DECEMBER 1996

National Science Foundation, Directorate for Education and Human Resources

Shaping the Future of Undergraduate Education

An ambitious year-long study that provides a detailed look at the state of undergraduate education in science, mathematics, engineering, and technology (SME&T) in U.S. colleges and universities has just been completed. The study, the first of its kind in a decade, was conducted by a special advisory committee to the National Science Foundation (NSF). The study report, ***Shaping the Future: New Expectations for Undergraduate Education in Science, Mathematics, Engineering, and Technology***, provides action-oriented recommendations for improving the quality of undergraduate education in SME&T. It is broad in scope, reflecting the advice and contributions of hundreds of individuals representing the public and private sectors, professional societies, and diverse academic groups.

continued on page 3

> The opportunities we offer during the undergraduate experience must allow all students to find career paths, properly educate them for these avenues, and prepare these students to be the future leaders of the Nation.

working together to revitalize science, mathematics, engineering, & technology education

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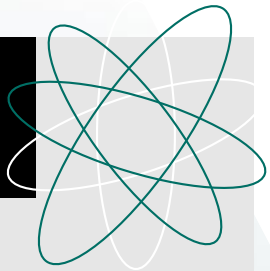

About Synergy

Synergy is a publication of the National Science Foundation's Directorate for Education and Human Resources (EHR). In newsletter format, it presents to the various science, mathematics, engineering, and technology education communities information on EHR programs and events, as well as summaries of project results. Each ***Synergy*** issue highlights an EHR activity that is demonstrating progress in reforming the teaching and learning of science, mathematics, engineering, or technology, prekindergarten through career entry. The "synergy" derives from NSF working in partnership with organizations throughout the United States and in all sectors of the economy to help foster the positive changes in education to which NSF is dedicated. The ingredients of these outcomes-based success stories are unchanging: access to quality science and mathematics education, high expectations for the success of these efforts, proven excellence of materials and their delivery, and measurable gains in learning by all students.

In this Issue...

Synergy looks at the ***Shaping the Future*** report to NSF on undergraduate science, mathematics, engineering, and technology education that was produced by the Advisory Committee to NSF's Directorate for Education and Human Resources. The Committee considered the needs of all undergraduates attending all types of colleges and universities. Using input and commentary from individuals, institutions, and organizations across the Nation and from many communities with an interest in excellent undergraduate education, the report comments on the most critical issues in higher education today, including the preparation of elementary and secondary school teachers, training for the technical work force, institutional reform, and the transition of students between levels of education or from education to the work force. This issue of ***Synergy*** summarizes the process and findings of the year-long study and outlines the steps necessary for enacting these substantive reforms, as determined by representatives of academia and "customers" of the academic experience, the students.

The views, opinions, and recommendations expressed in this document are those of the Advisory Committee and do not necessarily represent the official views, opinions, or policy of the Foundation.

Shaping the Future of Undergraduate Education *continued...*

The study described the centrality and importance to society of an undergraduate education. It also summarized the progress that has been made over the past 10 years, while presenting the challenges that need to be met and changes that need to be made if undergraduate education is to serve adequately its diverse clientele in the future.

> *All* students at *all* types of 2- and 4-year colleges and universities should have access to supportive, excellent SME&T education.
>
> *All* students should be afforded the opportunity to learn these subjects by direct experience.

As the U.S. economy continues to take new shape, fewer well-paying jobs will be available to those without at least some college education, and many of those jobs will require knowledge and competency in the sciences, mathematics, engineering, and technology. Future workers will need the skills and "professional agility" required to succeed in the modern workplace, and employers participating in the study have expressed concern that college curricula address that reality. In addition, because U.S. demographics are changing, efforts must be made to promote diversity in the population of students that are successful in their SME&T education so that the Nation can benefit from the talent that is potentially available.

The report provides a rich set of recommendations (see page 4) that, when taken together, constitute a coherent, broad-reaching call to action to improve SME&T education for all undergraduate students. Four ideas constitute a firm foundation for this plan:

- Every undergraduate should have access to an excellent education in science, mathematics, engineering, and technology and be encouraged to study and learn these subjects.
- A flexible SME&T curriculum should provide students with greater awareness of and preparation for career opportunities.
- The educational environment should be supportive of students, promote active learning, encourage collaboration, and emphasize inquiry more than rote acquisition of facts.
- All links in the education chain, including K-12, undergraduate, graduate, and professional schools, must work together to provide, assure, and reward sound learning.

