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ABSTRACT

Virtually every aspect of chemistry education was examined to determine changes needed to improve public understanding of science in general and chemistry in particular, and to improve the effectiveness of chemistry education. Among the findings reported are those indicating that: misunderstanding of science is widespread and public understanding of chemistry is poor; too few high school chemistry teachers are well grounded in the subject; laboratory exercises are slowly disappearing from general chemistry in high school and college; and that applications of both information technology and discoveries about learning are occurring haphazardly. Conclusions drawn from those and other findings take the form of 40 principal recommendations and numerous ancillary ones. Recommendations focus on the concern for the nationwide low level of public understanding of science and on problems and issues related to education at all levels, as well as to the following: science education in elementary schools, high schools, two-year colleges, colleges and universities; careers; continuing education; and role of the chemical industry. Recommendations include a minimum of three years of high school laboratory science for admission to college, a national effort to add science to the present basic triad of school subjects, and development of a model science program for each elementary school grade level. (JN)

TASK FORCE

FOR THE

STUDY OF CHEMISTRY EDUCATION IN THE UNITED STATES

PREPRINT -- RECOMMENDATIONS

20 March 1984

American Chemical Society
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TASK FORCE FOR THE STUDY OF CHEMISTRY EDUCATION IN THE UNITED STATES

Executive Summary

The American Chemical Society Chemistry Education Task Force finds that:

Mis- and dis- understanding of science are widespread and the public understanding of chemistry is poor. Too little science is taught in the elementary schools, possibly because too few teachers are well qualified to teach it; neither programs to assist improvement of teacher qualification nor good teaching materials are readily available. Too few teachers of chemistry in high schools are well grounded in the subject; those that are are spread too thin, have too few mechanisms available for maintaining and improving their qualifications, and are too easily wooed away to more satisfying and more remunerative employment. Laboratory exercises are slowly disappearing from general chemistry education in both high schools and colleges. College chemistry for nonmajors has yet to find an appropriate character; that for majors is beset with unanswered questions about curriculum content, especially as it relates to future professional employment. Applications of both information technology and discoveries about learning are occurring haphazardly. Demand for- and supply of- well-educated chemists are poorly related to each other. Arbitrary barriers to entry and progress in the profession continue to be reported. Industry does much to aid science education, but should do much more.

The Task Force recommends:

- Formation of a National Council on Education in Science and Technology to coordinate and oversee national educational efforts.
- Formation of a sub-Council on Public Understanding of Science and Technology.
- Formation of a sub-Council on Precollege Education in Science and Technology.
- Vigorous and large expansion of National Science Foundation and other Federal programs to upgrade the quality of science instruction through direct service to teachers.
- Expansion of Federal support of research and development in the use of computers and other information technologies in science education.
- Expansion of Federal support of research in science education.
- Coordinated effort by scientific and engineering societies to address the major problems of science education in the elementary schools.
- An immediate national effort to add science to the present basic triad of school subjects.

- That a model science program for each grade level K-8 be developed.
- Guidelines be developed for certification of elementary school teachers to teach science.
- Regional Science Centers be established for improvement of pre-college science education.
- That the ACS expand its activities in the area of pre-high school chemistry education.
- Creation of an ACS 5-year plan to improve chemistry education nationwide in the high schools.
- A national effort to raise teacher certification standards in science and mathematics and to secure adherence to such standards.
- A national minimum standard that 3 years of science taught with laboratory be required for graduation from high school.
- Study of changes necessary to improve the high school chemistry curriculum.
- That at least 30 percent of class time be devoted to laboratory exercises in the high school chemistry curriculum.
- Revision of the ACS 1970 "Guidelines for Chemistry in the Two-Year Colleges.
- Development by ACS of an outreach and consultation program to assist improvement of chemistry programs in two-year colleges.
- An ACS approval service for Chemical Technology programs.
- ACS approval of college transfer and other two-year college chemistry programs at the request of such institutions.
- National effort to attain acceptance of a requirement for admission to colleges and universities of a least 3 years of laboratory science and 3 years of mathematics taken in grades 9-12.
- National effort to assure that the laboratory science requirement for any baccalaureate degree is at least 10 percent of the undergraduate credit that must be earned by the student.
- Establishment of guidelines to the appropriate balance in college-level chemistry courses for nonscience majors among the fundamental principles of chemistry, applications of chemistry, and the place and role of the chemical sciences in contemporary society.
- A program of workshops and other activities to increase interaction among teachers of the natural sciences and engineering, the arts, humanities, and the social sciences.

- Substantial and significant laboratory work in all college-level foundational chemistry courses, whatever their student clientele.

- That the ACS Committee on Professional Training make recommendations concerning the content of chemistry courses intended for students who are not majors in chemistry.

- ACS development of curriculum modules in such aspects of chemistry as are germane to the curricula of professional schools of law, business, and the health professions, among others.

