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ABSTRACT

A colloquium of 53 Presidential Young investigators (PYIs), nominated by their institutions and selected by the National Science Foundation, was charged with the task of preparing a report of their vision and recommendations concerning the role of U.S. higher education in the year 2010 and beyond to assure high quality precollege and graduate instruction in engineering, mathematics, and the sciences for everyone. This report, which describes the principal conclusions of the group, includes reports of six individual panels that focus on different aspects of U.S. education. The six panel summaries address and make recommendations on the following issues: attaining and maintaining scientific and technological literacy for all people; encouraging curriculum renewal and the development of new learning environments; incorporating new and evolving technologies into the curriculum; encouraging and preparing students for careers as precollege and college teachers; assuring career participation by all societal groups; and developing young faculty during the critical years to tenure. The colloquium concluded that U.S. higher education must: (1) encourage and reward instructional excellence; (2) increase resources for instructional innovation and curriculum renewal; (3) assume responsibility for public understanding of science and technology; (4) assure career participation in engineering, mathematics, and the sciences by all segments of society; and (5) encourage the development of discovery-oriented learning environments and technology-based instruction. The report includes a list of participants, the charge to the colloquium, the colloquium agenda, and Massachusetts Institute of Technology President Charles M. Vest's colloquium address. (MDH)

AMERICA'S ACADEMIC FUTURE

A Report of the Presidential Young Investigator Colloquium on U.S. Engineering, Mathematics, and Science Education for the Year 2010 and Beyond

Directorate for Education and Human Resources
National Science Foundation
January, 1992

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AMERICA'S ACADEMIC FUTURE

A Report of the Presidential Young Investigator Colloquium on U.S. Engineering, Mathematics, and Science Education for the Year 2010 and Beyond

Co-Chairs:

Jack R. Lohmann
Georgia Institute of Technology

Angelica M. Stacy
University of California, Berkeley

November 4–6, 1990
Washington, D.C.

Directorate for Education and Human Resources
National Science Foundation
January, 1992

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OFFICE OF THE
ASSISTANT DIRECTOR
FOR EDUCATION AND
HUMAN RESOURCES

January, 1992

Dr. Walter E. Massey
Director
National Science Foundation
Washington, D.C. 20550

Dear Walter:

I am pleased to submit to you the report from the faculty who participated in the Presidential Young Investigator (PYI) Colloquium on U.S. Engineering, Mathematics, and Science Education for the Year 2010 and Beyond. The participants, all PYIs, represent a broad array of fields within engineering, mathematics, and the sciences and a wide cross-section of our Nation's colleges and universities.

Their recommendations merit serious consideration. As outstanding young faculty today, they represent the future leadership of our academic institutions. Their visions of the future and recommendations for action yield considerable insight into the long-term trends and directions for higher education well into the next century.

Sincerely,

Luther S. Williams

Luther S. Williams
Assistant Director

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FOREWORD

The long-term success of the national efforts to revitalize engineering, mathematics, and science education depends critically on outstanding young faculty today who will increasingly shape and define all our educational institutions. It will be through their efforts and leadership that higher education will improve the quality of instruction in engineering, mathematics, and the sciences for all students at all educational levels into the next century. Their counsel and involvement now is vital to the national education agenda.

The National Science Foundation, through the Division of Undergraduate Science, Engineering and Mathematics Education (USEME), and in collaboration with the Division of Research Career Development and representatives from all the Foundation Directorates, convened a colloquium of fifty-three Presidential Young Investigators (PYIs) on November 4–6, 1990. The PYIs, all recipients from the class years 1984–1989, represented a broad distribution of institutions and disciplines. The participants were nominated by their institutions and selected by NSF for their demonstrable concern for precollege and undergraduate education and for their potential for future academic leadership.

The charge to the colloquium, broadly, was to prepare a report of their vision and recommendations of the role of U.S. higher education in the year 2010 and beyond to assure high quality precollege and undergraduate instruction in engineering, mathematics, and the sciences for everyone.

This report describes the principal conclusions of the Presidential Young Investigator Colloquium on U.S. Engineering, Mathematics, and Science Education for the Year 2010 and Beyond, including their vision of the future, key courses of action, and recommendations to U.S. higher education in general, and the National Science Foundation in particular. NSF expresses its appreciation to Dr. Jack R. Lohmann, from the Georgia Institute of Technology (on leave of absence from the University of Michigan, Ann Arbor to NSF/USEME from 1989–1991), and Dr. Angelica M. Stacy, from the University of California, Berkeley, who co-chaired the colloquium, and to the participants for their thoughtful counsel and contributions. The opinions expressed in this report are those of the participants and do not necessarily represent NSF policy. The findings of the participants are currently under review by NSF.

Robert F. Watson

Robert F. Watson
Director, Division of Undergraduate Science,
Engineering and Mathematics Education

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EXECUTIVE SUMMARY

THE CONDITION OF U.S. EDUCATION

Numerous reports and studies have expressed serious concerns that the U.S. educational infrastructure is ill-prepared to meet the challenges and opportunities of the next century. The low level of scientific and technological literacy in our society is deplorable, and the trickle of talent flowing into careers in engineering, mathematics, and the sciences from all segments of society is deeply disturbing. The poor condition of our educational infrastructure is not the result of a few isolated, independent, or discipline-specific problems. Its condition mandates fundamental, comprehensive, and systemic changes in the way all of us go about the business of education.

A VISION OF THE YEAR 2010

"*...let me begin with one simple statement.* Professors should profess. *It is hard to think of anything more illogical than to become a university professor if one does not want to teach. So if you do not want to teach, you should immediately look for another job.*"

Charles M. Vest
President, MIT
Colloquium Address
November 5, 1990

The success of the current national efforts to revitalize engineering, mathematics, and science instruction depends on the commitment and collaboration of a number of communities, including industry, schools, colleges, universities, government at all levels, and the public. Mostly, however, it depends on the faculty in our Nation's schools, colleges, and universities. The faculty, be they elementary school teachers, community college instructors, or university professors, are the curriculum personified. The faculty, both individually and collectively, have considerable latitude in the curriculum content and in the instructional approaches used. Superior faculty motivate students to broaden and deepen their intellect, and aspire to higher achievements. Mediocre faculty dampen the enthusiasm of good students and stifle development of potential talents in others.

The faculty in higher education, however, have a special and critical responsibility. Higher education provides the professional preparation of many of our Nation's future business leaders, public officials, socially concerned citizens, and virtually all engineers, mathematicians, and scientists, including those who will become future faculty at all educational levels — elementary and secondary schools, community colleges, and colleges and universities themselves. Thus, the faculty in higher education and their commitment to teaching are absolutely critical to the quality of instruction in engineering, mathematics, and the sciences provided to both majors and non-majors on our college campuses and also to the quality of instruction in K-12 classrooms through the future teachers they prepare.

We believe strongly that higher education in general, and our institutions in particular, must be committed to assuring high quality instruction for all students in all segments of the American education pipeline. It is crucial that growth, change, and creativity that are so integral to research become equally integral to teaching. Thus, our vision of higher education in the year 2010 and beyond is that faculty in all our Nation's colleges and universities will be truly recognized for their individual leadership and achievements in support of broad institutional missions involving instructional scholarship, public service, and research excellence, and for their commitment to provide a quality education for all students at all educational levels.

FIVE PRINCIPAL POINTS

Many differing viewpoints, experiences, and ideas were expressed during the course of the colloquium. Six reports follow the Executive Summary that summarize the discussions of six individual panels, each of which focused on a different aspect of U.S. education. The reports include their visions of the future, major courses of action, and recommendations. Despite the diversity of the issues to be addressed by the panels and the diversity of the institutional, disciplinary, ethnic, and gender representation of the participants, five principal points emerged in common from the discussions.

To assure high quality precollege and undergraduate instruction in engineering, mathematics, and the sciences for all students and citizens in the year 2010 and beyond, U.S. higher education in general, and the National Science Foundation in particular, must:

"Federal, state, and other agencies that fund and evaluate education must undergo as much of a change in culture as that of academe."

Panel II: Encouraging Curriculum Renewal and the Development of New Learning Environments

1. **Encourage and reward teaching excellence, instructional scholarship, and public service as well as research.**

The lack of support, indeed, occasional outright discouragement, of faculty achievements in teaching, instructional scholarship, and public service is among the most pressing problems in higher education. At the heart of it is an application of tenure and promotion criteria that does not encourage faculty to aspire to broad scholarly achievements, especially in instructional innovation, nor to contribute to public understanding and support of science and technology. The tenure and promotion criteria, and related faculty rewards that are based on such criteria, need to be applied with greater recognition of individual faculty ability and potential. Goals for faculty achievement tailored to match individual abilities and institutional missions should be defined and used for faculty evaluation. There are also needs for: policies to provide leaves of absence that recognize the nature of contemporary faculty life, especially for younger faculty; significantly increased societal representation on engineering, mathematics, and science faculties; more balanced recognition of the interdependent roles of teaching and research; and more formal faculty career development initiatives.

"In short, there is a strong need to promote a higher quality of faculty life that more fully recognizes and develops the diverse talents and interests of all the faculty.

"In our opinion, the single most effective contribution NSF can make to elevate the status of teaching on the university campus is to provide broad-based, faculty-oriented programs to support high quality instructional experimentation and creative educational scholarship."

Panel VI: Developing Young College Faculty During the Critical Years to Tenure

2. **Increase substantially resources for instructional innovation and curriculum renewal, especially for undergraduate education.**

Support for disciplinary research may be increasingly inadequate but funds for instructional innovation are nearly nonexistent. Lack of adequate resources assures inadequate attention to long-term curriculum renewal, constricts the number of faculty engaged regularly in broad-based instructional scholarship, and sustains an unfortunate and inaccurate impression in the minds of many that teaching well is unimportant and without merit. The current condition of the American educational infrastructure should not be viewed as a problem to be fixed by a few, focused, temporary initiatives. All parties — education, industry, State and Federal agencies, and the public — must recognize that regularly budgeted, long-term programs for curriculum renewal to maintain the faculty's instructional excellence are as essential as funds for disciplinary renewal to maintain their technical currency.

