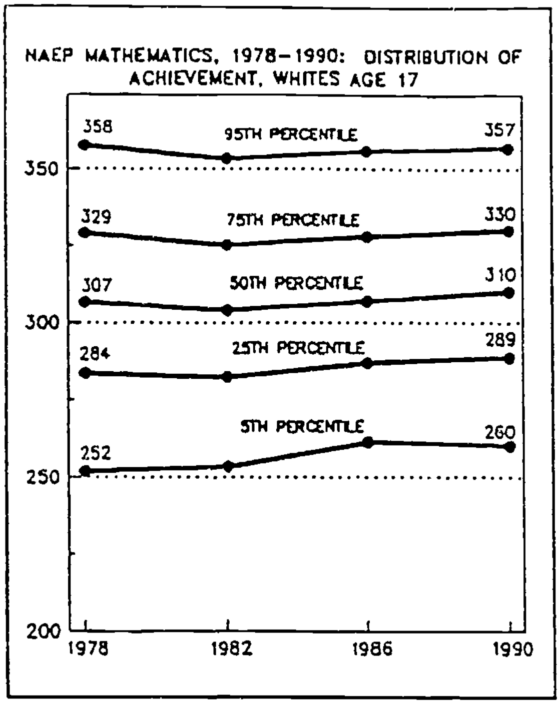
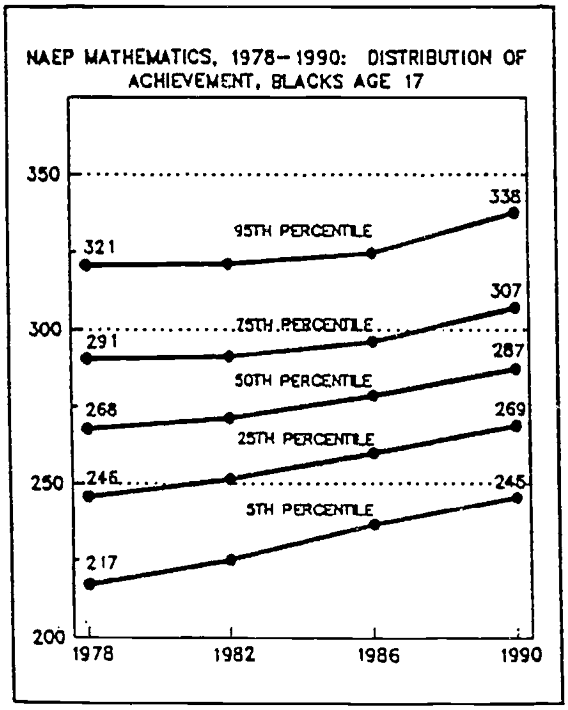
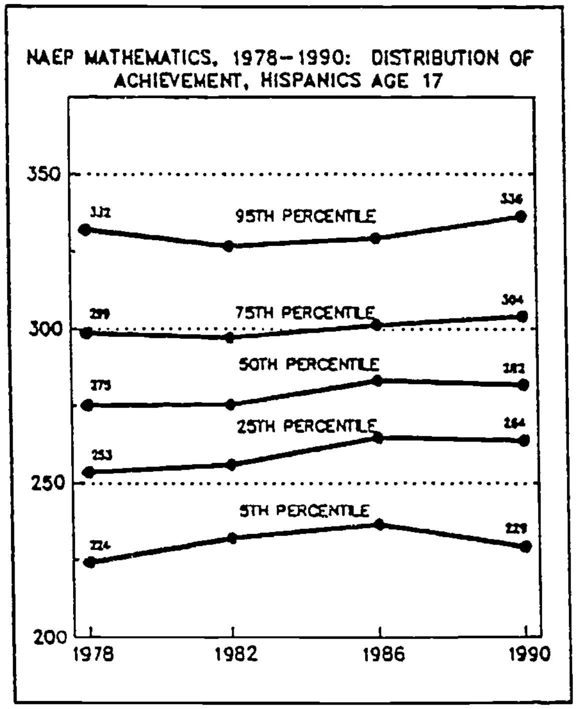
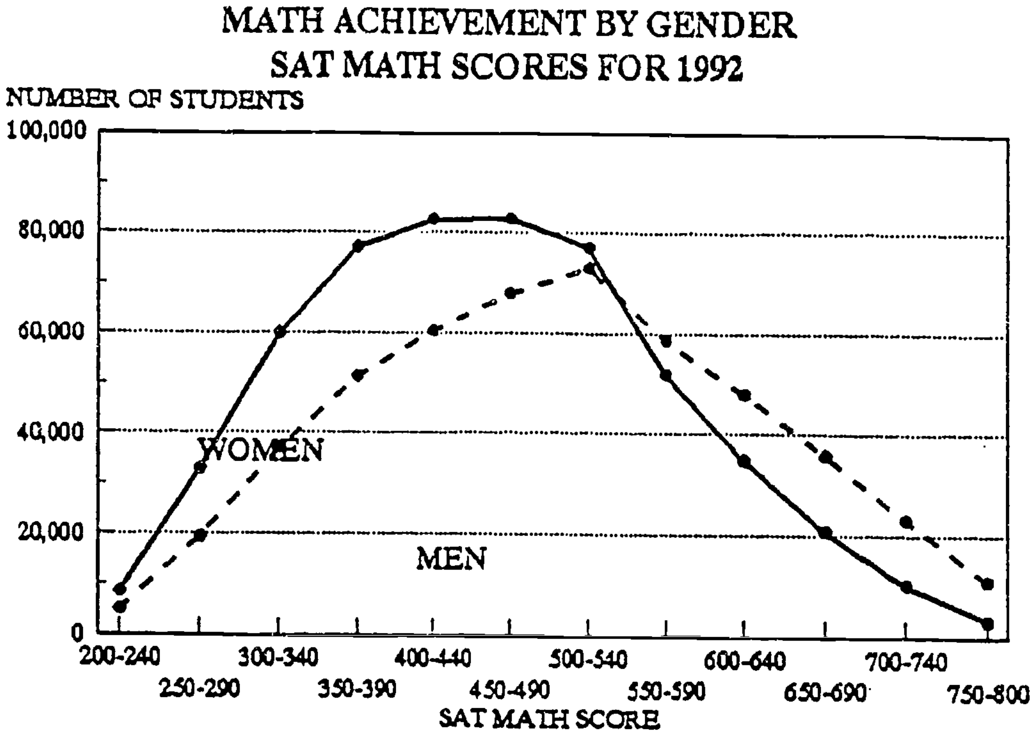




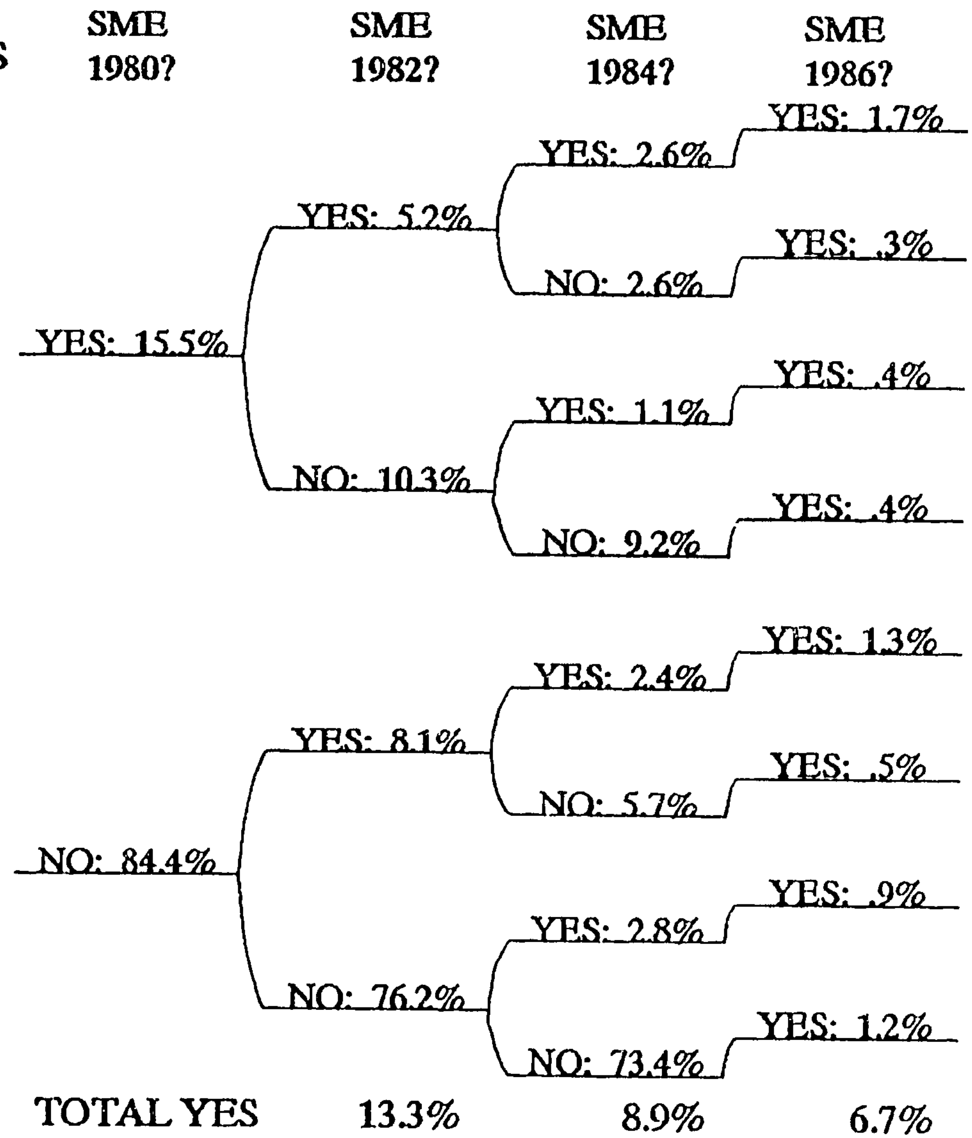


Source: NCES, Trends in Academic Progress, Washington, DC: U.S. Department of Education, 1991.



Source: The College Board, College-Bound Seniors:
SAT Profile, 1992.

PERCENT OF STUDENTS CHOOSING SCIENCE, MATHEMATICS, OR ENGINEERING AS THEIR FIELD OF STUDY: 1980 TO 1986 (HIGH SCHOOL AND BEYOND 1980 SOPHOMORE COHORT)



Source: Thomas B. Hoffer, Career Choice Models Based on the High School and Beyond, Paper present at the Annual Meeting of the American Educational Research Association, April 12, 1992.

NSF's Programmatic Reform: The Catalyst for Systemic Change

Joseph G. Danek, Roosevelt Calbert, and Daryl E. Chubin[1]
National Science Foundation

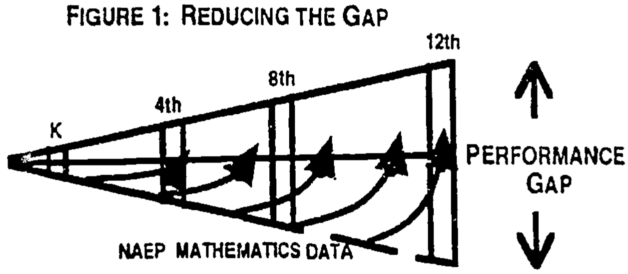
The Problem

There is agreement on the quality of K–12 mathematics and science education in the United States. It is not adequate.

Studies have documented that U.S. students are not acquiring sufficient skills and knowledge or developing appropriate attitudes to help them compete in an increasingly technological society. Among industrialized countries, U.S. students rank near the bottom in mathematics and science achievement for 9-year-olds and 13-year-olds on the International Assessment of Educational Progress (IAEP).

A large proportion of American students receive inferior educational experiences, in general, and exceptionally poor science and mathematics instruction, in particular. The children most adversely affected by our current education policies and practices are typically economically poor and/or belonging to a minority population. Figure 1 graphically displays the gap in performance among white students and underrepresented minority students from kindergarten through 12th grade. This national pattern is repeated in virtually every state and is even more striking in major urban areas.

FIGURE 1: REDUCING THE GAP



8th graders performing at or above basic achievement level

White:	73%
Latino:	37%
African American:	26%

Note: Figure is not drawn to scale.

[1]The authors are Division Directors in the National Science Foundation's Directorate for Education and Human Resource.

Within the United States, three quarters (73 percent) of all white 8th graders perform at or above basic level in mathematics on the National Assessment of Educational Progress (NAEP) tests, whereas only 37 percent of Latino 8th graders and 26 percent of African-American 8th graders perform at or above basic levels. Thus, after eight years of formal education, two-thirds of Latinos and three-quarters of all African-American students lack basic mathematics preparation. With such deficiencies, these students have little foundation to acquire jobs that will allow them to live full and productive lives.

Before age 14, U.S. schools confer second-class status on a majority of African-American and Latino youths, and other economically and disadvantaged youths, in the Nation. Yet, as a group, African-American and Latino children are expected to compose close to 50 percent of the Nation's precollege students by the year 2030. The key to improving the overall health of the Nation lies in raising the performance of Latino and African-American students and other economically disadvantaged youths to at least the current national average for white students. This national policy that fails to address the developmental and educational needs of these students is both irresponsible and shortsighted.

Every year inquisitive and talented children enter kindergarten with high expectations, a desire to understand the world around them, and a right to learn. For those in affluent America, the experience is mostly positive, even if it is not on a par with the Japanese or the Taiwanese. For others, education is a decidedly negative, debilitating, and unrewarding experience. The tragedy is that these youngsters know it, but feel powerless to change their fate, and ultimately conclude that they are inferior in capability.

