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ABSTRACT

Two-year colleges are often overlooked in undergraduate education even though they are responsible for educating 37 percent of all college students and over half of the minorities in higher education. In the fall of 1988, the Office of Undergraduate Science, Engineering, and Mathematics Education (USEME) convened a 2-day conference to discuss the improvement of undergraduate education at the two-year college level. This report includes a brief introduction to the issue, eight recommendations for the improvement of introductory science and mathematics education at the two-year college level, and a list of workshop participants. (CW)

Report on the National Science Foundation Workshop on Science, Engineering, and Mathematics Education in Two-Year Colleges

DIVISION OF UNDERGRADUATE SCIENCE, ENGINEERING, AND MATHEMATICS EDUCATION

DIRECTORATE FOR SCIENCE AND ENGINEERING EDUCATION
NATIONAL SCIENCE FOUNDATION
JUNE 1989

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Report on the National Science Foundation Workshop on Science, Engineering, and Mathematics Education in Two-Year Colleges

ROBERT E. PARILLA, CHAIR
OCTOBER 31-NOVEMBER 1, 1988
Washington D.C.

DIVISION OF UNDERGRADUATE SCIENCE, ENGINEERING, AND MATHEMATICS EDUCATION

DIRECTORATE FOR SCIENCE AND ENGINEERING EDUCATION
NATIONAL SCIENCE FOUNDATION
JUNE 1989

FOREWORD

A workshop sponsored by the National Science Foundation was convened to obtain a better understanding of the conditions and problems in undergraduate science, mathematics, and engineering education at two-year colleges, and to obtain recommendations for NSF actions to improve the quality of the educational programs at two-year colleges.

The two-year colleges are an often overlooked component in undergraduate education. These schools are responsible for educating a significant proportion of the nation's technical work force, as well as many students who continue their education at four-year colleges. In January 1989, NSF sent a report on two-year colleges to the Congress indicating that 37 percent of all college students and half of the minorities in higher education are enrolled in two-year colleges. Improvements in science education at two-year colleges will help to increase the supply of scientific and technical personnel, and significantly improve the science literacy of the general public.

In March 1986, the National Science Board (NSB) released its report "Undergraduate Science, Mathematics and Engineering Education" (NSB 86-100) that described the outcomes of a year-long study conducted by the NSB Task Committee on Undergraduate Science and Engineering Education. The NSB report identifies serious problem areas in U.S. undergraduate education and suggests remedial actions that should be taken by academic institutions, the private sector, states, the National Science Foundation, and other Federal agencies.

In response to the NSB undergraduate education report, the NSF created, in July 1987, the Office of Undergraduate Science, Engineering, and Mathematics Education (USEME) within the Directorate for Science and Engineering Education. The USEME Office, now a Division, initiates and manages programs that support improvements in undergraduate education. USEME is guided by a Steering Committee comprised of representatives from all of the NSF Directorates.

As an additional follow up to the NSB Report, USEME convened a two-day workshop in the fall of 1988. The workshop participants included two-year college faculty, administrators, and representatives of business and industry. The participants are listed at the end of the report. NSF expresses its appreciation to Dr. Robert Parilla, President of Montgomery College, who chaired the workshop, and to the participants for their assistance and hard work. This report describes the findings of Workshop and its recommendations concerning actions to improve the education of students at two-year colleges, particularly in the sciences and engineering. The opinions expressed in this report are those of the expert panel and do not represent NSF policy. The recommendations of the panel are currently under review by NSF.

Robert F. Watson
Director
Division of Undergraduate
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NATIONAL SCIENCE FOUNDATION
DIRECTORATE FOR SCIENCE AND ENGINEERING EDUCATION

June 9, 1989

Erich Bloch
Director
National Science Foundation
Washington, D.C. 20550

Dear Erich:

I am pleased to submit to you the report of the experts who participated in the National Science Foundation workshop on the state of undergraduate education in the sciences, engineering, and mathematics in the two-year colleges.