There is a critical need for review of existing budget priorities to provide both new resources and expansion of current educational programs consistent with the coequal importance of teaching and research.

3. Assume primary responsibility for public understanding of science and technology, principally through high quality precollege teacher preparation and lower division undergraduate instruction.

"There is a misconception in our universities that teaching and instructional innovation are less valuable, less difficult, less creative, and less scholarly than research. The Federal government, through its agencies and their past budget priorities, shares a principal responsibility for this misconception."

Panel I: Attaining and Maintaining Scientific and Technological Literacy for Everyone

Many Americans believe that knowledge of our fields has little to do with everyday life, and that coursework in our areas need only be taken by students preparing for careers in our fields. Whatever level of scientific and technological literacy we hope to attain in this country, indeed whatever basic level of common education, will be learned primarily in K-12 classrooms, and for those who go on to college, in the lower division curriculum in the Freshman and Sophomore years. Major, long-term improvement in scientific and technological literacy can be affected most by high quality, discovery-oriented learning, principally in precollege and lower division undergraduate curriculum. Especially critical, therefore, is the disciplinary preparation of those students aspiring to precollege teaching careers in mathematics and the sciences, and the instructional preparation of those graduate students aspiring to academic careers. Public understanding and appreciation of science and technology is important, not only for the preparation of an effective and competitive workforce, but also for broader concerns such as informed public choice and quality of life. To further these aims, faculty should: communicate their work to the public, not just among fellow professionals; be more encouraged and rewarded for activities that contribute significantly to public understanding and appreciation of science and technology; and be more involved in local, state, and national science policy.

We must assume a greater responsibility for public understanding of science and technology through high quality instructional offerings to all students and participation in science and technology education policy.

4. Assure adequate career participation in engineering, mathematics, and the sciences by all segments of society, particularly careers as precollege or college faculty.

"The engineering, mathematics, and science community cannot expect full support from society if large segments of that society perceive themselves as unwelcome and excluded."

Panel V: Assuring Career Participation by All Societal Groups

Science, mathematics, and engineering careers, be they professional practice, teaching, or research, are viewed by many as rather unexciting, unrewarding, and non-inclusive careers. They are viewed as disciplines suitable for a select, gifted few. Career choice is primarily a product of experiences. Although individual experiences vary considerably, and we, as faculty, often have little influence on those experiences (e.g., parental nurturing, role models, job experiences), we do have considerable control over the educational environment in general, and the quality of instruction in particular. Students are not encouraged to pursue careers in fields in which they perceive instruction to be tedious and uninspired, coursework to be irrelevant or excessively demanding, and success to result from special talent or demographic similarity. We, the science and technical community, represent a small fraction of our society, yet it is society-at-large that determines the conditions under which we work, and provides the resources for what we do. We must be more inclusive. Broad collaboration among universities, professional societies, industry, and government at all levels, is needed, including: more engaging curricula motivated by societal relevance; attention to the transitions in the educational pipeline; improvements in entry-level college courses; programs for career paths such as science journalism or technology policy; and special attention to precollege teacher preparation.

In large measure, we must develop both an inviting educational environment and one that encourages all students to succeed.

"The education of students in engineering, mathematics, and the sciences is crucial to the Nation's future. Equally crucial, therefore, is the need to foster an environment that, by our efforts and example, will make teaching careers an attractive option, and then to provide high quality programs for those aspiring to teaching careers."

Panel IV:
Encouraging and Preparing Students for Careers as Precollege and College Faculty

"University and college administrations must recognize that state-of-the-art, instructional technology will be part of the physical plant needed for a twenty-first century education."

Panel III:
Incorporating New and Evolving Technologies into the Curriculum

5. Encourage the development of discovery-oriented learning environments and technology-based instruction at all educational levels.

The ubiquitous lecture is the bane of true learning, especially in observation-based, hands-on fields such as engineering, mathematics, and the sciences. Our lecture-dominated system of education encourages a passive learning environment, invites the development of a mass production-oriented, highly compartmentalized (lecture-sized) curriculum, and, worst of all, instills neither the motivation nor the skills for life-long learning. The overdependence on the standard lecture must be diminished with emphasis given instead to discovery-oriented learning in which disciplinary and geographic boundaries become less distinct through networked, technology-based instruction. Students must be active contributors in their own education and in the education of their fellow students, and faculty must be as creative in their teaching as they are in their research. The curriculum must emphasize laboratory and field experiences, and reflect an integrated approach to engineering, mathematics, and science education. New technologies, together with advances in the cognitive sciences, offer significant opportunities for individualized learning and teaching styles. They also offer important opportunities to interconnect all levels of the educational infrastructure to bring more cohesion to the educational pipeline. There are also needs for: more concurrent learning opportunities involving simultaneous study and experimentation; an increase in information technology and computer literacy among faculty and students; and a change in the culture of academe, its funding agencies, and accreditation boards to better recognize the interdependence and coequal importance of teaching and research.

We must create discovery-oriented learning environments that capitalize on the full power of new communication, information, and visualization technologies.

PANEL SUMMARIES

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PANEL 1

ATTAINING AND MAINTAINING SCIENTIFIC AND TECHNOLOGICAL LITERACY FOR EVERYONE

PANEL MEMBERS. Robert Perry (Panel Chair), Gregory R. Baker, Barbara S. Beltz, A. Gordon Emslie, David E. Goldberg, William D. Hunt, Ian M. Kennedy, James V. Moroney, Marjorie A. Olmstead

In the year 2010, higher education will have assumed a leadership role and central responsibility for the scientific and technological literacy of all citizens.

A VISION OF THE YEAR 2010 AND BEYOND

We envision a society in which the public regards science, mathematics, and technology as relevant to their personal lives. Engineers, mathematicians, and scientists are perceived by the public as vital to society, and scientific and technological literacy are well defined. Engineering, mathematics, and science concepts and contributions are communicated effectively to all segments of society, principally through formal instruction in our schools and universities but also through informal, out-of-classroom educational opportunities and programs. The public can apply the principles of science to the solution of their everyday problems.

KEY COURSES OF ACTION AND RECOMMENDATIONS

As engineers, mathematicians, and scientists, our vision of the future naturally recognizes the importance and contributions of engineering, mathematics, and science to our everyday lives. To most of society, however, our work is largely one of arcane subjects pursued in unseen laboratories and whose environmental and social impacts are often questionable, if not potentially disastrous. Mention our professions, and most do not think about their home, their neighborhood, or their jobs, nor do they picture themselves as capable and confident in applying even the most rudimentary principles of our disciplines. Science and technology are seldom portrayed as human endeavors.

Our vision for attaining and maintaining scientific and technological literacy is based on fundamental challenges in four areas: the relevance of science and technology in society, defining scientific and technological literacy, communication of science and technology to society, and public perception of science and technical professionals.

Relevance of Science and Technology in Society

The manner in which science and technology are taught in our schools and universities is our greatest barrier to scientific and technological literacy. Too many science and technology courses fail to stimulate and engage the students, much less educate them. Mostly, students learn to sit and listen, observe demonstrations, memorize facts and formulas, and, basically, work alone. From the outset of their education, they progressively spend less and less time applying their knowledge, performing experiments, participating in field trips, or working in groups. Is it any wonder that most of society finds science, mathematics, and technology dull, tedious, and not relevant to their daily lives?

We recommend —

To higher education and the NSF:

— *emphasize creative, discovery-oriented, collaborative student learning at all educational levels.* Integrate instruction in science, mathematics, and technology as much as possible, and de-emphasize separation and compartmentalization. Students should be encouraged to develop informed opinions about scientific, ethical, and political controversies involving important scientific and technical issues.

— *expand support for collaborative efforts among engineering, mathematics, science, and education faculties to provide high quality collegiate instruction in engineering, mathematics, and science for undergraduate students preparing for precollege teaching careers.* No one would hire a teacher who could not read; by the same token, there is no reason all teachers should not be scientifically literate.

— *create an NSF Discovery Program to expand support for discovery-oriented, instructional materials development for use in K-12 classrooms, and encourage all engineering, mathematics, and science faculty to participate in such programs.* Collaborative efforts between engineering, mathematics, and science faculty, and education faculty and precollege teachers should be especially encouraged. New texts and materials should: incorporate science history and philosophy both in history and science texts; include science and technology applications more frequently as part of mathematics education; emphasize scientific concepts and processes and de-emphasize the memorization of facts and formulas; and include supplements relating contemporary issues of the day with discoveries in science, mathematics, and technology. Workshops for precollege teachers to become familiar with the new materials should also be encouraged. Of special interest to *engineering* faculty is the development of precollege instructional materials directly related to engineering and technology. It is noteworthy that presently little engineering-oriented coursework is included in the precollege curriculum, and precollege teachers receive little, if any, preparation oriented to engineering. Activities should include plans for the manufacture and distribution of developed materials, and the involvement of industry in such dissemination should be strongly encouraged.

— *support curriculum development and in-service programs designed to assure a high level of scientific and technological literacy for practicing teachers at all educational levels.* Especially encouraged are collaborative efforts involving engineering, mathematics, science, education faculty, and precollege teachers.

Defining Scientific and Technological Literacy

We are concerned about the low level of American scientific literacy. If we are to attain and maintain scientific and technological literacy among all citizens, then we must first define it in measurable ways. We must have standards by which to judge student progress at all educational levels.

We recommend —

To the White House Office of Science and Technology Policy:

— *appoint a Presidential Commission on Norms in Literacy in Science, Mathematics, and Technology.* The White House Office of Science and Technology Policy should assume a leadership role and appoint a Commission to 1) focus attention on the need for norms for literacy in science, mathematics, and technology, for both students and teachers, and 2) identify promising strategies for defining, measuring, and implementing these norms.