- Inclusion in the budgets of instrument purchase programs of additional funds to permit development of cooperative mechanisms for the maintenance and repair of such instrumentation.

- Sponsorship by the ACS Committee on Professional Training of the preparation of position papers providing advice and guidance to faculty members on ways to include or improve instruction in the undergraduate curriculum on a number of specific topics and areas.

- ACS consideration of how best to characterize opportunities in chemistry and the expectations of employers, identify necessary curriculum and resource elements, and utilize results of research to improve chemistry education.

- Consideration of the mission of the ACS Committee on Professional Training.

- ACS leadership of efforts to modernize the concept and structure of technical libraries.

- Government and industrial support of a program of postdoctoral appointments for research on problems of national concern to assist bridging temporary differences in employment demand and scientist supply.

- ACS sponsorship of efforts to identify and correct arbitrary restraints on women preparing for or practicing the profession of chemistry.

- Increase in development, testing, and evaluation of electro-optical systems for continuing education; expansion of ACS continuing education services.

- Strengthening and expansion of activities by the chemistry industry to improve the support science education at all levels.

- Establishment of an ACS staff Office to deal with activities at the academic-industrial interface.

The conclusions drawn from these findings by the Chemistry Education Task Force take the form of forty principle Recommendations and numerous ancillary ones, all set forth in the sections which follow. We begin with recommendations (N) that reflect our concern for the nationwide low level of public understanding of science, and our conviction that the momentum generated by recent national studies of school education, in general, and of education in mathematics, science, and technology, in particular, must be maintained. There follow some proposals (A) that relate to education at all levels. These are, in turn, followed by clusters which deal with problems at the levels of the elementary schools (E), high schools (H), two-year colleges (T), and colleges and universities (U). Sections dealing with matters related to the careers of some chemists (C), including continuing education, and with the special opportunity we believe exists for the chemical industry (I), complete the report.

RECOMMENDATIONS

National Concerns

N1. A National Council on Education in Science and Technology should be formed to coordinate and provide oversight of educational efforts at all levels in science and technology -- both for the general education of the population and for the practice of such specialties. In recognition of the size and complexity of the task of improving education in science and understanding of it, three sub-Councils should be formed to deal with: (1) the public understanding of science and technology; (2) pre-college education in science and technology.

This statement speaks to a result; a great deal of thought and planning will be required to make that result viable and effective. This Task Force believes that:

a. Such a National Council should be a pan-scientific body. Ways might have to be developed early to control its size, lest it become a "congress" unwieldly in numbers, but the National Council membership should include representation from scientific discipline societies (e.g. American Chemical Society, American Physical Society), disciplinary area organizations (e.g. American Institute of Biological Societies), pan-scientific organizations (e.g. American Association for the Advancement of Science), science teaching associations (e.g. National Science Teachers Association, American Association of Physics Teachers), among others. It is important that the Council be representative, so that the interpenetration and interdependence of the various technical disciplines be turned to advantage and that articulation be improved.

b. This Council should provide for stimulation, study, coordination, and oversight of policy development and activities concerned with: (1) the public understanding of science and technology and of their interactions with society; (2) the improvement of the science and the science-related components of precollege education.

N2. Whether or not a National Council is formed, the equivalent of its sub-Council or Commission on Public Understanding of Science and Technology must be

formed. This body should provide for the stimulation, study, coordination, and evaluation of a wide variety of activities designed to improve and advance the public understanding.

a. Such a sub-Council or Commission should include not only representation from the several domains of professional science [scientific discipline societies, disciplinary area organization, pan-scientific organizations, science teaching associations, and others], but membership drawn from the information community [media experts (print and electrooptical), communications organizations (e.g. American Museum Association, National Association of Science Writers, American Library Association, Corporation for Public Broadcasting), etc.] major support agencies [National Science Foundation, Department of Education, the private foundations, and others], and major industries and industrial organizations.

b. The initial responsibilities of this sub-Council or Commission should include: (a) working with the National Science Foundation and the National Assessment of Education Progress to establish programs for measuring the national, regional, and perhaps even state levels of public understanding of science; (b) working with various groups to develop a system for collecting and reporting information on the public understanding of science and technology; (c) developing programs for evaluating and reporting on the total national effort on communication of science and technology to the public and the related improvement in public understanding. In addition, this sub-Council or Commission might: (d) sponsor or convene national and regional conferences on various aspects of communicating science to the public; (e) sponsor the establishment of a National Center for Public Understanding of Science which would serve as a stimulating focus for research and development of a multi-disciplinary character.