And so, the negative slide accelerates. The issue is not one of capability but of the opportunity to learn and to develop habits of the mind for acquiring skills and applying knowledge.

Note the negative educational slope in Figure 1 with "breaks" that represent school dropouts. Up to the eighth grade virtually all students remain in school. Subsequently, a greater proportion of minority inner-city and rural-poor students fail to complete high school. Equally important is the very high number of students who remain in school but fall behind in performance. For example, at age 14 one in four white students falls one year behind their age cohort; twice as many African-American students fall one year behind. At age 17 the proportion of white and African-American students nationwide that have dropped out of school is equal, at about 10 percent. However, 47 percent of African-American students compared with 29 percent of white students lag behind their age cohort by at least one year. This "system failure" is a result of cumulative failures of parents, teachers, administrators, and other officials.

Because schools are embedded in communities and local economies, their failure reflects the conditions of the environment. This environment is often gripped by disadvantages. Many minority male dropouts end up in jail, while many of their female counterparts become young mothers. It is not uncommon for the child of a 14-year-old eigth-grade dropout to enter kindergarten with minimal preschool educational experiences before her mother reaches 20 years old. And so the cycle continues.

As a nation, we pay the price for such seeming irresponsibility in the form of welfare, unemployment compensation, food stamps, subsidized housing, high crime rates, teenage pregnancies, and infant mortality rates in our inner cities that exceed many third world countries. It is not surprising that poverty and disadvantages pervade schooling as well. The cumulative effect of these conditions on the Nation is devastating. Why do we continue in the 21st century to deprive selected children of the educational opportunities they deserve? Why do we tolerate the existence of educational enterprises that victimize participants?

Nowhere is this more pronounced than in our inner cities, where an intolerably low proportion of students achieve proficiency levels in reading, writing, and mathematics equal to their suburban counterparts. Clearly, the current system is not working. What rational public policy allows this to occur? Only one which believes that "inner city" students cannot perform, or, worse yet, one that seeks the current results.

Clearly, the health of the science and technology (S&T) enterprise is dependent on raising the capability of U.S. students in science and mathematics to a level where they are competitive with students in other countries. However, the economic well-being and future of the Nation would be more positively affected if we set, and achieved, a national goal to accelerate the rate of achievement of economically poor and minority students.

How can we close the science, mathematics, engineering and technology (SMET) performance gap between these students and their more affluent predominantly white counterparts by the year 2010?

It cannot be done through incremental enhancement to the existing system. It can only be accomplished by (1) changing the national mentality; (2) revising the goals of the U.S. educational system; and (3) developing a cadre of brave new educators who accept the risks associated with change rather than maintain the status quo.

It cannot be done until the system for allocating federal and local funds is reexamined and modified to serve the best interests of the Nation. Federal funds must reach critical regions and organizations that will take the leadership in closing the educational performance gap. In over half of the 25 cities designated as eligible for the Foundation's Urban Systemic Initiative, educational institutions, school districts, and other nonprofit organizations received less than $1 million from NSF for SMET education activities in FY 1993. This initiative and the newly proposed Rural Systemic Initiative begin to redress the imbalances by focusing attention on disadvantaged urban and rural regions.

The National Campaign for Systemic Reform

Nationally, we are engaged in a campaign, full of debate, to bring about systemic reform in science and mathematics education. We face major problems. Too many people use "buzz words," have not internalized their meaning, and often are not prepared to make the personal and organizational adjustments to achieve change. Even if we all agreed on what we seek through this process of systemic reform, we lack the educational infrastructure in many "states and regions" to deliver change, including qualified teachers, facilities, curriculum materials, governance structures, and leaders dedicated to systemic reform and to building complete K–12 mathematics and science education systems.

Many practitioners have defined systemic reform. However, most definitions share only some of the essential components: (1) national standards for mathematics and science content skills and attitudes, teaching and assessment standards, and opportunity to learn standards; (2) ambitious learning expectations and outcomes for all students connected to a rigorous academic core program; (3) examination of policies, practices, and behaviors, and their modification to remove barriers and achieve the standards; (4) broad-based involvement in designing and implementing an action plan, with considerable local autonomy in implementing the plan; (5) qualitative and quantitative outcomes that measure "systemic change"; (6) a system for monitoring and evaluating progress and adjusting programs accordingly; and (7) a timeline for delivering the outcomes.

When the above changes work in concert, then and only then do we have effective systemic reform. Systemic reform is a process, not an event. To engage in this process requires a set of hypotheses, working beliefs, operating principles, and a commitment and willingness to change to achieve specified quantitative and qualitative outcomes. Systemic reform must include all of the above components.

Systemic reform must engage all parts of the educational enterprise simultaneously. This includes teacher preparation and professional development, curriculum and materials development and implementation, school governance, finance, pedagogy, and assessment.

While the aforementioned concepts are important, we would argue that another set of principles must be set forth to guide the national systemic reform effort.

- If change is to be systemic in SMET education, it must be viewed within the context of the full science and technology enterprise. All sectors of our society must participate.
- Elimination of the performance gap between disadvantaged and minority students and their white advantaged colleagues must be a primary goal.
- Ambitious standards and strong core programs in science and mathematics for all students that go beyond "basic skills" to problem solving and critical thinking are required.
- Creation of an adequately trained S&T work force that reflects a population from which it is drawn is a necessary outcome.
- Student achievement must serve as the ultimate measure of effectiveness.

Adherence to these principles is a significant departure from prior policy and practice. In the past, SMET education focused attention on those students "preordained" as the most capable. The Nation employed an "innate ability" paradigm and "sort and select" was the operating principle that steered the education policies, practices, beliefs, and behaviors. Often judgments about children were made on the basis of educationally irrelevant criteria, including socioeconomic status, ethnic group, and gender.

Further, the "innate ability" paradigm is deeply embedded in the S&T pipeline metaphor that has guided much of our thinking, policy development, and practices in the 1980's. The Nation was obsessed with Ph.D. production and faculty regeneration. All other degrees were viewed as "dropouts" or "leaks" in the pipeline. Systemic change policies must seek S&T personnel at multiple levels, from technician through the Ph.D. The health of the S&T enterprise demands this. The Nation depends on exploiting, not wasting, the talents of all students.

Systemic reform requires a change to an "efficacy paradigm" designed to mobilize national resources to develop the majority of the students that will be in our classrooms in the next 20 years. "Sort and select" is not a viable national strategy. "Opportunity to learn" cannot be a hollow phrase. Standards and assessments are meaningless without a framework that integrates resources and practices into an effective educational delivery system.

Finally, reform for all students requires that we do more than develop "bias-free" curricula, embrace "choice-through-voucher" rhetoric, or ensure adequate representation on reform groups and projects. We must acknowledge the absence of a viable educational system for most students that reside in our inner cities and economically disadvantaged rural regions. It is too late to fix the system for these children; we must build a viable alternative system. In the absence of such action, systemic reform initiatives will fail.

The NSF Response: Programmatic Systemic Reform

Over the past three years, the National Science Foundation has modified and enhanced its core programs at all levels to be consistent with the above principles and has launched a set of comprehensive programs to reform K–12 mathematics and science education nationwide. These include the following:

- the Statewide Systemic Initiatives (SSI) program—operating in 25 states and Puerto Rico;
- the Urban Systemic Initiatives (USI) program—beginning in 1994 to serve 25 cities;
- the Rural Systemic Initiatives (RSI) program—to focus on critical economically disadvantaged rural regions; and
- a coordinated set of Human Resource Development (HRD) programs encompassing the entire educational continuum focused on underrepresented groups.

The SSI program currently operates in 25 states and the commonwealth of Puerto Rico. The focus of the program is on stimulating major reform in existing policies and practices in K–12 science and mathematics instruction. Broad-based teams composed of school administrators, teachers, university faculty, business and industry leaders, and parents are engaged in implementing standards for what students must know and be able to do in science and mathematics. These standards are being aligned with educational polices and practices to support the new standards and provide local school districts with the means to deliver the new standards to all classrooms and students in their states. This initiative, in which NSF is an active participant, started in 1991.

The Foundation has recently completed a formative evaluation of the SSI program and conducted a comprehensive review of the first 10 SSI states. SSI's principal goal is work force development; its secondary goal is performance gap reduction.

The USI program focuses on the 25 U.S. cities with the largest number of school-age children living in poverty. The program was initiated in 1992 with planning grants to cities to conduct self-studies, establish baselines, and design science and mathematics improvement plans that will radically alter current educational outcomes of city schools K–12 in science and mathematics. This program's primary goal is eliminating the performance gap between inner city students and their suburban counterparts by the year 2010. Currently, mayors, school superintendents, and other key leaders in the cities and states are developing systemic mathematics and science reform plans. A new relationship is being forged between the Foundation and these cities.

Cities are not in competition with one another per se for awards. They are in competition with the "problem" (i.e., the unacceptably low performance of their students) and with a standard of quality.

The RSI program is the most recent effort in addressing barriers to systemic and sustainable improvements in science, mathematics, and technology education in rural, economically disadvantaged regions of the Nation. The RSI is designed to fund projects from coalitions in regions defined by similarities in social, cultural, and economic circumstances, rather than by governmental boundaries. The program supports planning activities to form partnerships and determine present needs, resources, future goals; technical assistance to develop strategies to achieve those goals; and implementation of strategies directed toward systemic educational reform.

The HRD programs provide a comprehensive and coherent initiative to broaden participation of individuals from underrepresented groups in science and engineering.

HRD programs are directed toward an overall NSF goal of producing 50,000 baccalaureates and 2,000 doctoral degrees earned annually by minorities underrepresented in science and engineering. HRD programs will make a marked difference over the next decade in the number of minorities that enter and succeed in S&M careers. The programs are directed at stimulating systemic change and addressing the entire educational continuum, from precollege through career development. The Comprehensive Regional Centers for Minorities (CRCM) and Partnerships for Minority Student Achievement (PMSA) programs focus on the K–12 sector. The Alliances for Minority Participation (AMP) and Research Careers for Minority Scholars (RCMS) programs address increased retention and reform in undergraduate education.

Under these new ventures, NSF is a true partner and seeks the involvement of other federal agencies, local government, and the private sector in attacking directly what we believe to be society's most pressing problem for the next two decades.

The Foundation seeks to stimulate systemic reform that yields an appropriately trained science and technology work force and eliminates the performance gap between economically disadvantaged groups and other students nationwide. To maximize success, the Foundation is mobilizing its programs in teacher preparation, teacher enhancement, and curriculum and materials implementation to enable states, cities, and rural regions to meet these goals.

The advent of these programs raises serious questions and offers considerable challenges to NSF, the educational community, and the citizens of the United States. We challenge you to consider these issues during the course of this conference.

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Ohio's Statewide Systemic Initiatives: Lessons from the Trenches

Jane Butler Kahle
Co-Principal Investigator of Ohio's SSI

Background

Over the past three years, my colleagues and I have learned much about the nature of, and barriers to, change. We have learned, for example, that systemic reform is an evolutionary process with each change necessitating other ones. In addition, we have become acutely aware of the need to base change on a research/design/redesign process. In fact, Ohio, one of the original ten SSI states, is now in the redesign process, having learned many lessons during the past two and a half years. A brief description of the Project will set the stage for a discussion of systemic change, or lessons learned in the trenches of educational reform.

Ohio's SSI, Project Discovery, is based upon research on effective teaching and learning. Its foundation is the sustained professional development of teachers, supported by the active involvement of mathematicians and scientists, and its cornerstone is inquiry-based science and mathematics through which learners construct their own knowledge. Discovery focuses on strengthening the local role in instruction as teachers, schools, and regional entities assume leadership as agents for change in education. It has been designed to serve as a catalyst for educational reform in Ohio. Working with the Ohio Department of Education and the Ohio Board of Regents, Discovery is building an infrastructure for sustained reform by developing eight Regions.

Challenges to Systemic Reform

One of our greatest challenges has been to get all participants to think broadly and to build momentum to sustain and advance the goals of the Project following the end of the grant period. Another challenge is to model Project Discovery as a community initiative, not just an issue for teachers and schools. Additional, and immense, challenges include identifying and creating effective linkages and synergies among the many already existing local and national initiatives in educational reform.

One of the lessons learned is that sustained change requires a threefold process: first, the vision must be articulated and broadly communicated; second, the infrastructure must be changed and strengthened; and third, the infrastructure must embrace and support the reform. In Ohio, we are working within the system as a full and equal partner with the Ohio Department of Education and the Ohio Board of Regents to build an effective, supportable infrastructure.

Another key lesson learned, as well as an immense challenge, is that equity issues undergird all aspects of systemic reform. The reform initiative was instigated by, and is based upon, inequities in our educational system that leave an increasingly large number of students and citizens underprepared for work, for study, for life. In Ohio, we are addressing

- equity in access (who studies science and mathematics);
- equity in education (who has the curricula, materials, and instruction for optimal education);
- equity in outcomes (who achieves to his or her ability);
- equity in resources (who has optimal and equal facilities and other types of support);
- equity in leadership (who has access to and success in a myriad of leadership roles).

One lesson learned is that equity still requires firm affirmative action on all levels of a project or reform movement; for one cannot assume that others understand equity beyond the notion of equal numbers of girls and boys or appropriate proportions of majority and minority students studying math and science. The undergirding nature of equity in systemic reform is one of the most important messages from the trenches.