To higher education and the NSF:

— *encourage more faculty scholarship in defining and measuring scientific and technological literacy.* Research in scientific and technological literacy will also have an ancillary effect on shedding light not only on the scientific and technical education of non-majors but also on majors as well. Indeed, research in science, mathematics, and engineering education in general is as much an opportunity for faculty scholarship as research in science, mathematics, and engineering itself.

Communication of Science and Technology to Society

Communication of science and technology to the public is woefully inadequate, if not often misleading.

We recommend —

To higher education:

— *give greater consideration to popular forms of publication and dissemination of faculty work in tenure and promotion evaluations.* We, as engineers, mathematicians, and scientists, must communicate our work more frequently and effectively to the public, not just to our professional colleagues.

— *reduce the large communication barriers that exist in the classroom.* Effective communication begins in the classroom. Professors of engineering, mathematics, and science should be educated in effective teaching and communication, and their teaching effectiveness should be given more consideration in the tenure and promotion process.

— *encourage and support more faculty participation in local community organizations, public libraries, and schools to create discovery exploratoria to encourage hands-on involvement in science, mathematics, and engineering.* Especially encouraged are activities that provide more ready access to recent engineering, mathematics, or science achievements through contemporary information technologies and networks. Faculty should also be encouraged to serve in a variety of public forums, such as political office, school boards, museum advisory committees, and local, state, and national science policy organizations.

— *increase the number of professional science communicators.* Encourage more collaborative efforts among engineering, mathematics, science, and communication faculty. Engineering, mathematics, and science faculty on the one hand, and communications faculty on the other should seek to be more involved in each other's curriculum. We also suggest the creation of science/technology-oriented communication programs.

To the NSF:

— *expand support for collaborative programs between science and non-science faculty to facilitate effective science and technology communication.* The recent joint agreement between the National Science Foundation, National Endowment for the Humanities, and the Department of Education for collaborative support of Leadership Projects in Science and the Humanities is an example of an initiative with significant potential to address effective science communication.

Public Perception of Science and Technical Professionals

While it is gratifying that the public perceives science and engineering professionals as intelligent, we regret being viewed as dull and not reflective of the full diversity of American society.

We recommend —

To higher education:

— *expand extramural science and technology activities at schools and colleges.* Such events foster positive attitudes towards engineering, mathematics, and science through fun and competitive events. Similarly, we encourage efforts to highlight the true diversity among engineering, mathematics, and science professionals, including their involvement and participation in a wide variety of non-science activities.

— *create curricula and media presentations that demonstrate the social context within which engineering, mathematics, and the sciences are practiced.* Many persons have some idea about what lawyers and doctors do for a living, but little idea about what engineers, mathematicians, and scientists do.

To Federal funding agencies (including NSF):

— *re-evaluate budget priorities.* There is a misconception in our universities that teaching and instructional innovation are less valuable, less difficult, less creative, and less scholarly than research. The Federal government, through its agencies and their past budget priorities, shares a principal responsibility for this misconception.

— *create an NSF Ambassador Program.* Such a program would support outstanding engineers, mathematicians, and scientists to visit elementary and secondary schools, as well as participate in media, local, state, and national public forums. These individuals would serve as ambassadors to work with non-science professionals and students to improve their understanding of science, mathematics, and technology, and to appreciate the human endeavor associated with these disciplines. Participants in the program would be nominated by the president of their institution and would receive salary and travel support.

To the engineering community:

— *heighten the visibility of engineering*. Despite the fact that much of what the public encounters daily is as much an engineering and technological achievement as it is a scientific one, engineering is not often viewed as a principal contributor or originator. The engineering education community, industry, and engineering professional societies should: develop engineering and technology-oriented materials for the K-12 curriculum and for non-engineering college curriculum; promote visits by role models to schools; and include material describing the basic operating principles of technical products along with the operating/assembly instructions.

PANEL II

ENCOURAGING CURRICULUM RENEWAL AND THE DEVELOPMENT OF NEW LEARNING ENVIRONMENTS

PANEL MEMBERS: David L. Freyberg (Panel Chair), Steve Cramer, Solomon R. Eisenberg, Frank J. Feher, Nancy M. Haegel, Frank V. Kowalski, Peter D. Meyers, Brij M. Moudgil, Martha C. Zuniga

In the year 2010, growth, change, and creativity in higher education will be as integral to teaching as they are to research.

A VISION OF THE YEAR 2010 AND BEYOND

We envision an academic environment in which faculty are as creative in their teaching as in their research. The culture of the academy views and rewards teaching and research equally, and cultivates individual achievements accordingly. Students are active and creative participants in their own education as well as in the education of their fellow students. Curricula emphasize numerous, high quality laboratory and field experiences, and reflect an integrated approach to engineering, mathematics, and the sciences. The lecture-driven, compartmentalization of knowledge into individual course-sized blocks is replaced by team-teaching and other integrating, discovery-oriented learning paradigms, particularly in the lower division. Students view their formal undergraduate education as the catalyst of life-long learning. Specialization plays a smaller part of undergraduate education, and science, mathematics, and technology are part of general education requirements of all students. Substantial resources are available for curriculum renewal and instructional scholarship. Higher education actively collaborates with precollege education to assure high-quality academic preparation and a smooth transition for college-bound students. New technologies are used at all educational levels to enhance the quality of the learning environment.

A KEY COURSE OF ACTION AND RECOMMENDATIONS

Our vision of the future requires one principal, key course of action — a fundamental change in the culture of higher education, its funding agencies, and accreditation institutions. The culture of the university must be changed so that pedagogy and research become equal, dynamic partners in the mission of the university. The tenure, promotion, and reward system, the budgeting priorities, and the administrative organization of colleges and universities must be modified to foster and reward creativity and growth in teaching as well as in research. Federal, state, and other agencies that fund and evaluate education must undergo as much of a change in culture as that of academe. Resources for instructional experimentation must be equal to those for research. Accreditation organizations must value curriculum renewal and encourage innovation. We, therefore, recommend the following actions.

To higher education:

— *apply tenure, promotion, and reward criteria in ways that value and encourage teaching and instructional scholarship.* A faculty member's time is a limited resource that must be divided among creation of knowledge (research), dissemination of knowledge and thinking skills (teaching), and administration (service). The most effective means to encourage greater faculty activity and creativity in curriculum renewal and the development of new learning environments is to truly encourage, recognize, and reward faculty participation in educational experimentation and innovation.

— *develop peer-based measures of teaching quality and instructional effectiveness.* Teaching presents challenges for evaluation that are, in many ways, unlike those for research. Nonetheless, we believe peer-based mechanisms, now readily accepted for research, hold the most promise. Among the possible mechanisms are: refereed publications and proceedings, peer-reviewed grants for educational experimentation and innovations, professional and public presentations, classroom visits by faculty colleagues, alumni evaluations, and external peer-review of teaching materials and other distributable educational products (e.g. textbooks and courseware).

— *establish permanent funding for curriculum development and renewal.* Universities in general, and individual departments in particular, must recognize that the development and maintenance of a quality curriculum is a continuous process requiring predictable long-term resources, including faculty release time.

— *encourage and reward faculty involvement in precollege education.* The sophistication and effectiveness of any undergraduate program is inherently limited by the motivation and abilities of its entering students. Clearly, it is in our national interest and our interest as faculty to be actively engaged in improving the quality of precollege instruction.

— *assume greater responsibility for and dissemination of innovative education developments beyond the institution.* Successful and innovative educational programs are products of considerable effort, yet information about these efforts often does not reach beyond the immediate campus environment. Support for workshops, conferences, etc., should be provided to facilitate educational dissemination.

— *eliminate barriers created by departmental boundaries.* There are many exciting opportunities and possibilities for interdisciplinary curriculum innovation. Unfortunately, many aspects of the current organizational structure — particularly the practice of allocating faculty, staff, and teaching assistant resources on the basis of departmental undergraduate enrollments — discourages exploration of interdisciplinary approaches to teaching. Universities should explore the development of organizational structures that encourage interdepartmental development of curriculum, particularly in the core curriculum.

— *encourage more creative pedagogical techniques and novel learning environments as alternatives to the standard lecture format.* Alternatives to the standard lecture format, such as "just-in-time" instruction, team teaching, and classroom environments with open-ended problems, would de-emphasize rote or result-oriented learning in favor of more dialectical approaches to solving problems.

— *infuse more computer and information technologies into the curriculum to enhance both the intellectual and the computational elements of science and engineering education, such as interactive computer simulations and artificial intelligence.* Furthermore, undergraduate laboratories should be continually upgraded to include open-ended experiments employing new and emerging technologies as well as traditional equipment.

To funding agencies (including NSF):

— *increase substantially support for faculty instructional innovation and educational experimentation, especially for undergraduate education.* Current support is seriously insufficient to meet the needs and demand for curriculum reform at all educational levels.

— *encourage undergraduate and precollege educational components in research grants.* Besides the obvious technological benefits, federally-funded research at colleges and universities has the potential of contributing to the education of large numbers of students, both majors and non-majors. Funding agencies should develop methods for assuring that *all* students benefit from research performed at their institutions.

To the national scientific leadership:

— *The White House Office of Science and Technology Policy, the National Academies of Science and Engineering, the National Science Board, and similar* *institutions and organizations, should assume leadership in assessing and responding to the impact of Federal research funding policies on the educational mission of U.S. universities.* Since teaching programs compete with research programs for many of the same human resources, attention to the balance of the research and educational missions of colleges and universities is needed. Since Federal funding of research can have both positive and negative effects on the educational missions of colleges and universities, the national engineering and scientific leadership should assess the impact of such funding periodically and help assure the health and vitality of educational programs.