N3. Whether or not a National Council is formed, the equivalent of its sub-Council or Commission on Precollege Education in Science and Technology must be formed. This body should provide for the continuing oversight and evaluation of a wide variety of activities designed to improve and strengthen precollege education in science, and technology.

a. Since this body is intended to both inherit the mantles and to continue bearing the burdens of the National Commission on Excellence in Education and The National Science Board Commission on Precollege Education in Mathematics, Science and Technology in the areas of science and technology, at least, it is appropriate that its composition reflect theirs, with appropriate additional emphasis on expertise from the several technical disciplines.

b. The initial responsibilities of this sub-Council or Commission should include: (a) working with the National Science Foundation and the Department of Education to develop federal, state, and local support for efforts to improve the qualifications of present teachers; (b) working with Federal, regional, and state education agencies, and with the professional technical and teacher organizations, to coordinate and improve present systems for assessing the quality of precollege education in science, mathematics, and technology; (c) developing programs for evaluating and reporting on the total national effort to improve and strengthen precollege education in science (including mathematics) and technology.

N4. Within the American Chemical Society, a committee or task force (perhaps ad hoc) on public understanding of chemistry should be formed to: (a) provide the input for chemistry to the proposed National Council (N1) and its suggested sub-Council or Commission on Public Understanding (N2); (b) provide coordination and oversight of ACS activities in this area; and (c) establish a sub-unit to give needed attention to the implementation of the Society's educational efforts directed to non-scientists.

a. This Task Force believes that the American Chemical Society should place additional emphasis on its activities as a direct interpreter and adviser to Congressional and administrative decision-makers, and that it should expand its efforts to provide information to interpreters and popularizers of science. With respect to the latter, an appropriate ACS body should study magazine and other media services to the non-scientist citizen to determine whether there are needs and opportunities for mass communication to the public that should be met by allocation or re-direction of Society resources. The same or a similar body should examine television programming in the sciences to ascertain the balance and fairness with which chemistry is presented as a central science, then recommend appropriate ACS action (which might be the development of a series devoted to chemistry).

The sub-unit mentioned in N4(c) is urgently needed. Whether it be a subcommittee of the Society Committee on Education or a staffed Office within the Education Division, or both, is less important than the creation of the focus.

All Levels of Education

A1. The Chemistry Education Task Force recommends a vigorous and large expansion of National Science Foundation and other Federal programs designed to upgrade the quality of science instruction through direct service to teachers. Such programs should include not only college and high school faculty members (who were well served by earlier programs of the Foundation) but also elementary school teachers and those specialists in science education at all levels who will bear responsibility in improving the science literacy of the student and general populations. We recommend also that state and local governments match the federal contribution by facilitating and supporting teacher participation in such programs and, in due course, by developing their own systems for assuring teacher improvement and refreshment.

A2. The United States Government should be urged to continue and to expand its role as a major supporter of research and development in the use of computers and other information technologies in science education, including the establishment of a research and development center to explore the potential of information technology in science education.

a. At present, the National Science Foundation and the National Institute of Education are the main Federal vehicles for provision of support for research in science education. It is likely that the Department of Defense and other Federal agencies, however, are sponsoring research and development work that have substantial application to education. All such agencies should increase the number

and expand the support of joint or cooperative research projects that bring together physical and life scientists, teachers, computer scientists, and cognitive scientists to study and develop educational applications of information technology. Because of the number of different disciplines involved in such activity, we propose that the Government establish a demonstration research and development center to explore the potential of information technology in science education for all students.

A3. The United States Government should be urged to continue and to expand its role as the principal supporter of research in science education, especially through efforts that increase the interactions between and among scientists, science educators, and cognitive scientists.

a. At present, the National Science Foundation and the National Institute of Education are the main Federal vehicles for provision of support for research in science education. These two agencies should increase the number and expand the support of joint or cooperative research projects which bring together teachers, scientists and mathematicians concerned with teaching in their disciplines, and cognitive scientists. Such projects have proved very fruitful in increasing our understanding of both the learning and teaching of science and in suggesting ways to improve them.

b. The Education Division of the American Chemical Society, the corresponding units of other disciplinary associations, and the proposed National Council (N1 and N3) should encourage both the expansion of Federal support of science education (particularly that involving cognitive science) and the careful application of the results of such research to curricula, in the classroom, and in the education of teachers.

Elementary School Science

E1. A coordinated effort by the American Chemical Society and other national scientific and engineering societies, perhaps led by the American Association for the Advancement of Science, should be mounted to address three major problems of science education in the elementary schools: the insufficient time devoted to it; the less-than-desirable quality of the curriculum and educational materials; and the lower-than-necessary qualifications and preparation of the teachers charged with direct responsibility for it.

a. The centrality of chemistry to its sister sciences and the importance of chemical phenomena to every aspect of daily life require that there be a chemistry component to science instruction at all grade levels; chemistry is too important to be left until there is time for a "unit" or "mini-course" in the middle or junior high school curriculum, or for a "course" in high school. Leadership in this aspect of the national task is appropriately that of the American Chemical Society through instruments such as the (governance) Society Committee on Education, (staff) Education Division, and (membership) Division of Chemical Education.