Summary

Halfway through our Project, our vision of systemic reform has radically changed. Within the first few months, we knew that we had to look beyond mathematics and science. Shortly thereafter, we knew that we had to develop strategies that would be accepted by diverse stakeholders so that the changes initiated would continue to be supported by tax dollars. More recently, we have extended our collaborative activities in order to develop and promulgate a shared vision of reform with Ohio's three cities eligible for Urban Systemic Initiative grants, as well as with the Rural Systemic Initiative that includes part of Ohio. We know that our original vision for reform, although daunting and challenging, was not systemic. We know that systemic reform not only means encompassing change but also evolving change. Most of all, we know that systemic reform will not occur unless it is firmly based upon principles of equity; anything less results in a continuation of the status quo.

Discovery About Systemic Change

Ted Sanders
Ohio Department of Education

In 1990, the National Science Foundation (NSF) issued calls for proposals to the States for a new kind of initiative—statewide and systemic in focus—for the improvement of mathematics and science education. Ohio responded with a proposal, Project Discovery, and was fortunate enough to be among the first 10 states funded by this initiative. Now, midway through the five-year grant cycle, seems an appropriate time to reflect on what has been learned about systemic change through this effort.

New Vistas, Familiar Landscapes

The challenge to Ohio's State Systemic Initiative (SSI) project has been how to provide leverage to system-wide and system-intensive change with a limited resource ($4 million per year over five years). Project Discovery elected to target the middle grades, seeking to address a critical time period in students' development. It also intended to have an indirect "wedging" effect on the entire K–12 system. Specifically, the project outlined four systemic goals:

- enhance teachers' knowledge of mathematics and science through sustained professional development activities with inquiry-based curricula;
- expand the delivery capacity for systemic improvement through regional networks and professional development leadership teams;
- promote the uses of technology and new approaches to evaluation and assessment in students' learning;
- increase public understanding of the need for scientific and mathematical literacy.

Operationally, the project provides classroom teachers with an intensive six-week summer program in one of three areas: mathematics by inquiry, physics by inquiry, or life science by inquiry. This is followed by intensive interaction and follow-up during the academic year between regional teacher leadership teams and the classroom teachers who participated in the summer experience.

Regionalization

In Phase 1 of the process, teachers and regional leadership teams are trained by project staff at one of two host-site institutions (Miami University or the Ohio State University). After an academic year in training, leadership teams are sent, in Phase II, to one of eight Ohio regions to deliver the inquiry-based summer courses and academic year follow-up support to teachers working in that region.

Project fiscal support is provided on a limited basis to put a regional professional development network into place. Stipend support goes to teachers trained at a regional site during the first year. Project support for leadership teams members' salaries is covered for their academic year of training and first year of regional work. Thereafter, a region is asked to draw upon its own resources in providing the continued support that is necessary to sustain the network. Assisting with administration, coordination, and fund-raising is a full-time regional coordinator, paid by the project, and a coordinating council of major stakeholders within the region.

Successes

The sustained professional development model, delivered through inquiry-based courses at a host or regional site, is an immensely powerful means by which to affect middle grade teachers. Evaluation data indicate that profound changes occur in teachers' philosophies, sense of mission, classroom methodologies, targets of instruction, and modes of assessing student performance. These changes occur independent of teachers' experience levels and perceived expertise in providing mathematics and science instruction.

The delivery of staff development on a regional basis is a viable tool for initiating systemic reform. It bolsters the delivery capacity of the system through the increased number of leadership personnel providing staff development support. It also provides the mechanism for rallying regional support and redirection of resources for improving mathematics and science education. Particularly viable is the involvement of stakeholders who traditionally fall outside of the umbrella of educational decision-making.

Consolidation of effort and coordination of resources have been unanticipated systemic improvements that have arisen during Discovery. Closer cooperation has been seen among state agencies and targeted use of Eisenhower monies has occurred as a direct result of the project. Moreover, as an offshoot of the States' moving toward decentralized decision-making and delivery of services, the 13 major providers of staff development (including Discovery) are beginning a dialogue aimed at coordinating their efforts. Recommendations for improving the delivery of regional services are likely to result by the end of the current biennium.

Focal Point for Reform

Perhaps, Discovery's major reform contributions are serving as a locus of systemic thinking and activity. Setting up a professional development network of this magnitude and scale involves an enormous number of people working toward a common goal over a significant period of time. Issues of governance, communication, collaboration, consensus-building shared decision-making, and empowerment require new ways of thinking. Discovery has provided a large-scale medium for wrestling with new paradigms for improving the whole system of mathematics and science education.

This is perhaps the most critical step toward achieving systemic change—motivating people to think about the system in new ways. It takes enormous amounts of time and energy for individuals to begin this process and then to design new, more systemic ways of working together. Discovery itself functions as a training medium for those working toward systemic ends, and as such, it is recognized by agencies outside of Ohio as a communications link for their services and materials. NSF, the Education Commission of the States, the Education Development Center, the North Central Regional Educational Laboratory, and many others have been helpful in providing training, conferences, and support materials to advance our understanding of systemic change. Discovery, in turn, has initiated State-level activities and training events to help others.

Through our growth in understanding the dynamics of systemic change, we have come to discern major obstacles and challenges that must be met. Gaps in governance structures, the need for state strategic planning, shortfalls in addressing the needs of disadvantaged populations, and problems with mobilizing resources for reform represent just a few of the obstacles that must be targeted.

A Tiger by the Tail

Discovery, as an experiment in systemic change, has also yielded its share of frustrations. Because Discovery is a high-profile and much-publicized NSF—and State—funded project, many Ohioans developed expectations that it was never meant to deliver. Other shortcomings have arisen as a result of the shifting priorities of political time lines and limited resources. And still others relate to the limited scope of the project design.

An Initiative Primarily

Though Discovery was conceived by NSF to be a state systemic initiative, many in Ohio consigned it the responsibility for full-scale state systemic reform. This was due, in large measure, to perceptions about the need for changes in mathematics and science education that were statewide in scope and systemic in character. However, it also occurred through naïveté about the relative leveraging power of the project's limited financial resources and the difficulties in influencing such a large and complex system.

Four million dollars a year does not go far when undertaking the redesign of a system as large as Ohio's. There are 104,000-plus teachers and 9,000 administrators in Ohio, many of whom are engaged in the delivery of mathematics and science instruction. There are 50 institutions of higher education which prepare teachers and numerous two-year technical and community colleges which receive the graduates of the public school system. There is a complex array of overlapping networks of agencies that provide staff development experiences for teachers.

Many of the stakeholders in the existing system did not welcome a high-profile newcomer to the reform territory which they had already been tilling, especially since the newcomer's resources were focused on a predetermined project agenda. Efforts to establish a new regional delivery system were viewed with anxiety and with a desire to protect turf and influence the new agenda. Some stakeholders questioned the efficacy of the project's focus and whether its resources were being utilized wisely. Though understandable, these responses represent the difficult human elements of systemic change that must be negotiated when the status quo is threatened.

Political Exigencies

A dilemma of systemic reform emerges from the fact that, while the system must revamp itself significantly to meet newly emerging demands, it must simultaneously struggle to address current needs. And changes which are profound and long-range in scope will not always show short-term payoffs on high-profile concerns. In Ohio, two high-stakes problems cry for attention: (1) the difficulty students have had with the ninth-grade mathematics proficiency test, which must be passed as a condition for graduation; and (2) the gap in performance among advantaged and disadvantaged youngsters on all large-scale assessment measures.

Despite the fact that Discovery's focus on inquiry-based instruction at the middle grades will have a long-term payoff and despite the known validity of cooperative and constructivist learning approaches for disadvantaged youth, many wish Discovery to provide immediate and substantive assistance with short-term problems, such as the two cited above. Believing that

Discovery absorbs a significant state resource (in the $2 million per year state match of NSF funds), some legislators and educators tacitly expect that rectifying those problems should be part of Discovery's mission, in spite of the state's proposal agreement with NSF.

It is in the arena of shifting priorities and limited resources that Discovery finds itself struggling for its own operating budget. For the capacity of the regional staff development network to grow, the original proposal called for the Ohio General Assembly share of the funding to grow eventually to $7 million. But in the budget development for the second biennium of the project, only slightly more than $2.4 million was available. This resulted in several major structural shifts in the rate at which the network was brought up to operating capacity and severely reduced the length of time that regions were funded by the project. The shaky prospects for regional funding have generated enormous concerns about the long-term viability of the staff development structure and individual anxieties about the level of commitment to project goals.

Design Limitations

To date, Discovery has provided intensive professional development for 390 classroom teachers, trained 12 leadership teams, and enabled all 8 regions of the state to provide some level of sustained professional development activity. However, too few districts and too few teachers have been reached for the effort to be perceived uniformly as systemic. Though these numbers will grow substantially in the next two years, the immediacy of the need and the size of the teacher population argue for a wider range of influence. Though discussed, use of resource teachers (teachers already having received training) as they are used with the Reading Recovery model had not yet been attempted as a means to quicken the multiplying effect of the network.

Measures have also not yet been found for implementing the wedge notion, whereby the middle grades become a starting point for affecting the elementary and secondary school grades in mathematics and science education. Nor have effective avenues been discovered for blending and marshaling the resources of other major agencies, such as the National Science Teacher Center and the Eisenhower Clearinghouse.

In fairness to Discovery, these are built-in limitations that grow out of the NSF original request for proposals, stipulating the need to define explicitly and up front what the project will accomplish over the course of five years. Making substantive midcourse corrections, which NSF now seems to be encouraging, is not so easy to accomplish given the commitment of budgets and scheduling to a long-range plan.

Discovery is now poised at a critical juncture. The immense pressures of establishing a system of this scale have had an inward-focusing effect on visioning, planning, and management. The degree to which the project can realign its focus outward in the next two and a half years, define its relationship to other change agents, and use its resources to promote systemic activity outside its project scope will drastically affect the pace of reform in Ohio.

Charting the Future

Discovery, like its NASA namesake, has been aptly named. It is mapping out the unknown terrain of systemic change for Ohio mathematics and science education. In retrospect, NSF may have been shortsighted in committing States to such an enormous and complex enterprise with so little lead time (now giving one year planning grants for the Urban Systemic Initiative). And yet, from a discovery perspective, perhaps beginning quickly and learning en route is more efficient.

Whatever the case, Discovery has been and will continue to be an exciting venture—one of learning and building for the future. Discovery's prospects for success may be enhanced if it participates in and draws ideas from the ongoing dialogue over how to operate education in a systemic manner. For example, it might want to examine the "guiding principles for systemic operation" that are cited in a recent draft policy statement from the Council of Chief State School Officers. The principles emphasize some basic but critical understandings about the essential nature of schools and learning. They include the following: (1) schooling must be guided by a substantive vision of what students should know and be able to do; (2) the success of schooling rests on those who provide instruction; it is important for the state and the system to develop the capacity and foster the sense of professional responsibility of those at the school site; (3) the world and our understanding of it change, so the system and its policies must be dynamic to respond to those changes; and (4) fundamental change is difficult, requiring a long-term commitment. Adhering to such principles may give Discovery's participants a stronger sense of purpose as well as greater resolve in the face of criticism.

Ultimately, Discovery's success will be judged in large part by the impact data of the next few years and by its ability to continue its mission in the midst of changing political priorities. Its long-term value, of course, depends on what it does to pave the way for future systemic changes and projects that attempt to build on its foundations.

Issues in Rural Education and The Rural Systemic Initiative

Wimberly C. Royster
Kentucky Science & Technology Council, Inc.

Introduction

One principle upon which all reform efforts are based is all students should be provided the opportunity to learn and achieve to a level which affords them the capability of being productive members of society. Many groups of students do not have access to the requisite circumstances to attain this goal. Two such groups that the National Science Foundation (NSF) is focusing upon with its systemic reform initiative programs are minorities and students in rural areas of high poverty. This paper deals with the latter group. Some of the content results from discussions at a conference sponsored by NSF on systemic change, and its significance to mathematics and science education in rural schools, held this past fall in Central Appalachia. The Conference involved parents; teachers; local school administrators; local business and community leaders; state government and education officials; legislators; and community college, college, and university faculty in mathematics and science from the region. Central Appalachia is a region with high levels of rural poverty. It encompasses counties in southeastern Ohio, West Virginia, eastern Kentucky, western Virginia, eastern Tennessee, and western North Carolina. Many circumstances that affect systemic reform in this region exist in other regions of high rural poverty.

Definition of Rural

Several definitions of "rural" are used in the literature on rural education. What appears to be best in focussing on high-poverty-level rural school systems is the Bureau of Census definition in which the unit is the county and the rural county can be defined as one not in a "standard metropolitan statistical area," which the Bureau describes in some detail. (For the dilemma in defining "rural," see a paper by Joyce Stern on "How Demographic Trends for the Eighties Affect Rural and Small-Town Schools." *Education Horizons*, Winter 1992, pp. 71–76.)

Rural Economic Conditions

Poverty is an historical fact of life in many rural areas. There are 540 counties in the nation with persistent high poverty rates of 20 percent or higher in each census since 1960. During the 1980's, the number of counties with high poverty levels increased, in fact, over 70 percent of rural counties considered by the Department of Agriculture to be poor in 1990 had higher levels of poverty than in 1980.

