

Chapter 7

Conclusion—Pathways to Advancing SBE Science Education

Pipeline thinking has dominated science and engineering workforce preparation and education for decades. . . . We need to devise fundamentally new arrangements that convert “the pipeline” into pathways that are multiple, flexible and adaptable. . . . Cutting these fresh patterns is our challenge in preparing the 21st century workforce. This is a tall order, but we can do it. It means keeping our eyes open to new developments, and experimenting. We may believe that this is someone else’s job. But we are all in this together - educators, researchers, and administrators, whether from the private sector, academe, or government. We all want to be in the vanguard - to ride the crest of the wave, and not be bowled over by its force. Dr. Joseph Bordogna, Deputy Director, National Science Foundation⁵¹

In 2003, the National Science Foundation embarked on a historic mission to focus attention on improving education in the social, behavioral, and economic sciences. As part of this process, NSF organized a Planning Meeting in January 2003 of representatives of social and behavioral science societies and held a National Workshop in June 2003 of leading educators and social, behavioral, and economic scientists. The Foundation’s goal was to obtain advice from the scientific community on a plan of action that would permit it to formulate concrete programs to improve SBE education at all levels.

This report is the product of that process. Based on input from these meetings as well as analysis of extant studies, documents, and data, four chapters assess the current state of SBE science education, examine impediments and challenges, highlight best practices, and specify components of an action plan for improving education and training in the SBE sciences at each critical level of the education process—K-12, undergraduate, graduate, and postdoctoral and early career. A fifth chapter focuses specifically on fostering diversity in the SBE sciences.

Framework of an Action Plan

By design and at the request of the National Science Foundation, the action plan is core to this report. Components of the plan are presented separately for each education level and on the subject of diversity in order to make clear the connections between relevant issues and recommended actions. The full plan is outlined in the Action Plan Summary Table (see pages 86-87). The plan itself sets forth pathways for improving education in the SBE sciences through (1) expanding resources or giving higher priority to the SBE sciences in existing programs, (2) pursuing new opportunities and initiatives, and (3) taking some immediate steps.

⁵¹ “From Pipeline to Pathways.” Speech to ATE National Principal Investigators Conference, October 24, 2002.

The aim of the report is to provide a plan that is practical, feasible, and desirable within the context of NSF's structure, extant programs, and how the agency works. NSF has in hand many of the tools it needs to launch a vigorous program to advance SBE science education. The plan of action offered in this report seeks to provide recommendations that can improve extant programs and expand funding for them. The plan also identifies opportunities that flow from careful assessments of NSF funding mechanisms, needs in the SBE sciences, and plausible recommendations for new initiatives. The plan finally suggests immediate steps that might be considered the "low hanging fruit" to maintain and build further momentum. Strategic actions and implementation take time, but demonstrable progress by the Foundation can and should be possible.

The Road From Here

The state of the economy and the resources currently available for science may raise questions about how best to think about investments in education and training in the social, behavioral, and economic sciences in a context where support for SBE science itself is scarce. The National Science Foundation and in particular the leadership of the SBE Directorate determined that the need for a scientifically literate public and a robust talent pool of SBE scientists warrants engaging in this task. At one level, the action plan is ambitious in setting forth substantial ideas meriting resources within existing programs and new initiatives. There is a great deal that NSF can and should do in terms of SBE science education and training. At another level, the report is realistic in so far as it systematically examines needs and analyzes what can be done in the short- and longer-term to enhance support for the SBE sciences within the contours of extant programs and new initiatives.

What does this mean for NSF in terms of priority setting? In education and training programs within EHR or NSF-wide, where initiatives exist but have not been sufficiently inclusive of the SBE sciences, intentional steps to realign priorities are urgent and necessary. The plan also provides the SBE and EHR Directorates with analysis and recommendations that should form the basis for enhanced funding of existing initiatives and support of new programs. In moving from report and action plan to priority setting, there are a number of implementation issues that require attention. These include:

- how the language of extant programs and outreach needs to be changed;
- how funds need to be committed, dedicated, or reallocated to stimulate and support SBE education enhancements;
- which programs at each level are most ripe for immediate transformation and likely to produce the highest immediate return on investment;
- which new initiatives have the highest potential for adoption;
- what indicators of performance (for enhanced attention to SBE science education and training) can be specified and in what timeframe; and
- what structural arrangements need to be put in place to manage and monitor this strategic commitment.