E2. The American Chemical Society and other national science and engineering societies should begin an immediate national effort to add science to the present basic triad of school subjects -- reading, writing, and basic mathematics.

a. It would help to increase to 25-30 percent the proportion of the school day that is devoted to instruction in science and mathematics. Substantial improvement would also be attained if the percentage were maintained while the school day were lengthened. Mathematics already has 45 minutes of the elementary school day; it is time for science instruction that must be increased.

b. One sure way to assist the increase of emphasis on science instruction in the elementary school curriculum is to expect science achievement on the part of all students. Therefore, the testing of science learning must be made a major part of any program of assessment of student progress. Achievement testing is, however, but one of the mechanisms which must be employed to assure the quality and content of instruction in science (and in every other area); th nation does not need more time devoted to pap.

Finally, we observe that students can be required to read and write about science; no sacrifice of learning of communications skills is necessary in order to increase the efforts of science and mathematics.

E3. A model science program for each grade level K-8 should be developed under the auspices of the National Council (N3), with each major science society assuming responsibility for assisting the creation of curriculum guidelines components in its disciplinary area. It is critical that science instruction in the elementary grades be based on observation of phenomena, and that it contain descriptive, quantitative, and conceptual elements.

a. As part of its participation in the proposed national effort (E1), and consistent with the objectives of the present recommendation, the appropriate units of the American Chemical Society should sponsor the development of chemistry modules for each grade level with special emphases on ease and safety of use and on low cost.

b. This Task Force recommends that the American Chemical Society and its sister science and engineering associations join to inform the public of the need for observation-based elementary science education so that the local state financing bodies will be supported in their quest for the additional funds that many be required to equip classrooms and provide instructional kits for such "hands-on" science in the schools.

E4. This Task Force recommends that the National Council (N3), with respect to the development of model K-8 science programs under its auspices, set forth guidelines for the certification of elementary school teachers to teach science; and, we recommend that those guidelines require of such teachers before certification the successful completion of at least 3 one-year courses in the sciences, a balanced selection being required among courses in the biological, earth, and physical sciences.

a. Further we recommend that the National Council and its component scientific and engineering societies mount programs of public information in support of the changes in conditions of employment of elementary school teachers which, in fairness, should accompany more stringent requirements for their professional

certification -- changes such as: compensation competitive with alternate careers; scholarship, tax-preference, and other financial inducements to enter and remain in teaching; salary schedule advancement for subject matter continuing education in addition to that derived from methods education and longevity; and released time for the special preparations that are necessary for the safe and effective teaching of science to children.

b. We recommend that elementary schcol teacher specialists in science be used to provide sound instruction during the period in which classroom teacher preparation for science instruction is being brought up to adequate levels.

c. Finally, we urge the participation of present elementary school teachers in programs designed to improve their knowledge of science and science teaching (A1).

E5. As many as ten Regional Science Centers should be established and supported by the United States Government to provide focal points for the improvement of pre-college science education through teacher service programs, curriculum and materials development projects, the provision of expert consultation, etc. The small permanent staff of each center should be strongly discipline-oriented, and each center should serve several disciplines selected in view of regional needs.

a. It would be appropriate that the National Council (A3) (a) direct the selection of the host institution for each such center by formulating the selection criteria and in other ways, and (b) serve as an independent supervisory body for the whole program. It is most appropriate that the base funding for the Science Centers program be provided by the National Science Foundation since, in this and other ways, it is important that these centers have strong science discipline character.

We believe that there should be contributory financial support to the Regional Centers from the states. The financial role of school district and institutions of higher education will be manifest in their partial support of teachers and faculty members assigned to the Centers for limited periods. The contributions of industry to this program in the national interest can be the most varied of all, ranging from direct financial contributions, through the donation of other kinds of material resources, to the temporary loan of skilled and interested professionals.

E6. The American Chemical Society should expand its activities in the area of pre-high school chemistry education to implement the recommendations of recent ACS studies, those from other national reports, and other elements of ACS science education policy as they apply to the pre-high school years.

a. Initially, this assignment might be given to the present Office of High School Chemistry, making it, in effect, an office with responsibilities covering the whole of precollege education. Experience should determine the desirability of and need for a separate office for the pre-high school activities of the Society.

b. Among the specific responsibilities of the expanded staff function should be the stimulation of increased interaction between elementary school teachers

and science specialists with both academic and industrial scientists. It should also sponsor the preparation of teaching modules for use at various grade levels K-9, consistent with the curriculum recommendations of the National Council and presenting chemistry from a sound and balanced perspective appropriate to its centrality among the sciences.