In earlier years, farming was the major employer in rural areas. This is no longer the case. In fact, only eight percent of the rural population is employed in farming. In many rural communities, small manufacturing industries which employ low-skill labor tend to be among the largest employers. The largest single employer in many rural counties is the school system. What this means for many of these counties is that if there are not changes throughout the system—education, governance, and socioeconomic conditions—they will be doomed for another 30 years of economic conditions, which will continue to place them in the same category as they are today.

Renewed Interests

One-fourth of public school students attend rural schools. One-fourth of those attending rural schools live in poverty. In failing to focus more attention on the rural schools, we are losing a sizable part of the Nation's human resources that will not be regained. The Rural Schools of America Act of 1992, introduced in Congress this past fall, is one example of recognition. The proposed new directions in the reauthorization of Title I that focus on highest poverty counties, is another. A third is NSF's Rural Systemic Initiative (RSI) program, which focuses on rural school districts in an effort to improve scientific literacy for all children in economically disadvantaged rural communities.

Need for Systemic Reform

Nearly everyone is familiar with various data relating to student performance in mathematics and science. For instance, the bottom 40 percent of students are not doing well in mathematics and science. Many students attending rural schools in high poverty areas fall into this group. Also, the National Assessment of Educational Progress (NAEP) report, which compares mathematics proficiency by race/ethnic group percentages of eighth graders at or above basic achievement level, shows a marked differential between minorities and nonminorities, up to twofold in some states. The reform initiative must address these kinds of differentials.

Further, many rural areas whose economy has been supported by extractive enterprises, such as farming, minerals, and timber, now find the economic base shifting toward manufacturing, be it oft-times low-skilled, in which case, the infrastructure fails to support adequate systems. These areas must obtain assistance to help them become more economically competitive. For if they do not, their resources will become less adequate and the number of welfare dependents will grow.

There are many factors influencing economic growth. Education is only one. Other factors need to be addressed by community leaders in parallel with enhancement of programs in the school systems. In many of these rural counties, the school system is the largest single employer and economic growth in today's changing and competitive technological society will not occur if the school system does not provide for a more highly skilled work force. This means raising the academic performance level of students in the school system which requires a consolidation of resources—partnerships between local, state, regional, and national agencies. It also requires more mathematics, science, and technology skills to train a competitive work force. Consequently, this requires better learning skills and attitudes in pre-K–12 and a better teacher work force.

Rural Schools and Communities

In attempting to make fundamental changes in mathematics, science, and technology education in rural schools, we must take into account that there are numbers of agencies that have programs addressing different components of the educational and socioeconomic infrastructure—private foundations, health and human services agencies, economic development agencies, and other federal, regional, and state agencies. A properly focused collaborative effort among these groups can have a tremendous affect on systemic reform. The question is how to assist rural school districts in forming partnerships that strengthen the reform effort.

Many of these agencies have conducted numerous studies, often with the assistance of university faculty. Quite often these studies focus on negative aspects of the rural schools or the community and things that "need fixing." These views are not uniformly held by those living in rural areas, who believe there are strengths in rural schools upon which to build. They cite smaller schools as the natural setting for promoting "real" science, stronger community ties, and better opportunities for individual achievement. (They also feel their students are better improvisers and have learned to do more with less.) The systemic reform effort must build upon these and other advances already made in the school system.

Barriers to Reform

Systemically reforming mathematics, science, and technology education in rural schools in high poverty areas requires addressing critical barriers. The list of local barriers is extensive and includes lack of resources, low tax base, geographical and cultural isolation, low socioeconomic status, low value placed on education, low self-esteem perpetuated by a welfare system, low expectations for students' educational achievements due to parents' life experiences and regional values, dysfunctional families, lack of awareness of role of education in students' future, lack of role models and professionals in the community to provide community leadership, lack of awareness of how to obtain supplemental funding through grants in many cases, inadequate facilities to attract more talented teachers, insufficient staff development and distance to training sites, and in-service professional development often lacking in quality and content. More global obstacles include unwillingness to reallocate resources, inflexibility with regard to certain standards, willingness to accept different academic performances and standards for different groups, and inadequate measures of the quality of teaching and learning.

The question is "How does the systemic reform effort address these issues?" The approach must be coordinated. The RSI program cannot do it all, but it can serve as a catalyst to provide resources and assist with coordination of the effort. It can support teacher in-service and pre-service enhancement activities targeted toward needs of electronic and telecommunication training and workshop development. Other stakeholders must be involved.

Roles of Stakeholders

What are the roles of the various stakeholders, such as parents, school districts, communities, states, higher education, and other federal agencies? In the case of higher education, for instance, teacher education programs must be revamped to make them more relative and aligned with national standards [National Council of Teachers of Mathematics (NCTM) and National Science Education Standards (NSES)] and to model effective teaching practices. Programs must be developed that integrate curricula. Further, teachers must be assisted in utilization of instructional technologies and existing state, regional, and national communications networks. Because many rural students have better access to community colleges, their curriculum in mathematics, science, and technology education needs to be coordinated better with the curriculum in four-year colleges and universities. There are comparable lists of responsibilities other stakeholders should address.

Other Issues

In some rural areas, high school attrition rates are very high; as high as 60 percent of the adult population does not have a high school diploma. No industry or employer with high-skilled labor requirements will locate in such areas. Mathematics and science competency are a given, along with computer literacy, for high-skilled jobs. What can be done to influence students to plan for and commit to technical school, community college, or college education?

There are many programs utilizing distance learning. What are the roles of distance learning, tele-learning centers, and the "information highway?" How can these be used effectively in rural schools? Because of remoteness and other barriers to reform, these could be a way of providing access to quality programs otherwise unavailable. Telecommunication networks can open up a new world for rural teachers and students, yet, in most instances, there is no way to gain access to them.

In the foregoing, many of the issues raised relate to how certain circumstances affect systemic reform in high poverty rural schools and the role of various stakeholders in addressing these circumstances. Yet, for real reform in mathematics and science to be obtained, reform must occur at the school site. Partnerships must be formed to address the situation but, the success of reform boils down to the learning environment and teaching of mathematics and science in the schools—the teacher and the student. It means courses with content, connections with everyday life, critical thinking skills, and assessments embedded in instruction that will ensure targeted performance levels will be attained. Further, it means preparing teachers in content and methods to achieve the desired goals in performance.

The Rural Systemic Initiative

The stated purpose of the RSI is to provide catalytic support to school districts in disadvantaged rural counties for comprehensive programs that will broaden the effect, accelerate the pace, and increase the effectiveness of improvements in science, mathematics, and technology education. It is important to note the use of the term "catalytic." The RSI alone cannot effect systemic reform in mathematics, science, and technology education in these school districts. Other NSF programs must be considered in conjunction with the RSI—the Statewide Systemic Initiative (SSI), Collaboratives for Excellence in Teacher Preparation, Teacher Enhancement and Curriculum Development programs, and the Advanced Technology Education Program. As mentioned before, alliances must be formed. For example, other federal agencies could help if support and services can be coordinated. In particular, the proposed Title I changes could be very helpful. The U.S. Department of Education regional educational laboratories are another example. The U.S. Department of Agriculture Extension Service conducts programs that support science in rural schools. For reform to be most effective, the effort must build upon local, state, and national strengths.

There are exemplary programs throughout the country that have been successful in improving mathematics, science, and/or technology education. Their approaches involve distance learning, communications and networking, forming partnerships with industries to promote mathematics, science and technology, cross-disciplinary learning, teacher enhancement, problem-solving skills, and possibly other activities. Some may be systemic, but most are not. There are also schools which have been successful in establishing effective partnerships with outside groups to effect reform in the school—parents, community organizations, higher education, etc.

Programs that can be validated as being effective in improving student performance and can be adapted to rural schools should be identified. Information about them should be made available to rural educators and others interested in systemically reforming mathematics, science, and technology education in rural schools, since the Rural Systemic Initiative needs to build on successes.

NSF Workshop Report: Learning and Technology in the Future

Nora Sabelli and Lida K. Barrett
National Science Foundation

Introduction

This report is based on a workshop hosted by the National Science Foundation during October 4–6, 1993, at the Georgetown University Conference Center in Washington, D.C. The workshop was a follow-up to the National Academy of Sciences (NAS) Convocation "Reinventing Schools—the Future is Now" held earlier in the year. The NAS Convocation highlighted the differences between the technology available to young people outside of school with the technology available to students in schools. The NSF Workshop provided an open forum for a group of 50 individuals with different perspectives (private sector, classroom, education researcher) to address strategies and define next steps on technology usage in education. Individuals from the Department of Education, the Department of Energy, and the NAS chaired discussion sections.

The objective of this Report is to provide for the field the thoughts of this group of experts on the basic underlying principles of technology use in education, goals for integrating technology into the educational system, and methods of further enhancing the quality of education through technology use. The Report is their advice to the field and to themselves, and we hope it will lead to specific action plans and proposals—by participants in the workshop and by readers of this report.

The groundwork for the workshop was laid by the participants, who prepared lists of key issues to be addressed and examples of effective uses of technology that are in place or under development. These issues provided the backdrop for small break-out discussion sessions, which provided a forum for sharing of information, insights, and strategies; a thoughtful critique of current activities in the field; a look to what might happen in the future; and a definition of appropriate steps that need to be taken for technology to be effectively used in educational settings.

The participants' variety of expertise provided an opportunity for sharing outside the usual colleague groupings and permitted participants to explore each other's needs, constraints, and barriers for the development and adoption of innovative technology in education.

An effort was made to consider both short-term next steps and long-term goals; to think beyond a wish list of what teachers would like to have now in the classroom to what the opportunities are for the future; and to determine the immediate steps that should be taken to ensure that the opportunities are addressed in a timely fashion.

The Report that follows is broken into three parts: Underlying Principles, Goals, and Next Steps. These three main divisions were drawn from and reflect the discussions that were centered first on the classroom teachers and learners; then on social/organizational, economic, and pedagogical issues; and finally on technology, classroom and policy issues, during which the participants focused their thinking toward action items.

The Report is presented in a readily accessible outline format so that the individual principles, goals, and next steps are clearly delineated. The appendix presents additional information, including a summary of each of the discussion groups' reports, the lists of issues prepared defined by the participants. A copy of the letter of invitation sent to workshop participants, the agenda for the workshop, and a list of the participants are included.

It is the hope of the organizers that this information will be useful to those planning activities and programs related to the uses of technology in education. It is clear that the recommended next steps must be implemented by a variety of individuals and organizations, and it is the hope that this Report will lead to strategies and activities that will make it possible for these next steps to take place.

Underlying Principles

The workshop identified a set of principles that underlie effective and appropriate technology utilization in education. These principles frame different and necessary elements of successful technology utilization in support of education and of education reform.

Integration:

1. Technology is part of society education and should be tightly interwoven into education through curricula. Technology is a neutral tool; technology integrated into the curriculum and education progress go hand-in-hand.

    - Technology allows educators to redefine the core curriculum to include topics that were impossible to teach without technology.
    - Learning, the basic business of schools, should be engaging for teachers and students. Technology can help achieve this engagement.

- Technology can enhance the educational process without eliminating valuable traditional learning approaches and methods.

2. Educational reform must involve the entire educational system and increase the productivity of and communication among its members (e.g., students, teachers, administrators, parents, school board members, teacher preparation program faculty).

   - Educational reform is an on-going process, not an ideal end-state or product.
   - Educational reform must be integrated with the technological and social requirements of modern society.
   - Strategies and procedures to increase interactions between the community and all members of the educational system need to be developed.

3. Models and exemplars of the role that technology can play in educational practice are needed in order for schools to adopt and adapt appropriate practices; their distribution should take advantage of the technology and model its use.

   - Diverse models, appropriate for a variety of educational settings and local communities (e.g., rural, suburban, and urban) should be provided to support a range of learning communities. Alternative models of instruction must be available to teachers so they can explore new options for teaching and learning.
   - Models must demonstrate an acceptance of the diversity of the human experience with regard to race, gender, ethnicity, and learning styles.
   - Clusters of schools should be encouraged to work together and with others, such as the private sector and educational researchers, to implement models and exemplars, to be model sites for other schools, and to be proactive in making their experience available to educators by a variety of means.

4. The financing of technology must be built into the ongoing school and district base budget and not be considered an add-on. It must include training, service, maintenance, amortization, and timely replacement.

   - Leaders in budget policy-making need to plan for some technology that is short term and expendable.
   - Costs of personnel and training should be considered along with the equipment cost.

People's Roles:

5. Teachers as professionals (i.e., as educators, mentors, learners, facilitators, leaders, curriculum developers, etc.) are critical to the long-term success of any innovation.

   - Technology frees teachers' time and supports their efforts in expanding their professional activities and in carrying out their central role in reform, in next-generation instruction, and in the formation of learning communities.
   - Teachers work when and where they have time and resources, and this includes the home. They need a computer to take home to use for professional purposes, e.g., creating a multimedia presentation, linking with colleagues, using an electronic gradebook, continuing professional development.
   - Teachers need time for planning, experimentation, collaboration, and staff development.
   - Teachers should be recognized and receive credit for research and technological innovation in their classrooms.

6. Learning takes place in and out of school; contributions to the learning experience can be made by students, parents, and others in the community.

   - Everyone is a teacher and a learner, contributions by students, parents, and other community leaders is important. Students must be "met on their own turf," using the media they find attractive, in an environment that will engage them.
   - Home video game ownership has already crossed social and economic boundaries: for teenagers ages 12 through 19 was 48.5 percent for whites, 56.1 percent for African-Americans, and 47.1 percent for Latinos (Teenage Research Unlimited, Teenage Marketing and Lifestyle Study, WAVE 20, Fall 1992). Educational applications should be developed that take advantage of the widespread ownership of personal technology and help orient it toward non-violent, constructive ends.
   - Apprenticeships and mentoring are ways that can be used by members of the out-of-school-community to facilitate the connection with students and teachers.