In 2003, the National Science Foundation challenged itself to examine how best to invest in education and training in the SBE sciences. Embedded in this ambition was recognition that “business as usual” practices in NSF’s levels and forms of support would need to change. While institutional transformation is not easy (as this report makes clear), the momentum initiated by NSF in 2003 augurs well for how the Foundation can effectively use this report and action plan.

Cross-Cutting Themes

Beyond the specific plan of action set forth in this report, the meetings and deliberations identified a number of salient cross-cutting themes:

The Need for Improved SBE Science Education at All Levels of Education

Improved SBE science education is urgently needed at all education levels in the United States. Globalization; the complex leadership role that the United States plays; and the increasing awareness that behavioral, economic, political, and social relationships are central to sound policy and societal well-being have led to greater appreciation and demand for knowledge from the SBE sciences. Public officials need social and behavioral science insights if they are to chart a wise course, whether with respect to the education of our citizenry or the strategic decisions involved in dealing with the international community. Private entrepreneurs need social and behavioral science insights if they are to succeed or even survive in the fiercely competitive global marketplace. Citizens need social and behavioral science insights if they are to understand domestic and international policy choices, be effective consumers of public information, and make personal and professional decisions based on what is known about human interactions and organizations. Despite increasing awareness of the importance of social and behavioral science knowledge, the gaps in SBE science education remain large—especially at the earlier stages of science learning.

Public Understanding of SBE Sciences as Integral to STEM

A recurrent theme is the need for greater acknowledgement that the SBE sciences are an integral part of science, technology, engineering, and mathematics (STEM). The SBE sciences can point to genuine progress at the National Science Foundation and in other institutions central to understanding the texture and scope of this scientific enterprise. Nevertheless, the NSF has a continuing opportunity to foster a more complete acceptance of the SBE sciences in the “family of science.” No place is more ripe for building this awareness than in science education itself and, in particular, in K-12 education, where the SBE sciences are conspicuously absent from introductory materials on the nature of science and the identification of phenomena that are amenable to scientific analysis. Public comprehension of the SBE sciences would be greatly advanced by inclusion of the SBE sciences at early stages of science learning.⁵²

⁵² Full inclusion of the SBE sciences will take sustained leadership and rethinking from the science and education communities. For example, the biennial Survey of Public Attitudes Toward and Understanding of Science and Technology undertaken by NSF currently asks no specific questions that would probe awareness of the scientific study of human and social dynamics.

The National Science Foundation as Key to Advancing SBE Science Education

The National Science Foundation is the sole federal agency charged with advancing the health and well-being of science. As such, the Foundation plays a pivotal role in influencing the directions of and understandings about science and science education. No other organization or agency commands comparable respect in science, in the social and behavioral sciences, and in the science education communities. Therefore, the Foundation's commitment to identifying and taking strategic steps to advance education in the SBE sciences is of major significance.

Beyond its own programs, NSF is particularly well situated to support and encourage *systemic* improvement in SBE science education at all levels of education. An expanded presence in the secondary school curricula, for example, is critical to making students aware of the existence and fascination of SBE science. Students can hardly be expected to select career options when they are unaware that they exist. Similarly, a stronger presence in the kindergarten through grade 8 curricula is an essential building block for what might be offered in grades 9 through 12. "Early and often" are the basic ingredients of scientific literacy and interest in all fields. At each stage in the education process, there are important challenges and opportunities for SBE science where NSF's leadership is key.