PANEL III

INCORPORATING NEW AND EVOLVING TECHNOLOGIES INTO THE CURRICULUM

PANEL MEMBERS: Sally Wood (Panel Chair), Robert L. Bryant, Robert M. Hanson, Anthony R. Ingraffea, John R. Kender, John J. Lewandowski, Sue McNeil, Helen L. Reed, Ronald J. Roedel

In the year 2010, a wide variety of technologies will interconnect all levels of the education pipeline and provide individualized, discovery-oriented learning opportunities that develop the intellectual, computational, and physical elements of engineering, mathematics, and science education.

A VISION OF THE YEAR 2010 AND BEYOND

We envision a future of technology-based, discovery-oriented learning in which disciplinary and geographic boundaries become less distinct through networked, real-time teaching and research. Electronic learning libraries, direct access electronic media, and the integration of laboratory and instrumentation facilities provide concurrent learning opportunities involving simultaneous study and experimentation, inquiry and verification. New technologies facilitate new forms of learning, networking, and interaction among students and faculty, and redefine their mutual roles in education. New technologies, together with advances in the cognitive sciences, provide the resources to address different learning and teaching styles. Technological and computer literacy is nearly universal, affording more and higher quality opportunities for design, open-ended problem solving, and other hands-on experiences in precollege and undergraduate curricula. A wide variety of communication, information, and visualization technologies interconnect all levels of the educational infrastructure bringing more cohesion and coherence to the education pipeline.

KEY COURSES OF ACTION AND RECOMMENDATIONS

University and college administrators must recognize that state-of-the-art instructional technology will be part of the physical plant needed for a twenty-first century education. Therefore, our vision is based on fundamental changes and initiatives in two basic areas: networking and infrastructure development, and curriculum renewal and learning environments.

Networking and Infrastructure Development

Computing and information technology on most precollege and college campuses, more often than not, resides in isolated rooms and laboratories as stand-alone resources responding passively to student commands. The full potential of contemporary technology must be unlocked through universal networking and imaginative, interactive courseware. Faculty must learn to use these resources effectively and to develop new teaching techniques that help students navigate the network.

Actions recommended —

To higher education :

— *create a National Education Network (NEN), an information "super highway," that provides access to* all *colleges and universities, as well as elementary and secondary schools.* The NEN would afford uniform access (e.g., students, faculty, industry) and would support a broad array of information exchange activities, including informal communications, data transmission and manipulation, real-time experimentation, remote site interaction, recruiting, advertising, and so forth. The NEN would also require development of standards ('rules of the road') and programs for teaching users effective information navigation.

To the NSF:

— *expand precollege and undergraduate programs that encourage bold uses of technology, especially those that support exploration of alternative teaching and learning approaches to address differen' cognitive styles.* New technologies together with advances in the cognitive sciences may soon provide opportunities to develop learning environments that are more tailored to individual teaching and learning styles. In essence, through technology we may reorient our mass production, lecture-driven curriculum to one focused on individualized, discovery-oriented learning. Especially important are initiatives that encourage innovations involving both networking technologies and their interface with state-of-the-art laboratory equipment and instrumentation.

To government legislators:

— *provide incentives (legislation) for industry to 1) contribute new technology for universities, colleges, and K-12 classrooms, including maintenance and the reguler upgrading of the information technology base and instrumentation, and 2) provide support for employee involvement in and contributions to educational programs.*

Curricula Renewal and Learning Environments

The use of technology in the curriculum should not be a substitute for hands-on, experiential learning; rather, new technologies should be used to leverage all aspects of the intellectual, computational, and physical elements of engineering, mathematics, and science education.

Actions recommended —

To higher education:

— *assure that tenure and promotion criteria are applied so as to recognize and reward faculty creativity in incorporating new technology into instruction.* Without adequate recognition and reward for instructional innovations of all kinds, it is unlikely that curricular renewal and the development of new learning environments will evolve as quickly or creatively as current technology already allows.

To higher education and the NSF:

— *encourage curriculum innovations that focus on creativity and discovery-oriented learning through technology.* Create computer-oriented discovery laboratories that provide opportunities for both simulation and information manipulation and physical observation and experimentation, especially with remote site interaction. Instructional innovations tailored to different cognitive styles and the use of technology to foster group communication and problem solving are also encouraged.

— *create a National Design and Discovery Resource accessible through the NEN that provides a rich resource of design examples, problem sets, experimental data and results, and other instructional materials.* This electronic facility, a sort of "on line" exploratorium, will make special design and discovery resources available to all colleges and schools that might otherwise only be available at large research institutions or government laboratories. Encourage universities to provide release time for faculty to contribute "netware" to the NEN curricular database, and NSF to provide grant supplements for educational network software, data, video, etc.

— *promote and expand programs for undergraduate and secondary school research experiences and other in-depth learning experiences.*

— *develop programs to educate students and faculty in techniques to combat information overload, such as critical information navigation and information synthesis.*

To accreditation boards:

— *develop standards that encourage instructional experimentation and technological innovation, especially with respect to networking, group design experiences, interdisciplinary subjects, and non-traditional degree options.*

Implications for Increased Participation

A National Educational Network, a National Design and Discovery Resource, and an emphasis on the development of alternative instructional methods all address issues of equal access. This access would be independent of geographic location or institution and would allow more individualized instruction to meet differences in cognitive styles. Consequently, we believe that a well-developed and well-maintained networked technology infrastructure would provide significant opportunities for targeted programs aimed at increasing participation by underrepresented groups.

PANEL IV

ENCOURAGING AND PREPARING STUDENTS FOR CAREERS AS PRECOLLEGE AND COLLEGE FACULTY

PANEL MEMBERS: Mark S. Mizruchi (Panel Chair), Linda M. Abriola, Charles R. Doering, Phillip D. Gould, Wendell T. Hill, Carl R.F. Lund, Lynne Molter, Mamidala Ramulu, Peter Sarnak

In the year 2010, higher education will prepare outstanding students for *all* aspects of faculty careers at all educational levels.

A VISION OF THE YEAR 2010 AND BEYOND

We envision a future in which engineering, mathematics, and science faculty are actively involved in the preparation of future faculty at all educational levels. Teaching careers are viewed as open to all members of society because members from all major demographic groups are well represented at all levels and disciplines. Faculty are well-informed and well-prepared to assume all aspects of their academic challenges and responsibilities. There are adequate resources for effective teaching, including laboratory space and equipment, up-to-date teaching and research facilities, and funding for both research and teaching excellence. Good teaching is encouraged and rewarded at all institutions, including research universities. Extensive interaction among university, college, and precollege teachers facilitates the integration of teaching and research. Curricula encourage students to think critically, creatively, and independently at all levels. Pedagogy is important both in preparation of faculty as well as in their continuing professional development. Persons with experience in other areas, including industry and government, are encouraged and prepared to teach. Substantial efforts are made at all levels to identify, recruit, and retain potential teachers.

KEY COURSES OF ACTION AND RECOMMENDATIONS

The success of the current efforts to revitalize the U.S. educational infrastructure depends on the commitment and collaboration of a number of communities, but mostly it depends on the faculty. They, after all, teach the future leaders of our society and prepare those who, after them, will teach future generations. More importantly, long-term success will depend on those new faculty who enter the teaching profession within this decade because it is they who will shape and define our educational institutions well into the next century. It is they who, in large measure, will bring about the new paradigms needed in education.

This decade, however, is also a time of unique opportunity in the preparation of the next generation of new faculty. It is estimated that as many as half of the tenured college professoriate will retire within the decade. Further, only one qualified science and mathematics teacher graduates annually for every ten school districts in the country. Thus, with successful recruitment and retention strategies, the next generation of faculty who enter precollege or college teaching may do so in unprecedented numbers. Further, if adequate numbers of persons from all societal groups are to be encouraged to pursue teaching careers, then the demographic shifts in ethnicity and gender of the future workforce, and its consequent effect on societal expectations and demands of contemporary life, will need to be given special emphasis.

The education of students in engineering, mathematics, and the sciences is crucial to the Nation's future. Equally crucial, therefore, is the need to foster an environment that, by our efforts and example, will make teaching careers an attractive option, and then to provide high quality programs for those aspiring to teaching careers.

Our vision of the future requires fundamental changes in three major areas: faculty development, encouragement, and resources; desirability and perception of teaching careers; and curriculum development.

Faculty Development, Encouragement, and Resources

Highly-qualified, enthusiastic, and well-rewarded faculty as role models are probably the most effective means to attract students to pursue teaching careers.

We recommend —

To higher education:

— *establish significantly more endowed chairs for teaching excellence and instructional scholarship, especially for tenured, associate professors.* The prospect of receiving such near-term support should induce some of our most talented assistant professors to aspire to broader accomplishments, and for those faculty who receive such chairs, to propel them to higher levels of academic leadership.

— *encourage and support generously the best faculty to teach entry-level courses in engineering, mathematics, and the sciences.* The quality of instruction during the freshman and sophomore years has a profound affect on student recruitment and retention in general, and, therefore, on the pipeline of potential future graduate students in particular, especially American-born students. Indeed, we encourage support for all engineering, mathematics, and science faculty to participate in programs and activities to improve the quality of their teaching and instruction at all levels.

To the NSF:

— *provide support for faculty development sabbaticals for K-12 teachers and community college instructors at local industries and universities to encourage them to maintain both their technical currency and their enthusiasm.*

— *encourage faculty* exchange *programs between research universities and undergraduate colleges to cross-fertilize excellence in teaching and research among all institutions.*

Desirability and Perception of Teaching Careers

A recent survey of over 2,000 engineering graduate students revealed that nearly two-thirds had no desire to pursue an academic career. Indeed, since 1966 freshman interest in faculty and research careers has declined steadily by nearly 75%. While, undoubtedly, many factors affect career choice, one fact from these statistics is very clear — teaching careers are not perceived as very desirable to many students.