7. Change in the schools and in the education of teachers requires leadership; leadership for these changes can often be found in new places.

   - Schools will not change until the culture of schooling changes.
   - Teachers and others knowledgeable in technology are part of their source base for leadership (e.g., parents, the private sector, professionals in the community, students).

8. Technology freely used will change who is in control of information within schools and classrooms.

   - Technological tools that access information will open up the curriculum and change the way we view content.
   - Direct access to information and educational mentors at distant locations by means of technologies such as wide-area computer networks and satellites will change the teacher's role within the classroom and alter the school site administrator's role from authority figure and bureaucrat to that of learning facilitator/manager.
   - The new responsibilities of the authority, at the home, local, state, and federal levels, needs to be confronted explicitly.

Serving National Goals:

9. Technology can be, and must be, used as a tool for inclusion instead of for exclusion.

   - Technology changes the definition of community: it becomes borderless and expands beyond the traditional neighborhood concept. We must build learning communities of interest that promote inclusion.
   - All learners in all learning environments should have equal access to the information, communications tools, and the educational opportunities new technologies provide.
   - Technology can provide opportunities for lifelong learning and can help address the specific educational needs of those outside of the system, such as dropouts, prisoners, and people continuing their education. Technologies can be democratizing: text-based conferencing masks many personal attributes, and network conferencing can admit equal access.
   - The technology tools that are developed should be "transparent," easy to use, and helpful in overcoming barriers to multicultural and multilingual interaction and easy to use by people with disabilities.

10. Technology policy must promote the integration of educational technologies with the technologies outside of school.

   - Federally funded projects should provide models of such technology.
   - Scalability—the ability to start at any level and the ability to increase access and expertise—requires the development of standard tools, open architectures, and standard interfaces.

- Eliminate policies that prevent the development of a reasonable technical infrastructure (i.e., single-source providers).

11. Educational reform is in the best interest of all segments of American society. Collaboration with the private sector is essential to its sustainability.

    - Follow-on funding should be provided to support a research activity and its introduction into the commercial marketplace. Funding agencies should consider, from the earliest planning stages, possible technology transfer and the likely commercialization routes of the work in the event it is successful.
    - Business and industry should view collaboration with schools as the process of building a human infrastructure as well as an important product marketing opportunity.
    - Mechanisms need to be implemented to aggregate markets and provide managed risk for innovative technology. Cooperation between the public and private sectors is needed to achieve this. Private sector consortia, such as the Microelectronics and Computer Corporation (MCC), should be encouraged.

Goals

The workshop identified a set of goals, based on the agreed upon underlying principles. These goals are instantiations of the underlying principles, geared to the current status of the education community's understanding of and access to appropriate technology. These goals can be used to formulate and set directions for effective long-range flexible technology plans.

1. Provide for full participation in the global interactive electronic community.

   Implications:

   - More than access, full participation defined on the basis of individual and group needs.
   - Multiple definitions of participation that address the needs of diverse communities and individuals.

2. Adopt common tools and flexible modes of technology use for learning and discovery; these tools should facilitate the development of learner expertise and integration with the world outside the school.

Implications:

- Develop empowering tools, as well as specific technology-based materials.
- Develop flexible standards and protocols—and common libraries of software that implement them—and a cross-platform approach to infrastructure that can evolve and improve over time.

3. Create self-sustaining mechanisms for continuing dialogue and collaboration between educators and other sectors of the general community.

Implications:

- Particularly significant to this goal are collaborations with parents and private sector producers of educational materials and services.
- We must help the educational and general communities to understand that technology implementation is a long-term process that brings with it changes in teaching and learning practices. Restructured schools and classrooms look and feel different from traditional ones and parents may not recognize them as places where learning takes place.

4. Create mechanisms for continued support and development of a "culture of change and innovation" in schools.

Implications:

- Recognize and reward innovative teaching activities that technology makes possible.
- The most qualified educators using the latest techniques and content, through teaching practices that model innovation, should form the basis for teacher training and retraining. The educational community, appropriately reluctant to experiment with students, can utilize the model of the "teaching hospital."

5. Make regulations (local, state, federal) less restrictive and modify funding regulations that impede the integration of technology into the educational system.

Implications:

- Market and regulatory barriers must be removed to allow for an exploration of all educational options, to lower the risk for product introduction and school innovation, and to redefine the role of the private sector in supporting long-term change and reform.

- Develop appropriate technology goals and change those regulations that are barriers to achieving these goals (for example, by excluding funding for technology, or not allowing tax credit for teachers who purchase equipment to use at home).

6. Effect change in educational budget policy that will support the culture of change.

   Implications:

   - Allow for low-cost entry and provide a clear path for growth.
   - Teachers should not personally bear the burden of international competitiveness and national needs; we need mechanisms to support their purchase of equipment and software and provide them with appropriate financing.

Next Steps

The workshop identified a set of next steps to take, based on the agreed upon underlying principles and goals. The community at large must seek support from all sectors and design activities to implement these next steps. These steps are not admonitions for others but actions for us in the educational community itself to undertake. The agencies and the commercial sector must be proactive in their interaction with the education community.

1. By October 1994, define "full participation" by its expected outcomes.

   - The agencies involved should fund a multistakeholder group to look at basic common modes of technology use for education, such as empowering tools, shared general functions, and applications.

2. If the National Education Goals are to be achieved by the year 2000, a plan must be developed to provide timely access to implement full participation, including home, library, and community access, as follows:

   - Electronic links to every school should be in place by FY 1996. Electronic links to every classroom should be in place by FY 1998. Linked student clusters in every classroom should be in place by FY 2000.

3. By October 1994, have in place self-sustaining mechanisms and a starting set of related materials that support:

   - The dissemination of practical information and models to the citizenry, parents, school boards, schools, teachers, and students. Collaborations between private sector, education researchers, curriculum developers, classroom teachers, and non-profit centers—such as museums and libraries—to reduce developer risk and aggregate educational markets for innovative, interdisciplinary materials.

4. By October 1994, the participating agencies will articulate a shared strategy for addressing implementation and policy issues, such as financing, telecommunication costs, intellectual property rights, and agency regulations that impede the integration of appropriate technologies in education.

5. By October 1994, the participating agencies will have established an ongoing system of rewards and recognition for existing, innovative technology applications in the classroom and in teacher education and enhancement. This system will encourage master teachers and their schools to disseminate their strategies and act as models. The first round should be awarded by FY 1995.

6. By October 1994, the National Science Foundation and the Department of Education will have in place a strategy and funding for furthering the work of the mathematics and science standards groups (for curriculum, teacher preparation, and assessment) to incorporate a proper role for technology.

REMARKS BY
THE HON. GEORGE BROWN, JR.
AT
NATIONAL SCIENCE FOUNDATION CONFERENCE
ON
SCIENCE AND MATH EDUCATION

February 25, 1994

EXTERNAL FACTORS FORCING CHANGE ON
EDUCATION:HOW CAN THEY WORK FOR US?

I AM VERY PLEASED WITH THE OPPORTUNITY TO MAKE SOME REMARKS AT THIS SECOND NATIONAL CONFERENCE ON SCIENCE AND MATHEMATICS EDUCATION REFORM. . EVERY PARTICIPANT HERE THIS MORNING IS COMMITTED TO CHANGE; EACH OF YOU UNDERSTANDS THE NEED FOR SYSTEMIC REFORM; AND EACH OF YOU HAS A GENUINE DESIRE TO HELP AMERICA AND ITS CHILDREN GROW IN INTELLECTUAL ACHIEVEMENT. I CAN ONLY ADMIRE YOUR EFFORTS AND URGE YOU TO PERSEVERE WITH YOUR DIFFICULT TASK. DESPITE MY DISADVANTAGE IN KNOWING A LOT LESS ABOUT EDUCATION THAN ANYONE IN THIS ROOM, I HOPE THAT I CAN OFFER SOME SMALL CONTRIBUTION TO YOUR DELIBERATIONS.

MY KNOWLEDGE HAS BEEN IMPROVED RECENTLY BY THE OPPORTUNITY TO VISIT TWO SCHOOLS FROM MY OWN CONGRESSIONAL DISTRICT THAT ARE PART OF THE CALIFORNIA STATEWIDE SYSTEMATIC INITIATIVE (SSI), CALLED THE CALIFORNIA ADVOCACY FOR MATHEMATICS AND SCIENCE OR CAMS. I WILL COMMENT ON SOME OF THE THINGS I OBSERVED ON THAT VISIT LATER IN MY REMARKS.

HOWEVER, I WOULD LIKE TO FOCUS MY REMARKS LARGELY ON SOME OF THE EXTERNAL FACTORS THAT ARE FORCING CHANGES ON EDUCATION. I HAVE THEREFORE TITLED MY COMMENTS, <u>EXTERNAL FACTORS FORCING CHANGE ON EDUCATION: HOW CAN THEY WORK FOR US?</u> FIRST, HOWEVER, I WOULD ASK YOU TO REFLECT FOR A MOMENT ON THE TERM "<u>EDUCATIONAL REFORM</u>." THIS TERM IS SO COMMON IN OUR DISCOURSE THAT IT HAS BECOME "MENTAL BOILERPLATE." IF, HOWEVER, WE PAUSE TO CONSIDER EACH WORD FOR ITS GENUINE MEANING, I BELIEVE WE CAN DISCOVER A GUIDING PRINCIPLE FOR OUR WORK.

EDUCATION <u>MEANS DRAWING OUT OF YOU WHAT IS ALREADY IN THERE</u>, NOT MERELY INSTILLING SOMETHING NEW. THUS OUR TASK MUST BE DRIVEN BY THE RECOGNITION THAT EACH PERSON COMES TO EDUCATION WITH POTENTIAL DRAWN FROM HIS OR HER OWN SINGULAR QUALITIES, GIFTS, EXPERIENCES, AND CULTURE. OUR JOB IS TO HELP A CHILD TAP THAT POTENTIAL SO IT CAN BE UTILIZED IN MEANINGFUL PURSUITS. IT WILL NEVER BE ENOUGH TO ASK -- WHAT SHOULD CHILDREN IN EIGHTH GRADE SCIENCE OR MATH BE REQUIRED TO KNOW? -- AND THEN PREPARE TO OFFER UP THOSE SKILLS OR MEANINGS. IT WILL BE JUST AS IMPORTANT TO "DRAW FROM" AND "DRAW OUT" THE UNIQUE PERSPECTIVE THROUGH WHICH EACH CHILD VIEWS HIS OR HER OWN WORLD.

THE TERM REFORM MEANS TO AMEND OR IMPROVE BY CHANGE. SINCE REFORM MUST NECESSARILY TAKE PLACE IN A DYNAMIC, EVER-EVOLVING SOCIETY, WE MUST RECOGNIZE

REFORM AS A PROCESS, RATHER THAN A MOVEMENT WHICH HAS A BEGINNING AND AN ENDING. TO BE SUCCESSFUL, REFORM MUST BE CONTINUOUS, NOT END-STOPPED. WE CAN NEVER THINK OF ANY REFORM AS PERMANENTLY FIXED OR FINISHED. INSTEAD, WE MUST HUNKER DOWN TO A LONG-TERM TASK THAT WILL OUTLIVE THE LEADERSHIP AND PARTICIPATION OF ALL OF US IN THIS ROOM, AND WILL BE PASSED ON TO OUR YOUNGER PROTEGES, AND THEN TO THEIR YOUNGER PROTEGES. THIS SHOULD NOT BE INTERPRETED AS A GLOOMY JUDGEMENT OF OUR PROSPECTS. RATHER, IT SHOULD BE RECOGNIZED AS THE NATURAL PROCESS THAT REFORM SHOULD TAKE.

IN THE LANGUAGE OF TQM, OR TOTAL QUALITY MANAGEMENT, WE CALL THIS CONTINUOUS PROCESS IMPROVEMENT, AND IT IS ESSENTIAL TO PRODUCTIVITY IMPROVEMENT IN ALL HUMAN ACTIVITY.

IN RELIGION WE HAVE THE CONCEPT OF THE INFINITE PERFECTIBILITY OF THE HUMAN SPIRIT BY TRANSFORMATION FROM WITHIN, WHICH COMBINES THE CONCEPTS OF BOTH EDUCATION -- TO DRAW OUT FROM WITHIN -- AND REFORM -- TO CHANGE FOR THE BETTER.

IF WE CAN HOLD THESE TWO PERSPECTIVES -- ONE ON EDUCATION, ONE ON REFORM -- AS GUIDELINES, THEY WILL GO A LONG WAY TOWARDS PREVENTING BOTH RIGIDITY AND ATROPHY IN WHAT WE DO.

SCIENCE AND MATHEMATICS REFORM, OR ANY EDUCATIONAL REFORM, WILL BE STRONGLY INFLUENCED BY MANY FACTORS BEYOND THE BOUNDARIES OF EDUCATION. I HOPE THAT BY RAISING SOME OF THESE ISSUES WITH YOU THAT THEY WILL INFLUENCE YOUR DISCUSSIONS THROUGHOUT THE REMAINDER OF THE CONFERENCE.