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The Committee on Undergraduate Education

The Assistant Director of NSF's Directorate for Education and Human Resources, Luther Williams, appointed a subcommittee of the Directorate's Advisory Committee to conduct a nationwide study and report on the status and needs of undergraduate education in America.

The committee synthesized its findings in the report, *Shaping the Future: New Expectations for Undergraduate Education in Science, Mathematics, Engineering, and Technology.*

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Committee Consultant
Dean of Engineering
North Carolina A&T State University

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Recommendations from the Commit

THE RECOMMENDATIONS IN THE REPORT URGE THAT ALL NSF UNITS SHOULD:

- promote diversity in the population of students who are successful in their SME&T education
- support activities that advance the public understanding of SME&T
- consider mechanisms that assign responsibility and provide incentives and rewards to whole departments and entire institutions for achieving educational excellence

Who?	Are urged to...
THE PRESIDENT AND CONGRESS	• Establish a new social contract with higher education to prepare the Nation for the 21st century
OTHER FEDERAL AGENCIES & FOUNDATIONS	• Make strategic investments to support a common agenda for improving undergraduate SME&T education
STATE GOVERNMENTS AND HIGHER EDUCATION BOARDS	• Ensure that funding formulas reward excellent education • Encourage collaborations among institutions
ACCREDITING AGENCIES	• Incorporate principles of sound SME&T education into accreditation criteria, focusing on learning, not process
GOVERNING BOARDS & ADMINISTRATORS	• Hold departments accountable for SME&T education, stressing the importance of SME&T for all students • Provide strong programs of faculty development • Value and reward faculty who facilitate student learning • Reduce organizational rigidities, foster interdisciplinary work, and strive to improve teacher preparation • Support research on student learning
SME&T DEPARTMENTS	• Provide measurable expectations for students, and accept responsibility for student learning • Offer a curriculum to engage a broad spectrum of students • Use technology creatively, stressing life-long learning skills • Work collaboratively with education departments, business, and K-12 sectors to improve teacher preparation

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tee on Undergraduate Education

Who?	Are urged to...
SME&T Faculty	• Build upon the experiences of students and provide a supportive climate for learning, while maintaining high expectations • Model good practices that result in sound and significant learning • Encourage and require communication and teamwork
Business, Industry, & Other Employers	• Communicate their expectations for graduates' skills • Inform public opinion about the value of SME&T literacy • Form partnerships with academic institutions to advance institution-wide reform, and provide funds
National and Regional Media	• Become better informed about the condition of undergraduate education and inform the public about its critical significance for the Nation's future
Professional Societies	• Honor, promote, and support education equally with research
National Science Foundation	• Lead the development of a common agenda • Support a balance between education and research • Double real funds for undergraduate education over 10 years • Give more priority to implementation of innovative practices, especially for teacher preparation, faculty enhancement, the use of educational technology, and institutional reform • Intensify evaluation of results and codify what is known about effective practices • Support research on human learning at the undergraduate level

Shaping the Future

Shaping the Future

Findings of the Report

Among the overarching findings of the study was that an excellent, engaging education in SME&T subjects is critically important for *all* undergraduates, not solely SME&T majors. Equally apparent in the report was the number of successful and encouraging improvements made over the past decade, many funded by NSF programs or driven by NSF-funded projects. Among these improvements were the increased use of, and emphasis on:

- flexible, modular curricula
- introduction of complex concepts through practical, real-world scenarios
- interdisciplinary and multidisciplinary collaboration
- collaborative and active learning
- educational technology

At the same time, several barriers to continued improvement were identified:

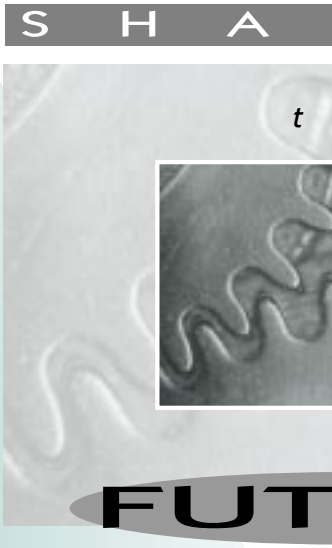
- dwindling resources
- a rigid academic establishment resistant of change
- high variability in the preparation and abilities of incoming students
- ineffective or inefficient use of technology in instruction and learning
- insufficient application of learning assessment and evaluation tools
- faculty reward systems inconsistent with the improvement of undergraduate education