We recommend —

To higher education:

— *increase substantially the number of faculty from underrepresented groups.* Such faculty serve as important role models for the fastest growing segment of our society from which to recruit future faculty. Further, we encourage support for continued study of fields of engineering, mathematics, and the sciences in which underrepresented groups already participate in significant numbers so as to better understand the issues and factors affecting their career choices.

— *develop prestigious teaching internships for engineering, mathematics, and science graduate students aspiring to faculty careers in higher education.* The internships would be to recruit and better prepare graduate students for their full responsibilities as future members of academe, and especially to improve their abilities in effective teaching and instructional scholarship.

To the NSF:

— *expand programs of grants to precollege teachers and precollege students to participate in research projects at local universities to encourage students to consider academic careers.*

— *increase support for informal science programs targeted to demystify and clarify science and technology in general, but especially those targeted to broaden public understanding of precollege and college faculty careers.*

Curriculum Development

Career attraction is one issue, but formal academic preparation is another.

We recommend —

To higher education and the NSF:

— *improve the quality of precollege and undergraduate instruction for all students, thereby encouraging more students to consider careers as precollege and college faculty.* Supportive, enthusiastic faculty set an example that students perceive favorably. There is no more convincing means of demonstrating that a teaching career is enjoyable, challenging, and rewarding.

— *encourage collaborative academic programs and curriculum development among engineering, mathematics, science, and education faculty to assure high quality disciplinary preparation of students interested in precollege teaching.* The collegiate preparation of students for precollege teaching is the most direct, effective, and long-term means in which higher education can affect the quality of precollege instruction for all students.

— *develop curricula to emphasize cross-disciplinary, philosophical, and historical discussions of engineering, mathematics, and the sciences.* Engineering, mathematics, and the sciences must be portrayed as more than a body of knowledge, but rather as a human endeavor rich in history, philosophical debates, and social implications.

To funding agencies (including the NSF) and industry:

— *expand the sources of support for classroom-quality precollege instructional materials and educational resources.* For example, we encourage local companies, colleges, or government laboratories to provide computer access to precollege students and teachers.

P A N E L V

ASSURING CAREER PARTICIPATION BY ALL SOCIETAL GROUPS

PANEL MEMBERS: Susan L. Brantley (Panel Chair), David T. Allen, Ilene Busch-Vishniac, Paul A. Cox, David E. Keyes, Diane Marshall, Carolyn W. Meyers, Daniel G. Nocera

In the year 2010, higher education will reflect the full range of societal diversity, and careers in engineering, mathematics, and the sciences will be viewed as accessible, challenging, and rewarding careers by all segments of society.

A VISION OF THE YEAR 2010 AND BEYOND

We envision in the year 2010 engineering, mathematics, and science professionals from all segments of American society, who are perceived as leading productive, interesting, and rewarding careers and lives. There is ready access to our disciplines regardless of ethnic, gender, physical, socioeconomic, or cultural background. Engineering, mathematics, and science curricula at all educational levels emphasize human processes, reinforce equal access in classroom techniques, and develop a sense of community among all students. Introductory-level undergraduate courses encourage, motivate, and invite students into our fields, and non-majors receive high quality instruction in the technical disciplines through an integrated curriculum. The educational infrastructure provides teachers with training and expertise to prepare students at an early age with the skills necessary for successful careers in engineering, mathematics, and science, including complementary technical careers such as technology policy and science journalism. The reward and compensation systems in academia and industry reward mentorship activities, community service, and political involvement. Professional advancement recognizes the career interests, social concerns, and personal needs of diverse groups within the faculty.

KEY COURSES OF ACTION AND RECOMMENDATIONS

The engineering, mathematics, and science community cannot expect full support from society if large segments of that society perceive themselves as unwelcome and excluded. Therefore, our vision of the year 2010 depends on systemic changes in three areas: enriching the pipeline, plugging the leaks, and career re-entry.

Enriching the Pipeline

The image and excitement of engineering, mathematics, and science must enhanced, particularly in the early grades. We must encourage continued interest and study of science and mathematics at all educational levels, regardless of career participation, and especially to underrepresented groups.

We recommend —

To higher education and NSF:

— *encourage more engineering, mathematics, and science faculty to work in partnership with education faculty and precollege teachers to 1) improve the quality of collegiate instruction in engineering, mathematics, and the sciences to undergraduate students preparing for precollege teaching careers,* *especially in the early grades, and 2) prepare high quality materials and instructional aids for the K-12 curriculum.* Helping to improve the overall quality of teacher preparation and educational materials for all K-12 students is the most direct, long-term action university faculty could take to assure greater inclusion of all segments of society in careers in engineering, mathematics, and the sciences.

— *encourage more faculty to interact with the news media, to educate journalists and other public communicators in technical matters, and to disseminate the results and importance of their work more directly to the public.* Encourage principal investigators of NSF grants to disseminate their results in public forums as well as in learned journals.

— *expand direct communications with precollege students through such means as weekly news reports (e.g. Scholastic Weekly Reader), television programs about science and technology, or computer networking with local universities and industries.* Expand outreach programs or extension courses for parents and the local school community.

Plugging the Leaks

Recruitment is one issue, retention is another. Too many students are lost to careers in engineering, mathematics, and the sciences by unengaging curricula, isolation, and lack of guidance and mentoring.

We recommend —

To higher education:

— *introduce more flexibility and individual career development in the application of tenure and promotion criteria, including, for example, part-time tenure-track positions.* There is a significant need to recognize dependent care, partner employment, and non-traditional career paths to encourage more persons from underrepresented groups into academic positions. Greater recognition must be given to the importance and demands of role models, to those who successfully recruit members of underrepresented groups into the disciplines, and especially to quality teaching - perhaps the one activity with the greatest impact on student interest, recruitment, and retention.

— *develop means beyond student evaluations to provide professional, peer-based feedback to the faculty on the quality and effectiveness of their teaching, especially with regard to their effectiveness in reaching members of underrepresented groups and non-traditional students.* Most universities and colleges have faculty and staff on their campus who are skilled in such evaluations, but, sadly, they are an underutilized resource.

— *expand support programs, such as need-based graduate fellowships, undergraduate scholarships, formal mentoring, and tutoring programs involving faculty-student and student-student interaction, for members of underrepresented groups.*

To higher education and NSF:

— *reshape and revitalize the lower-division, undergraduate curriculum.* Since the attrition of undergraduate students is greatest in lower division courses, this curriculum level most needs attention. In large measure, all faculty need to teach less, and uncover more. Introductory-level courses must emphasize scientific concepts more than isolated facts, including the development of courses that are more interdisciplinary, discovery-oriented, involve teamwork, and employ problems of interest and relevance to the students themselves.

— *encourage initiatives to foster interaction between faculty in education and in technical fields.* Collaborative educational research on the pedagogy of science and engineering should be strongly encouraged, and scholarly pedagogical experimentation should be an expectation of the faculty.

— *establish more flexible curricula for all students.* All students need to have more opportunity to flow into our disciplines apart from the traditional, highiy-sequenced, lock-step curriculum. Prerequisites should not necessarily impede a student's progress; for example, we suggest student tutoring teams be formed in classes with prerequisities in which students will help fellow team members with prerequisite material they know best, and vice versa. Further, we encourage special attention to instructional innovations for non-traditional students; for example, computer graphics and display technologies developed for the hearing impaired not only assists this group of underrepresented students but may also lead to new learning environments of broad applicability to all students.

To NSF:

— *consider institutional records of achievement in participation of underrepresented groups in science, mathematics, and engineering as part of the evaluation for funding for NSF research and education grants.*

Career Re-entry

Faculty, students, and professionals who leave engineering, mathematics, and the sciences must be able to re-enter and enrich the profession with the diversity of their experiences.

We recommend —

To higher education and NSF:

— *create fellowship and grant programs targeted at encouraging faculty and students to re-enter academic programs.*

— *create more flexible degree-granting programs that accommodate students with non-traditional interests.*

— *develop courses exclusively for non-majors that invite participation in science, mathematics, and engineering.* Such courses can also serve the dual purpose of increasing scientific and technological literacy among non-majors in general.

— *provide encouragement and programs to prepare technical professionals in both academia and industry who wish to teach, even temporarily, in the K-12 system.*

— *encourage more industrial role models to teach part-time or to take sabbaticals on college and university campuses.*

PANEL VI

DEVELOPING YOUNG FACULTY DURING THE CRITICAL YEARS TO TENURE

PANEL MEMBERS: Denice D. Denton (Panel Chair), Jim Golden, Lisa-Noelle Hjellming, Kathleen C. Howell, R.J. Dwayne Miller, Mark A. Prelas, Deborah L. Thurston

In the year 2010, higher education will encourage and value a broad diversity of faculty scholarship, especially in instructional excellence and public service.

A VISION OF THE YEAR 2010 AND BEYOND

We envision an academe where young faculty develop their early academic talents in an environment supportive of individual faculty interests and abilities. The physical and fiscal infrastructure supporting higher education provides adequate support for both quality research and instruction. Students view their faculty as having jobs that are fun and rewarding. Senior faculty view junior faculty development as a primary responsibility. Tenure, promotion, and related reward criteria are applied with more regard to individual's contributions to an institution's overall academic mission. All aspects of scholarship in teaching, research, and service are truly recognized. The status of teaching in the university is elevated, and young persons entering the professoriate do so because they want to teach and inspire all students to higher achievements.

KEY COURSES OF ACTION AND RECOMMENDATIONS

Our vision is predicated on fundamental changes in five areas: the tenure and reward system, the status of teaching in the university, the availability of instructional and research funding, the professional development of the faculty, and the quality of faculty life.

The Tenure and Reward System

The tenure, promotion, and reward system is our greatest barrier to a better future. Tenure guidelines uniformly denote that teaching, research, and service are the criteria for tenure. It is our experience, however, that the road to tenure is marked research, research, research. It is common for young faculty who excel in teaching to be chided by their senior colleagues for "wasting too much time" on such an endeavor: "It won't get you tenure." *This must change!* The tenure system at present confines the faculty to a narrow spectrum of activity. Although individual research programs may differ dramatically, it is unlikely that an outside observer would view our faculties as diverse. This lack of diversity is exhibited in sex, race, and breadth of intellectual pursuits.