The report is the result of the dedicated efforts of Dr. Robert Parilla, President of Montgomery College, who chaired the panel, and to whom we are very grateful.

The workshop participants included two-year college faculty and administrators, university representatives, and business/industry representatives. The report and the recommendations indicate a serious need for increased support of undergraduate education in these institutions in order to increase the supply of science, mathematics, and engineering personnel, and to improve general science literacy.

Bassam Z. Shakhashiri
Assistant Director
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EXECUTIVE SUMMARY

While recognizing that recent steps by the National Science Foundation (NSF) are appropriate ones for encouraging and supporting the improvement of undergraduate education, the Workshop Group expresses grave concern that the level at which these steps are being implemented is insufficient. The budgets for the several NSF undergraduate programs are inadequate for the task and its urgency. Further, the programs have not been sufficient for addressing the needs of the two-year colleges.

Thus, the Workshop Group concluded that there is no way out of the worsening dilemma other than to move ahead deliberately and recapture the spirit of forward progress and leadership the Nation once held. There is no equivocation about the conclusion.

PROGRAM RECOMMENDATIONS

1) NSF establish programs (or an office) for introductory collegiate science, mathematics, engineering and technology to enhance lower division education.

2) NSF support faculty development opportunities to promote and enhance the scholar-teacher concept in two-year colleges.

3) NSF support model programs and activities to attract and retain students, especially from underrepresented groups, into lower division courses.

4) NSF establish programs that support curriculum revision, develop improved equipment and offer laboratory "hands-on" activities for introductory courses.

5) NSF establish programs that enhance utilization of computers and other technological innovations for introductory science and engineering laboratory courses.

PARTNERSHIP RECOMMENDATIONS

6) NSF and the two-year colleges develop an ongoing partnership which enhances participation of two-year college representatives in NSF activities.

7) NSF establish programs to encourage formation of additional partnerships involving the two-year colleges with business/industry, universities, public schools and other institutions.

8) The American Association of Community and Junior Colleges (AACJC) establish a National Task Force for the Improvement of Science, Mathematics and Engineering Education in Community, Junior and Technical Colleges.

BACKGROUND

The national interest requires that more citizens select careers in the sciences, mathematics, and engineering disciplines. It also requires that the level of scientific literacy be dramatically increased in the general populace.

The community, junior, and technical colleges are an important and integral part of American higher education; the Workshop Group believes these institutions must and can play a vital role in addressing the Nation's scientific work force needs of the future. Over five million credit students, including 55% of first-time college students, are attending these two-year institutions. Also, 42% of black students, 54% of Hispanic students, 43% of Asian students and over 50% of all women collegiate students are in two-year colleges.

Increasingly, the two-year colleges are producing students who continue on to baccalaureate and graduate degrees in science and engineering.

While the pool is large, the percentage of two-year college students who choose and remain in science, mathematics and engineering programs is small (as in four-year institutions). This is particularly true for students traditionally underrepresented in careers in these disciplines, especially minorities and women. The entire group of two-year college students is a largely untapped source of scientific personnel for the Nation. For millions of students the two-year colleges represent the last realistic opportunity to elect an interest in science, mathematics or engineering or to improve their scientific literacy through formal study.

Two-year colleges have the potential to increase the number of students in science, mathematics, engineering and technical areas: the large cohort of students they serve and the large number of undeclared majors with which they deal underscore this potential. They are uniquely positioned to increase science career interest among minorities and women and to increase the general scientific literacy of the nation's population. The community, junior and technical colleges can accomplish these objectives through the formation of partnerships with four-year colleges and universities; with precollege education units; with business, industry and Government laboratories; with professional organizations in the science, mathematics and engineering areas; and among the two year colleges.