NSF and the Challenge of Culture Change

The National Science Foundation has supported cutting edge SBE science and has been at the cutting edge in advancing SBE disciplines and interdisciplinary fields. Great strides have been made internal to NSF in comprehending the role and importance of social, behavioral, and economic science theory, methods, and knowledge. The establishment of a separate Social, Behavioral, and Economic Sciences Directorate more than a decade ago was one indicator. The new NSF-wide competition on *Human and Social Dynamics*—the first ever where the entire scientific enterprise is studying phenomena grounded in social processes—is another. The initiation of this exercise on SBE science education, with the active participation of the EHR Directorate, is a further indicator that the culture of science at NSF is amenable to change.

Joint support from the SBE and EHR Directorates for a strategic plan for education and training in the SBE sciences will further affirm NSF's commitment to improving SBE science education in the short- and long-term. It will send a loud and clear signal that the integration of science and education should be a priority and not an afterthought. It will also signal that education in the SBE sciences requires the same level of intentional programming and support as in other fields of science. In the past, the SBE sciences were not eligible for support from some NSF education and training programs. Because ambiguities regarding eligibility pervade the SBE research community and were explicitly (and frequently) expressed at the National Workshop, clarification is necessary to ensure that SBE proposals are welcome independently or as components of institution-wide projects. Long-term patterns and practices can be hard to transcend without affirmative messages; full participation of the SBE sciences in all relevant NSF programs will require explicit encouragement.

Strengthening Collaborative Ties Between the SBE and EHR Directorates

The gains made over the last several years in communication, coordination, and rapport between the SBE and EHR Directorates are laudable. The full participation in and commitment of the EHR Directorate to this SBE-initiated activity are visible and welcome signs of the potential for further collaboration between these two Directorates. Because Assistant Directors (ADs) currently serve fixed terms, institutional mechanisms should be devised independent of the rapport that exists between particular incumbents. One step would be to institute a joint staff implementation committee that reports directly to the ADs; another is to institute cross appointments between the EHR and SBE Advisory Committees.

Appointing an expert or experts in science education to the SBE Advisory Committee and SBE scientists to the EHR Advisory Committee, with perhaps at least one individual serving on both advisory committees, would help to ensure that educational implications are kept in mind during SBE Directorate policy discussions, and that the SBE sciences are not overlooked during the formulation and review of EHR policies and programs. In contexts where it would be productive to do so, cross appointments between EHR and SBE proposal review panels might also be considered.

Strengthening Communication with the SBE Science Community

The importance of communication was a theme that emerged during the Planning Meeting and the National Workshop. The research community would benefit from knowing more about funding mechanisms available through NSF and about the results of projects that have been funded. Participants also thought that NSF would benefit from continued interaction with SBE scientists. A number of the recommendations speak to recognizing and publicizing best practices in SBE science education at all levels. NSF could use its website or other media to highlight model initiatives that might be adopted or modified for use by others.

Working with Scientific Societies and Organizations

Tremendous advantages would result from collaboration between NSF and scientific societies in promoting education and training at all levels in the SBE sciences. High priority should be given to working with other organizations, especially the relevant scholarly societies, the American Association for the Advancement of Science (AAAS), and the National Academy of Sciences (NAS). The elected officers and the professional staffs of social, behavioral, and economic science societies can offer useful expertise and deep commitment to education and training. They can also provide powerful links between NSF and relevant research communities. Many associations have effective, long-standing programs devoted to producing curriculum materials, enhancing the teaching of their subjects, and training students.

The American Association for the Advancement of Science and the National Academy of Sciences have fielded multiple committees, commissions, and programs focused on science education. Unfortunately, the social and behavioral sciences are far more conspicuous by their absence than by their participation in AAAS and NAS efforts to improve science

education. Given the number of other areas of successful integration of the SBE sciences in the work and programs of the AAAS and the NAS, this pattern of under-inclusion on issues of science education should, with the right points of contact and encouragement, be amenable to transformation and change.

Bringing Research and Evaluation To Bear

As might be expected in a national workshop of participants with research backgrounds, commitment ran high for better data and greater knowledge about education, training, career trajectories, and the processes that sort and select persons into, through, or out of scientific careers. More investment in scientific research on these and other issues was considered to be important to understanding scientific careers and professions and the role of educational processes and systems in that regard.