We recommend —

To higher education :

— *adhere to the true spirit of tenure and promotion criteria.* Excellence and quality of performance in teaching, research, and service must be truly encouraged, valued, and rewarded. Further, we encourage inclusion of members of underrepresented groups on tenure and promotion committees for candidates from these groups.

— *establish faculty career development programs based on mutually defined institutional and individual faculty goals.* Such programs should incorporate formal evaluation procedures, periodic faculty review (at least annually), and require mutual institutional and individual accountability.

— *require internal and external peer-review of a candidate's instructional accomplishments.* In addition to student evaluations, we suggest classroom visits by fellow faculty, alumni evaluations, and internal and external peer-review of instructional materials and other disseminable educational products, and refereed pedagogical publications.

To the NSF:

— *require Principal Investigators to adhere to the true spirit of the Importance of Education and Human Resources required on all NSF grant applications (per Important Notice No. 107 and GRESE NSF 90-77) "to improve the quality, institutional distribution, or effectiveness of the Nation's scientific and engineering research, education, and workforce."* Principal investigators must truly seek innovative and effective ways to disseminate the results of their research to *all* students. *Undergraduate participation as research assistants on NSF grants is not enough.* Attention must also be directed to the large and important majority of students enrolled in the undergraduate curriculum. We encourage all NSF staff and reviewers to consider the educational merits of research in preliminary proposals, grant applications, site visits, and progress and final reports.

— *assure long-term, faculty-oriented support for instructional experimentation and educational innovations.* We believe it is imperative that the NSF adhere to the true spirit of its Statutory Authority* : "to initiate and support basic scientific research *and programs to strengthen scientific research potential and science education programs at all levels* in the mathematical, physical, medical, biological, social, and other sciences, and to initiate and support research fundamental to the engineering process *and programs to strengthen engineering research potential and engineering education programs at all levels* in the various fields of engineering, by making contracts or other arrangements (including grants, loans, and other forms of assistance) to support such scientific, engineering and *educational* activities." (NSF Act of 1950; 42 U.S.C. §1861) *Emphasis added.*

The Status of Teaching in the University

According to MIT President Charles M. Vest: "...there is one overriding constant that is absolutely critical to the future, and that is the creation and dissemination of knowledge to new generations of young men and women." Creation and dissemination of knowledge - research and teaching. These two complementary and central endeavors of academe must be given equal weight. Sadly, it is our belief that the preferential status of research over teaching in the university has degraded the quality of instruction for generations of young people. We believe that the status of teaching in the university must be elevated to equal that of research.

We recommend —

To higher education:

— *regard teaching as both a privilege and a responsibility of the faculty.* Faculty who can not teach, should not teach. It is the responsibility of university administrations to assure that academic programs are staffed by well-qualified faculty and to provide guidance and assistance to those in need of improving their pedagogical skills. We encourage the creation of incentives that provide rewards and resources for use either in instructional or research innovation for those who excel in teaching.

To the National Science Foundation:

— *increase the NSF budget for undergraduate education substantially.* In our opinion, the most important contribution NSF can make to elevate the status of teaching on the university campus is to provide broad-based, faculty-oriented programs for high quality instructional experimentation and creative educational scholarship.

— *modify the Presidential Young Investigator award to become the Presidential Young Scholar award to recognize young faculty who excel in both teaching and research.* In its present form, the PYI program, unfortunately, reinforces the lesser status of teaching.

* For complete excerpts of Statutory Authority, see p. 26.

Availability of Instructional and Research Funding

Research and teaching are mutually supportive activities. They are also, jointly, the primary responsibilities of young faculty. However, the inadequacy of funds for research and instructional scholarship, especially the latter, has resulted in an inordinate effort to secure adequate funding. This has particularly degraded the quality of teaching. The decline in support for higher education has added an additional criterion for tenure: grantsmanship and fund raising. This state of affairs neither supports nor encourages quality undergraduate education.

We recommend —

To higher education and the NSF:

— *establish dependable, long-term, budgeted support for faculty initiated research* and *instructional innovation.* Higher education must assume a greater responsibility for support of its research and instructional programs beyond normal teaching activities and facilities maintenance. Similarly, NSF must fulfill its statutory obligation to support research and education in science and engineering consistent with their coequal importance.

— *provide adequate start-up resources to young faculty to initiate their research* and *teaching programs.* Young faculty must be encouraged to attract both undergraduate and graduate students into research as well as infuse new perspectives into both the undergraduate and graduate curricula.

To higher education:

— *value and reward peer-reviewed funding for educational innovation equally with funding for disciplinary research.*

Professional Development of the Faculty

Young faculty today are poorly prepared and lack adequate support to assume the full responsibilities of academic life. In large measure, young faculty are left to their own devices and therefore doomed to repeat the mistakes of their predecessors due to inadequate instructional preparation, lack of senior faculty guidance, and insufficient financial support.

We recommend —

To higher education and the NSF:

— *support instructional internships to better prepare graduate students for faculty careers in higher education, and especially to enhance their future teaching effectiveness and instructional scholarship.*

To higher education:

— *establish formal senior-junior faculty mentoring programs, ones that begin with the hiring process and are guided by the mutual pairing of the interests and abilities of individual faculty to the broad mission of the institution.*

— *provide special attention to the mentoring of underrepresented groups.* Their lack of participation in our fields and their growing prominence in the future workforce of our society mandates special attention to insure that they flourish in an academic environment.

Quality of Faculty Life

The quality of faculty life profoundly affects the productivity and career longevity of young faculty. Central to the quality of faculty life is an academic environment that provides adequate capital and human resource infrastructure to support high quality faculty instructional and research initiatives.

We recommend —

To higher education:

— *recruit and retain faculty more aggressively from all societal groups.* This is probably the single most important action to promote greater diversity in professorial contributions to the broad academic mission and to enhance wider student and public interest in science and engineering.

— *stop and start tenure clocks more flexibly through leaves of absence that recognize the reality of contemporary faculty life, including parental and personal obligations, and special opportunities for teaching, research, and professional enhancement.*

— *increase substantially capital expenditures to assure an adequate educational and research infrastructure and overall quality learning environment.*

— *establish faculty committees to evaluate and monitor the quality of faculty life.* Such committees could focus on issues related to flexible tenure clocks and formal leave policies for such issues as parental leave, "bridging" research fellowships, and personal, professional, and teaching leaves of absence.

Special Recommendation

In addition, the panel offers a suggestion aimed at one central and important concern about the health and vitality of our profession - attracting outstanding students to the professoriate to insure a quality educational and research infrastructure of the future.

To encourage young persons to enter academia, the panel recommends to higher education:

— *improve substantially the quality of instruction and quality of life of undergraduate students, and, by our efforts and example, encourage them to pursue graduate studies and faculty careers.* This is probably the most effective action we could take to the betterment and health of our profession.

NSF's Statutory Authority to Initiate and Support Programs in Engineering, Mathematics, and Science Education

NATIONAL SCIENCE FOUNDATION ACT OF 1950, AS AMENDED (P.L. 81-507; 64 Stat. 149)

An Act

To promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "National Science Foundation Act of 1950."

Functions of the Foundation (42 U.S.C. §1861)

SEC. 3. (a) (1) The Foundation is authorized and directed to initiate and support basic scientific research and programs to strengthen scientific research potential and science education programs at all levels in the mathematical, physical, medical, biological, social, and other sciences, and to initiate and support research fundamental to the engineering process and programs to strengthen engineering research potential and engineering education programs at all levels in the various fields of engineering, by making contracts or other arrangements (including grants, loans, and other forms of assistance) to support such scientific, engineering and educational activities.

NSF STATUTORY AUTHORITY AS AMENDED (P.L. 99-159, 99 Stat. 893)

Policy (20 U.S.C. §3911)

SEC. 101. (a) The Congress declares that the science and engineering education responsibilities of the National Science Foundation are —

(1) to improve the quality of instruction in the fields of mathematics, sciences, and engineering;

(2) to support research, fellowships, teacher-faculty-business exchange programs in mathematics, science, and engineering;

(3) to improve the quality and availability of instrumentation for mathematics, science, and engineering instruction;

(4) to encourage partnerships in education between local and State education agencies, business and industry, colleges and universities, and cultural and professional institutions and societies; and

(5) to improve the quality of education at all levels in the fields of mathematics, science, and engineering.

NATIONAL SCIENCE FOUNDATION
Directorate for Education and Human Resources
Division of Undergraduate Science, Engineering, and Mathematics Education

PRESIDENTIAL YOUNG INVESTIGATOR COLLOQUIUM ON U.S. ENGINEERING, MATHEMATICS, AND SCIENCE EDUCATION FOR THE YEAR 2010 AND BEYOND

Washington, D.C.
November 4–6, 1990

Colloquium Address by

Dr. Charles M. Vest
President
Massachusetts Institute of Technology

Good evening. I am delighted to offer my greetings this evening to such a remarkably talented group. In so doing, I am reminded of John F. Kennedy's famous greeting to an assemblage of Nobel prize winners at the White House. He looked out over the illustrious guests and commented that the room had never contained such a vast array of talent and accomplishment in so many fields - with the exception of those evenings when Thomas Jefferson used to dine alone.

I have something of the same feeling as I see all of you here, knowing that you represent the best that this nation has to offer. You have every reason to be very proud of your accomplishments and to look to your professional futures with confidence and excitement. It is about that future that I want to speak this evening.

The Academic Life

I am pleased and comforted by the fact that you have chosen to pursue academic careers. Our nation and world cry out for leadership, and faculty members can, by definition, provide a very critical component of leadership.