High School Chemistry and Science

H1. The American Chemical Society's Division of Chemical Education and the Society Committee on Education, in consultation with appropriate other bodies and individuals, should create a 5-year plan for using available and expected resources to improve chemistry education nationwide in the high schools. This plan should provide a priority listing of goals, programs, and activities for pursuit during five years by the education components of the Society, and should relate to likely and desirable programs supported by the United States Government, by state governments, and by private industry.

a. We recommend also, that the American Chemical Society's Committee on Education, in concert with selected representatives of the Society's governance and operating structure, develop machinery that will enable chemists to influence appropriately and significantly the planning, development, and implementation of the forthcoming changes in science education, especially at the high school level, that will follow upon the recommendations of The National Commission on Excellence in Education (which reported in April 1983) and The National Science Board Commission on Precollege Education in Mathematics, Science, and Technology (which reported in September 1983).

b. While it is unlikely that the Society could, at this time, undertake high school chemistry program approval, it should do more to add force to its recommendations for teacher preparation and continuing education. Education committees of ACS local sections might be willing to monitor high schools in their areas and prepare public reports from time to time on the state of chemistry education in their communities. The most powerful force for educational improvement is an informed and aroused constituency.

H2. The present mismatch between necessary and actual qualifications and numbers of high school teachers of science, especially chemistry, must no longer be tolerated. The National Council (N1), the American Chemical Society, other science societies, and the appropriate agencies of the United States Government should work more closely and more forcefully with state education agencies: (a) to raise teacher certification standards in science and mathematics; and (b) to limit severely the present administrative use of emergency or temporary certification (which tends to continue indefinitely) of persons underqualified to offer sound science instruction. To the former end, the American Chemical Society should review and update its 1977 "Guidelines and Recommendations for the Preparation and Continuing Education of Secondary School Teachers of Chemistry"; to the latter, the Society should increase its own efforts to bring into high school teaching already qualified professional scientists, either full- or part-time.

a. Workshops should be offered for college or other acceptable credit that would allow high school chemistry teachers, through evening, Saturday, or summer

attendance, to become more knowledgeable in the field of chemistry. Updating and strengthening of information on basic concepts, applications of chemistry, and chemical facts are especially useful and needed.

b. Colleges and universities should offer at similarly convenient times and in accessible locations those formal courses that would permit numbers of individuals in their service areas to complete certification requirements, pursue advanced degrees, and in other ways increase their potential as knowledgeable and qualified high school chemistry teachers. Similar programs, especially in the area of professional education, should be made available to already qualified professional scientists who wish, upon retirement or at other times, to assist the national effort to improve high school science instruction by becoming high school teachers themselves, full- or part-time.

c. We recommend that the National Council and its component scientific and engineering societies mount programs of public information in support of the changes in conditions of employment of high school teachers necessary to attract qualified persons to such teaching and to retain them there. These changes include: compensation competitive with alternate careers; scholarship, tax-preference, and other financial inducements to enter and remain in teaching; salary schedule advancement for subject matter continuing education in addition to that derived from methods education and longevity; released time for the special preparations that are necessary for the safe and effective teaching of science at the high school level; and the allocations of both personal assistance and material resources to the laboratory component of instruction required for its effectiveness and safety.

d. Because optimally-prepared high school chemistry teachers who keep abreast of their science are attractive to other employers, it would be in the national interest for such employers to work with school districts and individual teachers to develop programs which share these scarce persons between academic and private sector employment. Summer positions in industrial laboratories have long been available to qualified high school teachers; we commend such arrangements and urge their substantial increase and expansion. Industry can do much in other ways: by supporting special equipment needs, sponsoring awards for both student and teacher excellence, and by making its interested and qualified personnel available to share the instructional task of the nation's schools. (It is gratifying that Congress is now considering several pieces of legislation that would support such industry involvement in the improvement of science education.)

e. The overall effectiveness of education in science would be improved significantly by closer interactions between high school and college faculties. The Task Force recommends strongly that individual colleges and universities assume leadership in developing opportunities for such interactions. In the field of chemistry, the local sections (membership) of the American Chemical Society could provide interested and qualified persons to assist these efforts.

H3. The National Council (A1) supported by the American Chemical Society and other science societies should work closely and forcefully with state school boards and other education agencies toward a national minimum standard that 3 years of mathematics and 3 years of science taught with laboratory be required for graduation from high school, the latter including substantial amounts of biology, chemistry, and physics.

a. Parallel to the need for substantial science in the high school curriculum is that for improved guidance of students by high school counselors as to the career opportunities related to that science instruction. The science societies have an obligation to improve and extend their services to high school counselors through updating of t..eir present information materials, provision for counselor workshops, and other means of establishing and maintaining effective communication between the present and potential workers in science-related occupations.

b. We recommend also that high school guidance counseling be so conducted that students are made aware early that every career preparation of lasting value requires a sequence of commitments over the high school years and beyond. High school curricula should be broad and general so that options are not inadvertently foreclosed. This is an especially serious problem in technical areas because the ability of colleges and universities to remedy omissions from the high school years is decreasing rapidly.