In addition to a general call for more research, which itself is of merit, there was a parallel call for systematic study and evaluation of education and training programs. There was pervasive agreement that, whatever programs NSF alters or establishes in response to the need to improve SBE science education, they should contain mechanisms for evaluation. The funds earmarked for evaluation within each project should be appropriate to the individual goals, methods, and expected outcomes from that effort. But no project intended to yield specific and measurable improvements in SBE science education should miss the benefits that derives from built-in evaluation for both project improvement and for helping to shape and refine future investments for the field.

Elevating the Social Science of Science Education

The call for research noted above raises more fundamentally the need to encourage greater investment in the social science of science, including on issues of education and professional development. This important arena of scholarship could benefit from more resources and a broader mandate to widen its scope to explicitly include the SBE sciences. While charting a research agenda is beyond the scope of this report, just as education needs to be connected to science, so too does science need to be a central part of sound science education. This theme was emphasized at the National Workshop.

In reflecting on the need for research and data, workshop participants saw the concept of a center dedicated to the study of academic and scientific systems and institutions to be very promising. An NSF Center for Research on Innovation and Organizational Change in Academic and Scientific Settings could be appropriately supported within the scope of the *Human and Social Dynamics* Initiative. Widespread systemic change in SBE science education at all levels would benefit from a deeper understanding of how change has been and can be accomplished in academic and scientific settings. Funding a National Center for Research on Innovation and Organization Change in schools, colleges, and universities and in research contexts would signal the Foundation's long-term and continuing commitment to understanding the functioning and role of academic systems and building knowledge-based recommendations for change. Such a center could command the interest and support of all NSF disciplines and directorates, the

education community, scholarly societies, and such major institutions as AAAS and NAS. Establishing such a center and coordinating its efforts should yield the knowledge, strategies, and tactics needed to improve education and training in all science.

Final Thought

This report concludes with a note of optimism for what the National Science Foundation has achieved by mandating this exercise and by seeking to devise a strategic plan for the improvement of education and training in the social, behavioral, and economic sciences. NSF's next steps can have a major impact on SBE science and training, as we have known it. In five, ten, and twenty years from now, the public's capacity to understand the SBE sciences and the capacity of the SBE scientific community to contribute new and important discoveries will, we believe, be traced to NSF's seizing the opportunity to commit itself to this important educational mission and goal.

**Action Plan Summary Table: Training and Education in the SBE Sciences
By Education Level, Strategic Stage, and Priority**

Ed Level	Expand/Alter Existing Programs	New Initiatives	Immediate Steps
K-12	<ul style="list-style-type: none"> • SBE Center for Learning and Teaching (EHR) • Instructional Materials Development Program (EHR) • Teacher Professional Continuum Program (EHR) • Informal Science Education Program (EHR) 	<ul style="list-style-type: none"> • SBE Science in High School Initiative (SBE/EHR) • Teacher Training Initiative (SBE/EHR) • “Bridges to SBE Science Education” Program (SBE/EHR) • Research Experiences for High Schoolers (REHS) Program (SBE) 	<ul style="list-style-type: none"> • Place high profile NSF articles (e.g., in <i>Education Week, Science</i>) on the importance of SBE education in K-12 • Urge NRC to include SBE sciences in Committee on Science Education K-12 (COSE K-12) • Urge AAAS to integrate SBE sciences into project 2061
Under-Graduate	<ul style="list-style-type: none"> • Underrepresented Minorities Programs (EHR): <ul style="list-style-type: none"> • Lewis Stokes Alliance for Minority Participation (LSAMP) • Alliance for Graduate Education and the Professorate (AGEP) • Centers of Research Excellence in Science and Technology (CREST) • Historically Black Colleges and Universities Undergraduate Program (HBCU-UP) • Tribal College Undergraduate Program (TCUP) • Research Experiences for Undergraduates (REU) Program (SBE) • Course, Curriculum, & Laboratory Improvement (CCLI) Program (EHR) • Science, Technology, Engineering, & Mathematics Expansion (STEP) Program (EHR) 	<ul style="list-style-type: none"> • Systemic Reform of SBE Undergraduate Education Initiative (SBE/EHR) • SBE Educational Innovation Program (SBE/EHR) • Undergraduate Faculty Enhancement Initiative (SBE/EHR) 	<ul style="list-style-type: none"> • Publicize NSF Director’s Award for Distinguished Teaching Scholars (DTS) in SBE community • Convene workshop of REU site grantees and SBE-CCLI grantees to identify and disseminate promising practices • Urge NRC to include SBE sciences in Committee on Undergraduate Science Education