LET ME BEGIN WITH A COMMENT BY DIANE SAVITCH, AN HISTORIAN OF EDUCATION AND A VISITING FELLOW AT THE BROOKINGS INSTITUTION. IN A RECENT ARTICLE ENTITLED, <u>WHEN SCHOOL COMES TO YOU</u>, SHE WRITES, (QUOTE) "EDUCATION DOES NOT DEVELOP AUTONOMOUSLY; IT TENDS TO BE A MIRROR OF SOCIETY AND IS SELDOM AT THE CUTTING EDGE OF SOCIAL CHANGE. IT IS RETROSPECTIVE, EVEN CONSERVATIVE, SINCE IT TEACHES THE YOUNG WHAT OTHERS HAVE EXPERIENCED AND DISCOVERED ABOUT THE WORLD. THE FUTURE OF EDUCATION WILL BE SHAPED NOT BY EDUCATORS, BUT BY CHANGES IN DEMOGRAPHY, TECHNOLOGY, AND THE FAMILY. ITS ENDS -- TO PREPARE STUDENTS TO LIVE AND WORK IN THEIR SOCIETY -- ARE LIKELY TO REMAIN STABLE, BUT ITS MEANS ARE LIKELY TO CHANGE DRAMATICALLY." (END QUOTE)

I BELIEVE SHE IS RIGHT. THIS DOES NOT DISPARAGE THE CRITICAL ROLE OF EDUCATION AND EDUCATORS IN PREPARING THE CONDITIONS FOR CHANGE, BUT IT DOES SIGNIFY THAT EDUCATION AND EDUCATIONAL REFORM SERVE BEST WHEN THEY ARE RESPONSIVE TO THE EVOLVING LARGER CONTEXT. THIS MAY SOUND SIMPLE ENOUGH TO BE INSIPID, BUT MUCH OF WHAT WE ARE STRUGGLING TO CHANGE IN AMERICAN EDUCATION TODAY REMAINED CEMENTED IN PLACE DESPITE A VASTLY CHANGED CONTEXT OVER THE LAST 50 YEARS.

SINCE SOCIETY IS ALWAYS IN A STATE OF FLUX -- DYNAMIC AND TRANSFORMING -- WE MUST BE ALERT TO CHANGE THE <u>MEANS</u> BY WHICH WE EDUCATE, DESPITE THE FACT THAT THE <u>ENDS</u>, TO LIVE AND WORK IN SOCIETY, ARE LIKELY NOT TO CHANGE, AS SAVITCH REMINDS US. THIS SUBSTANTIATES THE CONCEPT OF REFORM AS A CONTINUOUS PROCESS THAT I MENTIONED EARLIER.

LET US CONSIDER THE THREE REALMS -- DEMOGRAPHY, FAMILY AND TECHNOLOGY -- WHERE IDENTIFIABLE CHANGE IS OCCURRING THAT WILL HAVE IMPACT ON EDUCATION. IN DEMOGRAPHY, JUDITH WALDROP, THE RESEARCH EDITOR OF AMERICAN DEMOGRAPHICS TELLS US THAT, (QUOTE) "BY 2010, MARRIED COUPLES WILL NO LONGER BE A MAJORITY OF HOUSEHOLDS. ASIANS WILL OUTNUMBER JEWS BY A MARGIN OF TWO TO ONE, AND HISPANICS WILL LEAD BLACKS AS THE NATION'S LARGEST MINORITY. ...BY THE YEAR 2020, IMMIGRATION WILL BECOME MORE IMPORTANT TO U.S. POPULATION GROWTH THAN NATURAL INCREASE (THE GROWTH THAT OCCURS BECAUSE BIRTHS OUTNUMBER DEATHS). [AT THAT POINT] THE POPULATION WILL DIVERSIFY EVEN MORE RAPIDLY." (END QUOTE)

HISTORICALLY, THIS NATION'S RICH DIVERSITY HAS BEEN ONE OF ITS PRIMARY STRENGTHS. WE SHOULD EMBRACE THAT CONTINUANCE. WE SHOULD, HOWEVER, PAY ATTENTION TO STATISTICS THAT INDICATE A HIGH DROP-OUT RATE IN HIGH SCHOOL AMONG HISPANIC YOUTH, AND ALSO RECOGNIZE THAT THE PERCENTAGE OF HISPANIC HIGH SCHOOL GRADUATES GOING ON TO COLLEGE HAS DECLINED SINCE THE 1970's. AS OUR SOCIETY BECOMES MORE MULTI-RACIAL AND MULTI-CULTURAL, WE MUST BE CONTINUOUSLY VIGILANT NOT TO LEAVE ANY STUDENT BEHIND.

THERE IS ALSO A TENDENCY TO USE DEMOGRAPHICS AS IF THEY WERE SOLELY RESERVED FOR CULTURAL AND RACIAL TRENDS. PERHAPS THE MOST SIGNIFICANT AND DISHEARTENING DEMOGRAPHIC INFORMATION FOR OUR PURPOSES WAS RELEASED LAST SEPTEMBER IN A COMPREHENSIVE STUDY OF ADULT LITERACY IN AMERICA.

IT IS FRIGHTENING TO REALIZE THAT AN ESTIMATED 90 MILLION ADULTS CANNOT FIGURE OUT A SATURDAY DEPARTURE ON A BUS SCHEDULE OR WRITE A BRIEF LETTER DESCRIBING A CREDIT CARD ERROR. THE HIGHEST SKILL LEVEL DOCUMENTED IN THE STUDY FOR THESE ADULTS WAS THE ABILITY TO FIGURE OUT THE DIFFERENCE IN PRICE BETWEEN TWO ITEMS.

DEMOGRAPHIC INFORMATION HAS AN IMPORTANT INSTRUCTIVE ROLE FOR EDUCATORS, ESPECIALLY BECAUSE THE BEST REFORM SHOULD NOT BE JUST IMPROVEMENT ON WHAT "IS", BUT ALSO ANTICIPATORY OF WHAT "WILL BE." EDUCATION CAN BE GREATLY INFORMED BY CAREFUL ATTENTION TO SUCH THINGS AS SOCIAL CHANGE AS REFLECTED IN OUR DEMOGRAPHICS. WE KNOW THAT DEMOGRAPHERS CAN BE MORE CONFIDENT ABOUT THE DIRECTION OF FUTURE CHANGE THAN OF ITS MAGNITUDE. HOWEVER, DEMOGRAPHIC SHIFTS EXERT GRADUAL BUT CUMULATIVE FORCE ON SOCIAL STRUCTURE, THUS ON SOCIAL LEGISLATION AND ALSO BUDGETS. EVENTUALLY, THEY RESHAPE THE NATION'S POLITICAL AGENDA. IF EDUCATIONAL REFORM DOES NOT INCORPORATE AN AWARENESS OF CHANGING DEMOGRAPHICS, THE USEFULNESS OF THE REFORM WILL BE DILUTED OR EVEN OVERTAKEN BY THESE EXTERNAL EVOLUTIONS.

LET ME MOVE ON TO THE ISSUE OF FAMILY CHANGE, RAISED BY SAVITCH AS A FACTOR FOR CONSIDERABLE IMPACT ON EDUCATION. I HAVE OFTEN COMMENTED THAT IN THE LAST FIFTEEN YEARS WE HAVE SEEN A DISINTEGRATION OF THE AMERICAN FAMILY STRUCTURE. LIKELY, MANY OF YOU WOULD AGREE WITH ME. I AM SURELY IN AGREEMENT WITH OPINIONS ESPOUSED IN THE MEDIA, AND WITH THE ORDINARY CITIZEN POLLED ON THE STREET. WELL, GUESS WHAT, MANY OF US WERE WRONG!

WHAT IS BOTH FASCINATING AND DANGEROUS ABOUT THIS AGREEMENT IS THAT DESPITE THE AVAILABILITY OF ACCURATE DEMOGRAPHIC DATA, WE AS A SOCIETY CREATE AND

PERPETUATE MYTHS THAT COMPLETELY CONTRADICT OUR INFORMATION AND HISTORICAL FACT.

I HAVE MADE THE COMMENT ABOUT FAMILY STRUCTURE BASED ON BOTH OBSERVATIONS AND CURRENT STATISTICS. THIS COMBINATION LEADS TO THE FURTHER SUGGESTION THAT THERE WERE "GOOD OLD DAYS" WHEN FAMILIES FUNCTIONED AS SUPPORTIVE UNITS WHERE CHILDREN THRIVED, AND ALL WAS WELL.

STEPHANIE COONTZ, A PROFESSOR OF FAMILY HISTORY, RECENTLY PUBLISHED A BOOK ENTITLED, THE WAY WE NEVER WERE, AND SUBTITLED, AMERICAN FAMILIES AND THE NOSTALGIA TRAP, IN WHICH SHE ELUCIDATES THE FAMILY MYTH ISSUE. NEITHER THE AUTHOR NOR I AM SUGGESTING THAT THERE ARE NOT SERIOUS PROBLEMS IN AMERICAN FAMILIES TODAY. HOWEVER, SHE DOCUMENTS, AND SHE HAS CONVINCED ME, THAT WHAT WE REMEMBER IS MORE "THE WAY WE WISHED IT HAD BEEN", THAN "THE WAY IT REALLY WAS."

FOR EXAMPLE, COONTZ TELLS US, (QUOTE) "TWENTY PERCENT OF AMERICAN CHILDREN LIVE IN POVERTY TODAY: AT THE TURN OF THE CENTURY THE SAME PROPORTION LIVED IN ORPHANAGES, NOT BECAUSE THEY ACTUALLY LACKED BOTH PARENTS, BUT BECAUSE ONE OR BOTH PARENTS SIMPLY COULD NOT AFFORD THEIR KEEP. AS LATE AS 1960, AFTER 10 YEARS OF LOW DIVORCE RATES, ONE IN THREE CHILDREN LIVED IN POVERTY. MODERN STATISTICS ON CHILD-SUPPORT EVASION ARE APPALLING, BUT PRIOR TO THE 1920's, A DIVORCED FATHER DID NOT EVEN HAVE A LEGAL CHILD-SUPPORT OBLIGATION TO EVADE." (END QUOTE)

SHE GOES ON TO POINT OUT THAT ALCOHOL AND DRUG ABUSE WERE ALSO PREVALENT LONG BEFORE THE "MODERN REARRANGEMENTS OF GENDER ROLES AND FAMILY LIFE." IN FACT, PER CAPITA ALCOHOL CONSUMPTION IN THE 1820's WAS ALMOST THREE TIMES HIGHER THAN IT IS TODAY. IN ADDITION, THERE WAS A MAJOR EPIDEMIC OF OPIUM AND COCAINE ADDICTION IN THE LATE 19TH CENTURY.

THIS LEADS HER TO CONCLUDE, (QUOTE) "THERE HAVE BEEN MANY TRANSFORMATIONS IN FAMILY LIFE AND SOCIAL RELATIONS IN AMERICAN HISTORY, BUT THEY HAVE BEEN NEITHER AS LINEAR NOR AS UNITARY AS MANY ACCOUNTS CLAIM. ...HOWEVER, THE HISTORICAL RECORD IS CLEAR ON ONE POINT: ALTHOUGH THERE ARE MANY THINGS TO DRAW ON IN OUR PAST, THERE IS NO ONE FAMILY FORM THAT HAS EVER PROTECTED PEOPLE FROM POVERTY OR SOCIAL DISRUPTION, AND NO TRADITIONAL ARRANGEMENT THAT PROVIDES A WORKABLE MODEL FOR HOW WE MIGHT ORGANIZE FAMILY RELATIONS IN THE MODERN WORLD." (END QUOTE)

MY POINT IN QUOTING COONTZ SO EXTENSIVELY IS TO SUGGEST THAT IF WE VIEW OUR CURRENT AND GENUINE DIFFICULTIES IN AMERICAN FAMILIES AS ANOMALOUS OR AS A VAST DEPARTURE FROM THE PAST, THEN OUR INSTINCT WILL BE TO TRY TO REINVENT A PAST THAT DID NOT WORK, AS SOLUTION TO OUR CURRENT PROBLEMS. TO BELIEVE THAT WE ONCE HAD THAT SOLUTION IN AN OLD PATTERN WILL ONLY THWART OUR FREEDOM TO RECOGNIZE THAT NO SINGLE PATTERN IS THE ANSWER.

OUR DEPENDENCE ON AN OLD MYTH WILL STIFLE OUR ABILITY TO DEVELOP CREATIVE WAYS OF DEALING WITH THE PRESENT. WE WILL NOT CHANGE, NOR SHOULD WE, THE TREND OF MORE WORKING WOMEN. WE WILL NOT MAKE CHILDREN SAFER IN ABUSIVE HOUSEHOLDS WHERE PARENTS DO NOT DIVORCE. WE MIGHT, HOWEVER, FIND THAT THE MANY VARIETIES OF FAMILIES THAT WE HAVE TODAY WILL WORK BETTER FOR CHILDREN IF THEIR SURROUNDING COMMUNITIES ARE ACCEPTING AND SUPPORTIVE.

WE MIGHT BEGIN BY ENVISIONING OUR COMMUNITIES AS THE FAMILY UNIT WHERE EVERYONE -- THE ELDERLY, COLLEGE STUDENTS, THE UNEMPLOYED -- HAVE A STAKE IN THE NOURISHMENT AND SUCCESS OF OTHERS. THEN THE "FAMILY UNDER ONE ROOF" BECOMES A SUBSET OF THE COMMUNITY FAMILY UNIT.