It is recognized that NSF has taken several steps recently that are designed to encourage and support the improvement of undergraduate education. The members of the Workshop Group affirm the need and the appropriateness of these steps and express grave concern that the Government response has been insufficient to even "stem the tide" let alone begin to resolve the issue. While the organizational response of the NSF to those recommendations was the creation of a Division of Undergraduate Science, Engineering and Mathematics Education and an exciting new slate of educational programs, funding support is inadequate to the task and its urgency. In particular, the budgets for the several NSF undergraduate programs offered in FY 1988 (Undergraduate Curriculum Development in Engineering; Undergraduate Curriculum Development in Mathematics: Calculus; Instrumentation and Laboratory Improvement; Undergraduate Faculty Enhancement; Research Experiences for Undergraduates; Career Access Opportunities in Science and Technology for Women, Minorities and the Disabled) do not even begin to address the need. The requests of the proposals for each of these programs were many times the funds available. This response showed that there are a great variety of significant ideas offered by the community, a large number of capable citizens ready to contribute their considerable talents to the cause, but, for a lack of adequate funding, execution is stymied. The Workshop Group thus concluded that there is no way out of the worsening dilemma other than to move ahead deliberately and recapture the spirit of forward progress and leadership the Nation once held. There is no equivocation about the conclusion. Much more needs to be done if undergraduate education in engineering, mathematics, and the sciences is to serve the Nation adequately.

It is imperative that the Nation: (1) increase the number of students, especially women and minorities, in science, mathematics, engineering and technology; and (2) increase the scientific literacy of the general populace. Therefore, the Two-year College Workshop Group offers the following recommendations.

PROGRAM RECOMMENDATIONS

General Needs: The Workshop Group determined that the needs of introductory science education are best met by aggressive intervention in three areas: (1) faculty development; (2) student needs; and (3) educational resources, including science, mathematics, engineering curricula and equipment. These are consistent with the needs of the two-year colleges identified in the National Science Board Report (NSF 86-100), *Undergraduate Science, Mathematics, and Engineering Education* (p. 34) (1) and in the *Report of the Critical Issues in Two-year College Chemistry Conference* (pp. 4-5) (2). Therefore we recommend:

Recommendation 1

The National Science Foundation (NSF) establish, within the Science and Engineering Education Directorate, programs (or an office) for introductory collegiate science, mathematics, engineering and technology whose purpose is to enhance lower division education in these disciplines.

Faculty Development: The heavy teaching loads of the two-year college faculty members make it difficult for them to pursue the few, existing opportunities for professional growth (3). In addition, these faculty tend to be isolated from other colleagues in their disciplines and many have not kept up-to-date in their fields.

To be effective as a teacher of introductory college science, mathematics or engineering courses, a faculty member must be broadly proficient in a discipline and also be a pedagogical expert. A teacher must be enthusiastic and effective to have an impact on the large, heterogeneous groups of students found in introductory courses. The NSF should develop new faculty initiatives that are consistent with the concept of scholarship found in the recent publication, *Building Communities* (p. 26) (3), which states:

> "In addition to the scholarship of discovering knowledge, through research, it is also important to recognize the scholarship of integrating knowledge, through curriculum development, the scholarship of applying knowledge, through service, and above all, the scholarship of presenting knowledge, through effective teaching. These are areas of vital importance to two-year colleges."

As teachers of introductory courses, with heavy teaching loads, limited research facilities and lack of emphasis on research, two-year college faculty members do not engage in research as traditionally defined. Not being traditional researchers, however, does not prevent them from being effective scholars.

We agree with the National Science Board Report (1) that "Earlier foundation programs for college faculty . . . had significant positive impact on the quality of science, mathematics and engineering instruction in the United States" (p. 34). Consequently, we recommend that:

Recommendation 2

The NSF support a broad range of faculty development opportunities that are designed to promote and enhance the scholar-teacher concept including summer institutes and conferences, weekend seminars and symposiums, science faculty fellowships, research opportunities, faculty-industry interchanges, short courses and Chautauquas (4). These programs should be readily available, economically affordable, geographically accessible and developed through one of the partnership arrangements discussed later in this report.