H4. The National Council should guide a study by the American Chemical Society, with appropriate contributions from societies centered in sister disciplines, of the high school chemistry curriculum and recommend such changes as are found necessary to improve the effectiveness and utility of that curriculum. Resources should be developed to encourage high schools with sufficient enrollment to offer two (or more) different chemistry courses, each targeted on the needs of a major fraction of the students. Chemistry for the citizen-to-be and chemistry for the scientist/technologist-to-be are equally deserving of best efforts.

a. We encourage experimentation with ways of incorporating chemistry into the description of phenomena widely throughout the entire school curriculum so that, as students approach upper-level courses, they have sufficient background to make intelligent choices among the different kinds of chemistry courses available to them, and that those choices are not foreclosed.

b. We discourage as strongly as possible developments in high school chemistry courses which make them into descriptive, elementary, or warm-up versions of the first year college chemistry courses. Introductory college chemistry has its own problems and the widespread emulation of its content in high school courses, and, worse, in texts intended for them, is a disservice to all students at both levels. Perhaps the most salutary result of closer interactions between college and high school chemistry faculty members would be spreading agreement on the division of the tasks we share.

H5. Chemistry is an experimental science; chemistry is a laboratory science. Simulation is not a desirable or effective substitute for direct experience with the behavior of chemical systems. The Task Force recommends that any American Chemical Society guideline for the high school chemistry curriculum provide that at least 30 percent of class time be devoted to student laboratory exercises. The Society's education bodies should study the costs as well as the content of laboratory instruction and recommend ways in which effectiveness can be maintained when resources are limited.

a. It is possible that some of the rapid increase in high school laboratory costs are the result of imitation there of the kinds of exercises done in the

first year general chemistry laboratories in colleges and universities. Colleges and universities are under the same kinds of fiscal pressures experienced by school districts; neither should do the work of the other. Academic chemists should join with interested chemists from industry to develop laboratory exercises for both school and college courses that are faithful to the content of modern chemistry without requiring its sophisticated instrumentation.

Surveys which have included students show that they are enthusiastic about laboratory work -- in all high school science courses, not just chemistry. It is important that constructive educational use be made of the enthusiasm, especially since this finding is independent of whether the student is self-classified as "science-oriented" or "general."

Two-Year College Chemistry and Chemical Toxicology

T1. The American Chemical Society Committee on Education should undertake to revise the 1970 "Guidelines for Chemistry in the Two-Year Colleges" to reflect the diversity of chemistry education responsibilities that have become the norm for individual two-year colleges in the past 15 years.

a. This revision should reflect the comprehensive nature of two-year college chemistry programs rather than be limited to the transfer programs for intended chemistry majors. Further, the revision should address two major issues which have special intensity in the two-year colleges: standards for student performance, and adequate funding requirements.

b. If there is to be acceptance and utilization of the revised Guidelines, they should be accompanied by suggestions of the appropriate audiences to receive them and effective methods for their implementation at the departmental, institutional, and system levels.

T2. The American Chemical Society should develop an outreach and consultation program that would make the expertise of the Society staff and membership more effectively available to two-year college administrators whose institutions are engaged in substantial efforts to improve the quality of their chemistry programs.

a. In support of such activities, it would be desirable for the National Council and its component discipline-related associations to undertake studies of the special costs needed to maintain science instructional programs of the necessary quality, so that such information is available to administrators and consultants. Further, these studies might well give attention to the development of new approaches to funding these special costs. Local industry, a major employer of the occupationally-educated two-year college graduate, has been a generous supplier of nearly-state-of-the-art equipment to such educational programs. These efforts need to be expanded, and their analogue for academic transfer program instrumentation and equipment needs must be developed.

T3. When the Revised Guidelines (T1) have been published and the outreach and consultation program (T2) is functioning, the American Chemical Society should

undertake to certify/approve Chemical Technology programs in two-year colleges at the request of such institutions.

a. Like the present program of the ACS Committee on Professional Training, this activity in support of quality chemistry education in the two-year colleges should be voluntary on the part of the institutions and based on curriculum guidelines and review procedures that have been developed carefully and sensitively by highly qualified chemistry educators working closely with representatives of a cross-section of employers of chemical technologies.

b. A useful first step could be to offer the opportunity to two-year colleges for external review of their own self-evaluations conducted in light of the published Guidelines.

T4. When Recommendations T1, T2, and T3 have been implemented, the American Chemical Society should undertake to certify/approve college transfer and other chemistry programs in two-year colleges at the request of such institutions.

T5. The American Chemical Society Office for Two-Year College Chemistry should be made a permanent staff operation.

University and College Chemistry and Science

U1. The National Council (N1) in concert with the American Chemical Society and other science and engineering societies should work with national and state educational agencies, sducational consortia and accrediting bodies, and precentor colleges and universities to attain acceptance nationwide of a requirement for admission to all colleges and universities of at least three years of laboratory science and three years of mathematics taken in grades 9-12.

a. We recommend that this science requirement be increased gradually to four full years of secondary school laboratory science, to include both chemistry and physics. We recommend that this mathematics requirement be increased gradually to four full years of secondary school mathematics, to include two full years of algebra. And, increases in content and achievement are the objectives, not just increase in time spent.