I have observed and studied the nature of academic life for many years. My own father was a professor of mathematics and my great uncle - a sort of surrogate grandfather to me - was an engineering professor and president of a small college. I, too, chose the academic life and I have a hard time envisioning any other calling for myself.

I must say, though, that during the last half of this century the life of professors has changed dramatically. The complexity of this life, the expectations of us, the pace and politics of the academy, and our connections beyond its boundaries have all changed greatly. On the home front, many of you are in dual career families, juggling competing responsibilities of family and work, and I know that this creates burdens that few of us in my academic generation had to bear. This fact is but one reflection of the changing face of America, which is represented in our universities in the increasingly diverse gender, racial, and ethnic makeup of our family and students.

The increasing richness and complexity of university life is a far cry from the traditional view of the academy. Sometimes we are called upon by both critics and colleagues to return to the golden age of universities, but I don't believe that the golden age ever really existed. And I don't believe we would really take that option if it were presented to us. Life in the academy today is filled with renewal, increased and varied opportunity, access to sophisticated laboratories and computers, greater productivity, better monetary rewards, a more diverse set of colleagues, and more opportunities for travel.

In short, I believe that the academic life is still the best life there is. In spite of all the changes, there is one overriding constant that is absolutely critical to the future, and that is the creation and dissemination of knowledge to new generations of young men and women. You will look back a few years hence and observe that your relations with students, your influence upon them, and your pride in their accomplishments will have been the most rewarding aspect of your professional lives.

I will have more to say about teaching and the balance between teaching and research later, but let me begin with one simple statement. *Professors should profess.* It is hard to think of anything more illogical than to become a university professor if one does not want to teach. So if you do not want to teach, you should immediately look for another job. If you don't get a thrill out of seeing a student's eyes light up with understanding, and if the thought of always having junior partners around — young men and women to inspire you as well as to draw sustenance from you — doesn't hold strong appeal for you, then perhaps you should reconsider your commitment to academia.

Now let me continue under the assumption that not too many of you are left with an uneasy feeling by this statement.

Opportunity and Service

Although it may be increasingly difficult to discern, I believe that being a university professor is a calling. It is a calling to service to our society. One of its pleasures comes in recognizing that what we do is terribly important — that the future depends in large measure on how well we do it. I hope that you share this belief, because it can sustain you through some of the difficult and lonely times of your lives.

Defining the Future

What you do as engineering and science educators has far-reaching consequences. What you do will affect the quality of the lives of your students. And from your laboratories and studies will come the ideas that will shape the intellectual fabric of the future and can greatly affect the strength and vitality of our economy.

Wherever your individual careers take you, I hope that you will be bold and that you will tackle the problems that appear to be of fundamental importance to you. The quality of your accomplishments will in large measure derive from the depth of your belief in their importance. Similarly, your ability to play a catalytic role in the research and studies of your students will depend on the depth of your scholarly commitment and belief in its importance.

The Research University

I would like to spend a few moments talking about the setting in which many of you will spend your careers — the research university — and the question of the balance of teaching and research.

Many of you are faculty members at research universities. Those of you who are not are probably products of research universities. I cannot speak about science and engineering education without offering a few comments about the U.S. research university. This is a uniquely American invention. And in my view this invention is the secret of the success of our higher education system. Indeed, I believe that our university system is the envy of the rest of the world. Here are the primary reasons:

1. For many decades Americans believed that higher education was singularly important for the betterment of their children's lives and they were willing to invest public, private and personal funds to create, sustain and enhance our public and private systems of universities.

2. The wonderful and unique blending of graduate education, undergraduate education and research that occurs in our leading research universities creates an unparalleled opportunity for learning and expanding one's horizons.

3. Our system, unlike that in most other parts of the world, provides great opportunity for young faculty members to quickly involve themselves in all levels of educational and research activities as full partners in the academic enterprise.

4. We have a decentralized system of autonomous public and private universities that allows for experimentation, variation and change.

5. Finally, although it is the bane of my existence as an academic administrator, I believe that competition - the competition of universities for faculty, and the

competition of faculty members for research support on the basis of peer review — is the yeast that keeps our system strong.

Our system of higher education, and our research universities in particular are under a lot of criticism these days. Some of our critics are sensational and strident. Others are thoughtful. We should listen to them and think about what they have to say. We must be willing to better explain to them and to the public what we do and why it is important. We must also be willing to make changes where our critics are correct.

Balancing One's Career

There is much discussion today both within and outside of the academy about the balance between teaching and research. Some may regard my view on this matter to be hopelessly old fashioned or unrealistic. Nonetheless, I will share it with you. As I do so, you might remember my earlier statement that if you don't want to teach, you shouldn't be professors.

However, having said this, I believe that research is fundamental to our activities. Following World War II this nation made a basic decision that its university system would become its research infrastructure. This remains true today, and I believe that it is in our best interest that it remain true. I further believe that the primary reason that we should do research in universities is that it is a form of teaching. It certainly is a form of learning for each of us, but it also should be an integral part of how we teach graduate students, and undergraduates as well.

I believe that over the long run, it requires the discipline, joy and continual renewal of original research, scholarship or other creative intellectual activity to keep lively and successful teachers. One may start out as an effective and even brilliant teacher, but without the kind of continuous renewal that research and scholarship provide, one will not grow in wisdom and breadth, and over time may lose rather than gain in effectiveness as a teacher.

Now how do we balance teaching and research? Must one be equally adept at both? Should you put the development of your teaching skills on hold until you receive tenure? Does teaching count?

My honest answers are: I don't know. Probably not. No. Yes.

Questions about the balance between teaching (whether in the classroom or the laboratory) and research must be answered both institutionally and personally. Each institution must decide for itself what the overall balance of activities should be, and then whether this balance should be met within each faculty member, or whether it is met by an appropriate mix of talents and activities across its entire faculty. Similarly, each individual must decide what his or her balance should be and whether this should be accomplished by a constant balance throughout each year of one's career, or simply as integral in one's activities over an entire career.

I won't answer this for you, but I will state my own personal preference to maintain a strong commitment to both teaching and research at each stage throughout one's career. I would also warn that if one prefers to emphasize research more in the early years of his or her career, it must not come at the expense of teaching poorly. That is an abrogation of responsibility. The quality of one's thinking and work are affected by habits and approaches developed very early on. It is a terrible mistake to think in terms of postponing the development of teaching skills until later, for example after tenure is earned. Given my view of what professors should do and the interrelation between teaching and research, that is a little like saying "I'll go out and write a wonderful computer program, and after it is completed I'll learn the programming language." Don't do it. Rather, devote yourself to excellence in all that you undertake.

Does teaching count for tenure? That is probably the question most frequently asked by assistant professors. The most likely answer to that question in each of your universities is that, yes, it definitely counts — probably more than you and many of your departmental colleagues think — and probably less than it ideally should. Furthermore, I would guess that its role in the evaluation of candidates for promotion and tenure will increase during the years ahead. We need to do a much better job in assessing contributions to teaching - that is, to the effective learning of students in our own institutions and, beyond that, to students in this country's educational system in general.

The Challenges

This brings me to my next point — the problems in public education and in social divisiveness that set the context for higher education in the United States today.

Our educational system is in deep trouble. We all know that within the international context our students on the whole are consistently at or near the bottom of the heap in objective tests of mathematics and science at the high school level. But this is only one manifestation of the underlying problems. Let me give you a specific example; it is one that would be roughly duplicated in most of our large cities.

In 1987, in the Detroit Public School System, 23,000 students started into the ninth grade. Four years later 6,700 of them graduated from high school. Of these, 2,800 took the ACT examination. And just over 500 of them scored 19 or higher. Hence, from an input of almost 23,000 students in the ninth grade, only about 500 emerged with any hope of advanced education of any sort.

A leading Japanese businessman recently was asked what were the most positive and the most negative factors affecting the ability of the U.S. to compete in the world marketplace. He answered that our greatest strength is our universities, and that our greatest weakness is our primary and secondary school systems. I agree. But how can it be that our higher education is the envy of the rest of the world, and our K-12 system is considered to be inferior? I have already spoken of the strengths of this country's university system. I will leave it up to you as citizens to determine why our K-12 system is failing. The point I wish to make is that this situation is not stable. The continued degeneration of our K-12 system, if unchecked, will eventually destroy our higher education system as well, or at least render it increasingly irrelevant and ineffective.

This has to be our common concern. In our professional lives and in our lives as citizens, we must recognize that there is a single spectrum of education starting at kindergarten (if not earlier still) and extending through postdoctoral education. Until this nation wakes up to the fact that it must increase its investment in human capital — in people and ideas — our education system will spiral downward, pulling our economy and way of life with it. This is a danger of the first magnitude and we must all work for its solution.

An even more fundamental danger, in my view, is the increasing bifurcation of our society into rich and poor, and the increasingly contentious splits along racial and ethnic lines. The first steps toward resolving these issues are to really understand how the face of this nation is changing and to ask how we can best respond to this in our personal and professional lives.

Let me review a few statistics that I assume you are already familiar with:

— Today's school population is 74% white, 14% African-American and 9% Hispanic-American. By the year 2020, when you will be ensconced in various leadership positions, this profile will have changed greatly. The school population will be 52% white, 20% African-American, and 24% Hispanic-American.

— Sixty-five percent of the entrants to the U.S. labor force before the year 2000 (just ten years hence) will be women; only 15% will be white males.

— In 1950 there were 17 active workers in the U.S. for each retired person. By the year 2020 there will be just 3 active workers to support each retiree.

These are quite dramatic changes and our educational and enterprise systems must recognize them. We are beginning to do so, but much of the burden will fall upon your generation.

Now I would like to consider specifically the so-called pipeline of students into science and engineering. You have probably seen these statistics many times, and have undoubtedly addressed them at this meeting. However, a little redundancy won't hurt when the message is this important. And the message is that it is absolutely essential to our economy and our society that we produce engineers and scientists.