The report strongly advises that SME&T undergraduate education become

- **more central** in the curriculum and in faculty rewards and recognition
- **more centered** around the student and in the processes of the various disciplines
- **more connected** with students' own experiences and to interdisciplinary content
- **more collaborative** among students as well as across institutions, organizations, professional societies, and industry
- **more comprehensive** across each institution and in all institutions offering SME&T education

This report does not set undergraduate education apart; it deals with the nexus of an educational continuum that runs from kindergarten through postgraduate study and beyond...

The final recommendation of the report is that NSF accept leadership of the efforts necessary to implement these recommendations as a whole.



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The Voice of the Nation

In April 1995, Luther Williams, NSF Assistant Director for Education and Human Resources, appointed a Committee on Undergraduate Education (see page 3) to seek input from the community at large that would reveal the current status and future needs of undergraduate education and review existing reports, data, and trends concerning SME&T education.

As part of the review process, Dr. Williams invited comments from more than 200 individuals and organizations known for their commitment to education. Through public hearings, focus groups, and other forums, the Committee was able to draw commentary and opinion from students and parents, faculty and administrators, accrediting groups and professional societies, employers of SME&T graduates, and state and local education officials. The respondents—nearly 80 percent of those surveyed—identified a multitude of improvements made in the past decade and recorded their perceptions of the most significant barriers to furthering improvement. The Committee addressed a number of specific roles played by the Nation's 2- and 4-year colleges and universities, such as:

- preparing future elementary and secondary school teachers
- educating persons entering the workforce
- preparing those who choose to major and seek careers in SME&T fields
- stressing science literacy for all

The review also covered a range of issues affecting undergraduate education, including:

- the quality of the curriculum
- the use of educational technology
- pedagogy and instruction
- the incorporation of research into the learning process
- institutional policies, practices, and reforms
- transition of students between levels of education and into employment

The Review of Undergraduate Education

APRIL 1995	AUGUST 1995	OCT/NOV 1995	FEBRUARY 1996	MAY 1996	JULY 1996	OCTOBER 1996
Review initiated with naming of a Committee on Undergraduate Education	NSF's Assistant Director for Education and Human Resources requested letters of opinion from more than 200 authorities and stakeholders in U.S. undergraduate education	Public hearings on Disciplinary Perspectives, Institutional Perspectives, Employers' Views	Preliminary report and recommendations issued by the Committee	Regional focus groups completed	NSF/NRC Shaping the Future Conference, Washington, DC	Final report released

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Focus Groups

Regional focus groups were held in the vicinity of Atlanta, Boston, Chicago, and San Francisco that included students, recent SME&T graduates, non-SME&T graduates, parents, employers, and prospective K-12 teachers.

Public Hearings

To consider successes, needs, and opportunities for improvement in SME&T undergraduate education, NSF hosted a series of public hearings. Testimonies were received from representatives of all SME&T disciplines, a diverse set of 2- and 4- year colleges and universities, employers, and other stakeholders in undergraduate education.

DISCIPLINARY PERSPECTIVES -
October 23, 1995 & February 22, 1996

MRC Greenwood - University of California, Davis (CA) / Rita Colwell - AAAS, University of Maryland, College Park (MD) / Alan Tucker - State University of New York, Stony Brook (NY) / Eleanor Baum - Cooper Union (NY) / Winfred Phillips - University of Florida (FL) / Peter Denning - George Mason University (VA) / Don Gentry - Purdue University (IN) / Durwood Huffman - Northern Maine Technical College (ME) / Ernest Eliel - University of North Carolina, Chapel Hill (NC) / Angelica Stacy - University of California, Berkeley (CA) / Robert Hilborn - AAPT, Amherst College (MA) / Eric Mazur - Harvard University (MA) / Tanya Atwater - University of California, Santa Barbara (CA) / Andrew Abbott - University of Chicago (IL) / Ronald Ehrenberg - Cornell University (NY) / Rochel Gelman - New York University (NY) / Kenneth Foote - University of Texas, Austin (TX) / Maureen Hallinan - University of Notre Dame (IN) / Jill Larkin - Carnegie Mellon University (PA) / Neil Stillings - Hampshire College (MA)