Student Needs: The Workshop Group believes that the two-year colleges need leadership from the Nation's science community if these colleges are to participate effectively in increasing the supply of people entering science, mathematics and engineering careers while they also concentrate on increasing the scientific literacy of the populace. Therefore, the Group recommends that:

Recommendation 3

The NSF support model projects and activities designed to attract and retain students, particularly from underrepresented groups, into the lower division science, mathematics and engineering curricula. These projects should identify potentially interested students and provide them with instructional support that motivates and enables them to access a scientific, mathematics or engineering career. These projects should also be designed to increase the scientific literacy of all students, not just those electing careers in engineering and the sciences.

Laboratory and Curricular Change Including Laboratory and Demonstration Equipment: Many students receive their only formal collegiate and career exposure to science and mathematics in the two-year colleges. Therefore, the courses in which they enroll must be excellent in both content and quality of teaching and strongly motivate the students if they are to contribute to the improvement needed in the retention of students in science and engineering careers, to generate an interest in science

and engineering and to assure a scientifically literate graduate. As noted in the National Science Board (NSB) Report (1), ". . .the two-year institutions are beset by . . . serious deficiencies in both the amount and condition of apparatus and equipment" (p. 34). In addition, we believe there are serious curricular deficiencies in the introductory college courses in the sciences, mathematics and engineering portion of the contemporary lower division curriculum.

The NSF supported projects should provide for the development of new materials and schemes for their utilization which will produce the desired improvements in the introductory programs. Improved lower division courses will permit upper division level courses to be more meaningful. The NSF should allow for the development of these materials and schemes at the local level and by regional and national partnerships.

Programs are needed to address curriculum and equipment deficiencies in the introductory science, mathematics and engineering courses. These deficiencies include both the inadequacy of the equipment available and insufficient resources to acquire the adequate equipment which is available. Colleges with insufficient resources to acquire needed available equipment should take advantage of the Instrumentation and Laboratory Improvement program recently opened to community colleges. We recommend that:

Recommendation 4

The NSF staff establish programs to support curriculum revision of introductory courses in science, mathematics and engineering; to develop improved laboratory and demonstration equipment; and to develop new introductory laboratory experiments of a concrete, hands-on style to complement other course activities.

Modern Technology: The Workshop Group concurs with the National Science Board Report (1) in their observation that, "The potential applications of technology to education are of great interest to two-year colleges. Computers and computer networks, television, videotape and videodisc technology are seen as bringing new dimensions to teaching and learning. Investments by NSF in this area can lead to great advances in the capability of two-year colleges to deliver high quality instruction" (p. 34). Therefore, we recommend that:

Recommendation 5

The NSF establish programs to support projects that enhance the utilization of computers and other technologies in the introductory science and engineering courses.

PARTNERSHIPS RECOMMENDATIONS

In addressing the needs related to faculty, students and resources, we believe that NSF should support various types of partnerships because alliances can improve and strengthen relationships while addressing specific programs. Specifically, we recommend that:

Recommendation 6

An ongoing partnership involving the NSF and two-year colleges be created which includes participation of two-year college representatives in the activities of the NSF at all levels including involvement of two-year science, mathematics and engineering personnel in proposal submission, proposal review, visiting scientists, advisory committees and the National Science Board.

Implementation of this recommendation, we believe, will ensure that the potential of two-year colleges is realized in providing (a) additional persor nel needed for science, engineering and mathematics and (b) improved science literacy.

The Workshop Group also believes that in order for the two-year colleges to improve the quality of their science, mathematics and engineering programs, they must reach out to other institutions and build partnerships. Accordingly, the community, junior and technical colleges should develop partnerships or cooperative arrangements between two-year and four-year colleges; two-year colleges and precollege institutions; two-year colleges and business, industry and Government laboratories; two-year colleges and professional associations; as well as among two-year colleges.