U2. The continuous downward draft in the fraction of credit in science offered in satisfaction of requirements for baccalaureate degrees is not in the national interest. The American Association for the Advancement of Science in concert with the American Chemical Society and other science and engineering societies should work with national and state education agencies, educational consortia and precentor colleges and universities to assure that the amount of laboratory science required for any baccalaureate degree is at least 10 percent of the undergraduate credit which must be earned by the student.

U3. An American Chemical Society Task Force on Chemistry Education for Non-scientists, which might be the body described in N4 or an ad hoc sub-unit

of the Society Committee on Education, should consider the general and diverse aims of college-level courses taught for nonscience majors and establish broad guidelines to the appropriate balance in such courses among the fundamental principles of chemistry, the methodology and philosophy of the disciplines, applications of chemistry, and the place and role of the chemical sciences in contemporary society.

a. After guidelines are available, the Society, with assistance of other funding sources, such as the National Science Foundation and private educational foundations, should sponsor workshops for the creation and improvement of chemistry courses for nonscience majors, whose needs might be met more effectively by offering them sophisticated courses as seniors instead of introductory courses when they are freshmen.

b. In both the pre- and post-guideline periods, the Education Division of the American Chemical Society, or a unit like the Institute for Chemical Education (University of Wisconsin-Madison), could assist the improvement of such course offerings by establishing a clearinghouse for the exchange of syllabi, instructional modules, and other information.

U4. The National Council and the supporting societies mentioned in U1 should promote the development and establishment of a program of summer workshops and other suitable mechanisms to bring together teachers of chemistry, other natural sciences, engineering, the arts, humanities, and the social sciences, to study issues of common societal and intellectual concern so that the fruits of such study may be applied directly to the improvement and expansion of multidisciplinary instruction.

a. Some of these workshops could be part of the series sponsored currently by the National Endowment for the Humanities; others could derive from existing National Science Foundation programs; and a new series designed specifically to bridge the gap between the "two cultures" might usefully be sponsored jointly be these two agencies. It is important to note that the Chautauqua-type short courses and some of the Summer Institutes sponsored by the National Science Foundation were especially effective in stimulating cross-disciplinary interactions.

b. Additional support for the faculty members participating in these workshops should be expected not only from their institutions but from the various academic discipline societies and associations.

U5. Whether they are taught to nonscientists, science majors, or chemistry majors, foundational courses in chemistry at the college level must include a substantial component of significant laboratory work.

a. "Substantial" is ordinarily determined locally. But, as chemists, it is our belief that devotion of less than 30% of scheduled time to the laboratory work in a foundational course is close to if not actually insubstantial. It is of paramount importance that any educational laboratory work be significant, not merely trivial or time-spending.

U6. The American Chemical Society's Committee on Professional Training should make recommendations concerning the level and content of college chemistry courses intended for nonscientists and for students majoring in fields of science other than chemistry.

a. This activity is proposed as an aid to the necessary continuous interaction between chemistry and other departments, not as a substitute for it. Some members of the Task Force feel that the American Chemical Society should examine other aspects of its organization and programming with a view to increasing their availability to scientists in non-chemistry fields.

U7. The American Chemical Society, through the body described in U3, above, and with the assistance of various of its membership Divisions (e.g. Chemistry and the Law; Chemical Marketing and Economics), should undertake to determine the needs and develop curriculum modules for advanced instruction in such aspects of chemistry as are germane to the curricula of professional schools in law, business, and the health professions, among others. The Society should join with other science societies to develop similar but more general modules in science, its content, and its methods.

U8. The National Science Foundation and other agencies supporting the purchase by colleges of instructional research instruments should include in the budgets of these programs additional funds to permit experimentation, demonstration, and implementation of cooperative mechanisms for providing maintenance and repair service for such equipment.

U9. The Committee on Professional Training of the American Chemical Society should sponsor carefully defined and designed studies to examine a number of specific problems with the approved (professional) curriculum, and with those of its components that are utilized regularly by students majoring in other science fields. Among such problem areas are the following: historical perspectives and humanistic values; the organic chemistry and physical chemistry courses; biochemistry, molecular biology, and organic chemistry; polymer and macromolecular chemistry; computers and computation; probability and statistics; communications; economics; safety and chemical hazards; and chemical information retrieval. These studies should generate position papers to provide advice and guidance to college and university faculty members on optimal ways to improve or include appropriate instruction in these areas in the curricula pursued by chemistry majors and by students in other fields of science.

U10. The Task Force recommends that the President and Chairman of the Board of the American Chemical Society either select an existing committee of the Society (perhaps the Society Committee on Education with some augmentation membership) or appoint one ad hoc to consider how best to characterize chemistry-related career opportunities and how best to prepare for them. This committee, whether selected or appointed, should include: (1) current members of the Committee on Professional Training (CPT); (2) former members of CPT; (3) representatives of a range of types of industrial employers of chemists; and (4) members of the

Society who have not been associated with CPT. Inter alia, this committee should consider how best to: (a) characterize opportunities in chemistry and the expectations of employers; (b) identify necessary curricular and resource elements; and (c) utilize the results of research on teaching, learning, and instructional technology to improve the effectiveness of chemistry education.