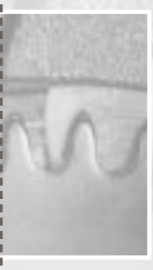
INSTITUTIONAL PERSPECTIVES -
October 25, 1995

Pamela Ferguson - Grinnell College (IA) / Thomas Morris - Emory and Henry College (VA) / Bruce Leslie - Onondaga Community College (NY) / Gwendolyn Stephenson - St. Louis Community College (MO) / Frederick Humphries - Florida A&M University (FL) / William Kirwan - University of Maryland, College Park (MD) / Paula Brownlee - American Association of Colleges & Universities (DC) / Saul Fenster - New Jersey Institute of Technology (NJ) / Judith Ramaley - Portland State University (OR) / David Ward - University of Wisconsin, Madison (WI) / Homer Neal - University of Michigan (MI)

EMPLOYERS' VIEWS -
November 1, 1995

Walter Amprey - Baltimore Public Schools (MD) / Eugene Galanter - Columbia University (NY) / Peggy Cole - New York Hall of Science (NY) / Israel Joseph Galvan - GHG Corporation (TX) / Alfred Moye - Hewlett Packard Company (CA) / John McMasters - The Boeing Company (WA) / Robert Jones - National Alliance of Business (DC) / John Sisler - Shell Oil Company (TX) / Patrick White - Bell Atlantic Corporation (VA)

A Celebration of Innovation



The Review of Undergraduate Education carried out for NSF was coordinated with the National Research Council (NRC)'s "Year of National Dialogue" on higher education. Both the report to NSF and the NRC report, ***From Analysis to Action: Undergraduate Education in Science, Mathematics, Engineering, and Technology***, were presented to over 500 delegates from 2- and 4-year colleges and universities, business and industry, and government agencies at the jointly sponsored conference ***"Shaping the Future: Strategies for Revitalizing Undergraduate Education,"*** held July 11-13, 1996, in Washington, DC.

In preparation for the conference, approximately 50 institutions were asked to develop written summaries of their plans to improve undergraduate SME&T education. These documents, distributed to conference participants as a basis for discussion, formed a rich collection of ideas to build on past successes and further improve higher education.

The conference revealed the unique perspectives of state legislators, college presidents, students, faculty, and representatives from industry. The employers of SME&T graduates stated clearly that more relevant and flexible skills are expected from graduates entering the workforce; legislators provided advice on how institutions can better communicate their needs and priorities to government; and a wide range of exhibitors — including awardees from NSF's new Institution-Wide Reform initiative (see the July 1996 ***Synergy***) — showcased their plans and examples of successful reform efforts. Among the outcomes of this event were recognition of the multiple influences on undergraduate SME&T education and a renewed call for the various constituencies to work cooperatively to achieve synergistic improvements.

Next Steps

The review of undergraduate education and the resulting report to NSF provide tangible guidelines for more effective use of the investments being made by organizations and agencies seeking to improve undergraduate SME&T education. The National Science Foundation will weigh the findings and recommendations in seeking to guide its commitment to undergraduate education through investment in an effective portfolio of undergraduate programs and to engage institutions of higher education, faculty, and students across the United States in the process of improvement.

To achieve its objectives, it is important that this report have potential impact beyond the National Science Foundation. The report and the *Shaping the Future* conference were intended to be catalysts for change. Toward this end, academic institutions and all interested individuals are asked to further the impact of the report by exploring the challenges and opportunities of undergraduate education in their own communities.

Shaping the Future

SHAPING

For more information on the undergraduate review, the report, or its recommendations, please contact NSF's Division of Undergraduate Education at (703) 306-1666. Highlights of the report can also be found on the World Wide Web at http://www.ehr.nsf.gov/ehr/due/start.htm.

Synergy **is published by the Directorate for Education and Human Resources (EHR), the National Science Foundation, under the leadership of Luther S. Williams.**

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Synergy can be accessed on EHR's Web site, http://www.ehr.nsf.gov/index.html. EHR welcomes readers' comments and questions on this issue. By phone, call 703/306-1666; by e-mail, use undergrad@nsf.gov.

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