FOR THOSE OF YOU, WHO LIKE ME, STILL HEAR A STUBBORN VOICE DEPICTING A PAST IDYLLIC TIME, LET ME CLARIFY THE DISSONANCE. THERE IS NO QUESTION THAT AMERICA EXPERIENCED A SHORT PERIOD THAT WE MIGHT RECALL AS A "GOLDEN TIME" OR A BRIEF MOMENT IN CAMELOT. THE YEARS BETWEEN 1945 AND 1960 WERE CLEARLY EXCEPTIONAL, ALBEIT ANOMALOUS, FOR THE NATION. THE GROSS NATIONAL PRODUCT (GNP) GREW BY ALMOST 250 PERCENT AND PER CAPITA INCOME BY 35 PERCENT. BY 1960, 62 PERCENT OF AMERICAN FAMILIES OWNED THEIR OWN HOMES. BY THE MID-1960's, NEARLY 60 PERCENT OF THE POPULATION HAD WHAT COULD BE CONSIDERED A MIDDLE-CLASS INCOME.

DURING WORLD WAR II, AMERICANS HAD SAVED AT A RATE THREE TIMES HIGHER THAN THAT IN THE DECADES BEFORE OR SINCE. THEIR BUYING POWER WAS BOOSTED BY THE VAST COMPETITIVE ADVANTAGE WE HAD AT WAR'S END WHEN OTHER WORLD ECONOMIES WERE IN VIRTUAL COLLAPSE. THIS ADVANTAGE WAS ENHANCED BY THE ROLE OF THE GOVERNMENT WHICH COULD SUDDENLY AFFORD TO BE GENEROUS WITH EDUCATION BENEFITS, HOUSING LOANS, HIGHWAY CONSTRUCTION AND JOB TRAINING. IN THIS EXCEPTIONAL <u>BUT TEMPORARY</u> CONFLUENCE OF ECONOMIC, SOCIAL, AND POLITICAL FACTORS, THE 1950's FAMILY HAD MORE AFFLUENCE, MORE OPTIONS, AND MORE SATISFACTION. THIS IS THE FAMILY THAT LIVED-ON FAR BEYOND ITS TIME BECAUSE IT WAS MEMORIALIZED AND SERIALIZED IN THE MOVIES AND IN THAT NEW INVENTION CALLED TELEVISION. LET US SUFFICE TO SAY ON THIS ISSUE OF FAMILY, THAT JUST AS THE ECONOMICS OF THAT SHORT GOLDEN ERA DID NOT LAST, NEITHER DID THE MANY BENEFITS THAT IT BROUGHT TO FAMILIES LINGER ON. OUR TASK IS TO BE COGNIZANT OF TODAY'S REALITY AND OPEN TO DIVERSE AND PERHAPS UNTRADITIONAL SOLUTIONS.

THE THIRD FACTOR LIKELY TO CHANGE EDUCATION AND THE VERY STRUCTURE OF OUR SCHOOLS IN THE FUTURE WILL BE TECHNOLOGY. WE ARE ACTUALLY VERY GLIB ABOUT TECHNOLOGY IN AMERICA. THAT GLIBNESS, HOWEVER, IS NOT NECESSARILY BACKED UP BY A GENUINE UNDERSTANDING OF HOW TECHNOLOGY CAN BE USED EFFECTIVELY TO ACHIEVE DESIRED OUTCOMES. THIS HAS SPECIAL IMPLICATIONS FOR EDUCATIONAL SYSTEMS WHICH WILL MAKE INCREASING OUTLAYS TO BRING TECHNOLOGY INTO THE CLASSROOM. THE EFFORT TO ACQUIRE TECHNOLOGY MUST BE MATCHED BY AN EQUAL EFFORT TO PROVIDE COMPREHENSIVE TECHNOLOGY EDUCATION FOR THE TEACHERS OR THE EXERCISE WILL BE IN VAIN. IT IS OFTEN STUDENTS WHO ARE MORE FACILE WITH THE EQUIPMENT THAN THEIR VERY INSTRUCTORS.

IN MANY SCHOOLS TODAY, SOPHISTICATED COMPUTERS ARE BEING USED SOLELY FOR WORD PROCESSING -- NOT MUCH MORE ADVANCED THAN A TYPEWRITER. IF THE USE OF TECHNOLOGY DOES NOT ENHANCE LEARNING, IT PROBABLY IS NOT WORTH THE EXPENSE TO ACQUIRE IT.

LEWIS MUMFORD, ONE OF THE 20TH CENTURY'S MOST ASTUTE SOCIAL PHILOSOPHERS, DECRIED OUR FASCINATION WITH "TECHNOLOGY FOR TECHNOLOGY'S SAKE." HE SAID, (QUOTE) "WESTERN SOCIETY HAS ACCEPTED AS UNQUESTIONABLE A TECHNOLOGICAL IMPERATIVE THAT IS QUITE AS ARBITRARY AS THE MOST PRIMITIVE TABOO: NOT MERELY THE DUTY TO FOSTER

INVENTION AND CONSTANTLY TO CREATE TECHNOLOGICAL NOVELTIES, BUT EQUALLY THE DUTY TO SURRENDER TO THESE NOVELTIES UNCONDITIONALLY, JUST BECAUSE THEY ARE OFFERED..." (END QUOTE)

MUMFORD BELIEVED THAT THE GREAT BULK OF TECHNOLOGY HAS MERELY MOVED US FROM ONE PLACE TO ANOTHER, NOT NECESSARILY BETTER OR WORSE FOR THE JOURNEY. WE HAVE A RESPONSIBILITY TO CONSIDER THIS NOT ONLY FOR THE CURRENT TECHNOLOGY AVAILABLE TO SCHOOLS BUT EVEN MORE SO WITH THE ADVENT OF THE INFORMATION SUPERHIGHWAY, WHICH I STRONGLY SUPPORT. I ADMONISH YOU TO INSURE THAT EVERY TECHNOLOGY INVESTMENT AND USAGE FOR EDUCATION GENUINELY ADVANCES LEARNING.

IF WE HAVE DIFFICULTY ENVISIONING THE DIVERSE POSSIBILITIES FOR PRESENT-DAY TECHNOLOGY IN OUR SCHOOLS, LOGIC SUGGESTS THAT WE WILL HAVE EVEN GREATER DIFFICULTY ANTICIPATING THE MONUMENTAL CHANGES IT COULD HAVE ON THE EDUCATIONAL FUTURE OF AMERICA.

DIANE SAVITCH POSES THIS QUESTION. (QUOTE) "WHAT WILL HAPPEN TO SCHOOL AS WE KNOW IT, IF ONE CAN LEARN ANYTHING AT A TIME AND PLACE OF ONE'S CHOOSING?" (END QUOTE) SHE SPECULATES THAT THE COINCIDENCE OF THIS "AGE OF TECHNOLOGY" WITH THE MASS MOVEMENT OF WOMEN INTO THE WORKFORCE, WILL TRANSFORM SCHOOLS INTO CUSTODIAL INSTITUTIONS. IN THIS TRANSFORMATION, TEACHERS WILL BECOME GUIDES HELPING STUDENTS THREAD THEIR WAY THROUGH THE NEW TECHNOLOGIES AND VAST SELECTION OF DATA BASES. I AM NOT AT ALL SURE THAT THE SCHOOL/TECHNOLOGY SCENARIO WILL UNFOLD THAT WAY. I DO KNOW THAT THE REFORMS IN EDUCATION THAT WE ARE FORMULATING TODAY ARE PROBABLY NOT EVEN TRYING TO ANTICIPATE SCHOOLS ON THE INFORMATION SUPERHIGHWAY.

PERHAPS AN IMPORTANT COMPONENT OF ANY CURRENT REFORM SHOULD BE THE SIMULTANEOUS DEVELOPMENT OF AN ALTERNATIVE REFORM-MODEL USING STATE-OF-THE-ART TECHNOLOGY. WHAT I AM MOST CONCERNED ABOUT IS THAT THE EXERCISE OF REFORM NOT SEEK TO CHANGE ONLY THE PRESENT BUT ALSO TRY TO ANTICIPATE THE FUTURE. WITHOUT THIS COGNIZANCE, WE WILL ALWAYS BE CATCHING UP INSTEAD OF MOVING AHEAD.

I HAVE TALKED TODAY ABOUT DEMOGRAPHY, FAMILY, AND TECHNOLOGY AS EXTERNAL FACTORS THAT WILL CHANGE EDUCATION IN DRAMATIC WAYS. LET ME MAKE A BRIEF SUMMARY COMMENT ABOUT EACH.

I URGE YOU NOT TO LOSE SIGHT OF THE DEMOGRAPHIC LANDSCAPE. IT PROVIDES VALUABLE POINTERS TO TELL US THE DIRECTIONS IN WHICH WE ARE HEADED. DEMOGRAPHICS PROVIDE US ONE OF THE FEW TOOLS TO CRAFT ANTICIPATORY REFORM.

ON THE ISSUE OF FAMILY CHANGE, WE KNOW FROM THE REAL PAST, RATHER THAN THE MYTHOLOGICAL PAST -- THAT NO ONE FAMILY MODEL TO DATE HAS BEEN ABLE TO INSULATE CHILDREN FROM POVERTY OR SOCIAL DISRUPTION. WE ALSO KNOW THAT MUCH OF WHAT CAN BE ACHIEVED IN A SCHOOL AND IN A CLASSROOM DEPENDS UPON WHAT IS HAPPENING OUTSIDE THAT SCHOOL, IN ITS COMMUNITY, AND ON ITS STREETS. DESPITE THE FACT THAT NO IDEAL FAMILY STRUCTURE HAS EMERGED, WE RECOGNIZE THAT THERE ARE EXAMPLES OF HIGHLY SUCCESSFUL AND SUPPORTIVE COMMUNITIES IN OUR MIDST WHERE FAMILIES OF DIVERSE INCOMES AND BACKGROUNDS HAVE FLOURISHED. JUST AS WE HAVE LEARNED TO SEARCH THE NATION FOR SUCCESSFUL MODELS FOR TEACHING, FOR BUILDING CONCEPTS, AND DESIGNING CURRICULA, LET ME ALSO SUGGEST THAT WE SEARCH THE NATION FOR COMMUNITY MODELS

TO IMITATE OR LEARN FROM. OUR COMMUNITIES ARE OUR LARGER FAMILIES BUT MANY OF THEM STOPPED FUNCTIONING AS UNITS THAT PROVIDED A SOCIAL INFRASTRUCTURE FOR INDIVIDUAL FAMILIES LONG AGO. IT IS DIFFICULT AND OFTEN INAPPROPRIATE TO INTERVENE IN THE PERSONAL LIFE OF A SPECIFIC FAMILY. IT IS, HOWEVER, BOTH REASONABLE AND RIGHT TO IDENTIFY SUCCESSFUL COMMUNITY MODELS THAT PROTECT AND NOURISH FAMILIES. WE OUGHT TO BE ABLE TO DEVELOP A REGISTRY OF THESE COMMUNITIES TO BE USED AS A RESOURCE. OUR GOAL SHOULD BE TO CREATE NEW FAMILY TRADITIONS AND FIND WAYS TO REVITALIZE OLD COMMUNITY TRADITIONS. OUR SUCCESS IN THIS ENDEAVOR WILL NECESSARILY BE PIECEMEAL, BUT IT HAS THE POTENTIAL TO WEAVE A NEW FABRIC ACROSS THE NATION.

FOR TECHNOLOGY AND EDUCATION, THE GOAL MUST ALWAYS BE HOW TO ENHANCE LEARNING THOUGH TECHNOLOGY. TODAY APPROXIMATELY ONE-THIRD OF MAJOR U.S. CORPORATIONS PROVIDE BASIC SKILLS- TRAINING FOR EMPLOYEES. U.S. INDUSTRY AS A WHOLE SPENDS ABOUT $25 BILLION YEARLY ON REMEDIAL EDUCATION. BUSINESSES SPEND AS MUCH ON <u>REMEDIAL MATH EDUCATION</u> AS IS SPENT ON MATH IN SCHOOLS AND COLLEGES. ALTHOUGH THIS SEEMS A TRAGIC WASTE, PERHAPS THESE BUSINESSES HAVE SOMETHING TO TEACH SCHOOLS ABOUT TECHNOLOGY USAGE AND LEARNING. A "TECHNOLOGY USE" ROUNDTABLE COULD BE ESTABLISHED WHERE EDUCATORS AND BUSINESS EXECUTIVES CAN EXPLORE TEACHING AND TRAINING TECHNOLOGIES THAT WORK. JOINT PILOT PROGRAMS MIGHT EVEN BE INITIATED. THIS TYPE OF PROGRAM WOULD ALSO HELP SCHOOLS BETTER IDENTIFY WORKPLACE NEEDS, AND WOULD HELP BUSINESS TO APPRECIATE THE VAST ARRAY OF CONFLICTING NEEDS THAT SCHOOLS FACE. HOWEVER, IT WILL BE IMPORTANT TO KEEP THE FOCUS ON "TECHNOLOGY FOR LEARNING" AND NOT LET THE GOAL BE DIVERTED TO A GENERIC BUSINESS/EDUCATION COOPERATIVE AGREEMENT.

THE INFORMATION SUPERHIGHWAY, OF WHICH I HAVE BEEN A STRONG AND PERSISTENT ADVOCATE, WILL PRESENT ENORMOUS CHALLENGES FOR EDUCATION INSTITUTIONS. WE ARE TOLD THAT THE BODY OF AVAILABLE INFORMATION DOUBLES EVERY FIVE YEARS. ACCORDING TO A BELL LABS REPORT, IN ONE DAY'S EDITION OF THE NEW YORK TIMES, THERE IS MORE INFORMATION THAN A SINGLE MAN OR WOMAN HAD TO PROCESS IN A LIFETIME IN THE SIXTEENTH CENTURY.