U11. This Task Force recommends that the President and Chairman of the Board of the American Chemical Society assign to an existing committee of the Society, or to the ad hoc committee described in U10 above as its second major task, the responsibility to consider the intended, actual, and appropriate future mission of the Committee on Professional Training and to recommend such specific changes in mission, structure, or both, as may be required to maintain and extend the effectiveness of the Committee, whether continuing as at present or in some new form(s).

U12. The American Chemical Society should identify an existing committee or create a new one to provide leadership within the whole scientific community for analyzing the needs and opportunities and for proposing implementation nationwide of programs to modernize the concept and structure of technical libraries. This committee should draw on the expertise of Chemical Abstracts Service, but should include other individuals skilled in information science and the use of computers for information management in both the industrial and academic communities. Among the committee's concerns should be the use of these techniques for formal and informal education, and the training of individuals for careers in chemistry applications of information sciences.

Careers in Chemistry

C1. This Task Force recommends that the United States Government establish a new program of postdoctoral research on problems of national concern which could support as many as 200 chemical sciences appointments per year in Federal, industrial, or institutional laboratories. Such appointments would be tenable for a maximum of two years, and their number an addition to those presently funded through grants for fundamental research. The American Chemical Society should assume leadership of an effort to secure parallel expansion of such appointments under industrial sponsorship and, in other ways, assist dampening of wide swings in the annual numbers of employment opportunities

C2. The American Chemical Society, through its Women Chemists Committee and other appropriate bodies, should sponsor a conference to identify the difficulties encountered by women qua women in preparing for or practicing the profession of chemistry. Following that conference, a specific charge should be made to an appropriate Society body to seek actively solutions to these problems and removal of such arbitrary restraints on career development as may have been identified by the conference. If this approach proves successful, the Society should apply it to the difficulties in the same areas experienced by minority, handicapped, and other special segments of the profession and the profession-to-be.

a. The Task Force urges that the conference consider questions like the following:

Are there factors that operate currently to impede the recruitment and advancement of women in chemistry, or have such factors as existed in the past been eliminated?

Are there constraints associated with certain career paths that effectively inhibit women chemists from pursuing these paths?

Do such factors or constraints tend to steer women into careers that are less challenging or rewarding than those open to men?

Are there factors, real or perceived, that operate to discourage young women from choosing careers in the chemical sciences?

What should be done to change the patterns that discourage women students in grades 6 through 10 from making career decisions that reflect their earlier enthusiasms for science? In particular, what should be done to make chemistry an attractive career for women?

b. Since the problems that do exist are more because of the attitudes of men than of women, men as well as women should be involved in planning the conference, conducting it, and implementing its recommendations.

C3. Federal agencies, private foundations, and scientific societies concerned with support of education in science should devote substantial resources to the experimental development, testing, and evaluation of electro-optical technological systems for providing maintenance, completing, and proficiency acquisition types of continuing education, with special emphasis on the accessibility of high quality instruction to individuals away from the workplace. Specifically, the American Chemical Society, through its Education Division, should continue to develop and expand its audio, video, computer-based, and other electro-optical continuing education services to both individuals and groups.

Industry and Education

I1. The Task Force recommends strengthening and expansion of the wide spectrum of activities that bring the resources of the chemistry industry more effectively to bear on the improvement, support, and service of education at all levels. This expansion is important in technical areas, but it is critical in the wider domain of the public understanding of science. The local sections of the American Chemical Society are natural sources of knowledge, interest, talent, and energy for such efforts.

I2. The American Chemical Society should establish a staff Office to deal with the numerous and diverse activities at the academic-industrial interface, so that the resources and potential of both communities may be brought more effectively to bear on the improvement of both science education and the public understanding of science through education.

a. This staff function could be created simply by expanding that presently concerned with Cooperative Education, one of the most effective kinds of interac-

tion between industrial and collegiate institutions. As the principal coordinating body for the Society's activities related to education, the Committee on Education should assume leadership in developing a proposal to the Board of Directors concerning the responsibilities, role, support and funding of such an Office.

b. An early task for this Office should be review of the recommendations of recent Society conferences and workshops on problems at the academic-industrial interface to determine which are being implemented and which are not. Successful implementation on the local level of suggested programmatic activities should be publicized and other local foci of interest stimulated and supported in their efforts to emplace such activities. Recommendations for new policies or modified statements of policy should be tracked and efforts made to assist the clearing of the docket.

c. The Office should devise strategies for using existing Society communications networks to disseminate information about successful efforts to solve problems at the interface and about new kinds of local and area attention to education that seem to be helpful, and in other ways should assist and reinforce local efforts.