To facilitate the transfer of students from two-year colleges to baccalaureate granting colleges and universities requires a close working relationship between the teachers and administrators of the two-year and four-year institutions. It is best if this is done at the grass roots level. The development of core curricula, the improvement and updating of lower division courses, the accurate advising of students, the execution of articulation agreements, the admissions process, all can be enhanced by working cooperatively.

The concerned faculty and administrators from closely related two-year colleges and four-year colleges should meet on a regular basis to ensure good articulation and student flow. Such meetings will increase mutual respect and understanding between the two segments of higher education with important subsidiary benefits related to the problems of faculty development, student needs and resources addressed in other sections of this report.

One very important partnership to be strengthened is the relationship between two-year institutions and secondary schools. Historically, this is the way in which the two-year college movement began, as an appen lage of secondary school programs. The success of the College Board's Advanced Placement Program has shown that many secondary students can achieve at the collegiate level. Some significant effects which might result from the strengthening would be: (a) relief of the boredom that now fills contemporary junior and senior level courses; (b) relief of the social problems present when students

are academically but not socially ready for college; and (c) strengthening of the introductory science courses by the presence of high ability secondary students. We believe that NSF could strengthen many types of partnerships; therefore, we recommend that:

Recommendation 7

The NSF establish programs designed to encourage the formation and strengthening of partnerships involving the two-year colleges and other institutions by: (a) providing Federal support for model programs; (b) supporting resource and faculty development necessary to make these viable; and (c) supporting liaison conferences among institutions with such programs.

Development of meaningful partnerships with business and industry should become a priority for two-year colleges. The two-year colleges, individually and collectively, should develop partnerships with business, industry and Government laboratories that: (a) provide real world experiences/applications for faculty and students and at the same time provide business industry and the laboratories the opportunity to make their needs known to the educational community in the areas of science, mathematics and engineering; (b) encourage cooperative arrangements for faculty and students; (c) utilize two-year institutions in the process of technology transfer; and (d) demonstrate to the community the cooperative spirit of education and industry working together to meet common goals.

Cooperation among two-year colleges can also strengthen the quality of science, engineering and mathematics programs. We believe that in many instances sharing of personnel, advanced scientific equipment and/or resources can enhance the delivery of programs and services at two-year institutions.

The National Science Foundation should encourage colleges to join together in cooperative alliances with secondary schools, senior institutions, business and industry, other two-year colleges and professional associations in their submission of proposals to the NSF and other agencies.

We further believe that the quality of education in science, engineering and mathematics in the two-year colleges can be significantly improved by an alliance between the colleges represented by the American Association of Community and Junior Colleges and the professional science, mathematics and engineering organizations that represent a community of common interest including the two-year college faculty within the organizations. Therefore, we recommend that:

Recommendation 8

The American Association of Community and Junior Colleges and appropriate discipline-based professional associations, such as the American Chemical Society, the American Association of Physics Teachers, the National Association of Biology Teachers, the National Association of Geology Teachers, the American Society for Engineering Education, the American Mathematical Association of Two-year Colleges, the Mathematical Association of America, the National Science Teachers Association, the Society for College Science Teaching and the American Association for the Advancement of Science, establish the National Task Force for the Improvement of Science, Mathematics and Engineering Education in Community, Junior and Technical Colleges and make recommendations for improvements to the respective associations, to state and Federal Governments and agencies and to the National Science Foundation.

CONCLUSION

The Two-year College Workshop Group believes that the community, junior and technical colleges of the country can make a significant contribution to increasing the supply of persons selecting science, mathematics and engineering careers as well as helping to improve the scientific literacy of the populace. To realize the full potential of these contributions, encouragement and support from outside the two-year college community is vital. Specifically, assistance is required for faculty development, student recruitment and resource development. We believe, strongly, that these necessary improvements can be effected only by strong leadership and support from the National Science Foundation along with building communities of cooperation involving two-year colleges, individually or collectively joining together with four-year colleges; business, industry and Government laboratories; precollegiate institutions; professional associations and other two-year colleges.

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