<p>Graduate</p>	<ul style="list-style-type: none"> • Integrative Graduate Education & Research Traineeship (IGERT) Program (NSF-wide) • Graduate Teaching Fellows in K-12 Education (GK-12) Program (EHR) • Research Experiences for Graduates (REG) Supplements (SBE) 	<ul style="list-style-type: none"> • Transformed SBE Doctoral Dissertation Improvement Program (SBE/EHR) • Transition & Early Career Initiative for Graduate Students (SBE/EHR) • Graduate Education Reinvention Program (SBE/EHR) • Preparing Future SBE Scientists Program (SBE/EHR) 	<ul style="list-style-type: none"> • Modify NSF review criteria to include proposal's effectiveness in graduate student training • Convene SBE leadership conference on 1995 NAS Graduate Education Report • Convene leadership of programs directed to rethinking graduate education • Commission or partner on study of SBE graduate education
<p>Postdoc & Early Career</p>	<ul style="list-style-type: none"> • Postdoctoral Fellowships & Small Grants for Training/Research Fellowships (SGTRF) in STS Program (SBE) • Minority Postdoctoral Research Fellowships & Supporting Activities Program (SBE) • Mid-Career support mechanisms for professional development in various programs (SBE) • Faculty Early Career Development (CAREER) Program (NSF-wide) • Research Opportunity Awards (ROAs) for faculty at predominately undergraduate institutions (NSF-wide) 	<ul style="list-style-type: none"> • Integrative Postdoctoral Research Traineeship (IPRT) Program (SBE/EHR) • Postdoctoral Research Fellowships Program (SBE) • Vertical Integration of Research and Education (VIGRE) Awards (SBE/EHR) • Stimulus Package Partnerships for Professional Development (SBE) 	<ul style="list-style-type: none"> • Promote SBE postdoctoral and early career opportunities • Allocate EHR evaluation funds for evaluations as part of postdoctoral training in evaluation research • Convene federal and private funders of SBE postdoctoral training programs • Convene leadership of postdoctoral programs to help design SBE postdoctoral initiative and solicitations • Extend statistical data collection in SBE/SRS to SBE postdoctoral and early career stages • Urge AAAS to include SBE sciences in postdoctoral networks
<p>Diversity</p>	<ul style="list-style-type: none"> • Explicit access/inclusion of SBE sciences in underrepresented minorities programs in Division of Human Resource Development (EHR) <ul style="list-style-type: none"> • LSAMP • AGEP • CREST • HBCU-UP • TCUP • Programs Directed to Women and Girls <ul style="list-style-type: none"> • HRD Program in Gender Diversity in Science, Technology, Engineering, & Mathematics Education (EHR) • Advance Program (NSF-wide) • Research Experiences for Undergraduates (REU) Program (SBE) • Integrative Graduate Education & Research Traineeship (IGERT) Program (NSF-wide) • SBE Minority Postdoctoral Research Fellowships & Support Program (SBE) 	<ul style="list-style-type: none"> • SBE Diversity Innovations Program (SBE/EHR) • Launch Awards Program (LAP) for SBE Minority Scholars (SBE) 	<ul style="list-style-type: none"> • Request CEOSE to review report and diversity recommendations therein • Clarify to staff NSF goal of <i>Integrating Diversity into NSF Program Projects and Activities</i> • Develop NSF incentive program to reward departments enhancing diversity • Support preparation of best practices manual for recruiting and retaining SBE minority students • Support research on diversity in SBE sciences • Urge AAAS to enhance relevance of Minority Scientists Networks to SBE sciences

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