READY ACCESS TO THE VAST AMOUNTS OF INFORMATION AVAILABLE ON THE INFORMATION SUPERHIGHWAY WILL CHALLENGE SCHOOLS AND TEACHERS TO CREATE LEARNING AND DEVELOP WISDOM, NOT JUST "INFORMATION NOISE" FROM THIS VERSATILE BUT OVERWHELMING RESOURCE.

AS I INDICATED EARLIER IN MY REMARKS, I RECENTLY VISITED TWO SCHOOLS IN MY DISTRICT WHICH HAVE ACCEPTED THIS CHALLENGE.

- AT NORTH VERDEMONT ELEMENTARY SCHOOL, WHICH IS A STATE-OF-THE-ART TECHNOLOGY SCHOOL, I OBSERVED STUDENTS INTERACTIVELY ENGAGED WITH TECHNOLOGY SIMULATIONS, STUDYING EARTHQUAKES AS SEISMIC WAVES, (WHICH TURNED OUT TO BE PROPHETIC INDEED). AND, A TEACHER IN ONE CLASSROOM WAS LITERALLY BROADCASTING A LESSON SHE HAD LEARNED IN THE SSI TO OTHER CLASSROOMS.

- AT MARSHALL SCHOOL, A HIGHLY DIVERSE SCHOOL IN SAN BERNARDINO, THERE WAS AN ELECTRIFYING HANDS-ON SCIENCE PROGRAM. STUDENTS AND TEACHERS USED INQUIRY METHODS AS THEY STUDIED THE WATER CYCLE IN ONE CLASS, ROCK COMPOSITION IN ANOTHER CLASSROOM, AND PAPER PLANE "AERODYNAMICS" IN YET ANOTHER CLASSROOM.

• ONE THING I LEARNED THAT DAY IS THE VALUE OF MULTI-FUNDED PROGRAMS THAT USE NSF FUNDS, EISENHOWER FUNDS, STATE AND LOCAL FUNDS, ALL IN SUPPORT OF CREATING A QUALITY SCIENCE PROGRAM. IF ALL SOURCES CONTRIBUTE TO THE WHOLE, ALL ARE INVESTORS, OWNERS AND WINNERS. AND I'M DELIGHTED TO NOTE CONGRESSMAN SAWYER HAS RESPONDED TO THE CALLS FROM THE MATH-SCIENCE COMMUNITY TO PROTECT AND PRESERVE THE MATH-SCIENCE FUNDS IN THE REAUTHORIZATION OF THE EISENHOWER PROGRAM.

• MANY TIMES CONGRESS ASKS THE FOUNDATION AND OTHER AGENCIES ABOUT THE NUMBERS THAT BENEFIT FROM FUNDS FOR SCIENCE AND MATH EDUCATION. THOSE NUMBERS ARE IMPORTANT BECAUSE WE NEED TO GAUGE PROGRESS OVER TIME FOR BOTH POLICY AND PUBLIC NOTICE. BUT THE REAL TEST OF SYSTEMIC REFORM, AS EDUCATORS CALL IT, IS SEEING STUDENTS DOING AND LEARNING SCIENCE. IT'S A REAL THRILL FOR ME TO SEE THE BEST OF SCIENCE EDUCATION IN ACTION AND IN MY OWN CONGRESSIONAL DISTRICT.

AS YOU AND YOUR COLLEAGUES MOVE FORWARD TO DEVELOP SYSTEMIC REFORM IN SCIENCE AND MATH EDUCATION, I BELIEVE YOU WILL BE ABLE TO HELP TRANSFORM THE NATION'S EDUCATIONAL ENTERPRISE INTO A "HIGH RELIABILITY ORGANIZATION," AN ORGANIZATION IN WHICH ALL STUDENTS SUCCEED. IN MANY WAYS, THIS IS SIMILAR TO THE TRANSFORMATION OCCURRING IN AMERICAN BUSINESS THROUGH TOTAL QUALITY MANAGEMENT. AT THE HEART OF THIS TRANSFORMATION IS AN INHERENT RESPECT FOR WORKERS AND THEIR INCLUSION IN THE ACTIVE DAY-TO-DAY DECISION-MAKING IN THE WORKPLACE.

AS MANY OF YOU KNOW, THE INVENTOR OF THE QUALITY MODEL WAS W. EDWARDS DEMING. DEMING, AN EMINENT AMERICAN SCIENTIST EDUCATED AS A MATHEMATICAL PHYSICIST, HELPED TRANSFORM THE JAPANESE ECONOMY INTO THE MOST PRODUCTIVE IN THE WORLD. THE WORK THAT HE PUBLISHED SHORTLY BEFORE HIS DEATH THIS YEAR IS A TREATISE CALLED <u>THE NEW ECONOMICS</u> IN WHICH HE TALKS REPEATEDLY ABOUT THE IMPORTANCE OF COOPERATION. THIS EVOLUTION OF HIS LIFETIME OF THINKING SEEMS PARTICULARLY RELEVANT TO YOUR TASK HERE TODAY. HE SAYS, (QUOTE) "WE MUST THROW OVERBOARD THE IDEA THAT COMPETITION IS A NECESSARY WAY OF LIFE. IN PLACE OF COMPETITION, WE NEED COOFERATION. [COMPETITION] SQUEEZES OUT FROM AN INDIVIDUAL, OVER HIS LIFETIME, HIS INNATE INTRINSIC MOTIVATION. WE HAVE BEEN DESTROYING OUR PEOPLE, FROM TODDLERS ON THROUGH THE UNIVERSITY, AND ON THE JOB. WE MUST PRESERVE THE POWER OF INTRINSIC MOTIVATION, DIGNITY, COOPERATION, CURIOSITY, JOY IN LEARNING, THAT PEOPLE ARE BORN WITH. ...EDUCATION AND GOVERNMENT, ALONG WITH INDUSTRY, ARE IN NEED OF TRANSFORMATION. ...THE AIM PROPOSED HERE- FOR ANY ORGANIZATION IS FOR EVERYBODY TO GAIN....(END QUOTE)

AND SO WE COME FULL CIRCLE TO THE MEANING OF <u>EDUCATIONAL REFORM</u>. WE MUST RECOGNIZE AND RESPECT THE INTRINSIC QUALITIES AND EXPERIENCES OF ALL OUR STUDENTS AND GIVE THEM THE OPPORTUNITY TO USE THIS POTENTIAL FOR SELF-GAIN AND FOR THE BENEFIT OF OTHERS AS WELL. THIS ACTIVITY TAKI 3 PLACE IN THE CONTINUING PROCESS WE CALL REFORM, A SYSTEM TO IMPROVE THROUGH ON-GOING TRANSFORMATION.

EACH OF THE EXTERNAL ELEMENTS WE EXAMINED THIS MORNING -- DEMOGRAPHY, FAMILY, AND TECHNOLOGY -- IS ALSO A TRANSFORMING FORCE. EACH CAN BE MARSHALLED TO BRING ABOUT GREATER EQUITY AND INCLUSIVENESS TO OUR EDUCATIONAL ENTERPRISE IF WE THINK IN TERMS OF CREATING A TRANSFORMATION ROOTED IN COOPERATION. LET US NOT BE INTIMIDATED BY THE DIFFICULTY OF SUCH A GOAL. IT WILL BE A DEMANDING AND

CREATIVE CHALLENGE. BUT IF WE BELIEVE THE BRITISH HISTORIAN, H.G. WELLS WHO SAID, (QUOTE) " HUMAN HISTORY BECOMES MORE AND MORE A RACE BETWEEN EDUCATION AND CATASTROPHE." -(END QUOTE) -- THEN WE HAVE NO CHOICE.

Technician Education: The Future of the U.S. Work Force

Flora Mancuso Edwards, President, Middlesex County College, New Jersey
Robert E. Parilla, President, Montgomery College, Maryland

To remain economically competitive with other industrialized countries, the United States must develop a highly qualified science and engineering technician work force. The current level of education and training in the U.S. is ineffective in raising productivity and quality to a truly competitive level. Furthermore, a connection between the skills needed in the work force and the education and training received through formal education is lacking. A well-educated and highly skilled cadre of technicians is essential to the national economy; this concept must be recognized.

Both work force preparation prior to employment and work force education and training after employment need to be strengthened. In 1990, the Commission on the Skills of the American Work Force of the National Center on Education and the Economy found what follows:

"America may have the worst school-to-work transition system of any advanced industrial country." And, "Our approaches [to education and training] have served us well in the past. They will not serve us well in the future."

Mounting a major national effort to improve the education of science and engineering technicians at this time will benefit greatly from the recognition that technicians are critical to future competitiveness in a global market. Further, the current national interest in educational reform should position technician education to gain its rightful place in the U.S.

Technicians employ skills and complex technologies to transform materials into useful products, to maintain and modify physical entities, and to provide services that are often not highly visible to others. While they often work side-by-side with other professionals, they are not junior scientists and engineers, nor are they merely trained to perform routine tasks. Their work emphasizes skilled technical applications, which require a significant theoretical framework. In other industrialized countries, the ratio of technicians to engineers and scientists is much higher than it currently is in the U.S. The changes currently occurring in industries in the U.S. require a more highly qualified and educated work force. Therefore, it is expected that the demand and professional recognition for technicians will continue to rise to the same level as in other industrialized countries. To ensure quality of this technological work force, a two-year associate degree technician degree beyond a regular high school experience must become the standard.

Effective technician education demands a close relationship between employers and academic institutions. For a highly skilled and competent work force, alliances must be organized to provide the unique strengths needed to support educational and professional activities. Two-year colleges should develop associate degree technician programs in close cooperation and as a joint venture with business and industry, government, professional societies, secondary schools, and four-year college and universities. Even though technician education is often considered the province of associate degree granting institutions, these institutions are part of a continuum of education, and technician education must be considered by other sectors of the education and industrial and business community as well.

Industry has a vested interest in technician programs in two-year institutions since they are the beneficiary of technical services provided by these colleges as well as employers of highly qualified technicians produced by two-year programs. Employers who demand top quality technicians must ensure that local institutions involved in educating technicians have appropriate resources, and they should encourage their own employees to use these resources. Thus, employers should

- cooperate with schools and colleges to provide well-equipped facilities;
- ensure that faculty members have adequate content knowledge and understanding of the workplace;
- make serious, long-term commitments of the time and financial resources required to provide faculty internship opportunities or other faculty enhancement activities in the workplace; and
- recognize that new educational strategies may require their commitment and cooperation, as well as input from their technical personnel in the design and/or implementation of new kinds of curricula.

Academic institutions, especially two-year colleges, have a responsibility to provide quality technician education programs. Faculty and administrators are both key to this endeavor. It is the faculty who create and implement the curriculum and utilize the instructional materials while using their expertise for effective education of the students they teach. Each faculty member must be current in content, effective in pedagogy, and knowledgeable about assessment if well-educated technicians are to be the result. Faculty in two-year colleges must also take a leadership role in the creation of curricula materials for technician education programs including the development of books, laboratory manuals, software, videodisks and tapes, etc. Administrators should provide time and resources for effective instruction and enhancement opportunities for faculty as well as employ faculty members who possess appropriate credentials. To ensure use of modern technologies, institutions must provide appropriate facilities and equipment for technical courses as well as be responsive to technological changes as they occur. In addition, two-year institutions should enable college faculty who teach mathematics, science, and other courses for technicians as well as those who teach technical specialty courses to obtain effective exposure to the technical workplace by granting leaves for industrial internships; by encouraging some courses to be delivered on-site to meet employer's needs and develop in instructors a sense of the workplace environment; and by providing educators with opportunities to participate with groups of employees in industrial training and orientation programs.

Studies have indicated that the education of those entering the work force as technicians and skilled workers has been particularly deficient at the secondary school level. Articulation between secondary school programs and postsecondary technician programs is being advocated and supported by government, business and industry, and education leaders to address this issue. These programs usually involve two years of secondary school plus two years of college, commonly referred to as 2 + 2. A number of successful programs for the education of technicians now concentrate on contextual learning situations and applied academics building on applied mathematics, applied sciences, and applied communications. These cooperative programs offer promise for a more highly qualified technical work force.

Technician careers attract students with highly diverse backgrounds in academic achievement and work experience. To address such diversity, two-year colleges should commit to recruitment and retention of students and placement of graduates with particular attention to women, minorities, people with disabilities, and students who have been in the work force (including work at home), as well as recent secondary school graduates. Many students currently lack the necessary educational background to enter technician programs. They must be provided with the extra assistance and time necessary to master the core competencies required by these programs. Two-year colleges should recognize that the diversity of the U.S. population may require the development of incentives for underrepresented groups in technical fields to enter technician education as students, teachers, counselors, and administrators.

A major national effort to improve the education of science and engineering technicians at this time is critical to future competitiveness of the U.S. in a global market. Two-year colleges must plan and work cooperatively with employers in business, industry, and government; four-year colleges and universities; secondary schools; and professional societies on ways to improve the quality of the U.S. technician work force. No one group can do it alone; all must cooperate. Working together academia and employers can improve the quality and effectiveness of technician education. With continued support from the National Science Foundation and others that share this vision, our Nation can remain a leader in the world economy and meet the challenges for the future.