— The NSF predicts a shortfall of around 700,000 scientists and engineers by 2010. In 1977 there were 4,000,000 high school sophomores in the U.S., 730,000 of these students expressed interest in science and engineering careers. In 1980, when this cohort entered college, 340,000 retained this interest. By 1984, 206,000 had actually graduated in scientific or engineering disciplines. Only 61,000 of these men and women entered graduate school in science or engineering. By 1992, just 9,700 will graduate with Ph.D.s.

I know that we are a selective bunch, but to have only 0.2% of these students end up with doctoral degrees in science and engineering does not bode well.

* * *

I have taken my personal enthusiastic and altruistic view of the academic life, added to it a sense of urgency and finally spread some doom and gloom statistics. What is my message?

It is that we need you, that what you do is very important, and that you had better do it well and in a manner that reflects the realities of the world around us, but that you can look forward to enjoyment and fulfillment as you take on the challenges.

Education in the 1990s

Why do we need you? What are the challenges of education in the 1990s?

The world is changing rapidly and in ways that are so fundamental as to be without precedent. We have already discussed the changing racial, ethnic, and gender mixes of U.S. students and of our workforce. But we must also look to even greater forces of change. The world political and economic order of the 1990s will be different than any we have experienced in our history. We are connected economically, physically and politically in ways that have never before been the case. At the same time, the nature of jobs and the qualifications and skills they require is also changing rapidly. Manufacturing processes are increasingly sophisticated, the acquisition and utilization of new knowledge is becoming the primary basis of commerce, and emerging working modes require mental agility, flexibility of approach and judgment skills, often quantitatively based. Yet, as we have discussed above, our populace is headed in the opposite direction.

We must work together to correct this growing disparity between the education of our populace and the realities of the changing nature of work that will be required in the years ahead. This is a task that will increasingly fall on us as engineering, science, and mathematics faculties. We must work to assure that our stewardship of the undergraduate education of our populace is a wise and effective one. But further, I believe that we are going to have to play some role in the reform of primary and secondary education — by speaking out, by working on the local level, by developing inspirational new curricula, by developing new educational technologies, by fostering interaction with industry and with retired scientists and engineers, by exposing school students to our laboratories, by demystifying what we do, and by opening discussions with students and faculty in other parts of our own campuses.

We at MIT are very concerned about the problems of scientific illiteracy and lack of numeracy. We have over 50 ad hoc programs to work with primary and secondary schools, and our alumni and alumnae associations are beginning to work on the problems in various localities around the country. Yet we are still searching for a way of making some really fundamental and far-reaching contribution to the betterment of scientific knowledge and understanding among young people. I can assure you that we will look with great interest at the results of your workshop.

Closure

Paul Krugman, a noted MIT economist has just published a very interesting book describing the nature of the current U.S. economy and what possible future directions it may take. He titled his book *The Age of Diminishing Expectations.* His exposition is straightforward and non-ideological, but throughout it he asks the haunting question "Why are we so satisfied with the way things are?"

If we are satisfied with "the way things are", then we will be the victims of a number of unpleasant self-fulfilling prophesies. I have faith that you will not be thus satisfied, and that we can count on you to apply your talents and abilities wisely in the service of your fellow men and women.

I wish you well on your journey.

CHARGE TO THE COLLOQUIUM

The charge to the colloquium is to prepare a report focusing on six major, interrelated issues of special significance to U.S. higher education to assure high quality *precollege* and *undergraduate* instruction in engineering, mathematics, and the sciences for all students. The issues are:

1) attaining and maintaining scientific and technological literacy for everyone,

2) encouraging curriculum renewal and the development of new learning environments, including laboratories and field experiences,

3) incorporating new and evolving technologies into the curriculum, especially information and computer technologies,

4) encouraging and preparing students for careers as precollege and college faculty,

5) assuring career participation by all societal groups, especially women, minorities, and persons with disabilities, and

6) developing young college faculty during the critical years to tenure.

For each issue, we would like you to: 1) develop a vision of what the role of U.S. higher education should be in the *year 2010 and beyond* to meet the challenges and opportunities of each issue, 2) identify the key courses of action needed to achieve that vision, and 3) make specific recommendations to higher education, in general, and faculty, in particular, the National Science Foundation, and others as identified by the colloquium.

I encourage you to approach your discussions from a broad and visionary perspective. We are interested in your thoughts about the fundamental, long-term, and systemic factors affecting the quality of precollege and undergraduate instruction in engineering, mathematics, and the sciences well into the next century. You should consider all human resources, including persons pursuing careers in the disciplines, the scientific and technological literacy of all citizens, and especially underrepresented groups who will make up most of our society of the future.

Luther S. Williams

Luther S. Williams
Assistant Director
Directorate for Education
and Human Resources

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AGENDA

Presidential Young Investigator Colloquium
on
U.S. Engineering, Mathematics, and Science Education
for the Year 2010 and Beyond

Holiday Inn Crowne Plaza
Arlington, Virginia
November 4-6, 1990

SUNDAY, NOVEMBER 4, 1990

7:00 p.m. **Registration**

7:30 p.m. **Welcome and Overview**

Dr. Luther S. Williams, Assistant Director
Directorate for Education and Human Resources, National Science Foundation

Dr. Robert F. Watson, Division Director
Division of Undergraduate Science, Engineering and Mathematics Education,
National Science Foundation

8:00 p.m. **Colloquium Agenda and Goals**

Dr. Jack R. Lohmann
National Science Foundation
(and the University of Michigan, Ann Arbor)

Dr. Angelica M. Stacy
University of California, Berkeley

MONDAY, NOVEMBER 5, 1990

8:00 a.m. **Panel Sessions: A Vision for the Year 2010**

AREA A: EDUCATION

Panel I - Attaining and maintaining scientific and technological literacy for everyone.

Chair: Dr. Robert Perry, Ohio State University

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Panel II - Encouraging curriculum renewal and the development of new learning environments, including laboratories and field experiences.

Chair: Dr. David L. Freyberg, Stanford University

Panel III - Incorporating new and evolving technologies into the curriculum, especially information and computer technologies.

Chair: Dr. Sally Wood, Santa Clara University

AREA B: HUMAN RESOURCES

Panel IV - Encouraging and preparing students for careers as precollege and college faculty.

Chair: Dr. Mark S. Mizruchi, Columbia University

Panel V - Assuring career participation by all societal groups, especially women, minorities, and persons with disabilities.

Chair: Dr. Susan L. Brantley, Pennsylvania State University

Panel VI - Developing young faculty during the critical years to tenure.

Chair: Dr. Denice D. Denton, University of Wisconsin, Madison

10:00 a.m. **Break**

10:15 a.m. **Area Sessions**

Area A (Panels I-III) and Area B (Panels IV-VI) meet in separate sessions to exchange ideas and develop a composite vision for each area.

11:30 a.m. **Plenary Session**

Both Areas meet together to present their composite visions.

12:00 p.m. **Lunch**

Speaker: *Dr. Edward A. Knapp, Director*
Los Alamos Meson Physics Facility
Los Alamos National Laboratory

1:15 p.m. **Panel Sessions: Key Courses of Action**

The six panels meet separately to identify the key courses of action to achieve the composite vision developed in the morning sessions.

3:15 p.m. **Break**

3:30 p.m. **Panel Sessions: Specific Recommendations**

The six groups continue to meet separately and draft specific recommendations to: 1) higher education, in general, and faculty, in particular, 2) NSF, and 3) others as identified by the panels.

5:30 p.m. **Reception**

6:30 p.m. **Banquet**

Speaker: Dr. Charles M. Vest, President
Massachusetts Institute of Technology

8:30 p.m. **Summary/Integration Session**

One person from each panel and the colloquium co-chairs will meet to summarize and integrate the highlights of the visions, courses of action, and recommendations in preparation for developing a draft of the report for Tuesday morning.

TUESDAY, NOVEMBER 6, 1990

8:00 a.m. **Panel Sessions: Report Drafts**

Each panel meets separately to review the highlights from the Summary/Integration session of Monday evening, develop a draft of the panel's contributions to the colloquium report, and prepare remarks for the next two sessions.

9:45 a.m. **Break**

10:00 a.m. **Plenary Session: Review of Report Drafts**

All panels meet to present their key courses of action and specific recommendations and to share their report drafts. The session will conclude with a general discussion of any other related issues, ideas, etc.

12:00 p.m. **Lunch**

1:30 p.m. **PRESENTATION AND DISCUSSION WITH THE SCIENCE ADVISOR TO THE PRESIDENT, NSF DIRECTOR AND ASSISTANT DIRECTORS**

Special Guest: Dr. D. Allan Bromley
Assistant to the President for Science and Technology

3:00 p.m. **Adjournment**

EPILOGUE

"The USEME-sponsored *Presidential Young Investigator Colloquium on U.S. Engineering, Mathematics, and Science Education for the Year 2010 and Beyond*, will, all hope, lead to a report which is useful to readers in academia and government with educational policy making responsibilities. However, its major benefits may already have been delivered in the lives of its participants.

The process used for identifying the colloquium participants selected young faculty, mostly from research universities, probably a majority of them non-tenured, with strong interests in teaching. This is a somewhat lonely group in the sense that most return to environments where many of their colleagues subordinate their teaching to research interests, and all are tempted to do so. It was, therefore, strongly encouraging to spend two intense days with colleagues attempting to articulate a vision of the future in which teaching shares with research a high priority. It was also useful to participants to be introduced to a directorate of the NSF with which most were previously not well acquainted, and which currently accounts for the most rapid funding growth within the Foundation. It was an honor, furthermore, to obtain the ear of the President's Science Advisor for an hour-and-a-half at the concluding presentation of the meeting. In short, the report outlined and drafted at the colloquium was as much a mechanism for creating valuable career links and reinforcing commitments to teaching among participants as it was a product of intrinsic value."

A Participant's
Post-Colloquium Evaluation